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Gotcha! Enhancing Argumentation as a Basis for Critical Thinking via Generative AI-Supported Learning in Higher Education

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Abstract

Generative AI introduces complexity by offering potential support for human skills development, while also generating noise and false information in a postdigital context. Grounded in a Vygotskian perspective, this study explores the combined use of argument mapping (AM) and ChatGPT as mediational tools for developing argumentative skills as a proxy for critical thinking in higher education. These tools are conceptualized as socio-technical assemblages providing double stimulation within students' Zone of Proximal Development (ZPD), addressing how multimodal texts and AI mediate comprehension of information (CoI) and critical thinking (CT). Adopting a case study approach with a quasi-experimental design, the research involved 17 female undergraduate students from the University of Padua, divided into three groups: G1 working with analog texts, G2 with multimodal texts, and a control group interacting only with ChatGPT (G3). Chatbot interactions were analyzed to explore its potential to support reflection and personal information re-elaboration. Results indicate improvements in comprehension and critical thinking, especially in the multimodal group (G2). G1 achieved weaker outcomes, possibly due to limited external stimulation. G3 outperformed G1 but showed stable yet comparatively lower results in advanced argumentative reworking despite a positive median. Overall, AM seems to support text comprehension and meaning reconstruction, while multimodality fosters the integration of multiple perspectives. Generative AI can further support critical engagement and understanding of AI systems when embedded in a structured pedagogical design rather than used "in the wild".

KEYWORDS: Argumentative Skills, Generative AI, Argument Maps, Critical Thinking.

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1. Introduction

Gathering and processing information is challenging (Colombo, 2018), especially in today's digital age, where pervasive digital systems make accessing and sharing true and false information effortless (Cortiana, 2017). Digital spaces have changed, evolving into what is termed the post-medial (Rivoltella, 2020) or postdigital era (Jandrić et al., 2024; Raffaghelli, 2024). The "post" prefix reflects a reaction to digital transformation, encompassing manipulation, misinformation, and personal data marketisation (Knox, 2019). All these phenomena raise educational concerns about addressing postdigitality critically, balancing individual agency with democratic values (Means et al., 2022; Macgilchrist, 2021).

The rise of generative AI (GenAI), such as ChatGPT (OpenAI, 2022), complicates this landscape. Unlike earlier tools that supported information navigation, ChatGPT generates personalized responses through dialogic interaction. Such generated information can be extremely problematic and, as with past digital paradigms (like the pro-social web represented by social

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media), it requires a critical stance more than ever. Not knowing how to deal with them consciously makes navigating the abundance of increasingly complex information even more difficult (Roose, 2022; Lund & Wang, 2023).

This research examines the incorporation of generative AI, particularly ChatGPT, in higher education to enhance argumentative skills, linked in the literature to critical thinking (Wang et al., 2023; Crudele & Raffaghelli, 2024a). The research is framed as an in-depth case study conducted in a single authentic educational context. It aims to explore how students engage with argument mapping (AM) and AI-mediated learning. The study does not pursue statistical generalisation. Instead, it seeks to develop a situated understanding of how these tools can support students' comprehension of information (CoI) and critical thinking (CT). Beginning with AM as the primary scaffold, ChatGPT was subsequently introduced as an additional socio-technical mediator to assist students in reworking argumentative texts. The study involved 17 female students enrolled in the "Training Evaluation" course at the University of Padua. A hybrid learning environment was established, combining asynchronous information with face-to-face interactions. A quasi-experimental structure was adopted with three groups: one using analog texts, another multimodal text, and a control group interacting solely with ChatGPT. The findings indicated an improvement in comprehension and critical thinking, particularly in the multimodal group. Students' interactions with ChatGPT were examined for its capacity to facilitate students' reflection and personal reinterpretation of material. The study posed critical inquiries on the role of multimodal texts and artificial intelligence in facilitating learning within the student's Zone of Proximal Development (ZPD). While both AM and ChatGPT contributed to CT development, challenges remain regarding the effective integration of AI in educational practices. Overall, results suggest that, within the limits of this case study, multimodal and AI-supported methods can enhance students' critical engagement and argumentative skills.

2. Background

2.1 The massification of Generative AI

Large Language Models (LLMs) and AI-driven chatbots, like ChatGPT, have recently become widely used for tasks such as verifying information, providing feedback, and generating ideas (OpenAI, 2022). These systems align with Luciano Floridi's (2023) notion of "artificial agents", as they can "do things" – such as generating responses – based on probabilistic associations of topics and words. Beyond their artificial nature, they exhibit "agency", meaning they act in contextually relevant ways.

AI holds promises for addressing significant challenges in education (Bozkurt et al., 2023). Chatbots offer distinctive opportunities for flexible learning experiences, immediate personalized feedback, complex problem-solving, and anytime access to resources (Al-Abdullatif, 2023).

However, their potential must be weighed against limitations identified by empirical research. Generative AI (GenIA) faces issues like "hallucinations" (Petkauskas, 2023) and inaccurate content generation (Haque & Li, 2024). Therefore, it cannot be considered as an enhancement per se. Without critical evaluation, such tools risk spreading misinformation (Petkauskas, 2023).

Moreover, the ability of AI to produce complex, human-like texts raises ethical concerns. Connected to this are all those concerns and consequent prohibitions of use in the school and university context, especially because of the possibility of using them to avoid intellectual work (García-Peñalvo, 2023). The use of chatbot technology is a valuable educational resource, but it sparks a broader debate about its implications. Developing "Artificial Intelligence Literacy" (Cuomo et al., 2022) is essential to ensure responsible use and to address its educational, personal, social, and ethical impacts (Ranieri et al., 2024).

2.2 Argumentative Skills and their role in the postdigital world

In today's digital and complex world, the ability to understand and rework information remains essential (Canale et al., 2021; Crudele & Raffaghelli, 2023a). Yet traditional cognitive and educational tools are increasingly insufficient for addressing contemporary learning demands. Although access to information has expanded significantly, this does not necessarily translate into greater autonomy in thinking. This condition has prompted renewed reflection on the effects of postdigitalization on learning (Ranieri, 2019) and on the personal and educational needs required to navigate this landscape effectively (Means et al., 2022).

These challenges become especially evident when students engage with arguments. The development of argumentative skills fosters critical thinking and prepares individuals to engage actively in society (Iordanou & Rapanta, 2021). Facing a discussion, if prepared to understand, evaluate, and reflect, one learns by "formulating new hypotheses" without mechanically repeating what has been read and deemed most correct (Avenia, 2021). However, many students still struggle with understanding, recognizing, and reframing arguments (Alotto, 2021; Crudele & Raffaghelli, 2023a). A difficulty further intensified by multimodal (Kress, 2013, 2015) and digital information systems (Pangrazio & Selwyn, 2019), which complicate traditional reading and writing processes (Howell, 2017).

For these reasons, this case study focuses on future educators and professionals in the educational sector. Providing them with tools that highlight the value of argumentation in the digital age enables them to apply

newly acquired skills to real educational contexts. The aim is not only to strengthen argumentative competence during the intervention, but also to prepare them to navigate an evolving educational environment and face the challenges of using AI critically and responsibly as future professionals.

Within this framework, argumentative maps (AM) offer graphical support for clarifying the logical-syntactic chain of complex reasoning (Carrington et al., 2011; Lidåker, 2018; Crudele & Raffaghelli, 2023c). Unlike common mind or concept maps, they use an inverted-tree structure with boxes and arrows to represent propositions and inferential relations. Propositions are color-coded according to their function (thesis, objections, reasons, etc.), while arrows indicate the type of logical relation involved ("because", "but", etc.). This visual system simplifies argument structures, helping readers follow the analysis and evaluate the coherence of the reasoning (Alotto, 2021). Already effective for decoding and reconstructing arguments, AMs have now been reimagined for navigating dynamic digital environments effectively (Crudele & Raffaghelli, 2023b).

An additional layer of complexity lies in interacting with human, non-human, or "multi-agent" systems. Recent research explores how AI integration into learning, such as algorithms drawing valid inferences (Kim et al., 2022), can support the development of new argumentative skills. Today, we can talk about how interaction with AI can foster argumentative learning, refining the "best way to talk to the machine" (Mollick & Mollick, 2023; Ranieri et al., 2024). Effective interaction with AI requires critical questioning of its outputs rather than passively accepting them (Panciroli & Rivoltella, 2024).

This approach reframes AI as an intelligent "peer" rather than a mere tool, encouraging a deeper, more specific engagement to generate meaningful outputs (Ferrarelli, 2024). One should think about introducing students not so much to the basic actions of interacting with AI, but to the activation of knowledge and more critical use of these new channels (Ranieri et al., 2024). This marks a new dimension of argumentative skills through a post-human lens.

2.3 Double Stimulation and Mediation

In a reaction to the behavioral psychology based on the "stimulus-response" deterministic vision, Lev Vygotsky (1978) asserted that human actions and psychological functions are facilitated by tools. The concept of "mediated action" is typically illustrated by a triangle including subject, mediating artifact/tool, and object (Wertsch, 2007). This scheme encompasses both technical tools that interact with objects and psychological tools that mediate the mind and environment. The tools introduce cultural symbols and signs (Vygotsky, 1934/2023), thereby supporting the relationship between the subject and her cultural context and highlighting that no response can just be triggered by a stimulus as an abstract entity. Vygotsky called this "double stimulation". The two categories of stimuli are, for example, a given piece of information in a digital context, and the ability to read it (hence introducing informational literacy). These categories aim to objectify internal psychological processes to track the evolution of advanced cognitive capabilities and elucidate their structure. Sannino (2015) problematizes this process, considering that "although second stimuli play a crucial mediating function, (…) the emergence of volitional action involves conflicts of motives as a key component which has largely been neglected in discussions of double stimulation" (p.2). The volitional action that this author brings to the fore is key to the subject's intention to interact with the signs.

Several authors have considered the relevant role of mediation within digital contexts, going beyond the idea of the digital as a phenomenon "producing" learning (Fadeev, 2019). In this literature, the digital spaces, interfaces and applications become mediational means that introduce socio-cultural and semiotic elements. In an intentional act of interacting with such elements, the learner decodes signs and triggers inner dialogues that let her cross the zone of proximal development (ZPD) in some direction. Building on this theoretical framework, this paper investigated the double stimulation produced by AMs and ChatGPT as socio-technical artifacts on students' argumentative responses. We emphasise here the relevant role of volitional interaction with such tools. With AMs, the study assumed that creating a structured space for understanding, revising, and reconstructing information (CoI) is a key element in the development of argumentative skills. Likewise, it was hypothesized that critical and goal-oriented interaction with the ChatGPT agent for reformulating and rethinking argumentative perspectives could develop these skills while fostering a deeper understanding of intelligent agents (Crudele & Raffaghelli, 2024a).

3. Materials and methods

3.1 Aims and Research Questions

The research starts with a) a macro-focus comparing the 3 groups, and b) within this, a more specific comparison between two of the experimental groups.

Starting with the second focus, the study aimed to 1) investigate whether AMs supported students' CoI enhancement and critical reframing (CT) and 2) investigate whether interaction with generative AI supported students in reframing information (related to CoI) and critically constructing assessment tools from scratch (skills related to CT).

These objectives led to an initial reflection on how the two tools mediated learning within the Zone of Proximal Development (ZPD), focusing on skill acquisition in CoI and CT. At the macro level, the research explored whether not mastering the mapping methodology might hinder students' ability to rework opinions effectively.

As a third objective, the study 3) investigated whether, required to produce a complete opinion about a given topic, communicative interaction with GenIA alone, without the mediation of AMs, still supported the reworking of information and integration of different points of view for one's reflection.

Following the order in which the objectives to be investigated were presented, the following research questions (RQs) were formulated:

RQ 1 - Does AM-based training support students' development of text comprehension and critical thinking?

RQ 2 - How do students and educators perceive and engage with artificial agents while reworking argumentative texts, and what learning needs emerge from their experiences?

RQ 3 - Are there differences in the effects of argument mapping combined with ChatGPT or the sole use of ChatGPT as mediators of critical thinking development and performance in educational tasks?

Starting from these general questions, some specific expected results were drawn (see Table 1).

3.2 Participants

The target sample consisted of 17 female students, aged 18 to 25 years old, enrolled in the course "Evaluation of Education", within the Bachelor of Science in Education and Training at the University of Padua (L-19).

3.3 Research Design

For this study, a case study approach was combined with a quasi-experimental design. As a case study, the contribution allows for a situated and context-sensitive understanding of how students engage with argument mapping and AI-mediated learning within an authentic university setting. Rather than aiming for statistical generalization, case studies pursue *analytical generalization*. They offer an in-depth empirical inquiry into a contemporary phenomenon and insights into future investigations (Yin, 1984/2014; Hollweck, 2016). The goal is therefore not to produce universally generalizable findings, but to examine in depth the dynamics emerging in a specific learning environment and to identify patterns that may be meaningful for similar contexts.

This methodological stance is particularly appropriate for early-stage research on rapidly evolving educational phenomena, such as the integration of generative AI into students' argumentative practices. In these contexts, the priority is to capture complexity, observe processes as they unfold, and refine emergent hypotheses. Within this framework, the quasi-experimental design serves an exploratory function, enabling comparisons across different learning conditions while preserving sensitivity to contextual features and ecological validity.

Embedded in the case study, we adopted a quasi-experimental design, which offers the flexibility required in dynamic educational settings. In educational settings – where variables are numerous and deeply interconnected – these designs enable exploration of causal relationships while preserving ecological validity (Shadish, 2002). Moreover, a mixed-methods approach was considered, with a triangulation of quantitative indicators and qualitative information to enhance the comprehensive understanding and robustness of the findings (McLeod, 2024).

Quantitative data supported the exploration of differences in trends in text comprehension and critical thinking development across the three conditions. While qualitative analyses provided insight into how generative AI mediated students' reasoning processes, sense-making, and reflective engagement.

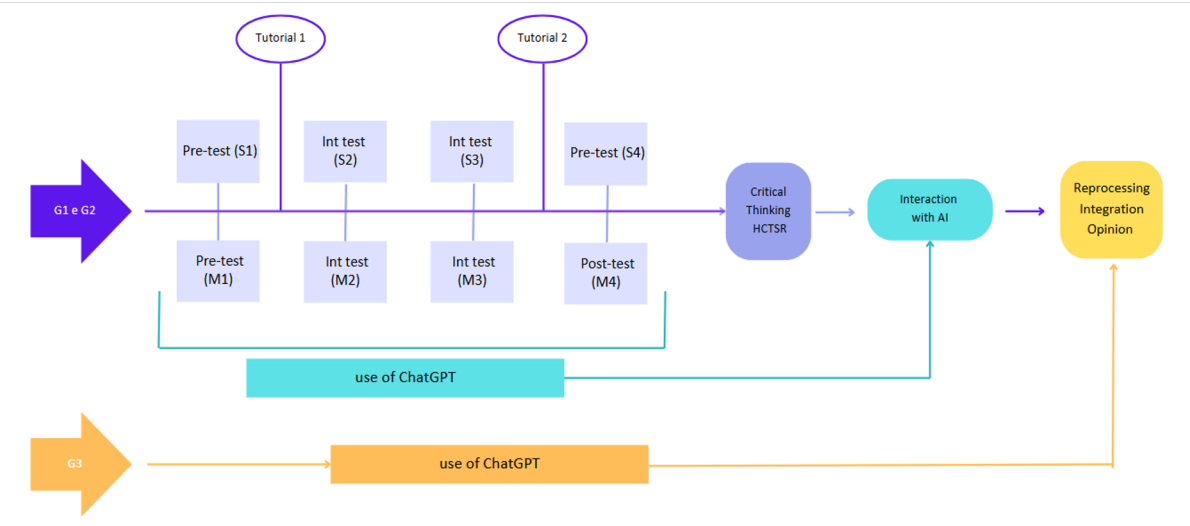

Figure 1 - Outline of the research design.

Together, these components enabled both a macro-level comparison among groups and a more fine-grained examination of differences between the two experimental conditions.

The first experimental group (G1) used maps with fully analog texts. The second experimental group (G2) used maps with multimodal texts. The control group (G3) was not subjected to the map variable but only to the ChatGPT interaction.

The study was conducted over the duration of a three-month university course (Figure 1). The course included three laboratory sessions focusing on different tools for learning assessment. The experimental activity took place in one of the three labs and centered on the use of AMs and rubrics as tools to develop and assess argumentative skills. The control group counted students from the other two labs on structured tests and peer feedback, respectively.

The learning environment was hybrid, combining in-person group work with asynchronous activities via the Moodle platform. Online materials included argumentative texts, tutorials, and guided activities. ChatGPT was integrated to compare and enhance students' argumentative interactions.

The experimental phase involved 10 female students (5 each in G1 and G2) across four data collection stages, starting with text comprehension (RQ 1). To investigate this ability to identify the basic structural components of an argumentative text, a semi-structured survey tool with closed stimulus questions (S1, S2, S3, S4) was developed.

Research question	Mediational means	Data Collection tools	Data Analysis tools	Expercted results for RQ
RQ 1. Does AM-based training support students' development of text comprehension and critical thinking?	Argument Maps (Analogical / Multimodal) Preparatory phase.	- Semi-structured survey instrument with closed stimulus questions. - Graphic elaboration of an AM.	- Checklist of students' ability to identify structural elements of the text. - Checklist of correct map construction. - An adapted version of the Holistic Critical Thinking Scoring Rubric (HCTSR).	- Increased comprehension of an argumentative text, in terms of identifying structural elements. - Increased AM construction skills, in terms of identifying and juxtaposing components in space. - Increased level of critical thinking, in terms of reconstructing the meaning of the text and constructing one's own thinking.
RQ 2. How do students and educators perceive and engage with artificial agents while reworking argumentative texts, and what learning needs emerge from their experiences?	ChatGPT	Student messages on the forum regarding interaction with GenIA.	Codebook Creation	- Indication of the presence or absence of prior knowledge and reflection on the positive and negative aspects of the first approach. - Indication of new emerging learning needs (including critical training in the use of chatbots). - Indication of the personal idea of the potential and limitations of intelligent agents in educational practice.
RQ 3. Are there differences in the effects of argument mapping combined with ChatGPT or the sole use of ChatGPT as mediators of critical thinking development and performance in educational tasks?	Argument Maps + ChatGPT	Final reworking of G1, G2 and G3 students in comparison.	Opinion detection grid	- Lower reworking performance of G3 than the other two groups. - Indication of the effectiveness of MAs and ChatGPT as a mediator of critical thinking development.

Table 1 - Tools and procedures of the method.

Students read an argumentative text, identified key components (problem, thesis, arguments, objections, evidence, conclusion) and expressed their opinion about the topic in a final open-ended question. Next, they built an AM (M1, M2, M3, M4), bringing together and arranging the components of the text they read in space. A checklist with scores from 0 to 7 was created to assess the completeness of map construction.

Based on the data collected from text comprehension, critical thinking (CT) was assessed using an adapted version of the Holistic Critical Thinking Scoring Rubric, HCTSR (Facione & Facione, 2014). The mastery levels of the rubric (strong, acceptable, weak, absent) were combined with four categories obtained from the text comprehension test questions:

- Identify important information.
- Identify arguments and counterarguments or alternative points of view.
- Conclude and explain the reasons.
- Understand and modify one's opinion based on the evidence.

The instrument was used by the researchers in parallel with the four phases mentioned above (CT1, CT2, CT3, CT4).

To address RQ2, ChatGPT's role as a "collaborator" for mediating argumentative reworking was analyzed through student prompts and forum posts. Students offer the chatbot the same tasks of comprehension and identification of argumentative text components. At the end of each activity, they reported the comparison between their answers and those of the chatbot. Forum contributions were qualitatively coded by preparing a codebook (see Open Data Crudele & Raffaghelli, 2024b). This focused on 1) interaction, in terms of prior knowledge, reflection on the prompt, and first-approach bias; 2) application, in terms of critical use, possible areas of use, and identified limitations; and 3) relevance, in terms of original insights to put into action, starting from and with ChatGPT.

The role of ChatGPT was tested on two main levels: 1) at the descriptive level, starting from their experience and input on the use of the tool, and 2) at the activation level, first in terms of developing a rubric for correct argumentation writing, and afterward constructing two new rubrics for analyzing text comprehension and constructing correct AMs.

These contributions were then organized and analyzed using NVIVO. Subsequently, a thematic analysis (TA) was conducted based on three themes with 11 sub-themes:

- students' interaction, including reflections on whether they had prior knowledge of using the intelligent agent and their initial approach to it (3 sub-themes);
- encompassing reflections on potential future uses, possible areas of application, and emerging training needs, such as fostering critical use (4 sub-themes);
- relevance, focusing on ChatGPT's demonstrated potential, starting from original insights and leading to future work (1 sub-theme).

To pursue RQ 3, the level of reworking and integration of personal and others' thinking was investigated. Final contributions produced during the last exam by students in the previous two groups (n=10) and those in the third group (n=7) were collected, analised and compared.

Data was analyzed using a grid assessing reworking and integration alongside the HCTSR (Annex 1). Differences in the mediation tools' impact on argumentative skills were explored, with results and tables available in the Open Data repository (Crudele & Raffaghelli, 2024b).

For clarity, please refer to the overview in Table 1.

4. Results

The following sections present the results in response to the proposed research questions.

RQ1 - *AM-training-based effects.*

To answer RQ1, data on the correct identification of the structural components of argumentative text (Figure 2) and the respective construction of an AM were first analyzed (Figure 3).

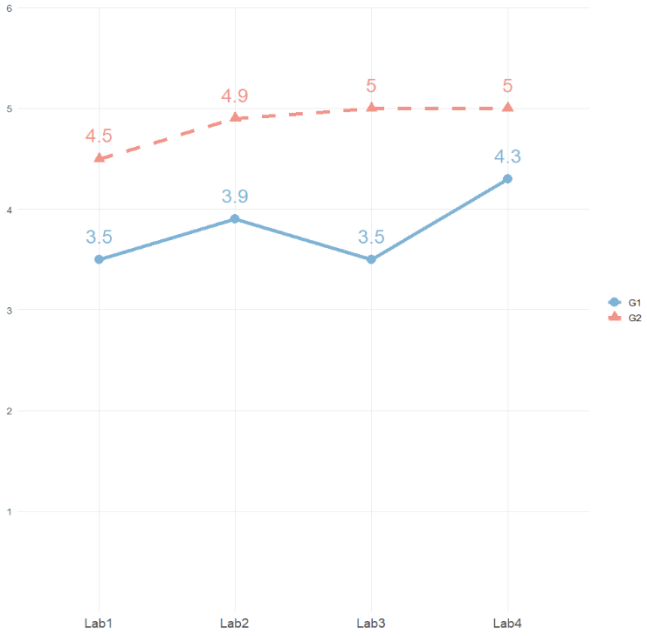

Figure 2 - Text comprehension between G1 and G2.

The data show an improvement in text comprehension scores from beginning to end. Despite initial challenges, G1 achieved strong final scores (S1 = 3.5; S4 = 4.3). G2, however, demonstrated a gradual and consistent increase across all data collection points (S1 = 4.5; S4 = 5.0).

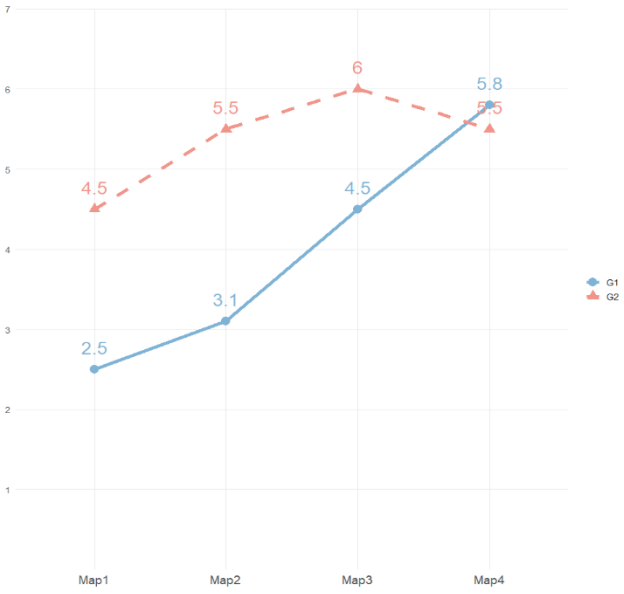

Figure 3 - AMs' construction between G1 and G2.

Similarly, AM construction results mirrored text comprehension trends. G1, starting with difficulty (M1 = 2.5/7), ultimately reached an excellent score (M4 = 5.8/7, "complete map"). G2 also showed significant progress, ending with high scores for correct argumentative map construction (M1 = 4.5; M4 = 5.5).

Assuming a correlation between text comprehension and critical thinking, the analysis examined students' ability to reconstruct the meaning of the text by identifying structural elements and formulating personal opinions.

Critical thinking levels were generally positive (Figure 4).

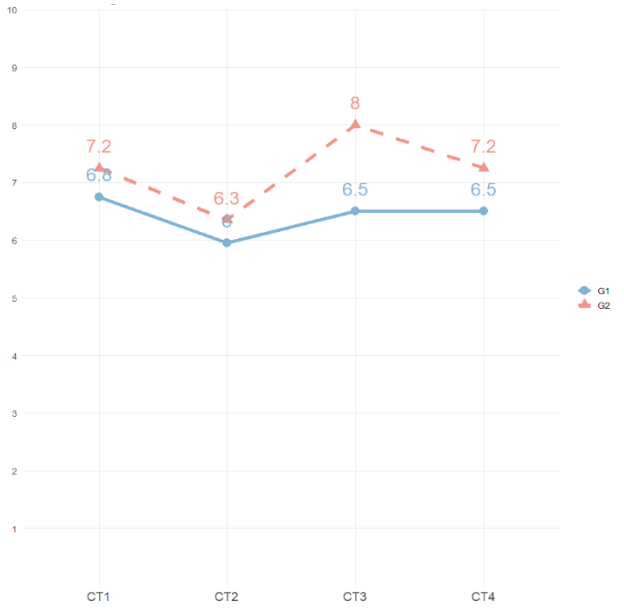

Figure 4 - Level of critical thinking between G1 and G2.

G1 achieved a final critical thinking score of 6.5/10, while G2 scored 7.25/10. A closer analysis revealed some instability in G1's ability to understand and reformulate opinions (CT1 = 6.75; CT4 = 6.5), whereas G2 maintained stable performance (CT1 = 7.25; CT4 = 7.25).

RQ2 - *Perceived engagement with AI agents*.

About RQ2, the contributions of 7 students, totaling 3,640 words in Italian, were analyzed and labeled based on themes and sub-themes identified in the codebook (cfr Annex 2). The text corpus was categorized into three key areas: interaction with the chatbot, students' needs and applications, and relevance for learning and education. These reflections will be addressed in the context of the three specific research questions.

4.1 Interaction

The analysis of the contributions revealed that most of the students had little to no prior knowledge of ChatGPT, also because at that time it had only recently been released to the market. This led to an initial approach to interaction driven by curiosity and expectations, some of which were pleasantly confirmed, while others were not. Among the five students who recorded their first impressions, six references were classified as positive, stating that it was "very interesting as a first use" and that ChatGPT was perceived as "a very useful tool in several aspects." Two references were negative: "In our case, it wasn't very helpful" and "I noticed flaws in the way it processes responses; in my opinion, they are often far from the central topic. I don't think I'll use it again!" Despite being in the minority, the negative reflections clarified potential initial difficulties with the interface and unmet expectations. The only student who had prior experience with ChatGPT moved beyond seeing it as merely "a useful but complex tool", particularly during rubric construction. She highlights its potential when paired with a more "human" element: "During the construction of the rubrics, we used ChatGPT and noticed how useful it could be to use the rubric it suggested for a particular topic. In fact, we used it as a starting draft to personalize and make it our own by adding the 'human' element that artificial intelligence can never provide."

Regarding prompt refinement, only one student detailed the steps taken to build her interaction with ChatGPT.

4.2 Application

In the "Application" section, reflections on potential uses and emerging new training needs were explored. Repeated interactions with the artificial agent during the course seemed to activate critical thinking among students. All the participants expressed at least one thought about the need to engage critically with available intelligent agents.

Two students explicitly demonstrated a critical approach in practice, interacting with ChatGPT while already

aware of the need for personal re-elaboration: the first student stated, “The only thing to pay attention to is not to use such tools improperly or incorrectly, but to consider them as a 'right-hand' helper to ask for assistance and collaborate with.” The second added, “It is necessary to rely on artificial intelligence not automatically but by reworking and enhancing the responses obtained, so we always keep our intellectual and re-elaboration skills active.”

Other students, however, expressed the need for further training in the critical use of ChatGPT: “With these technologies, we should start learning to live with them and use them correctly since they don’t always enhance our learning” and “From this, I can deduce and argue that there is a connection that goes 'beyond' the simple question-answer mechanism.”

Five contributions indicated that the interaction with ChatGPT during the course provided insights into further application areas and potential uses. Initially contextualized to lab activities, “as a starting point to add new indicators and criteria to the rubric proposed by the teacher”, or as “a source of inspiration to draft the indicators and criteria we then presented in the rubric more accurately and completely.” Later, the potential applications became broader: “useful for obtaining factual information in any field of interest” or “to provide solid starting foundations for formulating any type of task”.

4.3 Relevance

Lastly, this research question explored students' personal perceptions of ChatGPT's limitations and their reflections on its integration into learning and teaching.

Regarding perceived limitations, the main issues focused on difficulties encountered during activities: “as it was not able to provide us with a proper rubric”, or “it gives arguments, objections, and foundations that are very different from yours and often off-topic, missing the point of the question.”

A second recurring limitation across contributions was the “human-robot” dichotomy, particularly regarding creativity. This limitation concerned the chatbot's impersonal responses, excessive rationality, and the necessity of human intervention to “complete” the work. Notable statements included: “The limitations of a digital tool regarding creativity and reflective reasoning were very evident, in my opinion” and “ChatGPT, being artificial intelligence, tends to be entirely rational and objective, following a positivist approach that strictly adheres to goals and programs without adding personal and subjective critiques that only a human can provide.”

Building on this limitation, the “Original Insights” section reflected how, as future educators and evaluators, the students recognized “the qualitative leap a human can make when adopting the intelligent agent.” One student stated: “We used it as a starting draft to personalize and make it our own, adding the 'human' element that artificial intelligence can never provide.”

However, some reflections focused on the potential downsides of this integration. From an evaluator’s perspective, a student commented: “It’s impossible to assess someone’s competence solely based on the use of these 'artificial programs. This way, the human and intellectual aspects of the individual being evaluated are overlooked.” From the perspective of the evaluated individual, another student remarked: “Putting myself in the shoes of someone being evaluated, I cannot derive educational or learning benefits by asking questions to a 'person' that doesn’t even exist.”

RQ3 - *Impact of Mediation Type on Final Elaboration*.

Regarding RQ3, Table 2 and Figure 5 show that all three groups achieved above-average scores (out of 6 points) in constructing an elaborate and integrated opinion. Among them, G2 (the multimodal group) displayed the highest overall performance (M = 4.40, SD = 1.19). G3 also achieved a relatively high score (G3. M=3.93; SD=1.02), while G1 (the analog group) recorded the lowest values (M = 3.38, SD = 1.09). Distributional analyses revealed distinct group profiles: G2 showed the highest central tendency (Me = 5.00; IQR = 1.00); G3 displayed a slightly lower but still positive and relatively compact distribution (Me = 4.00; IQR = 1.50); while G1 presented the lowest median and the greatest dispersion (Me = 3.25; IQR = 2.25).

To further contextualize these findings, one-sample Wilcoxon tests were conducted using a high reference value (5). None of the groups scored significantly above this benchmark. When testing for deviation below the reference value, only G3 resulted significantly below the

Group	Mean	Std. Dev.	Min	Q1	Median	Q3	Max	Skewness	Kurtosis
General Opinion Level between G1-G2-G3									
G1	3.38	1.65	1.50	2.25	3.25	4.50	5.50	0.16	-1.90
G2	4.40	1.19	2.50	4.00	5.00	5.00	5.50	-0.61	-1.54
G3	3.93	1.02	2.50	3.00	4.00	4.50	5.50	0.06	-1.50

Table 2 - Descriptive statistics, overall opinion of the 3 groups.

standard (V = 2, p = .025). This finding indicates a consistent position under a demanding reference standard rather than low overall performance. Indeed, despite this deviation, G3 maintained a relatively high median and lower variability compared to G1, which displayed lower and more dispersed scores that did not reach statistical significance, possibly due to the small sample size.

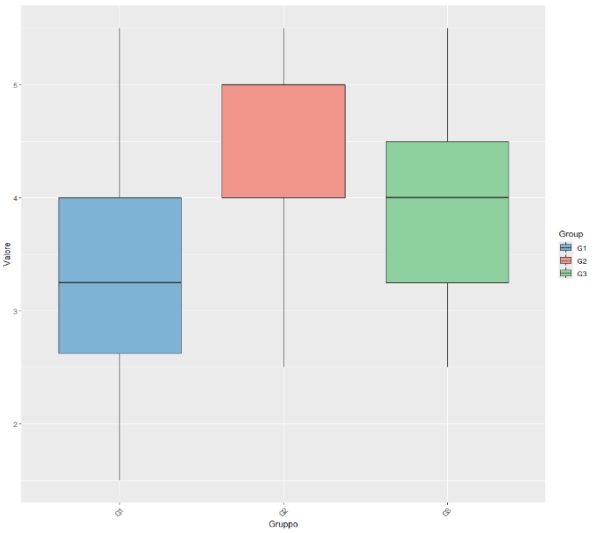

Figure 5 - Boxplot Opinion Trends Between Groups.

Focusing on the more specific comparison between G1 and G2, a further response emerges on the reflection about AMs' effectiveness as a mediator of the development of critical thinking. As seen in Figure 3, G2 achieved a higher critical thinking score, particularly in CT3 (M = 8.00), following engagement with AMs and multimodal texts. Integrating this with the results on written opinion elaboration provides additional insights. G2 scored higher on both clarity and coherence in opinion elaboration (G1: M = 2.25, SD = 0.65; G2: M = 2.50, SD = 0.35) and integrating supporting and opposing viewpoints (G1: M = 1.12, SD = 1.03; G2: M = 1.90, SD = 0.89). Notably, G2 displayed lower data dispersion compared to G1, further highlighting its advantage.

5. Discussion and Conclusions

Reconstructing information through broader thinking and reorganizing structural elements remains a complex task. Regarding RQ1, data on text comprehension – particularly the identification and spatial juxtaposition of structural components – suggested a general improvement in both experimental groups (G1 and G2). Within this overall trend, G2, which engaged with multimodal information, experienced a more consistent and gradual progression across phases. Although such results cannot be generalized, they provide initial indications that rethinking textual modalities and designing skill-development activities around them may offer meaningful support for learners.

Multimodality may have encouraged deeper reflection without introducing excessive cognitive noise. This is highlighted in how G2 outperformed G1 during the Cri-Think3 phase, which required exploring different sources of information and creating rubrics for text comprehension and spatial reorganization. These observations may suggest that consistent exposure to complex, multimodal information – combined with guided activities – offered students additional tools to navigate and be inspired by diverse perspectives. In this sense, AMs appeared helpful in supporting the identification of key elements and their use in designing assessment tools, ultimately contributing to the re-elaboration of critical opinions, particularly in G2.

Turning to RQ2, students' engagement with ChatGPT must be understood within the historical moment in which the course occurred – during the early public emergence of the chatbot. Unsurprisingly, many students approached it with limited prior knowledge. Their initial interactions reflected a mix of curiosity, apprehension, and occasionally unmet expectations due to irrelevant or inconsistent outputs. Over time, however, repeated use encouraged a more investigative stance: students began exploring possible applications and reflecting on forms of human-AI collaboration.

As prospective educators, they also considered the technological and pedagogical limits of the tool and the potential value of structured pathways for its integration into professional practices. From these reflections emerged the idea that targeted guidance might enhance both students' understanding and their development of argumentative skills.

For RQ3, G2 achieved the highest scores in opinion reworking, suggesting that sustained exposure to multimodal perspectives may have supported a richer integration of viewpoints. Although non-parametric analyses did not reveal statistically significant group differences, the observed descriptive patterns remain informative within the exploratory and case-based nature of the study. G1, while benefiting from AMs in reconstructing argumentative frameworks, obtained lower and more heterogeneous scores in the complete reworking of opinions. In contrast, G3 (interacting solely with ChatGPT) produced above-average scores with limited variability. Importantly, inferential analyses indicate that only G3's outcomes were positioned significantly below the high reference standard, despite maintaining a positive median. This result reflects a coherent and homogeneous positioning under a demanding benchmark rather than low overall performance. Compared to G1, which showed more dispersed outcomes and no significant deviation from the reference value, G3 showed greater stability and consistency. This pattern suggests a more complex profile for the control group. Interaction with the chatbot may have supported initial opinion refinement and stabilized students' responses, without necessarily

leading to fully developed or high-level re-elaboration. This grey result is consistent with recent research. Several studies suggest that conversational AI can reduce cognitive load but does not always foster critical re-elaboration, particularly when it overly facilitates task completion (Ayman et al., 2023). When used in isolation, such agents may support task execution. However, they are increasingly perceived as tools to which learners delegate argumentative decisions, potentially reducing critical functions and bypassing deeper learning processes (Ayman et al., 2023; Jahani et al., 2024). Conversely, when AI is embedded within a framework of structured engagement – as a support tool rather than a substitute for intellectual effort (Martha et al., 2025) – it may contribute to the development of critical thinking. In this case, AI can provide motivation and prompts that encourage students to reconsider their own positions (Song & Song, 2023).

Taken together, these preliminary findings do not allow firm conclusions but tentatively point toward differentiated contributions of the tools examined. AMs appear particularly useful for understanding and structuring information (CoI). Multimodal exposure (G2) and indirect multimodal exploration via ChatGPT (G3) may play a more prominent role in supporting argumentative reworking. However, if used as the sole tool for opinion elaboration, ChatGPT does not seem to provide sufficient support for fully articulated and structurally complex re-elaboration. Overall, the intervention suggests that multimodal resources may represent a promising avenue for fostering comprehension, openness to multiple perspectives, and early forms of opinion construction. Within this framework, AMs primarily functioned as scaffolds for structural understanding (CoI). Instead, ChatGPT could offer mediation for 1) re-elaborating information (CoI), 2) reorganizing it for the construction of critical tools (CT), and 3) promoting reflective thinking about the role of AI in educational contexts – particularly when integrated with other instructional supports rather than used in isolation. At this stage, critical re-elaboration emerges as a complex competence requiring multiple, structured phases that unguided interaction with a conversational agent alone does not appear to adequately support.

Rather than establishing the superiority of one tool over another, this case study sought to explore their potential complementarities and to inform the design of integrated learning approaches.

Several limitations must be acknowledged. First, the study was conducted as a small-scale case study with a reduced and homogeneous sample, limiting the possibility of statistical generalization. The quasi-experimental design, while suitable for exploratory purposes, entails inherent constraints, including the absence of randomization, the potential influence of contextual differences between groups and the challenge of controlling external variables. Moreover, the duration of the course allowed only a short period for the development of complex skills such as argumentative reframing, critical integration, and human–AI dialogic interaction. These abilities typically require extended, iterative instructional support. Additionally, students' limited familiarity with ChatGPT – understandable given the early stage of the tool's public release – may have shaped the nature and depth of their interactions. Patterns of use may therefore differ from more established applications of generative AI. The research design was also shaped by the emergent character of the technology under investigation. Working with a rapidly evolving tool limited the possibility of fully refining the design at the outset and introduced additional uncertainties. For these reasons, the findings should be interpreted as exploratory rather than as definitive evidence.

Future research could address these limitations by implementing longer interventions, involving more diverse samples, and refining the comparative design to isolate better the effect of multimodality, mapping, and AI mediation. Longitudinal approaches may further clarify how learners' argumentative repertoires evolve as they gain experience with AI-supported practices, offering a more robust understanding of the relationship between these tools and the development of critical thinking skills.

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The research was approved by the University of Padua Ethics Committee. Qualitative data include statements taken from university syllabi, which are public and visible to all. The transcripts are faithful to the original and have not been edited for the paper. The identities of professors and others involved in writing these syllabi have been left anonymous.

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Annexes

Annex 1 - Grid opinion argumentation

Categories	Indicators	Descriptors	Yes	Partially	No
Rielaboration	Clarity of the opinion expressed	The opinion emerges clear and concise			
	Coherence of the opinion expressed (before and after reading)	The opinion follows a logical thread, without contradictions			
	Originality of the reworking	The opinion does not stop at the surface, but contains original elements			
Integration	Integration of supporting arguments	The opinion is deepened by providing supporting arguments			
	Integration of counterarguments	The opinion is deepened by responding to objections and counterarguments			
	Integration of the author's opinion	The personal opinion is explored by also integrating that of the author			

Annex 2 - Nvivo labeling codes

Name	Description	Files	References
Interaction	Approach to activities and integration of the artificial agent response	6	16
Prior Knowledge	Presence or absence of prior knowledge regarding the use of the intelligent agent	6	6
Yes		1	1
No		5	5
Reflection on the prompr	There is a reference to the reworking of the prompt to better communicate with the AI	1	2
First approach	The first impression is given by the first approach to the intelligent agent	5	8
Positive		5	6
Negative		2	2
Application	Reflection on possible future uses and any new emerging training needs.	6	27
Critical approach to the intelligent agent		5	8
Yes	A critical approach to the use of the intelligent agent is already emerging.	2	3
No	The need for critical training in the use of ChatGPT and other artificial intelligences is emerging.	5	5
Future uses	There is a general reference to the possibility of future uses of ChatGPT.	1	1
Possible areas of use	The possible areas of use of AI are specified.	4	10
Limitations	The limitations found in practice with the intelligent agent.	5	8
Relevance	Personal idea of limitations and potential of ChatGPT and other artificial intelligences for educational practice	4	9
Original Ideas	Some original ideas that the students have implemented starting from and with ChatGPT.	4	9