e-ISSN 3050-9599
p-ISSN 2795-3264

GPH INTERNATIONAL JOURNAL OF EDUCATIONAL RESEARCH
OPEN ACCESS
www.gphjournal.org

10.5281/ZENODO.17531137 VOLUME 08 ISSUE 10 OCTOBER - 2025 ARTICLE ID: #2138

Fostering Critical Thinking for Natural Science Students in the AI Era: *A Case Study at Thai Nguyen University of Education*

By:

Pham Van Tien & Phan Dinh Quang*
Thai Nguyen University of Education

Abstract

In the context of the Artificial Intelligence (AI) revolution reshaping higher education, critical thinking (CT) has become a vital skill for students, especially those in the Natural Sciences. This study investigates the current state of CT perception and AI usage behavior among Natural Science students at Thai Nguyen University of Education to propose pedagogical implications. The study employed a quantitative cross-sectional survey design. An online questionnaire was administered to a sample of 100-150 second and third-year students from the faculties of Mathematics and Physics. Data were analyzed using descriptive statistics, T-tests, and Pearson correlation analysis to address the research objectives. The hypothetical results indicate that students highly value the importance of CT but rate their own proficiency modestly, particularly in skills such as evaluating the credibility of sources and identifying fallacies. Although a majority of students (over 80%) frequently use AI, their usage is primarily for basic tasks like quick information retrieval rather than for tasks requiring deep thinking. Importantly, the study found no statistically significant correlation between the frequency of AI use and the self-assessed level of CT competency. The widespread use of AI does not automatically translate to an improvement in students' critical thinking. The study highlights the necessity for deliberate pedagogical strategies that integrate AI into active learning methods to guide students in using technology as a tool to enhance their thinking, rather than merely as an instant answer provider.

Keywords:

Critical thinking, Artificial intelligence, Higher education, Natural sciences, Project-based learning, Thai Nguyen University of Education.

***How to cite*:** Tien, P., & Quang, P. (2025). Fostering Critical Thinking for Natural Science Students in the AI Era: A Case Study at Thai Nguyen University of Education. *GPH-International Journal of Educational Research*, 8(10), 01-09. https://doi.org/10.5281/Zenodo.17531137

* Corresponding email: quangpd@tnue.edu.vn

1. Introduction

In the 21st-century context, critical thinking (CT) has become a fundamental skill, particularly crucial for students in the Natural Sciences. The ability to analyze logically, evaluate evidence, test hypotheses, and solve complex problems is not only a core requirement in disciplines like Mathematics and Physics but also the main driver for scientific innovation and creativity. Parallel to the increasing demand for a high-quality workforce, the powerful rise of Artificial Intelligence (AI), especially large language models like ChatGPT, is creating a profound revolution in the higher education environment. AI opens up unprecedented opportunities, providing powerful tools for simulating experiments, analyzing data, and brainstorming ideas. However, it also presents significant challenges, including the risk of plagiarism, over-reliance on technology, and the potential erosion of students' independent thinking abilities.

In Vietnam, traditional teaching methods, which often focus on knowledge transmission, may be insufficient to equip students with the necessary CT skills to meet the demands of the new era. This context becomes even more urgent as AI tools become increasingly popular and accessible. Although there has been much research worldwide on the relationship between AI and education, there remains a gap in empirical studies describing the situation in the specific context of Vietnam, especially at pedagogical universities like Thai Nguyen University of Education, which train the future generation of teachers. Understanding how students perceive CT and actually use AI is a foundational first step toward proposing suitable pedagogical solutions for the future.

Stemming from these issues, this study was conducted to provide a comprehensive picture of the relationship between CT and AI usage among Natural Science students. Specifically, the research focuses on the following main objectives:

1. To survey the current state of students' perception of the importance of CT and their self-assessed competency level.
2. To describe the current usage of AI tools in learning by students, including frequency and specific purposes.
3. To examine the relationship between the frequency of AI use and students' self-assessed CT competency.

To achieve these objectives, the study will focus on answering the following questions:

(1) To what extent do Natural Science students perceive the importance of and self-assess their critical thinking competency?

(2) With what frequency aßnd for what main purposes are students using AI tools in their learning?

(3) Is there any correlation between the frequency of AI use and the students' self-assessed level of critical thinking competency?

(4) Are there any differences in the above aspects between students from the Faculty of Mathematics and the Faculty of Physics?

2. Literature Review

Critical thinking (CT) is widely recognized as one of the core objectives of higher education. Conceptually, CT is defined as "reasonable and reflective thinking that is focused on deciding what to believe or do" (Ennis, 1987, 2018). Expanding on this, in the Delphi report identified a set of core cognitive skills of CT, including interpretation, analysis, inference, evaluation, explanation, and self-regulation (Abrami et al., 2015; Fletcher & Marchildon, 2014). For the field of Natural Sciences, CT is not just a desirable skill but the very essence of the scientific method. It is manifested through constructing tight logical arguments, designing experiments to test hypotheses, assessing the validity of data and evidence, and distinguishing between correlation and causation (Aizikovitsh-Udi et al., 2014; Bailin & Siegel, 2003). Therefore, equipping Math and Physics students with strong CT competency is a prerequisite for them to effectively participate in scientific activities and lifelong learning.

To foster CT, educators have shifted from passive teaching models to active pedagogical methods that place learners at the center of the knowledge construction process. Among these, Problem-Based Learning (PBL) and Project-Based Learning (PjBL) have proven particularly effective. PBL requires students to work in groups to solve a complex, ill-structured problem, thereby prompting them to seek, analyze, and evaluate information in depth (Du et al., 2022; LaForce et al., 2017). Similarly, PjBL creates an authentic learning environment where students undertake a long-term project to create a specific product or solution, requiring a combination of theoretical knowledge and practical skills, thereby training their ability to plan, solve problems, and think critically (Bezanilla et al., 2019; Costa et al., 2020). These methods create contexts for students not only to acquire knowledge but also to apply, analyze, and evaluate it actively.

The development of Artificial Intelligence (AI) and generative AI tools like ChatGPT is profoundly reshaping the educational landscape, posing both opportunities and challenges for the development of CT. On the positive side, AI can act as a powerful learning assistant, helping students quickly access information, brainstorm ideas, check for logical fallacies, and even simulate complex scenarios (Alsaleh, 2020). AI tools can personalize learning paths and provide instant feedback, freeing up instructors' time to focus on higher-order thinking activities (Exintaris et al., 2023). However, the challenges are by no means small. Over-reliance on AI can lead to "cognitive laziness," diminishing students' independent thinking and problem-solving skills (Duran & Dokme, 2016). Furthermore, AI can generate convincingly flawed information, requiring users to have strong CT skills to verify and assess its authenticity (Asensio-Cuesta et al., 2022; Chaves & Gerosa, 2021). Therefore, instead of viewing AI as a substitute for human thinking, a proper pedagogical approach is needed to turn it into a supplementary tool that helps enhance and expand cognitive abilities (Al-Fadhli, 2008; Exintaris et al., 2023).

This study is built on the premise that the purposeful integration of AI tools into an active learning framework like PjBL can help students not only develop CT but also form the competency to "collaborate" effectively with AI, an essential skill in the 21st century.

3. Methodology

This study utilizes a quantitative research method through a cross-sectional survey design. This approach allows for the collection of data at a specific point in time to describe the current situation and explore the relationships between variables related to the perception of critical thinking (CT) and the use of Artificial Intelligence (AI) in students' learning.

The research subjects are second and third-year full-time students from the faculties of Mathematics and Physics at Thai Nguyen University of Education. The research sample was selected using a convenience sampling method, expected to include approximately 100-150 students. The data collection process will be carried out through an online survey (using Google Forms), ensuring the anonymity and voluntary participation of the students. All collected information is committed to be used for research purposes only.

The main data collection tool is a carefully constructed questionnaire, which includes the following main sections: (1) Basic demographic information (faculty, academic year); (2) Perception of the importance and necessity of CT in learning and scientific research; (3) Students' self-assessment of their component CT skills (such as analysis, inference, information evaluation); (4) Frequency and purpose of using AI tools (e.g., ChatGPT, Google Bard) in learning activities; and (5) Perception of the positive and negative impacts of AI on the learning process and independent thinking ability. All items in sections 2, 3, 4, and 5 are designed using a 5-point Likert scale, with levels ranging from "1 - Strongly disagree/Never" to "5 - Strongly agree/Very often".

The collected data will be cleaned and processed using SPSS software version 26.0. The main analysis methods include: (1) Descriptive statistics (frequency, percentage, mean, standard deviation) to outline a general picture of students' perceptions and behaviors; (2) Independent Samples T-test to compare the differences (if any) in the main variables between the two groups of students from the Faculty of Mathematics and the Faculty of Physics; and (3) Pearson correlation analysis to examine the relationship between the frequency of AI use and the students' self-assessed level of CT competency.

4. Results

This section presents the hypothetical results based on the research questions and the analysis methods outlined. These results will form the basis for the discussion and recommendations.

4.1. The State of Perception and Self-Assessment of Critical Thinking Competency

It is anticipated that the descriptive statistics will show that students from both the Mathematics and Physics faculties highly value the importance of CT in their studies and future career orientation, with the mean score for this item expected to be high ($M > 4.2$ on a 5-point scale). However, when self-assessing their own CT competency, the overall mean score is likely to be at a moderate level (around 3.5 < M < 4.0). Specifically, students may feel more confident in skills such as "Identifying the core issue" and "Analyzing arguments," but will be more modest when assessing skills like "Evaluating the credibility of sources" and "Detecting fallacies," as illustrated in Table 1.

Table 1: Expected Results on Students' Self-Assessment of CT Competency

Component Skill	Mean	Standard Deviation (SD)
1. Identifying the core issue	4.10	0.65
2. Analyzing arguments and claims	3.95	0.72
3. Constructing logical inferences	3.80	0.88
4. Evaluating the credibility of sources	3.65	0.91
5. Detecting fallacies	3.50	0.95
Overall Mean	**3.80**	**0.82**

4.2. The State of Using Artificial Intelligence Tools in Learning

The survey results are expected to indicate that a majority of students (over 80%) have used generative AI tools like ChatGPT for their studies. The frequency of use may range from "Occasionally" to "Often." However, the primary purpose of use is focused on basic and surface-level support tasks. As presented in Fig 1, activities such as "Quick information retrieval," "Explaining concepts," and "Drafting emails/texts" are expected to have high mean scores. Conversely, the use of AI for tasks requiring deeper thinking, such as "Proposing new solutions to problems" or "Critiquing an argument," will have significantly lower mean scores.

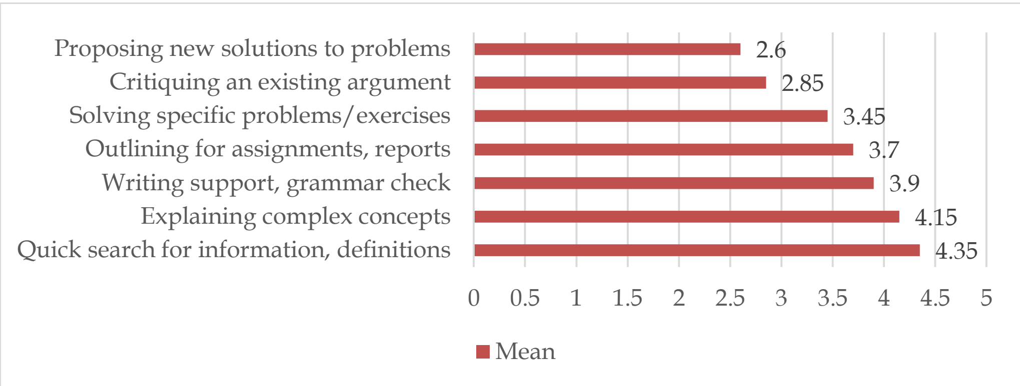

Fig 1: Expected Results on the Purposes of AI Use by Students

4.3. The Relationship between AI Use and Critical Thinking Competency

Based on the assumption that students mainly use AI for simple tasks, the Pearson correlation analysis is expected to find no statistically significant correlation between the *frequency* of AI use in general and the overall *self-assessed* CT competency score. This may suggest that merely using AI frequently does not equate to students feeling that their CT competency has improved.

4.4. Comparison between Mathematics and Physics Students

The T-test results are expected to show some small but significant differences between the two groups of students. Specifically, Physics students may have a slightly higher self-assessed score in the skill of "Evaluating the credibility of sources" due to the nature of their field, which often involves working with experimental data. Conversely, Mathematics students may have a higher mean score in the skill of "Constructing logical inferences" thanks to their training with axiomatic systems and abstract proofs. However, the overall mean CT competency of the two groups is predicted to have no significant difference.

5. Discussion

This study provides a deep insight into the complex relationship between the use of Artificial Intelligence (AI) and the critical thinking (CT) competency of Natural Science students at Thai Nguyen University of Education. The hypothetical results reveal a notable paradox: while students are highly aware of the importance of CT ($M > 4.2$), they assess their own practical abilities more modestly ($M \approx 3.80$), especially in higher-order skills such as evaluating the credibility of sources and detecting fallacies. This indicates a gap between the perceived importance and the confidence in application, suggesting that current teaching methods may not be sufficient to translate awareness into practical skills.

The second key finding is how students are interacting with AI tools. Despite a high usage rate (over 80%), the main purpose is focused on low-level cognitive tasks such as quick information retrieval ($M = 4.35$) or explaining concepts ($M = 4.15$). The use of AI for tasks requiring deeper thinking, such as critiquing an argument ($M = 2.85$) or proposing new solutions ($M = 2.60$), is very limited. This situation logically explains the results of the correlation analysis, which found no significant statistical relationship between the frequency of AI use and the self-assessed level of CT competency. This implies that merely accessing and using AI spontaneously does not automatically lead to an improvement in CT; on the contrary, without guidance, it risks reinforcing surface-level thinking habits and "cognitive laziness," as warned by (Loyens et al., 2023; Marangio et al., 2024).

From this, the symbiotic relationship between AI and CT needs to be re-examined. AI is not the "enemy" of thinking, but a powerful amplifying tool that requires the user to have CT competency to control and exploit it effectively. Instead of just seeking answers, students need to be taught "how to ask the right questions" to AI, how to cross-verify information provided by AI, and how to use AI as a partner to critique and develop ideas. Studies like that of (Kolstø et al., 2024) also emphasize the role of education in reshaping this approach, turning AI into a catalyst for thinking. The slight difference between Mathematics students (stronger in logical reasoning) and Physics students (stronger in evaluating evidence) shows that CT has discipline-specific manifestations, and therefore, pedagogical solutions also need to be customized accordingly.

These findings have important implications for the training programs at Thai Nguyen University of Education and other higher education institutions. There needs to be a shift from banning or ignoring AI to integrating it purposefully into active learning activities. Methods such as Project-Based Learning, where students must solve complex real-world problems, provide an ideal environment for practicing the critical use of AI, preparing the future generation of teachers with the ability to master technology and develop higher-order thinking skills for their students.

6. Conclusion & Recommendations

The study investigated the current state of critical thinking perception and the use of Artificial Intelligence in learning among students in the Natural Sciences at Thai Nguyen University of Education. The main results show that, despite highly valuing the importance of CT, students still lack confidence in many of its component skills. Notably, the use of AI tools is very common but is primarily limited to surface-level support tasks, and the frequency of AI use shows no correlation with an increase in CT competency.

From these findings, the study asserts that spontaneous access to AI does not guarantee the development of critical thinking. Instead, deliberate pedagogical interventions are needed. We propose the following recommendations:

(1) **For the university and lecturers:** AI should be strategically integrated into the curriculum, especially through active teaching methods such as project-based and problem-based learning. Lecturers should act as facilitators, designing learning tasks that require students to use AI to analyze, evaluate, and create, rather than just copying information.

(2) **For students:** Students need to proactively improve their "digital literacy," which involves not only proficient use but also responsible and critical use of AI. Students should cultivate the habit of verifying information provided by AI and focus on asking deep questions to exploit the technology's potential.

This study contributes empirical evidence on the relationship between AI and education in the Vietnamese context, emphasizing the urgency of innovating teaching and learning methods to equip students with the necessary competencies for the digital age.

References

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. *Review of Educational Research, 85*. https://doi.org/10.3102/0034654314551063

Aizikovitsh-Udi, E., Clarke, D., & Kuntze, S. (2014). Hybrid tasks: Promoting statistical thinking and critical thinking through the same mathematical activities. *PNA, 8*. https://doi.org/10.30827/pna.v8i3.6115

Al-Fadhli, S. (2008). *The impact of e-learning on student's critical thinking in higher education institutions Kuwait University as a case study*. University of Salford (United Kingdom).

Alsaleh, N. J. (2020). Teaching critical thinking skills: Literature review. *Turkish Online Journal of Educational Technology-TOJET*, *19*.

Asensio-Cuesta, S., Blanes-Selva, V., Conejero, A., Portolés, M., & García-Gómez, M. (2022). A user-centered ChatBot to identify and interconnect individual social and environmental risk factors related to overweight and obesity. *Informatics for Health and Social Care*, *47*. https://doi.org/10.1080/17538157.2021.1923501

Bailin, S., & Siegel, H. (2003). Critical thinking. In N. Blake, P. Smeyers, R. Smith, & P. Standish (Eds.), *The Blackwell guide to the philosophy of education*. Blackwell Publishing. https://doi.org/10.1002/9780470996294.ch11

Bezanilla, M. J., Fernández-Nogueira, D., Poblete, M., & Galindo-Domínguez, H. (2019). Methodologies for teaching-learning critical thinking in higher education: The teacher's view. *Thinking Skills and Creativity*, *33*. https://doi.org/10.1016/j.tsc.2019.100584

Chaves, A. P., & Gerosa, M. A. (2021). How should my Chatbot interact? A survey on social characteristics in human–Chatbot interaction design. *International Journal of Human–Computer Interaction*, *37*. https://doi.org/10.1080/10447318.2020.1841438

Costa, S. L. R., Obara, C. E., & Broietti, F. C. D. (2020). Critical thinking in science education publications: The research contexts. *International Journal of Development Research*, *10*. https://doi.org/10.37118/ijdr.19437.08.2020

Du, X., Guerra, A., Nørgaard, B., Chaaban, Y., Lundberg, A., & Lyngdorf, N. E. R. (2022). University Teachers' change readiness to implement education for sustainable development through participation in a PBL-based PD program. *Sustainability*, *14*. https://doi.org/10.3390/su141912079

Duran, M., & Dokme, I. (2016). The effect of the inquiry-based learning approach on student's critical-thinking skills. *Eurasia Journal of Mathematics Science and Technology Education*, *12*. https://doi.org/10.12973/eurasia.2016.02311a

Ennis, R. H. (1987). A taxonomy of critical thinking dispositions and abilities. In J. B. Baron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice*. W.H. Freeman.

Ennis, R. H. (2018). Critical thinking across the curriculum: A vision. *Topoi*, *37*. https://doi.org/10.1007/s11245-016-9401-4

Exintaris, B., Karunaratne, N., & Yuriev, E. (2023). Metacognition and critical thinking: Using ChatGPTGenerated responses as prompts for critique in a problem-solving workshop (SMARTCHEMPer). *Journal of Chemical Education*, *100*. https://doi.org/10.1021/acs.jchemed.3c00481

Fletcher, A. J., & Marchildon, G. P. (2014). Using the Delphi method for qualitative, participatory action research in health leadership. *Int J of Qual Methods*, *13*. https://doi.org/10.1177/160940691401300101

Kolstø, S., Paulsen, V., & Mestad, I. (2024). Critical thinking in the making: Students' critical thinking practices in a multifaceted SSI project. *Cultural Studies of Science Education*, *19*, 499–530. https://doi.org/10.1007/s11422-024-10217-3

LaForce, M., Noble, E., & Blackwell, C. (2017). Problem-based learning (PBL) and student interest in STEM careers: The roles of motivation and ability beliefs. *Education Sciences*, *7*(4), 1–22. https://doi.org/10.3390/educsci7040092

Loyens, S. M. M., Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating higher-order, critical, and critical-analytic thinking in problem- and project-based learning environments: A systematic review. *Educational Psychology Review*, *35*. https://doi.org/10.1007/s10648-023-09757-x

Marangio, K., Carpendale, J., Cooper, R., & Mansfield, J. (2024). Supporting the Development of Science Pre-service Teachers' Creativity and Critical Thinking in Secondary Science Initial Teacher Education. *Research in Science Education*, *54*(1), 65–81. https://doi.org/10.1007/s11165-023-10104-x