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AI literacy through the lenses of graduate students: insights from scenario analysis

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THE ED-AI LITERACY FRAMEWORK IN HIGHER EDUCATION

The Ed-AI Literacy framework in higher education: insights from scenario analysis

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Abstract

Generative artificial intelligence tools have gained notoriety since the launch of ChatGPT by OpenAI in November 2022. This technology is based on large language models, simulating a written ‘conversation’ between humans and algorithms, and is capable of generating text from the commands it receives. However, its use in academia is controversial and requires: knowledge of the tools (their strengths and weaknesses); the ability to evaluate sources and content generated by AI; interpersonal collaboration mediated by these systems; understanding the different contexts of use and the parameters for using AI in each context; autonomous and responsible interaction with AI; and consideration of the ethical implications of these tools (Allen & Kendeou, 2024). Considering the growing use of generative AI tools for learning and the complexity of the knowledge involved in their responsible use, the development of these skills – called artificial intelligence literacy – should be prioritised by teachers and students. The objective of this exploratory study was to analyse university students’ understanding of AI use in light of the theoretical framework of AI literacy developed by Allen and Kendeou (2024). The study employed a scenario analysis methodology to explore how graduate students assess the use of GenAI in a hypothetical learning situation. Students rated each framework component as represented in the scenario and provided justifications to their ratings. Results pointed to students’ difficulty in identifying Ethics in the scenario and a correlation between the marks for Ethics and Autonomy. Justifications based on Autonomy were prominent in students’ reasoning, overlapping with justifications based on Context and Ethics. Students interpreted Ethics as behavioral trace instead of machine-related. Self-efficacy did not explain variance in the scenario rating. GenAI literacy instruction informed by the *ED-AI lit* framework should stress the ethical limitations of GenAI and foster student autonomous and critical exploration of AI systems.

Keywords: generative artificial intelligence literacy, higher education, scenario task.

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The Ed-AI Literacy framework in higher education: insights from scenario analysis**1. Introduction**

Artificial intelligence (AI) is becoming a common learning resource, extending over diverse purposes such as queries, information checking and text generation. In higher education, its use may be involved in tasks such as translation, summarization, and linguistic revision. Although faculty members demonstrate concern with issues of academic integrity (Cotton et al., 2024), university guidelines tend to focus on assessment design and AI literacy (Moorhouse et al., 2023; UNIFI, 2025). However, the implementation of educational policies for GenAI use is uneven across higher education. Analysis of guidelines from eleven Asian universities revealed that some institutions restrict the use of GenAI tools among students, while others emphasize instruction on aspects related to AI knowledge, autonomy, ethics, and contexts of use (Wong et al., 2025). This complex scenario underscores the need to discuss the use of GenAI in higher education integrating institutional policies, professors, and students' perceptions.

Artificial intelligence is a machine-based system that can interpret input data, learn from input, and use the information learned in a flexible manner to perform specific goals and tasks (Haenlein & Kaplan, 2019). This technology is integrated in online translators, chatbot messages, and recommended content in streaming platforms. Generative AI (henceforth GenAI) makes a big leap by performing more complex language tasks at a human level, generating text, pictures, audio or video from the prompts (i.e., written commands) received (Naveed et al., 2024). The technology gained popularity since the release of ChatGPT by OpenAI in November 2022. ChatGPT is an artificial intelligence chatbot that uses natural language processing to create human-like conversational dialogue. It runs on large language models and predicts the next most likely word to form a response.

The use of GenAI tools has promising applications in educational contexts, but they may also promote undesirable effects on learning such as cognitive delegation, (Melumad & Ho Yun, 2025;

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Stadler et al., 2024; Urban et al., 2024), issues of authorship and questionable originality (Hodges & Kirschner, 2023). LLMs use is also associated with increased exposure to incorrect information, made-up data (also known as hallucination), and cultural bias (Kohnke et al., 2023) as well as risks of language homogenization, with the incorporation of words made frequent due to algorithm bias (Kobak et al., 2025). Concerns extend to whether students accurately monitor their performance in problem-solving tasks with LLMs (Urban et al., 2024). Learners should engage in critical reflection about more subtle aspects of GenAI such as its underlying mechanisms and ethical limitations (Weigelt et al., 2026). Even more explicit (and better known) aspects, such as evaluating the quality of an output, are part of a set of competencies that individuals alone may not be properly equipped to do. These challenges stimulated research and instruction on developing AI literacy frameworks, to align with already developed new literacies frameworks such as digital literacy, media literacy, algorithm literacy (Heung et al., 2026).

Studies on the impact of GenAI on learning have reached controversial results. On the AI-negative side, using ChatGPT was linked with lower source references on a source-based writing task among undergraduate students (Tarchi et al., 2024). Evidence from electroencephalography during LLM-assisted essay writing with young adults aged 18 to 39 years old (n=54) has shown detrimental effects of ChatGPT use compared to web search on the topic or no assistance at all (brain-only) among young adults (18-39 years old). Conversely, analysis of the essays revealed more citations among the LLM and search engine groups compared to the brain-only group. The researchers endorse the need for prior education with AI-free writing tasks (Kosmyna and colleagues, 2025). These divergent patterns of source citation emphasize the complexity of LLM-assisted writing and the need to develop AI literacy to ensure students evaluate the quality of the sources they use.

On the pro-AI side, meta-analytical evidence suggested a positive effect of ChatGPT on academic performance, although mental effort was reported to be lower and some of the studies lack power analysis (Deng et al., 2024). Of notice, a meta-meta-analysis of 1,840 effect sizes from 67 meta-analyses

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showed strong publication bias and between-study heterogeneity, concluding that alleged learning benefits of AI appear premature since they are not yet adequately supported by evidence (Bartoš et al. 2026). In answering the question *Are LLMs actually good for learning?*, Rus and Kendeou (2025) argue that GenAI is good for students given three conditions: if it preserves the effort one needs to learn, if students hold enough prior knowledge in the topic to evaluate the output (which is acquired when they engage in deep information processing), and if they are exposed to LLMs in a progressive manner to prioritize cognitive engagement and self-regulation processes. Bauer and colleagues (2025) suggest that AI may either a) replace traditional instruction; b) provide extra instructional scaffolding to students, or c) create more complex tasks that foster deep learning. There are also risks of inversion, with students outsourcing tasks to AI – which evidently reduces cognitive engagement. According to the authors, this problem can be approached through AI literacy and teacher education for technology. The field of AI literacy discusses how (and whether) GenAI should be incorporated in education, including what students need to know about these tools and how they affect learning.

AI literacy frameworks are theoretical constructs that aim to inform instruction, research and policies and promote conscious AI use. Considering the inseparability between theory and practice, the present study departs from the Ed-AI Literacy framework (Allen & Kendeou, 2024). This theoretical framework has relevance given its interdisciplinary nature and possible application across different educational levels. Specifically, we employed a scenario analysis method to explore how graduate students assess the use of GenAI as described in a hypothetical learning situation that was developed based on the Ed-AI Lit framework. Through this methodology, the present exploratory study aimed to investigate how graduate students identify and evaluate Ed-AI components when analyzing the use of generative AI in a hypothetical learning situation. This data might unveil learners' understanding of GenAI use and whether it reflects core theoretical issues in the field of AI literacy. Although previous studies sought to develop and validate instruments to assess AI literacy (reviewed in section 2.1), this is

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not our goal. Considering the predominance of quantitative and theoretical studies on AI literacy in higher education (Černý et al., 2024), the present study contributes to the discussion on AI literacy by providing a qualitative approach to the topic – including university student's views on GenAI literacy.

2. Conceptualizing AI literacy

For much time, knowledge in artificial intelligence has been restricted to technical areas in higher education such as computer science and data science (Wong et al., 2025). More recently, AI literacy extended to other areas as well as to basic education (Kong et al., 2023; Lin et al., 2023). Research on AI literacy had exponential growth especially since 2023 – a recent interest that unveils concern with the impacts of this technology on learning (Almatrafi et al., 2024; Yang et al., 2025). AI literacy comprises “a set of competencies that enables students to understand how AI works, critically evaluate them, and use them effectively to communicate and collaborate in various contexts (Allen & Kendeou, 2024, p.4).”

One of the first attempts to conceptualize AI literacy was proposed by Long and Magerko (2020), who described 17 competencies: recognize AI, understand intelligence, identify interdisciplinary AI use, differentiate general and narrow AI, know AI strengths and weaknesses and when to use it, imagine Future AI applications, understand knowledge representations, describe how computers make decisions, awareness of the steps involved in machine learning, recognize the prominent human role in AI, understand basic data literacy, recognize that computers learn from data, describe machine learning, understand the consequences of AI systems in society, knowledge about sensors, ethical issues involving AI (privacy, employment, misinformation, ethical decision-making), and programming.

AI literacy was also framed within Bloom's taxonomy (Ng et al., 2021). Their framework coded four dimensions of progressive complexity: 1) know and understand AI (i.e., related concepts, skills, knowledge and attitudes); 2) use and apply AI in different contexts and applications in everyday life

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under ethical considerations; 3) critically evaluate and actively engage in creating AI-powered products ; and 4) AI ethics, comprising issues of fairness, accountability, transparency and safety. These constructs are manifested in AI literacy interventions through explicit instruction on how machine learning works, examples of applications, evaluation of output quality, and discussions about fairness, transparency and safety (Almatrafi et al., 2024), as we discuss in the next section.

The higher education context requires specific knowledge and skills involving GenAI. A scoping review of chatbot use in this context found that chatbots are a common educational resource in the fields of health and computer science and as learning assistants, although variations across populations may hinder the generalization of the findings (Pereira et al., 2023). Still focusing on the Higher Education context, the framework proposed by Wong and colleagues (2025) comprises four skills: AI ethics (e.g. data privacy, algorithmic bias), computational thinking, collaboration with AI, and uniquely human abilities like creativity and critical thinking. Universities should thus focus on the development of human capacities, such as analytical thinking, problem-solving and critical reasoning over technical knowledge.

The frameworks just described have been developed before 2023, that is, before GenAI tools gained popularity among the general public, right after the release of ChatGPT. In response to the new demands posed by the widespread use of LLMs among students, Allen and Kendeou (2024) proposed the *ED_AI Lit*, an Interdisciplinary Framework for AI literacy that proposes overarching principles that can be adapted to different educational levels (table 1). This framework is divided into six components that describe the knowledge and competences that students should develop to use AI effectively: 1) awareness of AI tools and how they work; 2) evaluation of their strengths and weaknesses; 3) collaboration with AI systems; 4) knowledge about uses in real contexts; 5) development of autonomy when interacting with AI systems, and 6) consideration of ethical issues related to these systems. The authors also suggest possibilities for integrating each realm into instruction across diverse levels of education.

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Table 1

Summary of the ED-AI Lit framework (Allen & Kendeou, 2024)

Component	Description	Integration to instruction
Knowledge	Awareness of AI technologies and how they work and the incorporation of AI across domains.	Explain principles of machine learning and how AI technologies operate.
Evaluation	Ability to critically analyse AI-generated products considering their strengths, limitations, and potential biases. Evaluation of online information sources.	Foster evaluative skills to assess AI technologies and the credibility of information sources.
Collaboration	Interaction with AI systems and interpersonal collaboration skills mediated by AI systems.	Promote chatbot interactions and group work mediated by AI.
Contextualization	Understanding the diverse uses of AI in real-world contexts and their implications.	Create opportunities for the application of AI technologies (e.g. case studies, scenarios).
Autonomy	Independent and responsible interaction with AI systems. Self-determination and responsibility for one’s learning process.	Encourage free investigation of AI tools and discussion on the approaches how AI was used.
Ethics	Need to consider the ethical implications of AI technologies and their use e.g. algorithm biases, transparency and accountability.	Emphasis on the ethical considerations that need to be accounted for in employing AI technologies.

There are some points of convergence among the AI literacy theories reviewed above (table 2).

All frameworks mention the need for some understanding of how AI works as well as ethical issues involved in its use. Three of them point out the need to evaluate AI products and be able to imagine their use in different contexts and for diverse purposes.

Table 2

Equivalencies between AI literacy frameworks

Long & Magerko (2020)	Ng et al. (2021)	Allen & Kendeou (2024)	Wong et al. (2025)
Describe computer decision-making; understand machine learning and data literacy	Know and understand AI	Knowledge	AI literacy
Ethical issues	AI ethics	AI Ethics	AI ethics

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Identify AI strengths and weaknesses	Critically evaluate and actively engage in creating AI-powered products	Evaluation	-
Imagine future AI applications	Use and apply AI in different contexts	Contextualization	-
-	-	Collaboration	Human–AI collaboration
-	-	Autonomy	Human distinctive capacities

2.1 Assessing AI literacy in higher education

Across levels, students’ AI literacy has been assessed at the university setting either through subjective measures aimed at tracing students’ self-reported behavior, or objective measures such as standardized measurements aimed at testing knowledge about GenAI systems (Almatrafi et al., 2024). In a systematic review, Almatrafi and colleagues found that 75% of the studies used subjective instruments – which offer more descriptive data, although may be subject to interpretation biases. In relation to the purpose, these instruments the authors identified two types of use: to assess the level of knowledge and to evaluate the efficacy of interventions.

The quality of the instruments results in a more accurate picture of students’ strengths and weaknesses in GenAI-assisted learning. A more specific systematic review assessed the quality of AI literacy scales (Lintner, 2024). The studies recognize a set of core competencies as fundamental to AI literacy, which endorses the importance of theory-grounded / framework-based measurements. Although the scales had good structural validity and internal consistency, many were not tested for content validity, reliability, construct validity, nor responsiveness. Most studies did not report interpretability indicators, average completion time, nor provided open data. One of the scales reviewed was the MAIILS – Meta AI literacy scale draws from the conceptualization of AI literacy proposed by Ng et al. (2021) adding self-efficacy and self-perceived competency. It was developed as a subjective assessment to identify students’ uses of AI tools and awareness of AI literacy (Carolus et al. 2023). In the

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final model, Evaluation loaded with Knowledge of AI and Create AI did not load as a component of AI literacy – which diverged from the initial conceptualization. The scale was also validated in eastern Europe (Markova & Yordanova, 2025).

Focusing on the assessment of chatbot design and integration in higher education, Pereira and colleagues (2023) highlight knowledge limitations and technical difficulties (e.g. availability of resources and data security) in HE institutions. University students' conceptualization of AI literacy was approached through a theoretical review and the administration of a questionnaire (Černý et al 2024). The authors found a predominance of quantitative over qualitative studies. Students' responses emphasized ethical principles as a distinctive facet of AI literacy. Shifting away from self-assessment, knowledge about AI among university students was measured in a multiple-choice test (Hornberger et al., 2023) and validated cross-nationally (Hornberger et al., 2025). Results revealed that undergraduate students in Germany, the UK, and the US held generally low AI literacy level. Scores did not increase in comparison to the 2023 study, done prior to the release of ChatGPT – which indicates that increased interaction does not translate into higher literacy. However, AI self-efficacy was relatively high, demonstrating students' confidence. These studies underscore the need to develop instruments to assess AI literacy that go beyond basic skills and account for domain-specific aspects (Almatrafi et al., 2024). No study insofar has employed case-based learning scenarios to assess GenAI literacy in higher education – which may bring a more comprehensive perspective of what university students know about GenAI and how they use it for their learning.

2.2 Self-efficacy in GenAI use

Self-efficacy refers to the confidence students report of their own capacity to perform tasks in certain contexts and how reported confidence relates to actual performance (Bandura, 1986). According to the theory of planned behavior (Ajzen, 1985), intentions and perceived behavioral control predict voluntary behavior and learning outcomes. For instance, high internet self-efficacy is associated

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with better online searching activity and a positive perception of online search use for learning purposes (Strømsø & Bråten, 2010). One method to trace intentions towards the use of AI is through self-efficacy measures that tackle one's perceived behavioral control (Carolus et al., 2023). In the present study, students' attitudes towards GenAI-mediated learning may predict performance in the analysis of a scenario depicting the use of GenAI in an academic assignment.

Previous research in the HE setting found positive relationships between learning with GenAI systems and high self-efficacy measures across domains and skills. Among nursing students, chatbot-assisted learning (developed by the Taiwan Center of Disease Control to answer health-related topics) was linked with enhanced self-efficacy and learning achievement compared to a traditional lecture approach (Chang et al., 2021). In a visual design course, chatbot user satisfaction correlated with higher self-efficacy, but frequency of chatbot use did not (Durak, 2023). ChatGPT use was associated with increased self-efficacy in creative problem-solving (Urban et al., 2024), enhanced learning and student autonomy (Weigelt et al., 2026). AI self-efficacy also correlated with AI literacy in the factorial validation of an AI literacy questionnaire (Carolus et al., 2023). Taken together, these studies indicate a strong association between GenAI and self-efficacy.

3. The present study

This study aims to investigate university students' understanding of GenAI literacy in light of the theoretical framework developed by Allen and Kendeou (2024). Previous research on AI literacy has been mostly grounded in the computer STEM areas, resulting in greater focus on technical aspects such as knowledge about artificial intelligence, i.e., its underlying mechanisms, functions, and ethical problems. The ED-AI lit framework adds to the field by focusing on the interaction between GenAI and learning at diverse educational levels. It draws from well-established concepts of AI literacy such as knowledge about AI and AI ethics (Long & Magerko, 2020; Ng et al., 2021; Laupichler et al., 2022),

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extending its scope to context and human-related factors overlooked by previous literature that are crucial to learning such as evaluation, collaboration, and autonomy.

The study employs a case-based learning methodology to trace students' knowledge of GenAI and their ability to identify good and bad practices. Case-based learning has been used as a pedagogical tool to enhance critical thinking and problem-solving skills. It offers a more concrete perspective of abstract concepts such as ethics and autonomy in a real-life like context, which facilitates instruction on AI literacy (Allen & Kendeou, 2024). A few AI literacy programmes included case-based learning, with emphasis on the development of ethical awareness (Heung et al., 2026 for a review). These scenarios comprised analysis of dilemmas found in real-world AI applications (Lin, Wang, et al., 2023), and topics like autonomous vehicles and pedestrian safety and the misuse of personal data (Usher & Barak, 2024).

The scenario developed for the present study portrays a hypothetical academic assignment in which a student describes how they approached tasks using generative AI – which was allowed by the professor under restricted conditions. The premise is that reading and analysis of the scenario may unveil self-regulated learning processes. Specifically, the actions described may trigger the students' self-reflections through a judgmental subfunction, with evaluation based on personal standards (Bandura, 1986). Although endorsing certain standards of behavior does not ensure their incorporation in one's attitudes, analysing a scenario might play this metacognitive role. The scenario also offers a detailed narration that provides students with data to evaluate student behavior under the theoretical perspective proposed. The process of scenario analysis may foster critical understanding about what optimal use of GenAI looks like. Its product may reveal whether learners' knowledge of GenAI literacy aligns with relevant theoretical discussions on AI literacy – which in turn can inform future interventions in higher education.

Objectives and research questions

To reach this goal, three research questions were posed:

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1. Are the Ed-AI lit framework components (Knowledge, Evaluation, Collaboration, Contextualization, Autonomy and Ethics) perceived by students as equally represented in the rating of a hypothetical scenario of GenAI use?
2. Are students able to critically justify their evaluation of scenarios?
3. Is self-efficacy associated with ratings in the scenario task?

To answer RQ1, students were asked to rate how each component of the ED-AI lit framework was represented in a hypothetical learning scenario. RQ2 consisted of a qualitative analysis of students' written justifications to the rating based on the ED-AI lit framework. RQ3 was approached by testing the predictive effect of the self-efficacy measure on scenario analysis.

4. Method

4.1 Design and participants

This qualitative exploratory study employed convenience sampling. Participants were 44 students (10 male, 1 non-binary; mean age = 23.45; $SD = 2.42$) enrolled in the master's degree in educational psychology at an Italian university during the semester of data collection. Participants reported frequency of use of GenAI tools in three different settings: at work, university and daily life. Responses were reported on a 5-point Likert scale, with higher frequency of use in academic assignments (work = 1.84, $SD = 1.2$; university = 3.45, $SD = 0.87$; *daily life* = 2.90, $SD = 0.96$).

4.2 Materials and measures

The materials developed for this study and the instruments used to measure performance are available in the Appendix.

4.2.1 Self-efficacy measure

The self-efficacy measure (appendix A) developed for the present study aimed to trace students' self-perceived capabilities related to AI use based on the *ED-AI lit* framework. Each of the six items

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accounted for a specific *ED-AI lit* component (e.g.: *I know how AI tools work i.e., their principles, algorithms, and applications; I can evaluate the strengths and limitations of AI technologies and the quality of their products; I can interact with AI systems and use them to collaborate with peers*).

Responses were given on a 4-point scale ranging from "very little" to "very well", and all items were positively keyed. Internal consistency was estimated for the six-item composite. The scale showed acceptable internal consistency, Cronbach's $\alpha = .76$, 95% CI [.63, .85], and McDonald's $\omega = .76$, 95% CI [.56, .87]. The mean inter-item correlation was .33, and item–rest correlations ranged from .21 (Collaboration) to .67 (Contextualization and Ethics). The Collaboration item showed the weakest association with the remainder of the scale (item–rest $r = .21$; removing it would raise α to .79); it was retained to preserve the one-to-one correspondence between items and framework components. Given the small convenience sample ($n = 44$) and the brevity of the instrument, these estimates should be read as preliminary and specific to this administration.

4.2.2 Scenario task

Drawing from the principles of case-based learning, the scenario task (Appendix B) constructed for this study described a hypothetical case of GenAI use at university that illustrated the components of the ED-AI lit framework (Allen & Kendeou, 2024). The task comprised instructions, a description of the assignment (a group presentation about learning theories), and the student testimony reflecting about his use of GenAI in different stages of the assignment. The text material was 553 words long (including instructions) and was presented in Italian. The assumption is that providing participants with the scenario of an academic task similar to what they are usually assigned would trigger deeper behavioral analysis compared to self-reports.

The task was presented on a Google form that could be accessed from participants' own devices either via link or QR code. After reading, participants were asked to rate how each AI literacy component was considered by the student in the assignment (e.g.: *How do you rate the student's KNOWLEDGE*

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about AI tools? How do you rate the student's EVALUATION of AI products and sources?). Ratings were done on a 5-point Likert scale ranging from "very poor" to "very good". Likert scale ratings for the measures of evaluation and autonomy were reverse coded because these components were depicted as negative (i.e., non competent) behavior in the scenario. Therefore, high scores in all components were interpreted as rubric-congruent rating.

4.2.3 Justifications: thematic analysis

In addition to rating each scenario component, participants provided a written justification to their rating based on the scenario they read (Appendix C). These justifications underwent thematic analysis to discern patterns of argumentation. The categories were based on the ED-AI lit framework components and on other patterns that arose during analysis (e.g.: personal view, ethical behavior). All justifications to the component ratings were coded into nine categories: Justification based on knowledge of AI, Justification based on evaluation, Justification based on collaboration, Justification based on context, Justification based on autonomy, Justification based on ethical behavior, Justification based on ethics, Justification based on citation, Justification based on personal view. When a justification fell within two different categories, each was coded in a different column.

4.3 Procedure

Data collection took place during class time in November 2025. First, students were introduced to fundamental concepts in artificial intelligence and the *ED-AI lit* framework for AI literacy. Because this moment was similar to a lecture on the topic, they could interact with the researchers and ask questions. The slide material comprised a contextualization with definitions of artificial intelligence and how it distinguishes from generative AI, including examples of different types of large language models (LLMs). Next, the concept of AI literacy was presented and students were introduced to the *ED-AI lit*

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framework. Each component was described and illustrated with examples. The last slide provided a summary of the six components.

After instruction, students were directed to the scenario task. The researchers made clear that, upon their consent, the data collected through the form would be analysed in a study on AI literacy in higher education. Information about the study was also provided in the first section, i.e., the consent form. All students agreed to participate. The form could be accessed either via QR code or link found in the course digital environment. After consent, students answered demographics questions (name, age and education level), a survey about frequency of AI use, the self-efficacy measure, and the scenario task.

Instruction for the scenario task was as follows: “Now you are going to analyse a learning scenario that describes a course assignment followed by the testimony of one student describing how she approached the task. Your job is twofold: a) to rate how successfully each component was developed, and b) to select excerpts of the scenarios as examples of each AI literacy component. Please read and analyse the scenario carefully. Remember that each component might be either a good or a poor example of performance.” After reading the scenario, participants rated the behavior described according to each framework component and provided a written justification for the rating. Total task time was set to 15 minutes.

5. Results

RQ1 Are the Ed-AI lit framework components (Knowledge, Evaluation, Collaboration, Contextualization, Autonomy and Ethics) perceived by students as equally represented in the rating of a hypothetical scenario of GenAI use?

Descriptive data shows high scores in the scenario rating, indicating that participants successfully identified the components of the Ed-AI lit framework as represented in the scenario (table

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3). However, participants failed to recognize the Ethics component ($M = 2.09$, $SD = 0.85$), which resulted in inaccurate rating. In the scenario, Ethics is approached as the student highlights a positive feature of the LLM: the possibility of working only with uploaded documents since “having control over the database enhances transparency and decreases the risk of bias”. This was coded in the rubric as a positive example of Ethics. However, participants interpreted Ethics as a behavioral trait, rating this component as poor in the scenario.

Table 3*Descriptive Statistics – scenario*

	Mean	Std. Deviation	Minimum	Maximum
Knowledge	3.205	0.632	2.000	5.000
Evaluation	3.045	0.806	2.000	4.000
Auton	3.341	0.861	1.000	5.000
Context	2.932	0.846	1.000	5.000
Autonomy	3.568	0.974	1.000	5.000
Ethics	2.091	0.858	1.000	4.000

We also ran paired-sample t-tests to compare students’ ratings across components. Ethics was the only measure with significant differences: in specific students assigned to ethics a lower rating than they did to all the other five components , with large effect sizes (see Table 4). Overall, participants’ ratings indicate that they perceived the framework components in the scenario – only the representation of Ethics was not as successfully interpreted. In addition, there was an overlap between Autonomy and Ethics, suggesting that students may not clearly distinguish these two aspects when reflecting on AI.

Table 4*Paired Samples T-Test*

Measure 1	Measure 2	t	df	p	Mean Difference	SE Difference	Cohen's d
Knowledge	Evaluation	0.943	43	0.351	0.159	0.169	0.142

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Paired Samples T-Test

Measure 1	Measure 2	t	df	p	Mean Difference	SE Difference	Cohen's d
Knowledge	Collaboration	-0.973	43	0.336	-0.136	0.140	-0.147
Knowledge	Context	1.575	43	0.123	0.273	0.173	0.237
Knowledge	Autonomy	-2.074	43	0.044	-0.364	0.175	-0.313
Knowledge	Ethics	6.337	43	< .001	1.114	0.176	0.955
Evaluation	Collaboration	-1.482	43	0.146	-0.295	0.199	-0.223
Evaluation	Context	0.565	43	0.575	0.114	0.201	0.085
Evaluation	Autonomy	-3.390	43	0.002	-0.523	0.154	-0.511
Evaluation	Ethics	5.456	43	< .001	0.955	0.175	0.823
Collaboration	Context	2.285	43	0.027	0.409	0.179	0.344
Collaboration	Autonomy	-1.010	43	0.318	-0.227	0.225	-0.152
Collaboration	Ethics	6.397	43	< .001	1.250	0.195	0.964
Context	Autonomy	-3.053	43	0.004	-0.636	0.208	-0.460
Context	Ethics	4.893	43	< .001	0.841	0.172	0.738
Autonomy	Ethics	6.332	43	< .001	1.477	0.233	0.955

Note. Student's t-test.

RQ 2 Are students able to critically justify their evaluation of scenarios?

One participant did not provide proper justifications for their Likert scale ratings (n=43). Data on the categories of justifications were converted into a binary presence-absence matrix with 9 columns (one per justification category) × 6 columns (one per framework component). Justifications were in most cases framework-congruent for the categories of Knowledge (n = 23), Evaluation (n = 24), Collaboration (n = 32) and Autonomy (n = 30). That is, students justified their rating of knowledge by referring to knowledge about AI. However, justifications were more mixed for two categories, Context and Ethics. Context received equally a framework-congruent justification (n = 10) and justifications based on Autonomy (n = 10). Similarly, ratings to the Ethics component were justified based on Autonomy (n = 10)

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and Ethical behavior (n = 7), in line with the findings of RQ1 which indicate overlaps between Ethics and Autonomy.

Table 5

Observed frequencies of justification categories by Likert scale item (framework component)

Justification category	Knowledge	Evaluation	Collaboration	Context	Autonomy	Ethics	Total
Knowledge of AI	23	5	2	5	1	1	37
Evaluation	8	24	2	7	7	3	51
Collaboration	2	0	32	1	1	0	36
Context	3	0	0	10	0	3	16
Autonomy	1	8	2	10	30	10	61
Ethical behavior	0	0	0	0	0	7	7
Ethics	0	0	0	0	1	5	6
Citation	2	0	0	0	0	0	2
Personal view	4	2	2	1	1	2	12
Total	43	39	40	34	41	31	228

Note. Values are observed counts (number of participants using each justification category per Likert item). Total N = 228 category mentions.

As the summary matrix (table 5) shows, Autonomy was the most used justification category (n = 61). Thematic analysis of the justifications based on Autonomy revealed that participants criticized the outsourcing of parts of the task to GenAI such as summarising (represented in the scenario). In addition to the six framework-related categories we found justifications based on personal view i.e., written in first person singular and related to one's thoughts and perceptions on AI use – which were unrelated to the framework. Although explicitly required in the instructions, only two instances of citation to the framework components were found. In relation to the Ethics component, twelve participants did not provide a structured justification to their rating. Two types of Ethics-based justifications were found: justification based on ethical behavior related to responsible use of GenAI (n=7), and justification based on ethical dilemmas related to GenAI technology (n=5). In answer to RQ2, students reasoned critically about the ratings they gave by providing justifications that could be traced back to the framework in our analysis. Although other types of justification arose, they were few.

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RQ 3 Is self-efficacy associated with ratings in the scenario task?

Still drawing from the *Ed-Ai lit* framework, we constructed six questions to assess participants' self-efficacy in relation to generative AI use. We hypothesized a positive correlation between the self-efficacy measure and high scenario ratings. To check this assumption, a linear regression model was fitted with scenario mean scores as response and self-efficacy as predictor. However, self-efficacy did not explain variance in scenario scores ($F(1, 42) = 1.67$, $p = 0.20$, $R^2 = 0.038$). Adding frequency of use during university as covariate did not significantly enhance model strength. As a result, in RQ3 we found no associations between self-efficacy and scenario ratings, neither positive nor negative.

Table 6*Descriptive Statistics – Self-efficacy*

	Mean	Std. Deviation	Minimum	Maximum
Self-efficacy Knowledge	2.000	0.715	1.000	3.000
Self-efficacy Evaluation	2.545	0.627	1.000	4.000
Self-efficacy Collaboration	2.886	0.579	1.000	4.000
Self-efficacy Context	2.386	0.655	1.000	4.000
Self-efficacy Autonomy	3.182	0.691	1.000	4.000
Self-efficacy Ethics	2.750	0.811	1.000	4.000

6. Discussion

The present study sought to investigate how graduate students perceive the use of GenAI for academic assignments through the lenses of the *ED-AI lit* (Allen & Kendeou, 2024), a theoretical framework of AI literacy. We employed a case-based learning methodology in which participants analysed a scenario describing a GenAI-assisted academic assignment and provided justified ratings. Taken together, the results endorse the relevance of the *ED-AI lit* framework to inform AI literacy in the higher education context, shedding light on how graduate students understand AI literacy, how the framework components interact, and which aspects require more careful instruction.

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6.1 Ethics as individual responsibility

In reading and analysing the scenario, participants were able to identify the framework components as expected with the exception of Ethics. However, there was some overlap between Ethics and Autonomy in their ratings. The correlation found between the ratings of Autonomy and Ethics indicates that students perceive these components as closely related. In the justifications, Ethics was perceived more as a behavioral trait than as machine-related. In this line, participants in the study of Tarchi and colleagues (2024) reported in their retrospective think-alouds that using AI-assisted writing seemed unethical to them. These data converge in showing that graduate students endorse an interpretation of ethics as an individual decision-making process. Nevertheless, four relevant frameworks of AI literacy (reviewed in table 2) endorse instruction on *AI ethics* as a major literacy component (Long & Magerko, 2020; Ng et al., 2021; Allen & Kendeou, 2024; Wong et al., 2025). The *Ed-AI lit* framework stresses that ethical dilemmas are inherent to any use of GenAI. Even if all individuals make ethical applications of these tools, the risks will remain. These risks pertain to the negative outcomes of GenAI operation such as the consumption of energy and natural resources for data center maintenance, as well as issues of transparency, fairness, safety, data privacy and accountability (Allen and Kendeou, 2024). A scoping review approaching AI ethics warns that, with the rise of GenAI, new ethical and safety issues emerged such as jailbreaking (designed to bypass safety mechanisms), hallucination, alignment with human values (training AI for to be harmless, helpful, and honest), harmful content, copyright, leaking private data, and impacts on human creativity (Hagendorf, 2024). GenAI literacy interventions need to be aware of these emerging issues and incorporate them into instruction.

Because these ethical issues related to how the technology operates are not apparent, they are difficult for users to identify. Therefore, promoting AI ethics involves knowledge about how GenAI tools function (Celik, 2023) as well as the social, environmental and political consequences of their operation. Looking at ethics in GenAI use as an individual concern reduces the real dimension of the problem and

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transfers its responsibility from the big techs to individual users. It is therefore crucial that educators draw students' attention to the implications of GenAI and their role as citizens in demanding a more democratic and transparent relation with these products.

6.2 *Autonomy as academic integrity*

Results of RQ2 indicate that participants provided framework-congruent justifications to their ratings for Knowledge, Evaluation, Collaboration and Autonomy. However, justifications based on Autonomy were also evoked during reasoning about other components such as Context and Ethics. In fact, Autonomy was the most used justification category – which reveals students' concern about issues of academic integrity such as lack of proper attribution, accusations of cheating in assignments, or outsourcing tasks to GenAI (Cerny et al., 2024; Tlili et al., 2023). This is also in line with previous works that associate GenAI ethics in academia to academic integrity (Weigelt et al., 2026).

Academic integrity is a genuine concern considering its centrality in guidelines orienting the use of GenAI at university, which include forms of plagiarism and how instructors should respond to them, proper acknowledgment of AI use (e.g., how to disclose), and GenAI detection tools (Moorhouse et al., 2023; Wong et al., 2025). Structured guidelines can assist faculty members in developing authentic assessment and promote transparent use among students – which fosters both academic integrity and AI literacy (Moorhouse et al., 2023). In addition to guidelines, other policies may include the creation of multidisciplinary ethics committees to oversee AI applications at university for research (Sampaio et al., 2024). These policies aim to preserve academic integrity by defining honest uses of GenAI and the consequences of misconduct. However, they should be included – albeit not restricted to – AI literacy practices.

In the ED-AI lit framework, responsible interaction with AI systems is situated within the Autonomy component. It involves self-determination and considerations about what an honest use of GenAI tools looks like. However, Autonomy is not restricted to academic integrity in the framework; it

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extends to conscious exploration of the tool and informed decision-making. Although a skeptical stance is healthy, students may refrain from exploring LLMs fearing their integrity will be questioned – which hinders the development of their Autonomy in using GenAI. It is therefore vital that AI literacy instruction encourages students to experiment with GenAI in a non-judgmental way. This experimentation should be carefully designed, including problem-solving tasks and discussions to ensure students' deep and critical engagement (Allen & Kendeou, 2024).

6.3 Self-efficacy and task performance

We expected that self-efficacy would have a positive predictive association with scores in the scenario task; however, this assumption was not confirmed. Studies on the relationship between self-efficacy and AI literacy are scarce and non-convergent. Lin, Zhou and colleagues (2024) self-efficacy was a predictor of task performance, with computational thinking efficacy as positively related to AI literacy. However, among European undergraduate students, Hornberger and colleagues (2025) found high self-efficacy scores but low AI literacy levels. A systematic review investigating the effect of ChatGPT on learning showed no significant effects of GenAI use on self-efficacy (Deng et al., 2025), although the studies reviewed investigated self-efficacy as a response variable.

Other variables might have interfered with the usual predictive power of self-efficacy such as context and type of task (Bandura, 1986). The developing nature of AI systems with constant innovations may negatively interfere with perceived behavioral control (Carolus et al., 2023). In this new learning context, students may either adopt a suspicious stance towards the use of AI or not yet understand how familiarity (or the lack of familiarity) with these tools affects their ability to understand, evaluate and use GenAI – and therefore self-efficacy is compromised. More studies are needed to fully grasp the interaction between self-efficacy, interest and motivation to explore GenAI systems, GenAI literacy, and perceived learning outcomes.

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Conclusion

The present study sought to explore how the *ED-AI lit framework* intertwines with graduate students' understanding about AI, including issues of knowledge, source and output evaluation, collaboration, context, principled use, and AI ethics. The results revealed that the framework provides a consistent theoretical orientation for the development of AI literacy practices. We recommend that instruction oriented by the *ED-AI lit framework* underscores the ethical limitations of the tool and provide learners with structured opportunities for autonomous and critical exploration of GenAI systems. Academic integrity in AI use should be addressed in institutional guidelines with a focus on transparent, responsible use. One limitation of the study regards the lack of randomization in the items comprising the scenario analysis task. As a consequence, students providing justifications for the last or next-to-last answers may have experienced some fatigue. A further limitation concerns the self-efficacy measure, which was purpose-built for this study with a single item per framework component; although its internal consistency was acceptable ($\alpha = .76$), the confidence interval was wide given the sample size, and the Collaboration item was weakly related to the remaining items.

Regarding the pedagogical implications, the scenario task offered insightful data on what students know about GenAI and how they perceive its use for learning purposes through a more real-situation-like format of assessment. In addition, our methodology allowed the identification of components of GenAI literacy that students' may either not fully understand (such as AI Ethics) or over rely on (such as Autonomy). These aspects deserve closer attention in future GenAI literacy studies oriented towards this framework. A next step in the investigation of GenAI literacy through the *ED-AI lit framework* is the development of an intervention. This instructional material should include tasks such as scenario analyses, discussions, simulations, and projects (Allen & Kendeou, 2024). The scenario constructed for this study is openly available and might be used either to assess students' skills or to trigger discussions about the technological and behavioral issues involved in the use of GenAI in

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academic assignments. Our findings highlight the need for AI literacy that is concerned not only with teaching technical aspects of AI but also – and crucially – with developing awareness of the ethical implications of to the tool. On the learner side, AI literacy should help students build confidence and self-regulation in their learning process.

Authors contributions (*contribuição de autoria*)

Juliana do Amaral: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, writing – original draft preparation, review and editing. **Christian Tarchi:** conceptualization, formal analysis, investigation, methodology, project administration, supervision, writing – review and editing.

Conflicts of interest disclosure (*conflito de interesses*)

We have no conflicts of interest to disclose.

Ethics approval statemet (*declaração de aprovação do Comitê de Ética*)

The project was approved by the ethics committee of University of Florence (protocol nº 005487 decision nº 463).

Data availability statement (*declaração de disponibilidade de dados de pesquisa*)

Materials and data are openly available at <https://doi.org/10.5281/zenodo.19652652>.

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Appendix A – Self-efficacy measure

Survey – use of artificial intelligence tools

1. Rate your frequency of AI use in each context:
I use AI at work
() never () rarely () sometimes () often () very often
I use AI at university
() never () rarely () sometimes () often () very often
I use AI in my everyday life
() never () rarely () sometimes () often () very often
2. I know how AI tools work i.e., their principles, algorithms, and applications
() very little () little () well () very well
3. I can evaluate the strengths and limitations of AI technologies and the quality of their products
() very little () little () well () very well
4. I can interact with AI systems and use them to collaborate with peers
() very little () little () well () very well

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5. I understand the diversity of uses for AI tools and how they operate across domains
() very little () little () well () very well
6. I take agency for my learning process when employing AI in academic tasks
() very little () little () well () very well
7. I acknowledge the ethical limitations of AI technologies
() very little () little () well () very well

Appendix B – Scenario

Instruction: *Now you are going to analyse a learning scenario that describes a course assignment followed by the testimony of one student describing how she used AI in the task. Your job is twofold:*

- a) to rate how successfully each AI literacy component was developed, and*
- b) to select excerpts of the scenarios as examples of each AI literacy component.*

Please read and analyse the scenario carefully. Remember that it might portray either a poor or a good example of *each AI literacy component*.

The assignment consisted of delivering a group presentation in a seminar about learning theories. Students were asked to revisit the course readings and add recent academic works on the topic to bring an updated perspective of research in each theory. After the themes were distributed, students gathered in their groups to start organizing their presentation. Some AI tools were allowed for initial exploration of ideas, bibliographical search and language enhancement. The professor advised students to choose tools that were appropriate academic tasks. AI use should be acknowledged on a note with the names of the tools and a description of what they were used for.

Student testimony:

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To start organizing the presentation, we used Perplexity AI to assign roles and set deadlines. The tool sends notifications about the colleagues' progress so we kept track of what each one was doing. My role was to review the Introduction section. The tool is good, but we used the demo version so not all resources were available. We also scheduled another meeting to rehearse the presentation. Individually, I used NotebookLM to explore suggestions on how to organize the presentation and search for bibliography.

I understood that these two tools were suitable for academic assignments because you can ask them to work only with the documents you upload. I believe having control over the database enhances transparency and decreases the risk of bias. In addition, NotebookLM is allowed at the university.

At Notebook LM I wrote the prompt "give me an overview with the main aspects of behaviorism". The AI-generated topics helped me structure the slides.

I also interacted with the chatbot to ask for "updated perspectives of research on behaviorism". It gave me a list with five articles and the links to access each article. I could find all the suggested readings – which proves the tool did not hallucinate in generating references.

I checked year of publication and read the abstracts. All articles were about behaviorism and were published in the last 25 years, so I evaluated them as good. I selected the shortest article to include in the seminar.

Honestly, I had little time to read everything (the book chapter on behaviorism was sixteen pages long and the article was twelve!) so I uploaded all the materials I selected as references to NotebookLM and asked it to summarize it for me. Then I asked it to transform the written output in video format because I am a visual learner.

When we presented the professor said the article was *anecdotal evidence* and that more studies would be needed to be sure these findings were generalizable. He showed us a *meta-analysis* on the topic with a divergent result.

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Appendix C – Likert scales and justification questions

1. How do you rate the student's KNOWLEDGE about AI tools?

() very poor () poor () average () good () very good

Please provide examples from the scenario that support your answer:

2. How do you rate the student's EVALUATION of AI products and sources?

() very poor () poor () average () good () very good

Please provide examples from the scenario that support your answer:

3. How do you rate the student's COLLABORATION with AI systems and colleagues?

() very poor () poor () average () good () very good

Please provide examples from the scenario that support your answer:

4. How do you rate the student's awareness of CONTEXT?

() very poor () poor () average () good () very good

Please provide examples from the scenario that support your answer:

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5. How do you rate the student's AUTONOMY in learning?

() very poor () poor () average () good () very good

Please provide examples from the scenario that support your answer:

6. How do you rate the student's awareness of ETHICAL implications of AI use?

() very poor () poor () average () good () very good

Please provide examples from the scenario that support your answer:

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