

*Bidragsformat: Workshop*

# Is there space for critical thinking competence in STEM education in the age of Generative AI?

Marius Mikalsen<sup>1</sup>, Syed Sajid Hussain<sup>1</sup>, George Adrian Stoica<sup>1</sup>

<sup>1</sup> Institutt for datateknologi og informatikk, NTNU, Trondheim

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**Abstract:** This workshop explores the evolving role of critical thinking competence in STEM education amidst the rapid integration of Generative AI (GenAI) tools. Critical thinking, central to STEM disciplines, involves evaluating evidence, analyzing problems, and developing reasoned solutions. While GenAI offers opportunities for personalized learning, diverse perspectives, and enhanced engagement, it also poses risks such as over-reliance, uncritical acceptance, and exposure to misinformation and biases. The impact of GenAI on students' critical thinking skills depends on how educators design learning environments that balance AI-enhanced efficiency with inquiry-based learning. Drawing on insights from the FreeThought project, which investigates societal challenges of GenAI, this workshop aims to explore practical strategies to foster responsible AI use. Participants will explore pedagogical approaches that promote inquiry and evidence-based reasoning. Through interactive activities, including group discussions using Miroboards and real-time surveys via Mentimeter, participants will co-develop strategies to integrate AI tools without compromising critical thinking outcomes. The workshop aims to support educators in leveraging GenAI's capabilities while mitigating its risks, ensuring that students remain active, reflective learners.

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Keywords:

Critical thinking, competence, STEM education, Generative AI

# 1 Introduction

Recent research published by Statistics Norway (the national statistical institute of Norway) points to very significant trends in the use of AI tools. On the one hand, the adoption of AI tools in industry is growing quite fast, the numbers doubling in the past couple of years. One in five companies use AI tools (Walther-Zhang & Rybalka, 2024). The ICT sector is, unsurprisingly, having the highest levels of adoption. On the other hand, as outlined in the study barometer (survey conducted by NOKUT on behalf of the Norwegian Ministry of Education and Research), four out of five students use AI tools in their day-to-day while the numbers are almost reversed regarding their received training for using such tools (Studiebarometeret, 2025). More research and insight are needed to produce educational blueprints that can harness the potential of AI tools positively and constructively.

Critical thinking is central to STEM education. Critical thinking can be defined as “the ability to thoughtfully analyze and evaluate situations and recommend courses of action that consider stakeholders, implications, and consequences” (Lovelace, et al., 2016: 101). Critical thinking enables STEM students to evaluate evidence, analyze problems, and develop well-reasoned solutions (Ananiadou & Claro, 2009; Kelly, 2012). However, the rapid integration of Generative AI (GenAI) in educational environments presents opportunities and challenges for fostering this essential skill. GenAI – an umbrella term for AI solutions that generate text, audio, and visual content – can enhance active learning by offering personalized feedback, dynamic exploration, and exposure to diverse perspectives (Gonsalves, 2024; Lee et al., 2025). On the other hand, GenAI poses challenges such as over-reliance on AI-generated content, the risk of uncritical acceptance of AI-generated content, the potential for misinformation and embedded biases, over-reliance on automated solutions, and ethical concerns related to accuracy and transparency, all of which may hinder the development of independent critical thinking skills (Gonsalves, 2024; Larson et. al, 2024; Lee et al., 2025; Mogavi et al., 2024).

GenAI has the potential to either enhance or hinder critical thinking, depending on how it is integrated into educational practices. Bloom’s Taxonomy provides a useful framework for analyzing this impact, as it structures cognitive skills into hierarchical levels ranging from basic recall to higher-order reasoning (Bloom et al., 1956). If GenAI is used to support inquiry and active learning, it can facilitate deeper learning by encouraging students to analyze, evaluate, and synthesize information. However, if its use is driven primarily by efficiency, it may reinforce passive learning habits and reliance on AI-generated content, limiting opportunities for higher-order cognitive development. This concern is particularly relevant in STEM fields, where students are encouraged to adopt a solution-oriented mindset that prioritizes efficiency and problem-solving (Li et al., 2019). While the efficiency mindset is valuable, it may sometimes lead to accepting AI-generated outputs too readily, focusing on quickly arriving at solutions rather than critically evaluating their reasoning (Lee et al., 2025). Recent adaptations of Bloom’s framework for AI-enhanced learning emphasize the need to integrate AI-specific competencies, such as information validation, ethical reasoning, and the ability to selectively integrate AI-generated insights into problem-solving processes (Gonsalves, 2024; Miao & Shiohira, 2024). By embedding these competencies into educational design, educators can use GenAI as a tool for independent reasoning.

This workshop explores educator strategies to foster critical thinking with GenAI. Research suggests that students may develop evaluative reasoning skills by actively engaging with AI, critically analyzing its outputs, and validating AI-generated content against reliable sources (Lee et al., 2025; Mogavi et. al, 2024). Well-structured prompts and reflective practices can enhance critical thinking by encouraging students to question assumptions, assess credibility, and refine AI-generated material. However, over-reliance, misinformation, and ethical concerns can be addressed through proactive educator guidance, AI literacy training, and curriculum design that balances AI-enhanced learning with foundational problem-solving skills (Gonsalves, 2024). By intentionally structuring learning experiences, educators can consider how GenAI can complement, rather than replace, students' ability to think critically. This is particularly important for STEM education as these students will be the ones creating these technologies in the future.

Building on these insights, we are already engaged in *FreeThought*<sup>1</sup>, an ongoing project that examines the societal challenges of generative AI and surveillance capitalism, focusing on strengthening sociotechnical critical thinking and protecting democratic values. One of *FreeThought*'s objectives is to organize workshops that translate research into practical strategies for fostering critical engagement with AI. This workshop will continue that series, extending our focus to STEM education by equipping educators with tools to cultivate evaluative reasoning, structure effective prompts, and balance AI-enhanced learning with foundational problem-solving skills.

## 2 About the workshop

### 2.1 What are the participants of the workshop expected to learn?

The following are the learning objectives of the workshop:

- Evaluate the role of critical thinking in STEM Education:
  - Participants will be able to assess the importance of critical thinking competence in STEM disciplines and how it contributes to problem-solving, innovation, and scientific integrity.
- Analyze the impact of generative AI on critical thinking skills:
  - Participants will critically analyze how the use of generative AI tools in STEM education influences students' ability to engage in independent, reflective, and analytical thinking.
- Develop pedagogical approaches for critical thinking:
  - Participants will discuss activities that promote critical thinking, emphasizing inquiry, evidence-based reasoning, and problem solving in the context of AI-assisted learning.

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<sup>1</sup> <https://www.ntnu.edu/community/prosjekter/freethought>

- Reflect on ethical implications of Generative AI in STEM:
  - Participants will reflect on the ethical considerations and potential biases introduced by generative AI tools, discussing their implications for STEM education.

## 2.2 Why is the workshop relevant and attractive for the participants?

The relevance of the workshop lies in the growing need to reflect on educational practices in relation to the rapid integration of artificial intelligence (AI) in higher education.

From a pedagogical perspective, the workshop draws on constructivist principles, emphasizing critical education reflection (Brookfield 2017). Research indicates that when students are encouraged to critically evaluate AI-generated content, they engage more deeply with subject matter and develop better analytical skills (Holmes et al., 2023). Generative AI can serve as a cognitive tool that supports, rather than replaces, critical thinking if implemented appropriately (Gonsalves 2024). For instance, designing learning activities that require students to critique the reliability and accuracy of AI-generated solutions can enhance their critical thinking skills. Furthermore, AI literacy is now recognized as a critical component of STEM education, as students must understand the limitations, biases, and ethical considerations of generative AI use (Gueral 2024).

The pedagogical rationale for the workshop is grounded in the need to prepare STEM educators to integrate AI tools while safeguarding and promoting critical thinking. As AI reshapes knowledge production and problem-solving practices, STEM educators must adopt strategies that align with the development of 21st-century competencies (such as; communication, collaboration, critical thinking, and problem-solving) (Celik et al. 2024). This workshop will thus explore practical, research-informed approaches for participants to design learning that leverage generative AI to support, not compromising the development of critical thinking skills.

## 2.3 How are the participants activated?

The 1-hour workshop will be organized as follows to maximize participation:

- 10 minute introduction to set the stage, critically assessing STEM education, the role of critical thinking and generative AI (by the organisers or invited speaker)
- 5 minute survey on participants (using Mentimeter <https://i.ntnu.no/wiki/-/wiki/Norsk/Mentimeter>)
- 25 minute groupwork (using Miroboards <https://i.ntnu.no/wiki/-/wiki/Norsk/Miro>)
- 15 minutes plenary presentations of groupwork
- 5 minute summary and information about the takeaways

The activities planned for the workshop maximize participation and data generation during the workshop. Mentimeter will be used to collect background information from

the participants (such as education background, field) and input on key items regarding critical thinking and generative AI in STEM education.

The groupwork will be facilitated using prepared Miroboards where the groups will enter relevant thoughts and input regarding the key learning outcomes.

The use of the tools will serve the dual purpose of activating the participants and allow us to quickly assemble a report from the workshop.

Following the groupwork each group will present their thoughts and input in a plenary session.

## 2.4 How will the results be summarized

Takeaways for the participants are the following:

- Input on the theme from presentations
- Critical reflection on critical thinking in STEM education with generative AI with peers (group work and plenary presentations)
- We will compile a preliminary report based on the input from the survey and the miro-boards and distribute this to the participants as well as publish the preliminary report on FreeThought website: <https://www.ntnu.edu/community/prosjekter/freethought>
- We will write a paper based on the data collected combined with research on STEM education (as indicated in this paper), critical thinking and generative AI and publish in the conference proceedings.

## 2.5 How is the theme relevant for STEM-education

As indicated above, the theme of this workshop is relevant for STEM education for the following reasons:

- Critical thinking, a core learning outcome across STEM disciplines, is increasingly influenced by the pervasive presence of generative AI tools like ChatGPT
- Critically reflecting on the status of critical thinking in general and with generative AI in particular in STEM education
- AI literacy (of which generative AI is one) is now recognized as a critical component of STEM education
- It is relevant to reflect on key critical thinking competences with generative AI – to strengthen the good, and mitigate any bad outcomes of generative AI
- The workshop is relevant as it will explore practical, research-informed approaches for participants to design learning that leverage generative AI to support, not compromising the development of critical thinking skills in STEM education.

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## References

- Ananiadoui, K., & Claro, M. (2009). 21st century skills and competences for new millennium learners in OECD countries.
- Bloom, B. S., Engelhart, M. D., Furst, E., Hill, W. H., & Krathwohl, D. R. (1956). Handbook I: Cognitive domain. David McKay.
- Brookfield, Stephen D. (2017) *Becoming a critically reflective teacher*. John Wiley & Sons.
- Celik, I., Gedrimiene, E., Siklander, S., & Muukkonen, H. (2024). The affordances of artificial intelligence-based tools for supporting 21st-century skills: A systematic review of empirical research in higher education. *Australasian Journal of Educational Technology*, 40(3), 19-38.
- Gonsalves, C. (2024). Generative AI's Impact on Critical Thinking: Revisiting Bloom's Taxonomy. *Journal of Marketing Education*, 02734753241305980
- Guerra, E. (2024). The contribution of critical thinking to STEM disciplines at the time of generative intelligence. *STEM Education*, 4(1), 71-81..
- Holmes, W. (2020). Artificial intelligence in education. In *Encyclopedia of education and information technologies* (pp. 88-103). Cham: Springer International Publishing.
- Kelly, R. (Ed.). (2012). *Educating for creativity: A global conversation*. Brush Education.
- Larson, B. Z., Moser, C., Caza, A., Muehlfeld, K., & Colombo, L. A. (2024). Critical thinking in the age of generative AI. *Academy of Management Learning & Education*, 23(3), 373-378.
- Lee, H. P. H., Sarkar, A., Tankelevitch, L., Drosos, I., Rintel, S., Banks, R., & Wilson, N. (2025). The Impact of Generative AI on critical thinking: Self-reported reductions in cognitive effort and confidence effects from a survey of knowledge workers.
- Li, Y., Schoenfeld, A. H., Disessa, A. A., Graesser, A. C., Benson, L. C., English, L. D., & Duschl, R. A. (2019). Design and design thinking in STEM education. *Journal for STEM Education Research*, 2, 93-104.
- Miao, F., & Shiohira, K. (2024). *AI competency framework for students*. UNESCO Publishing.
- Lovelace, K. J., Eggers, F., & Dyck, L. R. 2016. I do and I understand: Assessing the utility of web-based management simulations to develop critical thinking skills. *Academy of Management Learning & Education*, 15: 100–121.
- Mogavi, R. H., Deng, C., Kim, J. J., Zhou, P., Kwon, Y. D., Metwally, A. H. S., ... & Hui, P. (2024). ChatGPT in education: A blessing or a curse? A qualitative study exploring early adopters' utilization and perceptions. *Computers in Human Behavior: Artificial Humans*, 2(1), 100027.
- Studiebarometeret 2025 . Studiebarometeret 2024 – Hovedtendenser. Retrieved February 14, 2025, from [https://www.nokut.no/globalassets/studiebarometeret/2025/studiebarometeret-2024-hovedtendenser\\_1-2025.pdf](https://www.nokut.no/globalassets/studiebarometeret/2025/studiebarometeret-2024-hovedtendenser_1-2025.pdf)
- Walther-Zhang, Y & Rybalka M, (2024). Dobling i bruk av KI. SSB. Retrieved February 14, 2025, from <https://www.ssb.no/teknologi-og-innovasjon/informasjons-og-kommunikasjonsteknologi-ikt/statistikk/bruk-av-ikt-i-naeringslivet/artikler/dobling-i-bruk-av-ki>