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Metacognition, teacher education, and generative artificial intelligence: insights from a study group

Metacognição, formação docente e inteligência artificial generativa: aprendizagens em um grupo de estudos

Metacognición, formación del profesorado e inteligencia artificial generativa: aprendizajes en un grupo de estudio

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Abstract

In the educational context, generative artificial intelligence (AI) challenges traditional conceptions of language, authorship, and knowledge. Given this, the main objective of this article is to identify the metacognitive strategies employed by participants in a study group regarding the use of generative artificial intelligence in their daily lives and in their teaching practices. This is a qualitative, exploratory-descriptive study conducted with 12 participants at a private higher education institution in southern Brazil between February and June 2025. Data collection was carried out via a questionnaire with open-ended questions, administered following readings, theoretical discussions, and experiences with generative AI. Data analysis was conducted using the content analysis method (Bardin, 2016). The results reveal that collective practices enhanced the

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teachers' metacognitive awareness. This process allowed for the problematization of naturalized discourses and the shared construction of meanings. It is concluded that metacognitive development is central to teachers adopting a critical stance toward generative AI, promoting a more ethical, situated, and transformative pedagogical practice.

Keywords: Metacognition. Learning. Teacher training. Generative artificial intelligence.

Resumo

No âmbito educacional, a inteligência artificial (IA) generativa desafia concepções tradicionais de linguagem, autoria e conhecimento. Diante disso, o objetivo principal deste artigo é identificar as estratégias metacognitivas mobilizadas pelos participantes de um grupo de estudos acerca do uso da inteligência artificial generativa no cotidiano e em suas práticas pedagógicas. Trata-se de uma pesquisa qualitativa, de caráter exploratório-descritivo, realizada com 12 participantes em uma instituição de ensino superior privada no sul do Brasil, entre fevereiro e junho de 2025. A coleta de dados ocorreu via questionário com perguntas abertas, aplicado após leituras, discussões teóricas e experiências com a IA generativa. O tratamento dos dados foi realizado com base no método de análise de conteúdo (Bardin, 2016). Os resultados revelam que as práticas coletivas potencializaram a consciência metacognitiva dos professores. Esse processo permitiu a problematização de discursos naturalizados e a construção compartilhada de significados. Conclui-se que o desenvolvimento metacognitivo é eixo central para que os docentes assumam uma postura crítica frente à IA generativa, promovendo uma atuação pedagógica mais ética, situada e transformadora.

Palavras-chave: Metacognição. Aprendizagem.Formação docente. Inteligência artificial generativa.

Resumen

En el ámbito educativo, la inteligencia artificial (IA) generativa pone en tela de juicio las concepciones tradicionales sobre el lenguaje, la autoría y el conocimiento. Ante esto, el objetivo principal de este artículo es identificar las estrategias metacognitivas que emplean los participantes de un grupo de estudio sobre el uso de la inteligencia artificial generativa en la vida cotidiana y en sus prácticas pedagógicas. Se trata de una investigación cualitativa, de carácter exploratorio-descriptivo, realizada con 12 participantes en una institución de enseñanza superior privada del sur de Brasil, entre febrero y junio de 2025. La recopilación de datos se llevó a cabo mediante un cuestionario con preguntas abiertas, aplicado tras lecturas, debates teóricos y experiencias con la IA generativa. El análisis de los datos se llevó a cabo basándose en el método de análisis de contenido (Bardin, 2016). Los resultados revelan que las prácticas colectivas potenciaron la conciencia metacognitiva de los docentes. Este proceso permitió la problematización de discursos naturalizados y la construcción compartida de significados. Se concluye que el desarrollo metacognitivo es un eje central para que los docentes adopten una postura crítica frente a la IA generativa, promoviendo una actuación pedagógica más ética, situada y transformadora.

Palabras clave: Metacognición. Aprendizaje. Formación del profesorado. Inteligencia artificial generativa.

1. Introduction

Over the past decades, technological advances have driven significant transformations in our daily lives and in society as a whole; in recent years, these transformations have been marked by the growing impact of the popularization of generative artificial intelligence (AI). Tools such as ChatGPT and other language-model-based platforms have become embedded in our everyday routines, changing the way we communicate, consume information, goods, and services, relate to one another, and conduct research.

According to Santaella (2023, p. 10), "almost everything that reaches us in dailly life is already impregnated with AI algorithms: books, movies, news, games, search engines, and all the Web platforms and applications with which we have learned to live and without which it would be difficult to live1". The fact is that we find ourselves in a hyperconnected, digital, and algorithmized society, in which human relationships, knowledge production processes, and social dynamics are increasingly mediated by automated technologies.

Within this context, the school practices of students and teachers are also being reshaped. While students make use of these tools—albeit often intuitively and with little critical awareness—faculty members across different levels of education seek to understand this new scenario and rethink their pedagogical practices in light of the transformations brought about by digital technologies, particularly generative AI. However, more than mastering these tools, it becomes urgent to critically reflect on the impact of these technologies on how one "reads the world2" (Freire, 1921–1997), how one teaches, how one learns, and how knowledge is constructed.

Indeed, reading the world through the productions and outputs generated by different AI tools requires a constant exercise of critical thinking, as such artifacts are not neutral: they carry within them the marks of algorithmic choices, of the databases that feed them, and of the human and institutional intentions that guide them (Harari, 2024). Understanding these productions, therefore, goes beyond assimilating ready-made content; it implies unveiling the technological mediation processes that structure such responses and recognizing the limits and possibilities of AI in the educational process.

Given this scenario and the urgency of rethinking formative processes at a time marked by the intensifying presence of technology in social and educational practices, a study group sponsored by a private university in southern Brazil felt called upon to address this theme. Thus, over the course of one academic semester, from February to June 2025, its members dedicated themselves, on a weekly basis, to studying and reflecting on AI from perspectives that examine its social, economic, and educational impact, seeking to understand not only its functioning but also its ethical and cognitive implications.

Accordingly, this article aims to identify the metacognitive strategies that participants mobilized in a study group regarding the use of generative artificial intelligence in their daily lives and pedagogical practices.

In this context, the articulation between metacognition, artificial intelligence, and teacher education becomes a central axis for understanding how teachers reflect on, regulate, and transform their practices in environments mediated by digital technologies. As discussed by authors in the field of metacognition, such as Flavell (1985) and Mayor, Suengas, and Marques (1995), the capacity to monitor and regulate one's own learning process is fundamental to the construction of meaningful knowledge. When transposed to the context of generative artificial intelligence, this competency takes on new contours, as the use of these technologies demands not only technical mastery but, above all, a critical and reflective stance toward the information produced. Along these lines, as Lucia Santaella (2023) argues, the growing presence of AI in social and educational practices calls for the formation of subjects capable of interpreting, questioning, and reframing the content generated by algorithmic systems.

Building on these premises, we present the results of a qualitative study involving 12 participants who were part of the "Learning and Teaching" (*Aprendizagem e Ensino*) study group between February and June 2025. Data

[1] From Portuguese, "quase tudo que chega até nós no cotidiano já está impregnado de algoritmos de IA: livros, filmes, notícias, jogos, motores de busca e todas as plataformas e aplicativos da Web com os quais aprendemos a conviver e sem os quais ficaria difícil viver".
[2] From Portuguese, "se lê o mundo".

collection was carried out through an open-ended questionnaire, administered after reading and discussion activities addressing theoretical frameworks on contemporary generative artificial intelligence. Data processing was based on content analysis (Bardin, 2016), involving the stages of pre-analysis, material exploration, and treatment and interpretation of results.

For organizational purposes, this article is structured as follows: first, the conceptual foundation underpinning the study is presented. Next, the research methodology is described, with the investigative context, the procedures adopted, and the data collection instruments characterized in detail. This is followed by the presentation and discussion of the main findings, articulated with the theoretical frameworks underlying the analysis. Finally, the concluding remarks revisit the study's main findings, highlighting the results obtained through the analyses conducted, with a view to enriching future teacher education initiatives.

2. Metacognition and Artificial Intelligence in Education

Reflecting on human learning processes amid the rise of generative artificial intelligence first requires clarifying the concept of learning that anchors this study, before presenting the relationships between human and machine learning.

The literature offers different theoretical strands that conceptualize and understand human learning from distinct perspectives. This study understands the learning process as complex and multifaceted, involving cognitive, cultural, social, and emotional aspects. Explicitly, learning means:

> Transformation into a process and co-existence, occurring as a result of experience, of the organization and reorganization of cognitive structures, of what I already know, of what is part of my inner world, with what I did not know, what I was not familiar with, coming from the external world. And this is only possible because we think, act, feel, and interact with our environment (Portilho, 2023, p.5)[3].

This conception reinforces the understanding of learning as a dynamic, relational process, in which the subject continuously transforms their cognitive structures through interaction with the environment. Thus, learning implies articulating prior knowledge with new experiences, promoting internal reorganizations mediated by cognitive, emotional, and social dimensions.

Within this process, metacognition "mobilizes the learning subject to reflect on what they have just done and how they did it" (Portilho, Jackiw, Vaz, Beraldo, 2025, p.30)., 2025, p. 30)[4].

Briefly, Flavell (1985, p. 906) defines metacognition as "knowledge and cognition about cognitive phenomena.[5]" This implies that subjects not only think but also consciously reflect on their own thinking, evaluating and regulating their own paths of understanding. This process encompasses awareness of one's own cognitive activity, showing that learning requires developing knowledge about oneself and about the strategies used to learn.

Building on Flavell's work, Mayor, Suengas, and Marques (1995) contend that metacognition can be understood as a broad process in which monitoring and self-regulation are interdependent, complementary activities responsible for planning, monitoring, and evaluating cognitive activity. For these authors, metacognition comprises three metacognitive strategies: awareness, control, and autopoiesis.

According to Mayor, Suengas, and Marques (1995), the metacognitive strategy of awareness involves the knowledge individuals hold about themselves as learners, the nature of the task at hand, and the strategies

[3] From Portuguese, “Transformação num processo e co-existência, que acontece como resultado da experiência, da organização e re-organização das estruturas cognitivas, daquilo que eu conheço, que faz parte do meu mundo interno, com aquilo que eu não sabia, que eu não conhecia, vindo do mundo externo. E isso só é possível porque pensamos, agimos, sentimos e interagimos com o meio”.
[4] From original, “mobiliza o sujeito aprendente a refletir sobre o que acabou de fazer e como fez o que fez”.
[5] From original, “conhecimento e cognição sobre o fenômeno cognitivo”.

available to accomplish it. Portilho, Jackiw, Vaz e Beraldo (2025) note that it is through this awareness—of the processes and competencies required for a given task, and of the strategies to be used—that learners decide whether to undertake it and how to proceed. This involves knowledge about learners' personal characteristics, what is learned, and how it is learned.

The metacognitive strategy of control relates to the executive control and self-regulation employed in carrying out cognitive activity (Mayor; Suengas; Marques, 1995). Portilho, Jackiw, Vaz e Beraldo (2025) clarify that this strategy encompasses planning the most appropriate approach for a task, self-regulating its use, and evaluating the results. For Zimmerman (2002), self-regulation is a cyclical process: evaluating prior performance informs adjustments to current activities, allowing for correction and continuous improvement.

The strategy of autopoiesis was proposed by Mayor and colleagues (1995), based on the understanding that it enables individuals to transform or reconstruct their learning process, or to self-organize accordingly. Portilho, Jackiw, Vaz e Beraldo (2025) explain that this concept is fundamental for subjects to integrate into reality, regulate mental activity, and adapt to their environment. The theory of autopoiesis was first developed in the 1970s by Maturana and Varela (2003) to describe the capacity of living cells to reproduce and self-organize. In the learning process, autopoiesis can thus be characterized as an effective action that enables a living system to exist within a given environment, creating its own world—its own way of acting and interacting, of creating and re-creating, of understanding and being understood. As such, autopoiesis is fundamental as a metacognitive component, as it enables the transformations required of the subject based on lived experience and on the changes arising from this intrapersonal, recursive movement.

Understanding learning as a dynamic, self-referential process opens space for reflecting on how artificial systems, too, can operate through mechanisms of adaptation and learning, even when grounded in algorithmic structures.

Regarding generative artificial intelligence, it should be kept in mind that “the fundamental principle of machine learning is that algorithms can learn new things on their own by interacting with the world, much as humans do, thereby producing a fully developed artificial intelligence” (Harari, 2024, p. 418)[6]. This means AI “is not a mindless automaton that repeats movements endlessly, without regard for outcomes. In fact, these technologies are equipped with robust self-correction mechanisms that allow them to learn from their own mistakes” (Harari, 2024, p. 419)[7].

This shows that generative AI systems operate through learning processes based on the continuous analysis of data and feedback from their outputs, allowing them to adjust performance over time. Unlike traditional computational models centered on the rigid execution of predefined commands, contemporary systems incorporate adaptation mechanisms that emulate, to some extent, the dynamics of learning—identifying patterns, correcting deviations, and refining responses based on ongoing interactions.

Santaella (2023) argues that generative AI marks a rupture with earlier forms of artificial intelligence, particularly through its capacity to produce new content and to establish closer, more dynamic, and more accessible interaction with users. Unlike systems that operated predominantly through specific commands and functions, generative AI tools now participate in text production, image creation, problem-solving, information synthesis, and idea development, becoming present across everyday activities. This expansion, however, also brings to light dilemmas around the reliability of the information produced, authorship, privacy, intellectual autonomy, and the boundaries between human and automated contribution. In education, these issues carry particular weight, since AI use should

[6] From original, “o princípio fundamental do aprendizado de máquina é que algoritmos podem aprender coisas novas sozinhos interagindo com o mundo, da mesma forma como os humanos fazem, produzindo assim uma inteligência artificial plenamente desenvolvida”.
[7] From original, “não é um autômato estúpido, que repete movimentos ao infinito, sem levar em conta os resultados. Na verdade, essas tecnologias estão equipadas com robustos mecanismos de autocorreção, que lhes permitem aprender com os próprios erros”.

not be understood merely as a way to facilitate or expedite tasks but as a phenomenon that interferes with the very processes of learning, thinking, and knowledge production.

Not by chance, the United Nations Educational, Scientific and Cultural Organization (UNESCO), in a 2023 guide on Artificial Intelligence in Education, warns that content produced by these systems—beyond carrying ideological and cultural biases of various kinds—may contain errors and other limitations. It is therefore important that users, especially teachers and students, adopt a critical stance toward any results, in particular guarding against the automatic acceptance of these responses.

Building on this reality, Díaz Bernal and Santos (2025) contend that developing metacognition is essential today, particularly when using technologies such as artificial intelligence. According to these authors,

> it is not merely a matter of the student obtaining the correct answer, but of being able to reflect on the process that led to it. Encouraging students to become aware of their own learning process—recognizing when they truly understand a concept versus when they are merely memorizing it or using a tool to reach a quick solution—is essential for AI use to translate into an enriching educational experience rather than a way of avoiding genuine learning (Díaz Bernal, Santos, 2025, p. 5)[8].

This perspective highlights that, today, completing tasks and activities cannot be reduced to obtaining correct answers, especially given the growing mediation of technologies that quickly provide seemingly accurate solutions. By emphasizing metacognition, Díaz Bernal and Santos (2025) call attention to students' need to develop the capacity to monitor and evaluate their own cognitive processes, distinguishing genuine understanding of a concept from the merely instrumental use of digital tools.

The expansion of generative AI thus introduces new possibilities for accessing, producing, and circulating information, while also placing greater responsibility on subjects for their own cognitive processes. If learning implies selecting information, establishing relationships, formulating hypotheses, and evaluating knowledge, then systems capable of producing answers within seconds blur the boundary between what subjects have actually understood and what they have merely received from a technology. Metacognition thus becomes especially important by fostering awareness of one's own ways of thinking, learning, and deciding. More than a competency to be developed, it can serve as a regulatory dimension in the use of these systems—allowing subjects to question what they seek, recognize what they know and do not yet understand, track their cognitive path, and critically evaluate the technology's output (Xu, 2025; Lowry et al., 2026).

The relationship between metacognition and artificial intelligence can therefore transform the learning experience itself, insofar as interacting with AI prompts subjects to make their intentions explicit, formulate questions, confront answers, identify inconsistencies, and reconstruct understanding. Upon receiving a seemingly coherent answer, for instance, subjects must decide whether that information matches what they are looking for, whether it is sufficiently substantiated, and how it relates to their existing knowledge. From this perspective, the contemporary educational challenge lies not in teaching subjects to use AI ever more efficiently, but in forming individuals who remain intellectually active in the face of it—who know how to interrupt the ease of a ready-made answer to ask, verify, compare, doubt, and rework (Xu, 2025; Fan, 2025).

Fan et al. (2025) draw attention to a possible 'metacognitive laziness,' whereby easy access to AI-generated answers may reduce students' active engagement with certain stages of the learning process. When technology takes over elaboration, inquiry, doubt, and verification, subjects risk offloading not just a task, but a substantial part of the cognitive effort required to learn, onto the system.

[8] From original, "não se trata apenas de o estudante obter a resposta correta, mas de ser capaz de refletir sobre o processo que o levou a essa resposta. Incentivar os estudantes a tomarem consciência de seu próprio processo de aprendizagem, sendo capazes de reconhecer quando realmente compreendem um conceito e quando apenas estão memorizando ou utilizando uma ferramenta para alcançar uma solução rápida é fundamental para que o uso da Inteligência Artificial se traduza em uma experiência educativa enriquecedora e não em uma forma de evitar a aprendizagem genuína".

This shifts the debate on AI in education away from a focus solely on its risks or technical potential, toward an essentially formative question: what kind of subject do we want to shape in a reality where producing an answer grows ever easier, while understanding, evaluating, and making sense of knowledge remains a fundamentally human task? Metacognition, in this light, must play a central role in building an ethical, critical, self-regulated relationship with AI—helping ensure that technological advancement is matched by the development of humans' capacity to think about their own thinking.

This discussion underscores the centrality of teacher education, since teachers play a strategic role in mediating technology, knowledge, and learning, and are responsible for pedagogical practices that critically integrate these elements.

In teacher education, metacognition is imperative: teachers need to understand their own learning paths in order to intervene intentionally and critically in their students' development. In an educational landscape transformed by generative AI, teaching demands more than passively consuming data. It requires teachers to monitor, evaluate, and regulate their own engagement with AI-produced information and transform their practice in the digital age. Badia and Monereo (2010) emphasize the importance of metacognitive strategies today: in a society where information is the primary consumer good, competently managing it and transforming it into knowledge is a skill schools should foster at every educational level.

In light of these discussions—which underscore the centrality of metacognition in teacher education within AI-mediated contexts—the following section presents the methodological pathways underpinning this investigation, along with the context in which it is situated, in order to show how these theoretical assumptions materialize in the empirical field.

3. Methodology

3.1 The Researche Context

The 'Learning and Teaching' study group (Grupo de Estudos Aprendizagem e Ensino, GEA) began its activities in 2005 at a private higher education institution in southern Brazil, with the aim of studying the concept of learning and related research from the perspective of authors who prioritize this process in their work. The group included undergraduate, specialization, master's, and doctoral students, as well as education professionals and teachers from different fields of knowledge and school systems. It was an open space for anyone interested in deepening their understanding of learning and teaching topics, fostering interdisciplinary dialogue, the collective production of knowledge, and the continuing education of researchers and education professionals.

Meetings took place weekly and lasted 1.5 hours. Each session opened with a prompt on the topic to be studied that day—ranging from group dynamics and excerpts from interviews or videos to accounts of practice, song lyrics, and other materials. This was followed by a discussion of the themes based on a previously selected book. Within the group, individually constructed understandings were expanded and reframed in light of participants' prior experiences and knowledge. These were moments of exchange that allowed the group to rethink practice and ground the underlying theory. GEA's coordination always fell to one of the participants, who ensured the organization and quality of the discussions.

This organizational structure shows that the formative process emerged from the relational dynamics established among participants. In this context, sharing experiences and jointly constructing meaning became structuring elements of learning, reaffirming its dialogic nature. It was, therefore, a movement that recognized the power of collectivity in shaping critical, reflective subjects capable of developing broader, more complex understandings of the phenomena under study.

Organized in this way, the group constituted a collective learning space: "the shared task, doing things together, conversation [...] generates feelings, which manifest as emotions, which unite the group, generate thoughts, connect with other thoughts, producing knowledge" (Parolin, Carvalho, Portelinha, 2025, p. 115)[9].

Accordingly, sustaining this collective learning space required selecting theoretical frameworks that could ground and deepen discussions about the presence of AI in everyday life and the current educational landscape, in response to the group's own demands. For the semester of study spanning February to June 2025, the core theoretical reference was Nexus: A Brief History of Information Networks from the Stone Age to Artificial Intelligence, by Yuval Noah Harari (2024), read alongside other references and materials addressing the same theme.

3.2 Data Collection and Processing

This study adopts a qualitative, exploratory-descriptive methodological approach. Qualitative research investigates subjects' practices and interactions in everyday life. According to Flick (2009), qualitative research is necessary because most everyday phenomena are too complex to be explained in isolation. If empirical studies were designed exclusively around cause-and-effect relationships, he argues, all complex objects would need to be excluded. Qualitative research is therefore grounded in the idea of discovering the new and developing empirically based theories.

As Flick (2009, p. 20) notes, "qualitative research is of particular relevance to the study of social relations due to the pluralization of life spheres, which calls for new sensitivity in empirical studies."[10] This means qualitative research engages with the deeper layer of relationships, processes, and phenomena that cannot be reduced to the operationalization of variables. Its essential features thus include the choice of methods and theories, the recognition and analysis of different perspectives, researchers' reflections as part of the knowledge production process, and a diversity of approaches and methods.

This investigation has an exploratory-descriptive scope. Sampieri, Collado, and Lucio (2013) explain that exploratory studies aim to examine an underexplored research topic, unfamiliar phenomena, or existing themes from new perspectives. Their value lies in enabling more comprehensive research within a particular context. Similarly, Gil (2018) argues that descriptive research aims to survey a population's opinions, attitudes, and beliefs about a given phenomenon without analyzing the relationships between variables. Its main purpose is to accurately describe the phenomenon under investigation, rather than to understand why it manifests in a particular way.

Having outlined the nature of the study, we now describe the participants, instruments, and procedures used for data collection and analysis. The study group comprised 20 members, of whom 12 voluntarily agreed to take part in the research. Of these participants, 10 identified as female and 2 as male, with ages ranging from 20 to 60 years. Their educational levels included 2 undergraduate students, 4 master's students, 3 doctoral students, and 3 individuals who already held a doctorate. Their fields of training and professional practice spanned Education, Psychology, and psychopedagogical clinical practice.

Data were collected in July 2025, immediately after the semester of study concluded, using an online questionnaire comprising 5 open-ended questions addressing participants' perceptions of artificial intelligence, current teaching practice, and their views on the content produced by these tools.

It is worth noting that, to ensure compliance with ethical research principles, the study was approved by the Institution's Research Ethics Committee for Studies Involving Human Subjects (CAAE No. 60949522.7.0000.0020). Furthermore, participants' identities were protected through anonymization, with each participant identified by a letter followed by a number (P01 for Participant 1, P02 for Participant 2, and so on).

[9] From original, "a tarefa comum, o fazer juntos, a conversa [...] gera sentimentos, que se manifestam em emoções, que une o grupo, gera pensamentos, conectam com outros pensamentos, produzindo conhecimento".
[10] From original, "a pesquisa qualitativa é de particular relevância ao estudo das relações sociais devido à pluralização das esferas de vida, que exige uma nova sensibilidade para os estudos empíricos".

Data analysis was based on the content analysis method proposed by Laurence Bardin (2016), understood as a set of techniques for grasping the meanings underlying discourse. This method comprises the stages of pre-analysis, material exploration, and the treatment and interpretation of results.

During the pre-analysis stage, a preliminary reading of the empirical material was conducted, allowing for initial familiarization with the data, the formulation of hypotheses, and the identification of indicators relevant to the investigation.

During the material exploration stage, the data were coded—that is, organized and systematized into smaller units of meaning to enable their classification, articulation, and interpretation (Bardin, 2016). Rather than following a strictly inductive approach, coding was guided by categories defined a priori—awareness, self-regulation, and autopoiesis (Mayor, Suengas, and Marques, 1995). Fragments of meaning extracted from participants' responses were thus analyzed in light of these categories and grouped according to their conceptual proximity to each. This coding process revealed the metacognitive strategies that participants mobilized during the investigation; to clarify this process, Table 1 presents representative excerpts organized by these categories.

Table 1 – Category of Analysis for Metacognitive Strategies

Metacognitive Strategy	Analytical Indicators	Examples of Recording Units (Excerpts)
Awareness	Recognition of AI's presence in daily life; perception of its use in everyday life and pedagogical practice; understanding of how AI works	" At first [of the study], I used it almost the same way as Google" (P02). "Personal use out of curiosity, at work to generate ideas for extra activities" (P10).
Control	More careful use; filtering of information; adjustment of strategies	"I became more careful" (P04); "I started paying more attention to the sources cited by AI" (P06).
Autopoiesis	Reframing of practice; broader critical reflection; shift in professional stance	"I developed a more critical view of the impact of digital tools on our lives" (P06). "I became more careful about the data I provide to my students" (P02).

Source: The Authors (2026).

Regarding enumeration rules (Bardin, 2016), the frequency of occurrence of recording units was adopted as the analytical criterion. This means that each time a participant expressed an idea aligned with one of the predefined categories (metacognitive strategies), one occurrence was counted. A higher incidence of elements related to the metacognitive strategy of awareness was observed (25 occurrences), followed by control (16 occurrences), and, less frequently, autopoiesis (6 occurrences). This finding points to a progressive movement in participants' metacognitive development, in which expanding awareness of AI use precedes and sustains processes of regulation and, subsequently, the reframing of pedagogical practices. Table 2 presents the frequency of recording units identified in participants' responses.

Table 2 – Distribution of Occurrences by Participant and Category

Participant	Awareness	Control	Autopoiesis
P01	2	1	1
P02	3	2	0
P03	2	1	1
P04	2	1	0
P05	2	1	0

P06	2	0	0
P07	2	2	0
P08	2	2	0
P09	2	2	2
P10	1	1	0
P11	3	2	1
P12	2	1	0
TOTAL	25	16	6

Source: The Authors (2026).

Based on the distribution of occurrences by participant presented in Table 2, the data were then organized by total frequency and percentage for each category, as shown in Table 3.

Table 3 – Frequency and Percentage by Category

Category	Frequency	Percentage
Awareness	25	53.2%
Control	16	34.0%
Autopoiesis	06	12.8%
Total	47	100%

Source: The Authors (2026).

With the data organized in this way, it becomes possible to proceed to the interpretive analysis stage, seeking a deeper understanding of the meanings participants attributed to their practices and reflections throughout the study.

4. Results and Discussion

The analysis of participants' responses reveals the mobilization of metacognitive strategies across three a priori categories: awareness, control, and autopoiesis. This points to a progressive formative process within the group under study.

The data indicate a predominance of the metacognitive strategy of **awareness** (53.2%), showing that participants significantly expanded their understanding of generative AI use and expressed perceptions and attitudes adopted when using it.

Initially, most participants had already been using these tools in an exploratory way, driven by curiosity or a desire to streamline everyday tasks, often reflected in practices such as asking 'random questions' (P02; P11) or using the tool as an extension of search engines (P02; P10; P11). Similarly, P10 reports using AI out of 'curiosity' and to generate 'ideas for extra activities,' reinforcing the exploratory nature of this initial contact and a still largely unsystematic form of appropriation.

These responses reinforce that, with the popularization of tools such as ChatGPT, there has been a significant increase in the everyday use of artificial intelligence, particularly as a resource for searching, organizing, and quickly producing information. As Santaella (2023) argues, these interactions continuously generate data linked to human activities—including experiences, relationships, and ways of thinking—highlighting how deeply integrated these technologies have become into contemporary social life.

At the same time, a significant portion of participants already used AI in a more structured and intentional way, particularly in academic and professional contexts. Reported practices included identifying articles for research purposes (P03), teaching and research activities (P04), designing assessments and rewriting texts (P05), using AI as a professional resource for filtering information (P07), and supporting academic research (P08; P12). The case of P09, who works as a teacher and researcher in Europe, points to an already highly diversified prior use, suggesting a more advanced level of appropriation of these tools. In her words:

> […] these tools are employed for multiple purposes: the drafting and revision of academic texts […] support for qualitative data analysis, the design of research instruments, lesson preparation, and the production of accessible and inclusive teaching materials […] (P09).

This positioning reveals not only technical familiarity, but also a broad understanding of AI's potential and limits within the educational context. This perspective aligns with Moura and Carvalho (2023), who argue that artificial intelligence can serve as a tool for collaboration and innovation, supporting teachers' work and mediating learning. More broadly, Accoto (2020) notes that the emergence of generative AI ushers in a new configuration of human-technology relations, in which not only are connections expanded, but cognitive functions themselves may be reconfigured, enabling more complex forms of creation, analysis, and problem-solving. The author nonetheless stresses the need to maintain a critical stance toward these technologies, particularly regarding their ethical and epistemological implications.

Perceptions of risk associated with AI use also emerged, as noted by P03, who mentions "uncertainty about research sources," and by P04, who acknowledges "how much algorithms can do with our data." These statements show that participants moved beyond simply using these technologies to also questioning their broader implications.

Taken together, these findings indicate that participants mobilized the metacognitive strategy of awareness to recognize their individual characteristics, the specific demands of tasks, and the conditions under which they used AI—thereby guiding more appropriate choices. As Mayor, Suengas, and Marques (1995) emphasize, awareness of situations and contexts constitutes the initial, foundational stage of the metacognitive process, since it allows subjects to intentionally access their goals, the strategies they will use to achieve them, and their characteristics as learners and, in this case, as users of generative AI tools.

The metacognitive strategy of control (34%) reflects the adoption of more intentional strategies for using AI tools, such as filtering AI-generated information, validating content, using tools more ethically and carefully, and formulating prompts with greater precision. These elements point to the activation of cognitive control mechanisms, through which subjects deliberately plan, monitor, and adjust their actions—reflecting a more elaborate level of metacognitive functioning.

Empirical evidence supports this process. P07, for example, reports having started to "filter information more carefully" when using AI, indicating a shift toward critical evaluation of the tool's output. Similarly, P05 reports using the technology "with more caution," while P11 notes that their use became "more responsible," reflecting a shift in stance regarding AI's possibilities and limits. P08 also mentions using it "more effectively," suggesting not only greater technical mastery, but also more strategic, goal-oriented use.

These changes in practice are directly linked to the critical reflections mobilized within the study group, particularly following the reading of *Nexus* and the collective discussions it prompted. These interactions encouraged participants to problematize issues such as algorithmic surveillance, data storage, and the influence of intelligent systems on human behavior. A representative example of these concerns comes from P04: "[...] I worry about what algorithms can do with our data and how much I may have already been manipulated by them." Similarly, P08 highlights "the power algorithms have to persuade," reflecting a more attentive stance toward these technologies.

Control thus emerges as a direct extension of awareness, as recognizing AI's risks and potential comes to guide more careful decisions regarding its use. Participants gained greater control over their interactions with the technology, adjusting their strategies according to task goals and the implications involved. This movement is also reflected in the

value placed on "individual and collective responsibility in AI use" (P02; P11), as well as in concerns about "excessive monitoring" and "manipulation" of data (P01; P04; P11)—aspects that came to directly shape their choices.

These findings align with contemporary literature on artificial intelligence, which points to the impacts of the so-called "software society" (Accoto, 2020), in which algorithms not only record data but come to shape behavior, influencing perceptions, decisions, and forms of social participation. In this scenario, as the author notes, every human interaction is potentially converted into data, feeding back into systems that continuously learn about individuals and the world. This dynamic reinforces the need to develop critical and regulatory competencies in the use of these technologies, particularly in educational contexts.

From a metacognitive standpoint, self-regulation guides thought and conduct, enabling the prior organization of activities, monitoring their execution, and making adjustments when necessary. As Mateos (2001) argues, this process is strongly influenced by social interaction, since group work encourages the explicit articulation of cognitive and metacognitive strategies, allowing subjects to share, compare, and adjust their ways of acting.

Within the context analyzed, this collective dimension proved particularly relevant. Discussions within the study group functioned as a space for mediation, in which participants could articulate their strategies, confront differing viewpoints, and incorporate new forms of regulating their practices. As Mateos (2001) notes, interaction with peers and more experienced individuals contributes to the progressive internalization of metacognitive control mechanisms, encouraging the development of planning, monitoring, and evaluation strategies. The self-regulation observed in the data is thus not an isolated process, but a socially mediated construction that is strengthened through dialogue, exchange, and collective reflection.

These results indicate that the study group not only broadened participants' awareness of AI use, but also fostered more regulated, critical, and intentional practices, underscoring the formative role such spaces play in developing metacognitive competencies.

The strategy of **autopoiesis** (12.8%), in turn, points to signs of deeper transformation in participants' relationship with knowledge, technology, and their own teaching practice. Unlike the previous categories, which concern awareness and the control of actions, autopoiesis refers to a movement of reconfiguration of the subject, in which new ways of thinking, acting, and understanding reality are produced. As Mayor, Suengas, and Marques (1995) argue, this metacognitive strategy goes beyond recognition and regulation, accounting for the transformation of action and the self-production of the subject within their learning processes.

Empirical evidence reflects this movement more qualitatively than quantitatively. Some participants, for instance, began to reframe the role of artificial intelligence in their pedagogical practices, articulating its potential and limits more cohesively. P09, in describing her use of AI to support students with specific educational needs and to produce accessible materials, illustrates a reconfiguration of her teaching practice. This positioning suggests a deeper incorporation of technology as a mediator of learning, rather than merely an instrumental tool.

This movement is also evident in critical reflections on the limits of artificial intelligence. Participants such as P01, P03, P05, P07, P11, and P12 warn of the risks of 'intellectual complacency' and 'rigidity of thought and production,' expressing concern about the possible replacement of critical thinking with technological dependence. Similarly, P09 stresses the need to preserve 'analytical thinking,' while P07 and P12 mention the production of 'weakened and fragmented content,' pointing to a broader problematization of AI's epistemological impact on knowledge construction. These statements suggest that participants not only recognize these risks but have begun to critically reposition themselves in relation to them—characterizing a deeper process of transformation.

Regarding AI's potential, participants also demonstrate a broader understanding of its pedagogical possibilities. They mention aspects such as the 'personalization' of learning (P08; P09), the 'speed and diversity of information' (P03), and the 'automation of administrative tasks' (P02). These elements point to a reconfiguration of teaching practice, in which technology is strategically integrated to expand teaching and learning opportunities. This understanding aligns with Moura and Carvalho (2023), who highlight AI's potential to personalize instruction, automate administrative tasks, and expand opportunities for accessing knowledge across different modalities.

It is precisely in the tension between potential and risk, however, that the autopoietic character of these transformations becomes most evident. While recognizing AI's benefits, participants also problematize its limits, such as the "spread of misinformation" (P07), "erroneous and superficial interpretation" (P02; P11), and the so-called "hallucinations" produced by these systems, particularly in academic contexts. These reflections point to a process of cognitive reorganization in response to the disruptions caused by contact with the technology—a process that, drawing on Maturana and Varela (2003), can be understood as autopoietic, whereby the organism continuously reorganizes itself in response to its interactions with the environment.

In this sense, autopoiesis manifests as a recursive process of transformation, through which participants integrate experience, reflection, and knowledge to construct new forms of practice. This involves more than using technology more consciously or in a more regulated way; it means redefining the subject's role in relation to knowledge and pedagogical practice.

The data analysis thus reveals a metacognitive continuum, in which awareness forms the basis for the development of self-regulation, which, in turn, sustains more complex processes of autopoiesis. This trajectory suggests that the study group not only provided access to information about artificial intelligence but also fostered a formative process that shaped how participants think about, regulate, and transform their pedagogical practices.

5. Concluding Remarks

This article sought to identify the metacognitive strategies mobilized by participants in a study group regarding the use of generative artificial intelligence in their daily lives and pedagogical practices.

The analyses developed in this study show that participation in a study group fosters the mobilization and development of metacognitive strategies relevant to teacher education. Through content analysis (Bardin, 2016), it was possible to identify a progressive movement in which awareness, control, and autopoiesis operate as interdependent dimensions of a formative process—one that involves not only the technical use of technology, but also its critical problematization and its reflective integration into pedagogical practice.

The results indicate that awareness constituted the starting point of this process, reflecting participants' broadened understanding of the potential, limits, and implications of artificial intelligence. This movement aligns with what metacognition scholars such as Flavell (1979), Mateos (2001), and Mayor, Suengas, and Marques (1995) describe as the subject's capacity to reflect on their own cognitive processes, recognizing their strategies, limits, and possibilities for action. In the context investigated, this awareness was driven by collective discussions and engagement with theoretical references—particularly the book *Nexus: A Brief History of Information Networks from the Stone Age to Artificial Intelligence* (Harari, 2024)—allowing participants to move from intuitive, exploratory use toward a more critical stance.

The metacognitive strategy of control emerged as an extension of this awareness, manifesting in the adoption of more intentional and careful AI use practices. Participants demonstrated greater control over their actions and heightened attention to the pedagogical implications of AI use. This finding reinforces the understanding that metacognition is not limited to reflection but also involves the capacity to adjust one's behavior to specific goals and contexts (Zimmerman, 2002), a skill strengthened in collaborative learning environments.

Autopoiesis, in turn, though less frequent, proved to be the most complex dimension of the process, pointing to deeper transformations in how participants understand their teaching practice and their relationship with knowledge. Drawing on Maturana and Varela's (2003) contributions, this metacognitive strategy helps explain how subjects, in engaging with the "disturbances" caused by contact with artificial intelligence, reorganize their cognitive structures and produce new forms of practice. It is, therefore, a process of self-formation, in which experience, reflection, and theory come together to build pedagogical practices that are more critical, autonomous, and context-sensitive.

Regarding the presence of artificial intelligence in education, the data corroborate Santaella's (2023) perspective that these technologies are already deeply embedded in contemporary social practices, both shaping and being shaped by human interactions. In this sense, AI should not be understood merely as a tool, but as a constitutive element of new ways of producing, accessing, and validating knowledge. This finding reinforces the need for its incorporation into educational contexts to be mediated by formative processes that prioritize critical reflection, ethics, and the development of intellectual autonomy.

The discussions presented here show that the relationship between generative artificial intelligence and metacognition constitutes a promising field for contemporary education, particularly when technology is integrated into processes intentionally oriented toward reflection and self-regulated learning. Metacognition in AI-mediated environments can encourage students to plan, monitor, and evaluate their own learning. Moreover, structured interactions with AI systems can contribute to the development of metacognitive awareness and self-directed learning (Xu et al., 2025; Lowry et al., 2026).

Accordingly, rather than merely producing users capable of obtaining quick, efficient answers, today's educational processes must form individuals capable of thinking about the answers they receive, evaluating their relevance, recognizing their limits, and taking responsibility for the decisions built upon them. In this context, metacognition can constitute an important mediating dimension between the subject and technology, fostering a more critical, conscious, and self-regulated relationship with AI systems.

In light of this, it is concluded that the study group analyzed constituted a powerful formative space—one that promoted not only access to information about artificial intelligence, but, above all, the construction of meaning around its use in educational contexts. By fostering the mobilization of metacognitive strategies, this space helped shape more aware, self-regulated individuals capable of reframing their practices in the face of contemporary challenges. This reinforces the importance of formative initiatives that bring together technology, critical reflection, and collaboration—particularly at a time marked by the growing presence of artificial intelligence in education.

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