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We Need to Rethink Scientific Training

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Treating scientific literacy as a one-time curricular requirement obscures its cognitive demands and social consequences. Reframing methodology and philosophy of science as recurrent, metacognitive training highlights scientific thinking as a context-dependent way of knowing, essential for navigating complex problems and epistemic pluralism.

I am a professor of methodology and philosophy of science, a subject offered in the first year of the undergraduate course in Biological Sciences at the university where I work. I have always considered this one of the most important subjects in academic training, not only because it introduces fundamental concepts about how scientific knowledge is produced, validated and criticized, but because it occupies a strategic place in a world marked by polycrisis (Lawrence et al. 2024), by the erosion of public trust in science and by the open defense of practices that put collective health at risk.

We live in a scenario where scientific denialism has ceased to be a marginal phenomenon. It is present in public debates, institutional policies, and, even more worryingly, professional discourse. In Brazil, for example, there were public statements by physicians denying the existence of breast cancer precisely in a month dedicated to raising awareness about the disease (Albuquerque 2025a). Similar examples can be found in different countries, areas of knowledge, and institutional contexts (Bartoš et al. 2022). The underlying pattern suggests that the problem is not only informational but also structural, leading me to believe that scientific literacy is undergoing a global crisis.

For a long time, I believed that this crisis could be addressed, at least in part, by offering a solid foundation in methodology and philosophy of science right from the start of undergraduate courses. The idea was to provide students, from the beginning, with conceptual tools to understand what distinguishes science from opinion, evidence from belief, informed criticism from empty skepticism. However, by following students throughout their courses, it became evident that many of the concepts discussed in the first year are lost, diluted, or no longer mobilized in everyday scientific practice. The training progresses, the content becomes more specialized, the technical demands increase, but reflection on how knowledge is produced, validated, and limited is rarely systematically revisited. Given this, I began to argue that scientific literacy should not be treated as a one-off event in training, but as a transversal content throughout the entire academic trajectory.

My defense rests on the observation that producing scientific knowledge is, in many respects, counterintuitive. It conflicts with well-documented human cognitive tendencies, such as the search for quick confirmation, the preference for simple explanations, resistance to evidence that challenges prior beliefs, and difficulty with uncertainty. Doing science requires learning to suspend intuitions, accept errors, live with inconclusive results, and submit ideas to collective scrutiny. It is therefore not surprising that these ways of thinking need to be continually reinforced, practiced, and revisited throughout training (see Ellefson et al. 2026).

A consistent body of research has shown that learning science does not imply the complete replacement of intuitive conceptions with formal scientific explanations (Ellefson et al. 2026). On the contrary, intuitive ideas continue to coexist with scientific knowledge, even after years of schooling and academic practice. This coexistence is clearly manifested in counterintuitive scientific reasoning tasks, in which adults, including those with advanced training, are systematically slower and less accurate than in intuitive tasks. The cognitive cost does not disappear with expertise, suggesting that conceptual conflict remains active throughout academic and professional life (Ellefson et al. 2026).

This phenomenon has been interpreted as evidence that scientific thinking requires, above all, the inhibition of prior intuitions (Ellefson et al. 2026). However, it has been found that individual differences in switching (the ability to flexibly alternate between competing sets of explanations) more robustly explain performance on scientific tasks, both intuitive and counterintuitive. Cognitive inhibition, although related, has been shown to play a secondary or indirect role. If intuitive and scientific conceptions coexist, the central challenge does not seem to be eliminating intuitions, but learning to recognize conceptual conflicts and to switch, in a contextualized way, between different forms of explanation.

The previous perspective reinforces the argument that scientific literacy should be transversal to education, but also suggests that transversality, by itself, is not sufficient. It is not simply a matter of repeating epistemological content throughout the course, but of creating formative environments that systematically expose students to real conceptual conflicts, requiring them to deliberately switch between intuitive and scientific explanations. Ignoring this aspect may help explain why, even among highly educated professionals, we find adherence to denialist discourses or defenses of epistemically weak practices, or even the denial of science. Based on these arguments, Box 1 presents a proposal for scientific literacy throughout academic training.

Box 1. Principles for a scientific literacy proposal.

Recurring offer throughout the training
Scientific literacy should be offered at multiple points in academic training, not just in the initial stages of undergraduate studies. This recurrence is necessary because scientific thinking remains cognitively challenging throughout academic life and because conflicts between intuitions and formal explanations are not definitively resolved with initial exposure to the content.

Emphasis on metacognition, not memorization
Teaching should not be primarily based on memorizing forms of logical reasoning, argumentative structures, or rigid classifications between science and other forms of knowledge. The central objective should be to empower students to identify how their own thinking operates, recognizing cognitive weaknesses, explanatory limitations, and intuitive tendencies that influence judgments and decisions.

Systematic exploration of the limitations of intuitive thinking
The disciplines should employ pedagogical methods that expose students to situations in which intuitive explanations are plausible, but insufficient or misleading. This confrontation should be used as a formative tool to explain why certain ways of thinking fail when faced with complex, ambiguous, or counterintuitive problems.

Presenting science as an alternative form of knowledge production
Science should be presented as a specific and alternative way of obtaining knowledge, with its own rules for validation, bias control, and uncertainty management. Education should avoid treating it as an absolute standard or as the only legitimate way to understand reality, emphasizing its scope and limitations.

Recognition of the alignment between problems and modes of knowledge
Students should be guided to identify that different types of problems demand different modes of investigation and explanation. Not all relevant questions are adequately addressed by a single epistemological framework, and part of scientific literacy consists of recognizing this contextual adequacy.

Advanced recovery focused on complex social problems
In later stages of their training, there should be specific courses dedicated to the analysis of complex social problems. In these courses, students should compare how different scientific and non-scientific traditions construct diagnoses, causal explanations, and intervention strategies for the same problem.

Shift from binary confrontation to plural confrontation
Training should not be limited to contrasting intuitive thinking and scientific explanation. It should include confronting multiple explanatory traditions, allowing the student to understand convergences, tensions, incompatibilities and complementarities between different forms of knowledge (Albuquerque 2025b).

Forming an epistemic stance, not a classificatory repertoire
The goal of scientific literacy is not merely to train students to classify discourses as scientific or non-scientific, but to develop a reflective epistemic stance, characterized by vigilance over one's own judgments, tolerance for uncertainty, and the ability to mobilize differ-

ent explanatory logics in a contextualized manner.

My final thought is not simply that we need more scientific training throughout academic life, but that this training must be cognitively diverse and experientially rich, stimulating formative trajectories that integrate multiple disciplines, modes of thought, and epistemological practices. It is possible that, as a study suggests for elite performance across different areas (Güllich et al. 2025), excellence in scientific thinking will emerge not from a narrow, early focus, but from the ability to connect, confront, and integrate diverse perspectives along a broad, continuous formative trajectory.

DISCLOSURE OF AI USE

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