



STEM OR STEAM IN THE ERA OF AI

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When we talk about technology-oriented education in the 21st century, it is necessary to distinguish certain directions of this education worldwide. As early as the 20th century, we began to see again that the division and partialization of science into narrow scientific fields caused more harm than good in science, and especially in education. The first real step towards reintegrating scientific fields was in the 50s. In the 20th century, in response to the cybernetics movement and strict behaviorism, an integrative science called *Cognitive science* provided an understanding of how cognitive processes work in our brains. It is an interdisciplinary, scientific study of the mind, the brain, and intelligent systems. At its core, cognitive science is based on the assumption that “thinking is the processing of information.” The mind is modeled by cognitive science as a system that relies on representational structures and computational procedures to convert sensory inputs into behavioral outputs. It explores how humans, and in the technological age, also machines, perceive, learn, reason, and remember.

Cognitive science has brought together research from the fields of philosophy, psychology, artificial intelligence (AI), linguistics, neuroscience, and anthropology. The field of cognitive science thus combines several approaches and views, but they share a common goal: a complete understanding of cognition. *Philosophy* thus examines the fundamental nature of consciousness, knowledge, and body-mind problems. *Psychology* studies the mechanisms of behavior, attention, and memory through empirical observation. *Artificial intelligence (AI)* models mental processes by computer, enabling the simulation of intelligent behavior. *Neuroscience* maps how brain structures and neural circuits physically carry out mental functions. *Linguistics* studies how language is represented and processed in the mind, and *anthropology* studies how culture and the environment shape cognitive development and human behavior, and, in recent decades, AI-based machine behavior.

The field of cognitive science and STEM

The field of cognitive science is thus driving progress in many industries, including human-computer and human-AI interactions, and the integration of cobots¹, education, the design of intelligent learning environments, and data science. Similarly, in the field of education, we have begun to find that strict separation into individual subjects is harmful because students do not get all the necessary knowledge. Still, the problem is that we do not teach them how to use these skills in real life at school. And in doing so, we forget the fundamental premise of education: *school is a school for life*.

Therefore, in the middle of the 20th century, integrative science began to develop worldwide, combining the sciences, technology, engineering, and mathematics. In the early nineties of the 20th century, educators and educational policymakers at the U.S. National Science Foundation (NSF, 2026) realized that pure and applied sciences needed better and, above all, more meaningful integration. Initially called “SMET” (Science, Mathematics, Engineering,

¹ Cobot is an abbreviation for collaborative robots. Unlike traditional industrial robots, which are confined to protective cages and perform predetermined, often dangerous tasks independently, Cobots are specifically designed to share a workspace with humans. Equipped with advanced sensors, they can detect human presence and safely stop operations in unexpected environments.

and Technology), in 2001, this critique was reorganized as STEM² (science, technology, engineering, and mathematics). In the 21st century, STEM has evolved from a simple academic categorization to a purposeful learning paradigm that fosters collaboration, critical thinking, and applied learning. The landmark 2009 *Educate to Innovate* initiative has put STEM literacy at the forefront of national curricula around the world (Yeping, Zheng, Naiqing, 2024).

STEM education today emphasizes hands-on, exploratory learning, replacing traditional lectures with research and problem based learning, problem-solving, and real-world projects. Today, however, the question is increasingly asked: Is solving problems alone enough? Can we really develop everything we know how to do, or should there be any safeguards in education? Can STEM philosophy really evolve without taking society and its norms into account? Surely the answer to all these questions is *a categorical no!* STEM needs something else, briefly called the *humanities*, a social and environmental responsibility. Therefore, STEM is further evolving increasingly into the *STEAM* movement, which includes the arts and humanities to promote design thinking, creativity, critical thinking, and creative problem-solving, and social and environmental responsibility³. When comparing STEM and STEAM, the difference is in the way they approach scientific concepts. STEM explicitly focuses on hard science, technology, engineering, and math skills to drive progress or to create new concepts. While STEAM advocates both hard and soft problem-solving skills. When the arts and humanities are added to STEM fields, education shifts from simply teaching integrative basic science skills to exploring the human and social impacts of those skills (Arce, Güler, 2026), which also represents:

1. *Responsible innovation*: For example, educators can use the *Open Research Europe study on STEAM education* (Arce, Güler, 2026) to show how combining art with new technologies fosters responsible innovation, environmental awareness, and critical thinking.
2. *Ethical dilemmas*: STEAM programs often use methodologies to show students how to balance technological developments with environmental, ethical, and technological implications for societal problems, such as global warming or the rational use of AI.

In addition, STEAM promotes understanding and implications of STEM hard science concepts. By integrating arts and humanities concepts and practices, STEAM uses tools such as data visualization or fine art to deepen its understanding of science, mathematics, and technology. STEAM education thus advocates the integration of science, technology, and mathematics with the humanities, whereby we can/must emphasize the need to include the ethical and moral dimensions of the impact of technologies on our environment and on social changes in the development of products and technologies. The latter, in particular, is even more important in the era of the integration of generative artificial intelligence (GenAI) into education and society. The goal should also be to develop critical thinking, adaptability, and transdisciplinary skills to prepare students for real-life challenges.

Education for tomorrow

When we talk about education in the 21st century (after 2020), we are asked new questions related to the goals, contents, and methods of modern technology-oriented and AI-oriented education (Aberšek, 2025). In the foreground, the search is mainly for the following answers:

- What educational content and didactic concept (paradigms) choose to maximize the educational impact?

2 <https://pbiss.ac.th/news-updates/what-is-stem-education>

3 https://ballotpedia.org/STEM_education

- How to design new goals that hardly anyone thought about in the past: *understanding and responsible handling of technology, key qualifications and competencies, ethics in technology, and the interrelationship between society, technology, and nature?*
- What should be the development of pedagogical solutions that will enable rational and didactically diverse education, successful learning, and teaching in all its areas?

But there are certainly more of these and such questions than we have answers to at the moment. Let's briefly hint at some possibilities.

Education and Technology in Modern STEAM Teaching

When we talk about the integration of modern technologies based on artificial intelligence into educational processes, we need to highlight two key challenges:

1. *Education and technology*: Education must make meaningful use of technological advances to personalize learning experiences, provide interactive content, and facilitate lifelong learning, while always and everywhere putting the human being at the forefront. This reflects the vision of technology as a factor that enables a better quality of life and social progress of modern society, but human society (Flogie, Aberšek, Pesek, 2025).
2. *Society and technology*: The technological approach requires a population that will be trained to apply and innovate the well-being of people's lives through new technologies, e.g., based on *Industry 5.0* (NEF, 2024). Modern education, let's call it *Education 5.0* (Aberšek, 2025), plays a key role in equipping individuals with digital literacy, engineering and technological literacy, and technological knowledge necessary for active participation and contribution to the progress of *Industry 5.0*.

Conclusion

Education 5.0 and Industry 5.0 are intertwined in their efforts to shape a future that combines technological innovation, human well-being, and sustainable development. Education 5.0 should equip individuals with the skills and mindset needed to actively participate in a technologically enhanced Industry 5.0 ecosystem. In contrast, Industry 5.0 provides a context in which these skills can thrive and contribute to a more prosperous and inclusive society. Industry 5.0 addresses human society from a global perspective, especially social and economic. At the same time, Education 5.0 emphasizes, above all, the holistic, social aspect of development and the well-being of society as a whole. Education 5.0 is not tied to economic development, but to how to achieve this economic development through a knowledge-based society. And finally, let's not forget: *school is a school for life*.

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