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# Metacognition and Complex Learning: Assessment, Feedback, and Artificial Intelligence in Health Education

*Metacognição e aprendizagem complexa: avaliação, feedback e inteligência artificial na formação em saúde*

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## Abstract

Metacognition constitutes a strategic dimension of contemporary learning because it enhances students' ability to monitor, evaluate, and regulate their own learning processes. This theoretical-reflective essay aims to discuss the role of metacognition in complex educational contexts, with an emphasis on health education, a field marked by uncertainty, decision-making, theory-practice integration, ethical responsibility, and lifelong learning. It is argued that metacognition should not be understood as a spontaneous disposition on the part of the student, but rather as a formative competency to be taught, practiced, assessed, and supported by intentionally designed environments. Assessment, feedback, clinical simulation, debriefing, guided self-assessment, the use of video, and post-practice reflection are analyzed as tools capable of expanding the learner's awareness of performance, errors, progress, and strategies for improvement. The role of artificial intelligence as a resource for personalized feedback, adaptive tutoring, dashboards, and longitudinal analysis is also discussed, without disregarding risks such as cognitive dependence, superficial reflection, and the outsourcing of thought. It is concluded that metacognition is essential for developing critical, self-regulated, ethically responsible individuals capable of continuing to learn in complex educational and professional settings.

Keywords: Metacognition. Self-regulated learning. Educational assessment. Feedback. Artificial intelligence.

## Resumo

A metacognição constitui dimensão estratégica da aprendizagem contemporânea por favorecer a capacidade do estudante de monitorar, avaliar e regular seus próprios processos de aprendizagem. Este ensaio teórico-reflexivo tem como objetivo discutir o papel da metacognição em contextos educacionais complexos, com ênfase na formação em saúde, campo marcado por incerteza, tomada de decisão, integração teoria-prática, responsabilidade ética e aprendizagem ao longo da vida. Argumenta-se que a metacognição não deve ser compreendida como disposição espontânea do estudante, mas como competência formativa a ser ensinada, praticada, avaliada e apoiada por ambientes intencionalmente desenhados. Avaliação, feedback, simulação clínica, debriefing, autoavaliação orientada, uso de vídeo e reflexão pós-prática são analisados como dispositivos capazes de ampliar a consciência do aprendiz sobre desempenho, erros, progressos e estratégias de melhoria. Discute-se também o papel da inteligência artificial como recurso para feedback personalizado, tutoria adaptativa, dashboards e análise longitudinal, sem desconsiderar riscos como dependência cognitiva, superficialidade reflexiva e terceirização do pensamento. Conclui-se que a metacognição é essencial para formar sujeitos críticos, autorregulados, eticamente responsáveis e capazes de continuar aprendendo em cenários educacionais e profissionais complexos.

Palavras-chave: Metacognição. Aprendizagem autorregulada. Avaliação educacional. Feedback. Inteligência artificial.

# 1. Introduction

Contemporary education is challenged by the rapid expansion of knowledge, the complexity of social and professional problems, and the persistence of pedagogical practices centered on the transmission, memorization, and reproduction of information. In fields involving complex professional education, such as the health professions, this tension becomes even more evident: it is not enough for students to accumulate content or execute procedures; they must learn to recognize what they know, identify what they do not know, monitor the quality of their own reasoning, and regulate strategies in the face of new evidence, uncertainties, and practice contexts.

In this scenario, metacognition assumes a strategic role. Since Flavell (1979), the concept has been understood as knowledge about one's own cognitive processes and the ability to monitor and regulate them. Brown (1987) emphasized its executive dimension, while Schraw and Dennison (1994) organized the construct into knowledge of cognition and regulation of cognition. This foundation allows metacognition to be understood not as generic reflection, but as the ability to plan, track, evaluate, and adjust one's own learning process.

Metacognition is closely linked to self-regulated learning. According to Zimmerman (2002), self-regulated learners set goals, select strategies, monitor progress, evaluate outcomes, and reorganize actions. Pintrich (2000) adds that this process involves cognitive, motivational, behavioral, and contextual dimensions. Therefore, self-regulation should not be treated as a spontaneous individual disposition, but as a competency that depends on educational experiences capable of teaching students to interpret evidence, deal with errors, use feedback, and transform difficulties into improvement plans.

In health professions education, this discussion acquires particular relevance. Professional practice demands decision-making under uncertainty, integration between biomedical, clinical, ethical, and psychosocial knowledge, communication with patients and teams, recognition of personal limits, and commitment to lifelong learning. Berkhout et al. (2018) highlight that self-regulated learning in clinical contexts is situated within the practice environment, shaped by both social relationships and the opportunities available for learning. Versteeg et al. (2021) reinforce that medical students may experience difficulties in using metacognitive strategies, especially in planning and evaluation, which supports the need for explicit teaching of these competencies.

The emergence of generative artificial intelligence adds new complexity to the debate. AI tools can support adaptive tutoring, personalized feedback, longitudinal analysis, and identification of gaps, but they can also foster cognitive dependence, superficial reflection, illusion of competence, and the outsourcing of thought. As Kasneci et al. (2023) and UNESCO (2023) warn, the educational use of AI requires a clear pedagogical purpose, transparency, human oversight, and users who are prepared to engage with it critically.

This theoretical-reflective essay aims to discuss the role of metacognition in complex educational contexts, with an emphasis on health professions education. It argues that assessment, feedback, clinical simulation, post-practice reflection, and artificial intelligence can foster self-regulated learning when embedded in an institutional culture that provides appropriate support, ensures safety and explainability, understood as the ability to understand and account for AI-generated outputs, and promotes continuous development.

As a theoretical-reflective essay, the article draws on classical and recent contributions from the literature—without aiming for a systematic review—to construct a conceptual analysis applicable to complex educational contexts.

# 2. Metacognition and self-regulated learning: conceptual foundations

Metacognition is a foundation of deep learning because it allows students to observe, judge, and regulate their own cognition. Since Flavell (1979), the concept has been understood as knowledge about one's own cognitive processes and the ability to monitor them according to specific goals. Brown (1987) emphasized its executive dimension, related to planning, monitoring, control, and evaluation, while Schraw and Dennison (1994) organized the construct into knowledge of cognition and regulation of cognition. This distinction is relevant because knowing learning strategies does not mean knowing when, why, or how to use them in concrete situations.

Self-regulated learning expands this discussion by integrating cognitive, metacognitive, motivational, behavioral, and contextual processes. Zimmerman (2002) describes self-regulation as a cycle of forethought,

performance, and self-reflection, in which students set goals, select strategies, monitor execution, interpret outcomes, and adjust future actions. Pintrich (2000) adds that this process occurs in interaction with motivational beliefs, task characteristics, environmental conditions, and opportunities for support. Thus, self-regulation should not be confused with spontaneous autonomy or solitary study; it is a competency progressively developed through instructional support.

In health professions education, this discussion is particularly relevant. Students must learn extensive and changing content, but also develop judgment, clinical reasoning, communication, decision-making, recognition of limitations, and commitment to lifelong learning. Wijnen-Meijer (2020) argues that preparing students to learn continuously requires explicit attention to metacognition. Berkhout et al. (2018) emphasize that self-regulated learning in clinical environments is situated, relational, and dependent on the opportunities offered by the context, which precludes treating it as a simple individual attribute.

In this field, the interest lies not only in metacognitive awareness as a general disposition, but also in metacognition-in-action: the ability to monitor and regulate reasoning while the student formulates hypotheses, interprets evidence, discards alternatives, and decides under uncertainty. This distinction is important because self-report instruments may capture general metacognitive perceptions, but do not always grasp how learners effectively regulate their thinking during authentic or simulated clinical tasks. Thus, evaluating and developing metacognition requires considering both relatively stable dispositions and situated processes of real-time reasoning, monitoring, and regulation (ARTINO et al., 2014; VERSTEEG et al., 2021).

Recent studies show that health professions students do not always spontaneously develop sufficient metacognitive competencies. Versteeg et al. (2021), investigating medical students through think-aloud tasks and interviews, observed greater use of monitoring than planning and evaluation, alongside reliance on superficial cues to judge their own learning. These findings reinforce the need to integrate metacognition into the everyday curriculum, rather than assuming it as a natural outcome of academic progression.

Literature applied to health professions education indicates that metacognition can be taught. Medina, Castleberry, and Persky (2017) propose strategies such as intentional questioning, reasoning modeling, guided reflection, exam review, goal setting, feedback, and making thought processes explicit. Hajiabadi et al. (2022) add evidence that structured interventions combining a learning diary and explicit self-regulation training can improve dimensions of self-regulated learning in low-performing medical students.

Thus, metacognition and self-regulated learning support the central argument of this essay: students must be trained to understand, monitor, and regulate their own learning. In complex educational contexts, especially in health professions education, developing metacognition means preparing students to learn critically, responsibly, and adaptively throughout their professional lives.

## 3. Metacognition in complex educational contexts

Metacognition becomes especially relevant in complex educational contexts, where students must navigate open, ambiguous, and context-dependent situations. In these scenarios, learning does not mean merely retrieving information, but interpreting problems, integrating knowledge, formulating hypotheses, making decisions, and revising strategies in the face of new evidence. Complexity shifts learning from a linear logic to a situated, reflective, and self-regulated logic.

This understanding aligns with situated learning, according to which knowledge is constructed through progressive participation in social, cultural, and professional practices. Lave and Wenger (1991) show that learning involves integration into communities of practice, where individuals develop ways of thinking, acting, and belonging. From this perspective, metacognition is not limited to internal monitoring of thought; it involves understanding how the environment, relationships, quality criteria, and shared practices influence learning.

Health professions education provides a prime example of this complexity. Students must articulate biomedical, clinical, epidemiological, ethical, psychosocial, and organizational knowledge to act in situations marked by uncertainty, risk, resource limitations, human suffering, and social responsibility. Frenk et al. (2010) highlight that health

professions education must overcome fragmented curricula and prepare individuals capable of responding to the needs of evolving health systems.

Decision-making in health underscores this requirement. Confronted with a clinical situation, students must recognize patterns, formulate hypotheses, consider risks, communicate decisions, and reevaluate courses of action. This process is cognitive and metacognitive: learners must question whether they have adequately understood the problem, whether they have selected relevant information, whether biases are influencing their reasoning, whether they should seek help, and whether their decision remains defensible in light of new data. Thus, metacognition enables critical monitoring of thinking in action.

This perspective aligns with Schön's (1983) notion of the reflective practitioner, for whom competent practice requires reflection-in-action and reflection-on-action. Kolb (1984) complements this view by stating that experience only transforms into learning when accompanied by reflective observation, conceptualization, and active experimentation. Without reflection, feedback, and regulation, practice can reinforce automatisms or consolidate errors.

Recent studies reinforce that self-regulated learning in clinical settings is context-dependent. Berkhout et al. (2018) demonstrate that, in practice environments, learning occurs in planned ways, but also reactively and opportunistically, arising from available situations, interactions with supervisors and teams, and concrete opportunities for participation. This means metacognition is also relational and situated, as it depends on environmental opportunities, supervision quality, safety to acknowledge doubts, and the possibility of seeking feedback.

This social dimension avoids an overly individualistic view of learning. Chue (2017) argues that, in medical education, metacognition should be understood as a socially mediated process in which collaborative interactions, requests for feedback, articulation of reasoning, and co-construction of understandings help learners monitor and regulate their learning. Medina, Castleberry, and Persky (2017) add that metacognitive skills are relevant for critical thinking, problem-solving, and error prevention in clinical contexts by fostering supervision of one's own judgment and action processes.

In summary, metacognition in complex educational contexts must be understood as a cross-cutting competency for interpreting, deciding, acting, and continuing to learn. In health professions education, it underpins the development of professionals capable of acting with prudence, critical judgment, and ethical commitment in situations where error, uncertainty, and the permanent need for learning are part of the very nature of professional practice.

## 4. Assessment and feedback as metacognitive devices

Assessment plays a decisive role in the development of metacognition because it yields evidence that allows students to confront their subjective perception with external performance criteria. When reduced to a grade or certification, it conveys little about the cognitive processes supporting correct answers, errors, and gaps. When designed for formative purposes, however, it helps students understand how they learn, where they make mistakes, how they progress, and which strategies they need to regulate.

In health professions education, this discussion intersects with a recurring assessment paradox: the proliferation of measurement instruments does not always enable an understanding of the cognitive processes that integrate knowledge, skills, clinical judgment, and decision-making. Written exams, OSCEs, portfolios, and observational assessments yield important evidence, but, when analyzed in isolation, tend to capture fragments of performance. Therefore, assessment must move beyond serving merely as an end-point measure and instead become a formative tool for self-regulation, capable of helping students recognize patterns, gaps, and improvement strategies (EPSTEIN, 2007; VAN DER VLEUTEN et al., 2012).

This understanding is consistent with the tradition of formative assessment. Black and Wiliam (1998) demonstrated that assessment fosters learning when it generates information usable by students and teachers to adjust teaching and studying. Sadler (1989) adds that students improve performance when they understand quality criteria, compare their work against these criteria, and identify paths to reduce the gap between observed and expected

performance. Thus, assessment becomes metacognitive when it ceases to merely record results and begins to inform decisions about improvement.

Feedback is central to this process. Hattie and Timperley (2007) propose that effective feedback indicates where the student is going, how they are progressing, and what the next step should be. Boud and Molloy (2013) expand this perspective by arguing that feedback should build the learner's capacity to judge and refine their own work. Carless and Boud (2018) call this capacity feedback literacy—that is, the ability to interpret, value, and use feedback to improve learning.

This discussion is important because students do not always accurately judge their own learning. Self-assessment can be influenced by overconfidence, anxiety, low familiarity with criteria, or reliance on superficial cues. Versteeg et al. (2021) observed that medical students may use inefficient predictive cues to judge their learning. Morley (2024) warns that self-perceptions of knowledge or confidence should not replace objective or observable measures of performance.

For this reason, self-assessment should be understood as a pedagogical practice to be calibrated, rather than sufficient evidence of competence. Rivers, Dunlosky, and Persky (2020) emphasize that assessing metacognition requires distinguishing between metacognitive knowledge, monitoring, and control. Comparing performance estimates with observed outcomes, reviewing errors, analyzing rationales, and stating confidence levels are ways of making metacognitive accuracy visible. In health professions education, this calibration is especially relevant, as students may overestimate or underestimate their capacity for clinical reasoning, communication, procedural execution, or decision-making.

Programmatic assessment expands this potential by understanding each assessment event as a data point within a longitudinal system. Van der Vleuten et al. (2012) propose that robust educational decisions depend on integrating multiple pieces of performance evidence over time. From a metacognitive standpoint, this approach enables students to recognize patterns of difficulty, gradual progress, discrepancies between self-assessment and external assessment, specific weaknesses, and responses to feedback.

To foster metacognition, assessment data must be provided in an interpretable and actionable manner. This requires explicit criteria, performance exemplars, narrative feedback, opportunities for dialogue, re-takes, and faculty support to convert evidence into improvement plans. Medina, Castleberry, and Persky (2017) propose strategies such as structured exam reviews, questions about the reasoning applied, identification of error patterns, thinking aloud, and feedback on thought processes.

In summary, assessment and feedback become metacognitive devices when they render learning and performance processes visible. Assessment generates evidence; feedback helps interpret it; calibrated self-assessment allows comparison with the learner's perception; and self-regulation transforms this information into strategic change.

## 5. Clinical simulation, post-practice reflection, and experiential learning

Clinical simulation provides a particularly valuable approach for developing metacognition in health professions education, as it allows students to act in situations close to professional practice, observe their performance, receive feedback, and revise decisions in a safe environment. Its pedagogical value lies in the possibility of turning experience into an object of analysis, connecting action, observation, assessment, reflection, and regulation.

Kolb's (1984) experiential learning theory holds that learning from experience demands reflective observation, abstract conceptualization, and active experimentation. This perspective aligns with Schön (1983), for whom competent practice involves reflection-in-action and reflection-on-action. In simulation, these dimensions can be intentionally organized, allowing students to experiment, make mistakes, receive guidance, and reconstruct their reasoning without exposing patients to unnecessary risks.

Literature on healthcare simulation reinforces that feedback and debriefing are central components of its effectiveness. Issenberg et al. (2005) identified feedback as one of the features associated with effective learning in high-fidelity simulation. Fanning and Gaba (2007) highlight that debriefing is essential to transform simulated experiences into learning, as it enables the analysis of decisions, interpretations, actions, and alternative courses of action. Therefore, the simulated scenario alone does not guarantee metacognitive learning; it is the subsequent reflective processing that gives the experience educational value.

Debriefing can support metacognition by helping students make their thought processes explicit. Models such as debriefing *with good judgment* combine objective observations of performance with questions that explore participants' mental frames, making it possible to understand not only what was done, but why a particular course of action was chosen (RUDOLPH et al., 2006). Husebø, O'Regan, and Nestel (2015) extend this perspective by discussing the application of Gibbs' reflective cycle to debriefing, providing a structured approach to analyzing the experience and ultimately developing an action plan.

This perspective can be expanded by structured debriefing models, such as PEARLS, which combines different facilitation strategies to promote experience analysis, articulation of reasoning, and synthesis of learning. In a metacognitive approach, debriefing is not limited to reviewing correct or incorrect behaviors, but helps students reconstruct the thought process that supported their decisions, recognize gaps, and plan future actions (EPPICH; CHENG, 2015).

Post-practice reflection can be structured at different points in time. Immediate reflection captures perceptions close to action, such as decisions made, acknowledged difficulties, and performance estimates. Delayed reflection, supported by criteria, feedback, or video review, allows for more detached analysis. This combination is relevant because part of learning emerges when students revisit the experience, compare their perception with evidence, and reorganize their improvement plan.

The use of video enhances this process. Recording simulations allows the observation of behaviors, hesitations, omissions, decisions, and communication breakdowns that may not have been noticed during action. Cleary et al. (2020) highlight that video resources can promote reflective judgments and analysis of regulatory processes, especially when coupled with methods examining reasoning and self-regulation during clinical tasks. Video thus functions as external evidence to calibrate learner perception.

This calibration is central to the relationship between simulation and metacognition. Analyzing video, checklists, or feedback can reveal discrepancies between intention, perception, and observed performance. Comparing self-assessment, external criteria, and observable evidence fosters greater metacognitive accuracy and guides improvement strategies.

Self-assessment, in this context, should be planned as a guided practice. Before receiving feedback, students can estimate their performance in specific domains; afterward, they compare this estimate with external assessment, review the video, and formulate an action plan. Medina, Castleberry, and Persky (2017) argue that questioning, modeling, thinking aloud, and feedback on thought processes help make metacognition more explicit and actionable in health professions education settings.

The expansion of virtual and asynchronous simulations increases the importance of structured reflection. MacKenna et al. (2021), in an integrative review of self-debriefing, show that well-designed self-guided debriefings can produce outcomes comparable to those facilitated by instructors in certain contexts, although reflective capacity remains underexplored. This finding reinforces the need to carefully structure post-practice reflection activities, especially when immediate in-person guidance is unavailable.

In summary, clinical simulation fosters metacognition when it is not limited to enacting cases or repeating procedures. Its educational value lies in integrating experience, assessment, feedback, debriefing, self-assessment, video, and post-practice reflection. When these dimensions are integrated, students learn to recognize limits, understand errors, revise reasoning, and transfer learning to new situations, strengthening a critical, safe, and self-regulated professional practice.

## 6. Artificial intelligence and metacognition: between adaptive support and cognitive dependence

The incorporation of artificial intelligence into educational processes expands possibilities for personalization, tracking, and learning support, but also introduces risks to metacognitive development. Intelligent tutoring systems, generative models, adaptive platforms, dashboards, and learning analytics tools can assist students in organizing study plans, receiving feedback, identifying gaps, and monitoring progress. However, they can foster superficial reflection,

cognitive dependence, and the outsourcing of thought when they replace, rather than enhance, the learner's intellectual activity.

The relationship between artificial intelligence and metacognition should be guided by a central pedagogical question: does the technology help students think more effectively about their own learning, or does it merely provide answers that reduce cognitive effort? Holmes, Bialik, and Fadel (2019) note that artificial intelligence can support personalization, tutoring, assessment, and learning management, but its use requires a clear pedagogical purpose. AI is not inherently educational; it becomes educationally meaningful when aligned with learning objectives and assessment criteria, supported by faculty guidance, and accompanied by opportunities for reflection.

The pedagogical design of AI can follow two paths. In "oracle" mode, the tool delivers answers and tends to reduce student cognitive effort. In "metacognitive mirror" mode, it returns questions, inconsistencies, alternatives, and rationales, stimulating monitoring, articulation of reasoning, and self-regulation. The former usage can increase dependence; the latter can foster metacognitive learning. Thus, the educational value of AI depends less on its capacity to respond quickly and more on its ability to prompt students to examine how they think, why they decide, and how they can revise their strategies (TOMISU; UEDA; YAMANAKA, 2025).

From a metacognitive perspective, one of its primary capabilities lies in supporting self-regulated learning. Intelligent tools can assist students in setting goals, organizing routines, receiving guiding questions, reviewing answers, and identifying error patterns. They can also facilitate more frequent and personalized feedback, especially when offering understandable and actionable information about performance, progress, and next steps (HATTIE; TIMPERLEY, 2007; CARLESS; BOUD, 2018).

Educational dashboards and learning analytics tools can support metacognition by revealing patterns that students might not otherwise recognize on their own. By bringing together data on performance, participation, self-assessment, feedback, and longitudinal progress, these systems can help students monitor their learning and identify persistent gaps. However, they should be designed to encourage reflection rather than merely monitor or compare students.

In health professions education, such possibilities are relevant because curricular complexity and the diversity of required competencies make longitudinal tracking of development difficult. AI-supported systems can assist in synthesizing multiple pieces of assessment evidence, identifying performance patterns, and generating individualized recommendations. This logic aligns with programmatic assessment, in which different data points are integrated over time to support learning and educational decisions (VAN DER VLEUTEN et al., 2012).

AI can also weaken metacognition. Generative models produce texts and explanations with high linguistic fluency, creating an impression of understanding without genuine learning. The metacognitive risk lies in confusing rapid access to a well-formulated answer with actual mastery of content, encouraging an illusion of competence and cognitive offloading—that is, excessive delegation of mental effort to the tool. When used as a recurring shortcut, AI reduces opportunities to formulate hypotheses, justify decisions, review errors, and reconstruct arguments (KASNECI et al., 2023).

Therefore, a metacognitive pedagogy for AI use must shift focus from the answer to the process. Students should be guided to question assumptions, evidence, unconsidered alternatives, potential errors, and what they would still need to explain without the tool.

In health professions education, such faculty guidance is essential, as clinical decisions involve patient safety, ethical responsibility, and context-sensitive judgment. AI can assist students in organizing hypotheses, reviewing content, working through simulated cases, and generating study questions, but it should not replace faculty supervision, consultation of reliable sources, clinical reasoning, or human responsibility for decision-making. UNESCO (2023) emphasizes that the use of generative AI in education should be guided by transparency, data protection, equity, human oversight, and the promotion of student and teacher agency.

It is also necessary to reconsider assessment. If assessment tasks focus solely on final written products, distinguishing real learning from AI-assisted production becomes difficult. This requires shifting part of assessment toward processes: rationales, draft versions, oral defense, application in novel situations, reflection on AI usage, and the ability to critique automated outputs.

Furthermore, it must be recognized that language models lack genuine metacognition in the human sense. They can produce plausible answers, estimate uncertainties imperfectly, and simulate rationales, but they do not monitor their own cognitive processes like a human learner or professional. Thus, AI can be designed to prompt metacognition in students, but it should not be taken as a substitute for clinical judgment, faculty validation, or professional responsibility (GRIOT et al., 2025).

In summary, artificial intelligence can strengthen metacognition when it helps students plan, monitor, evaluate, and regulate their learning. But it can weaken it when replacing the effort to understand, justify, err, revise, and reconstruct one's own thought. The educational challenge is not accepting or rejecting AI, but designing pedagogical uses that preserve human agency, promote critical reflection, and expand intellectual autonomy.

## 7. Pedagogical, Methodological, and Ethical Challenges

Incorporating metacognition into educational processes requires addressing challenges that go beyond simply endorsing reflection and autonomy. Although students are often expected to "learn how to learn," this competency does not develop automatically. It requires explicit learning objectives, sustained practice, appropriate assessment tools, faculty guidance, an institutional culture that supports feedback, and ethical safeguards for the responsible use of educational data.

The first challenge is pedagogical: teaching metacognition without reducing it to generic guidance. Asking students to "reflect" may yield descriptive accounts, but not necessarily effective regulation. Medina, Castleberry, and Persky (2017) advocate intentional strategies such as guided questioning, modeling expert thinking, structured exam review, goal setting, thinking aloud, and feedback on cognitive processes. Thus, reflection becomes more effective when linked to authentic tasks, clear criteria, and concrete improvement decisions.

The second challenge is methodological: assessing metacognition requires recognizing its multiple components. Classical literature distinguishes metacognitive knowledge, monitoring, and control or regulation of cognition (FLAVELL, 1979; BROWN, 1987; SCHRAW; DENNISON, 1994). Questionnaires and scales can indicate perceptions and dispositions, but do not, in isolation, demonstrate whether students regulate their learning during real tasks. Rivers, Dunlosky, and Persky (2020) reinforce the need to use appropriate methods for each dimension.

Instruments like the Metacognitive Awareness Inventory can support the evaluation of metacognitive awareness, but must be interpreted as partial and complementary measures. Recent psychometric evidence indicates their utility in health professions education contexts, but also reinforces that self-report questionnaires do not replace situated measures of performance, reasoning analysis, direct observation, and triangulation of evidence (CALE et al., 2025). Thus, assessing metacognition requires combining self-report measures with methods capable of observing how students plan, monitor, and regulate learning during concrete tasks.

Self-reports and self-assessments should therefore be interpreted with caution. Although important for metacognitive development, they can be influenced by overestimation, underestimation, unwarranted confidence, or superficial cues. In health professions education, this caution is essential, as low metacognitive accuracy can impact practice safety (ANDREWS et al., 2023; MORLEY, 2024).

Therefore, evidence triangulation is indispensable. Assessing and developing metacognition requires combining self-reports, observed performance, rubrics, checklists, interviews, video analysis, think-aloud protocols, portfolios, faculty feedback, and longitudinal data. Versteeg et al. (2021) demonstrate the utility of methods like think-aloud and interviews to identify medical students' metacognitive competencies, observing how they plan, monitor, and evaluate their reasoning.

Another challenge is avoiding confusion between reflection, self-assessment, and metacognition. These concepts are related, but not equivalent: reflection involves analyzing experiences; self-assessment corresponds to judging one's own performance; and metacognition involves knowledge, monitoring, and regulation of cognitive processes. Husebø, O'Regan, and Nestel (2015) show that structured reflection models, such as Gibbs' cycle applied to debriefing, can guide students from experience description to analysis and action planning.

Faculty guidance plays a critical role. Metacognition should not be treated solely as the student's individual responsibility. Teachers and supervisors need to make criteria explicit, model their reasoning, provide opportunities for practice, ask guiding questions, offer meaningful feedback, and create environments in which errors can be examined without humiliation. Boud and Molloy (2013) argue that feedback should develop students' capacity to judge and improve their own work, a perspective further developed by Carless and Boud (2018) through the concept of feedback literacy.

This process depends on a coherent institutional culture. Isolated interventions are insufficient if the curriculum remains driven by norm-referenced assessments, vague feedback, and few opportunities for revision. In health professions education, this is particularly relevant because professional competencies develop longitudinally and depend on supervision, deliberate practice, and guided reflection.

There are also ethical challenges regarding the use of educational data. Assessments, digital platforms, videos, dashboards, and artificial intelligence systems can support learning tracking, but can also generate excessive surveillance, undue exposure, premature tracking, or non-transparent automated decisions. UNESCO (2023) highlights that generative AI in education must respect transparency, data protection, equity, human oversight, and the empowerment of individual agency.

Finally, excessive student responsibility must be avoided. Valuing self-regulation can be interpreted as shifting full responsibility for learning onto the individual. This reading ignores that metacognition is situated and depends on institutional conditions, opportunities for participation, supervision quality, and psychological safety to seek help (BERKHOUT et al., 2018). Promoting metacognition does not mean individualizing failure, but building environments that provide real support for student development.

In summary, pedagogical, methodological, and ethical challenges converge on a common requirement: coherence between curricular design, assessment, feedback, technology, and institutional culture. Only then does metacognition cease to be an abstract expectation of autonomy and become a concrete formative competency.

Table 1 synthesizes the main pedagogical dimensions involved in metacognitive development, their formative functions, examples of educational practices, and risks when poorly conducted.

Table 1 – Metacognition as an integrating framework for experience, assessment, feedback, and self-regulation

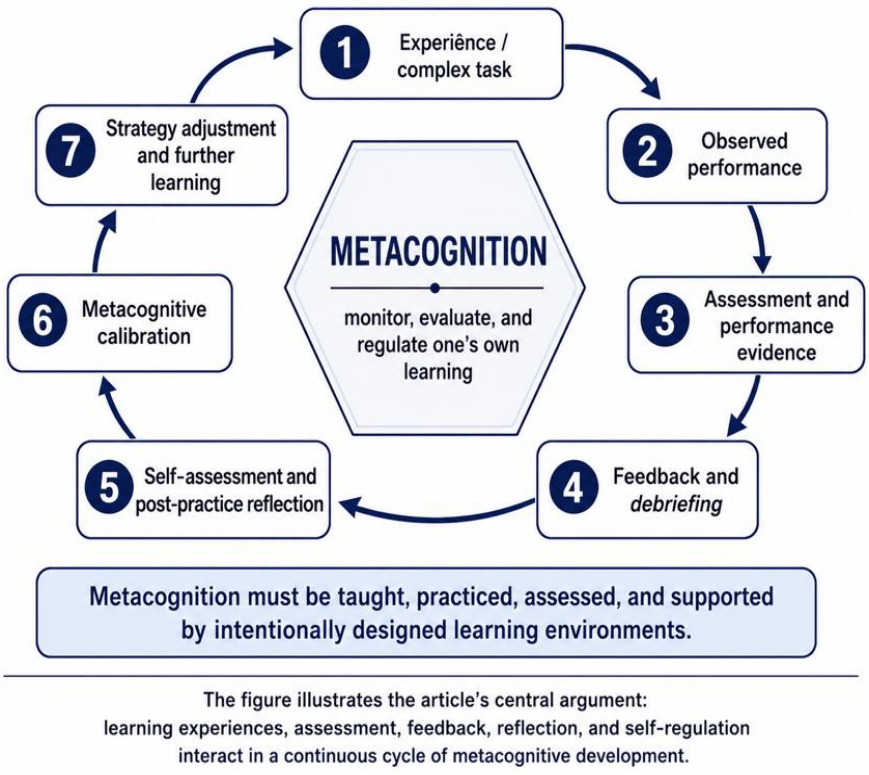
| Pedagogical Dimension | Function in Metacognitive Development | Examples of Educational Practices | Risk if Poorly Conducted |
|---|---|---|---|
| **Formative experience** | Exposes the student to authentic or simulated situations requiring decision-making | Clinical simulation, case discussion, complex problems, supervised practice | Experience without reflection; repetition of automatisms |
| **Assessment** | Yields evidence on performance, gaps, and progression | Exams, OSCE, oral exam, rubrics, checklists, portfolios | Reduction of learning to grades or rank ordering |
| **Feedback** | Helps the student interpret evidence and set next steps | Faculty feedback, peer feedback, narrative debriefings, dashboards | Vague, punitive, or non-actionable comments |
| **Self-assessment** | Allows comparison between subjective perception and observed performance | Prior performance estimate, written reflection, video analysis | Overestimation, underestimation, or low metacognitive accuracy |

| Pedagogical Dimension | Function in Metacognitive Development | Examples of Educational Practices | Risk if Poorly Conducted |
|---|---|---|---|
| **Post-practice reflection** | Transforms experience into critical analysis and improvement planning | Debriefing, immediate reflection, delayed reflection, reflective portfolio | Generic, descriptive reflection disconnected from criteria |
| **Artificial intelligence** | Supports personalization, longitudinal analysis, and adaptive feedback | Adaptive tutoring, feedback synthesis, study recommendations | Cognitive dependence, superficial reflection, and outsourcing of thought |
| **Self-regulation** | Translates evidence and feedback into strategy adjustments | Individual improvement plan, learning goals, longitudinal monitoring | Individual accountability without institutional support |

Source: author's own elaboration.

Based on these dimensions, Figure 1 represents the metacognitive cycle of learning in complex educational contexts, illustrating the interplay among experience, evidence, feedback, reflection, self-regulation, and institutional support.

Figure 1 – Metacognitive cycle of learning in complex educational contexts.




Source: author's own elaboration.

## 8. Final Considerations

Metacognition plays a strategic role in contemporary education because it addresses the challenge of preparing individuals who are capable of understanding, monitoring, evaluating, and regulating their own learning processes. In contexts characterized by the rapid expansion of knowledge, increasingly complex professional problems, and the growing role of technology, learning cannot be reduced to memorization or the reproduction of content.

Throughout this essay, it has been argued that metacognition should not be understood as a spontaneous student capacity, but as a formative competency dependent on explicit instruction, recurring practice, assessment, feedback, and intentionally designed educational environments. This argument brings together classical foundations of metacognition and models of self-regulated learning, in which autonomy is the progressive result of consistent instructional support (FLAVELL, 1979; BROWN, 1987; SCHRAW; DENNISON, 1994; ZIMMERMAN, 2002).

These considerations are particularly relevant in health professions education. Future professionals must act in situations of uncertainty, integrate diverse knowledge, recognize risks, revise courses of action, and continue learning throughout life. Recent studies reinforce that self-regulated learning in clinical contexts is situated, relational, and dependent on environmental opportunities, which prevents its reduction to an individual student characteristic (BERKHOUT et al., 2018; VERSTEEG et al., 2021).

Assessment, feedback, clinical simulation, debriefing, self-assessment, video usage, and post-practice reflection were discussed as devices capable of rendering learning and performance processes visible.

Assessment, feedback, clinical simulation, debriefing, self-assessment, video use, and post-practice reflection were discussed as ways of making learning and performance processes visible. Artificial intelligence adds new possibilities and risks. It can support adaptive tutoring, personalized feedback, dashboards, and longitudinal analysis, but can also foster superficial reflection, cognitive dependence, illusion of competence, and the outsourcing of thought. Therefore, its educational use must be guided by pedagogical intentionality, human oversight, transparency, explainability and data protection (HOLMES; BIALIK; FADEL, 2019; KASNECI et al., 2023; UNESCO, 2023).

As a limitation, it is acknowledged that, as a theoretical-reflective essay, this text does not aim to produce a systematic synthesis of the literature or empirically evaluate metacognitive interventions in specific educational contexts. Its contribution lies in conceptually integrating metacognition, self-regulated learning, assessment, feedback, clinical simulation, and artificial intelligence, taking health professions education as a primary field of analysis. Future investigations may empirically examine how different pedagogical designs, feedback strategies, post-practice reflection methods, and artificial intelligence uses influence the development of metacognition, self-assessment accuracy, and self-regulated learning in health students and professionals.

In conclusion, developing metacognitive students means educating individuals capable of learning with awareness, responsibility, and flexibility. Particularly in health professions education, this means preparing professionals to acknowledge uncertainties, monitor their own performance, revise decisions, learn from practice, and respond ethically to the needs of people and care systems. An education committed to metacognition is, therefore, an education committed to lifelong learning, intellectual autonomy, ethical responsibility, and the development of critical individuals facing contemporary challenges.

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The authors declare no conflict of interest related to this manuscript.

## Authors' contributions

All authors contributed to the conception, drafting, critical revision, and approval of the final version of the manuscript.

## Use of artificial intelligence

During the preparation of this paper, the authors used ChatGPT, GPT-5.5 Thinking model, for assistance with textual organization, language editing, and editorial refinement. After using this tool, the authors reviewed and edited the content as necessary and take full responsibility for the conception, argumentation, bibliographic selection, critical analysis, and final version of the manuscript.

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