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Student interaction with ChatGPT can promote complex critical thinking skills

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ABSTRACT

Background: The widespread adoption of AI-based chatbots has revolutionized the interaction between individuals and machines, providing personalized and immediate responses. Within the educational sector, students increasingly rely on ChatGPT to address academic challenges, but the consequences of this interaction on critical thinking abilities are not well understood. This study aims to explore the relationship between factors such as attitudes and trust towards AI, engagement, knowledge, and the ability to solve complex critical thinking in a sample of Italian students.

Methods: Two hundred and thirteen students completed self-report questionnaires and performance measures on the Critical Reasoning Assessment.

Results: The results highlighted significant relationships among the variables considered, emphasizing a direct impact of attitude and trust on knowledge and engagement with AI. Furthermore, engagement proved to have a particularly significant impact on critical thinking performance compared to knowledge.

Conclusions: These findings are relevant in the educational context, suggesting that interaction with AI-based chatbots can be a valuable resource for the development of students' critical thinking skills. However, it is emphasized the importance of adopting an educational approach that fosters active engagement and in-depth understanding to promote the critical analysis of information provided by AI-based chatbots.

1. Introduction

The proliferation of AI-based chatbots has triggered a significant transformation in the interaction between individuals and machines. These sophisticated conversational systems demonstrate an increasing ability to understand human language and provide immediate, personalized responses, adapting more and more to users' needs. Although there is still debate about their actual ability to pass the Turing test (Turing, 1950), the advancement of AI chatbots like ChatGPT, developed by OpenAI in November 2022, marks a turning point. ChatGPT uses natural language processing (NLP) to interact in a surprisingly realistic manner. It not only responds to follow-up questions but is also capable of admitting mistakes, challenging incorrect premises, and rejecting inappropriate requests, demonstrating a sophisticated understanding of conversation context and nuances (OpenAI, 2023). This wide range of abilities has opened the doors to numerous applications in different fields, with a user base exceeding 100 million (Cheng et al., 2023). Particularly in the education sector, students increasingly harness the power of ChatGPT to tackle academic tasks and challenges (Raman et al., 2023; Zhai, 2022; Lo, 2023). According to Social Cognitive Theory (Bandura, 1986), behavior, cognition, and emotions are influenced by the surrounding environment, including the technology with which individuals interact (Fabio & Suriano, 2021; Zhuo et al., 2023). Several studies have highlighted how the use of technology can impact cognitive processes, including attention, memory, executive functions, and reasoning (Amez & Baert, 2020; Nakagawa et al., 2022; Meltzer et al., 2023). In particular, it has been demonstrated that technology use can affect a crucial cognitive ability in education, namely the ability to engage in complex critical thinking (Cheng et al., 2022; Hartanto et al., 2023; Ku et al., 2019). This process allows students to analytically evaluate information, recognize valid arguments, and develop a reflective approach to the world around them (Chang et al., 2022; Guerrero et al., 2022; Li et al., 2021).

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1.1. Critical thinking and ChatGPT

ChatGPT can offer immediate access to a vast amount of information presented in a personalized manner, but it also raises questions about the potential influence of these interactions on students' ability to critically evaluate such information (Enkelejda Kasneci et al., 2023). On one hand, ChatGPT could be a valuable tool to enhance critical thinking skills, as it allows for the examination of the same topic from multiple perspectives (Rudolph et al., 2023). This process of diversified analysis can broaden people's views, enabling them to consider the subject from different angles and enriching their thinking processes (Mollick & Mollick, 2022). However, a passive use of ChatGPT could supplant thinking processes by generating a kind of cognitive dependence. Individuals using ChatGPT might be inclined not to actively engage in cognitive processing since they can easily rely on this system that incorporates a wide range of functionalities (Cotton et al., 2023). In this perspective, excessive use of ChatGPT could undermine critical thinking ability by inducing cognitive economy. As proposed by the dual-process theory, there are two distinct reasoning systems (Stanovich & West, 2000; Tversky & Kahneman, 1974). System 1, characterized by automatic and intuitive mental processes, occurs without the conscious control of the individual who forms quick judgments and decisions based on previous knowledge and beliefs (Dewey, 2023). System 2, characterized by controlled processes, occurs under the deliberate control of the individual (De Neys, 2019). The latter system is slower than the former and requires more cognitive resources but allows for the logical processing of information, adhering to the standards of critical thinking (Sowden et al., 2019). The interaction with ChatGPT can influence these processes. The passive use of such resources could amplify heuristic thinking, compromising the ability to reason critically. Only when heuristic responses are blocked and replaced by critical thinking can we accurately choose the information we use to form opinions or make decision (Fabio et al., 2023).

In consideration of the cognitive load theory (Sweller & Chandler, 1994), the use of ChatGPT presents two possibilities. On one hand, it could replace System 2 thinking processes and induce cognitive dependency, leading to cognitive overload and deterioration of critical thinking skills. Interacting with ChatGPT might lead users to avoid active engagement in complex cognitive processes, compromising their critical abilities. On the other hand, ChatGPT can alleviate cognitive load by offloading complex tasks, enhancing users' working memory efficiency and critical thinking. By providing quick access to information and effectively organizing data, ChatGPT helps prevent cognitive overload and facilitates the creation of long-term memory schemas, thereby reducing the burden on working memory.

Current literature on generative AI such as ChatGPT and its impact on critical thinking offers an intriguing and evolving perspective, maintaining a predominantly theoretical and commentary-based foundation until recent times (Chan et al., 2023; Michel-Villarreal, Vilalta-Perdomo, Salinas-Navarro, Thierry-Aguilera, & Gerardou, 2023a, 2023b; Peblani, 2023; van den Berg & du Plessis, 2023). Some current empirical studies appear to support the hypothesis that ChatGPT can enhance users' critical thinking. Essel et al. (2024) conducted a significant study involving university students in Ghana, revealing that interaction with ChatGPT positively impacted students' critical, reflective, and creative thinking abilities. This suggests that the use of advanced language models like ChatGPT could represent a promising innovation for developing advanced cognitive skills among students. Guo and Lee (2023), in a specific educational context within the field of chemistry, observed significant improvements in students' ability to formulate insightful questions and analyze complex information through interaction with ChatGPT. This highlights the potential of generative AI in facilitating deeper and more critical learning processes. Minh (2024) further explored how the use of ChatGPT not only increased the depth of students' arguments but also improved the structure and complexity of their argumentative presentations. Van Rensburg's study (2024) examined how ChatGPT 3.5 could be used to model critical thinking through the generation of textual responses. It was found that targeted educational involvement is crucial for maximizing the effectiveness of this process, emphasizing the importance of active pedagogical guidance in utilizing these technologies. Particularly relevant, the findings from Avello et al. (2024) indicated a significant reduction in cognitive load in the group using ChatGPT. This suggests that the use of artificial intelligence tools can facilitate critical thinking by freeing up cognitive resources for analyzing and solving complex problems.

However, few studies, such as that of Krupp et al. (2024), show that many students accept inaccurate answers and use copy-and-paste without critically evaluating information, highlighting the importance of educating students on the responsible use of AI. In contrast, Kosar et al. (2024) find no significant differences in academic performance between students who use ChatGPT and those who do not. These conflicting results underscore the need for a deeper understanding of the effects of students' interaction with ChatGPT on their critical thinking ability and the potential intervening variables in this relationship.

1.2. Variables intervening in the relationship between ChatGPT and critical thinking

The factors influencing the use of ChatGPT, and critical thinking ability are diverse, including user attitudes and trust in Artificial Intelligence (AI), representing the emotional and cognitive orientation towards AI (Ajlouni et al., 2023). Additionally, variables such as the level of engagement and in-depth knowledge specific to ChatGPT play a role (Rad et al., 2023). Trust and attitude towards artificial intelligence play a fundamental role in shaping individual approaches to knowledge and engagement in this field. While attitude toward AI is defined as the set of evaluations, feelings, and predispositions that an individual or a group holds towards artificial intelligence, trustworthy AI, is defined as artificial intelligence that is lawful, ethical, and robust (High-Level Expert Group on Artificial Intelligence (AI HLEG, 2019). Both attitude and trust in AI is influenced by predispositions and actual experiences with AI (Glikson & Williams Woolley, 2020). When an individual has established trust and a positive attitude towards artificial intelligence, they are more likely to be open to learning and actively exploring information related to this technology (Celik & Muukkonen, 2023; Jo et al., 2023). These variables could influence the acquisition of knowledge about artificial intelligence and active engagement in related topics. An individual who trusts in the safety and importance of artificial intelligence is more inclined to invest time and effort in understanding its principles, workings, and potential societal impacts (Choudhury & Shamszare, 2023; Michel-Villarreal et al., 2023a, 2023b).

The ability of artificial intelligence to provide immediate and personalized feedback, guidance, and support can promote an active attitude, increasing user interest and engagement (Patel, Yadav, & Gaurav, 2022). This trend has found resonance in the educational context, where the use of chatbots has proven effective in stimulating students' enthusiasm and attention (St-Hilaire et al., 2022), with positive implications for the learning process (Abbas et al., 2022). Chatbots can offer students a welcoming environment where they can ask questions and seek assistance without fear of judgment (Ait Baha et al., 2023). Therefore, interaction with ChatGPT could promote deeper engagement, encouraging users to mobilize their cognitive energies and apply critical thinking.

Knowledge also plays a central role in promoting responsible and effective interaction with these systems. This implies the ability to understand, use, communicate, collaborate, and critically reflect on artificial intelligence applications (Long et al., 2021; Ng et al., 2021). Students with good knowledge and experience in the field of AI may maximize the benefits and reduce the risks associated with this technology, avoiding uncritical influence, and making more informed and conscious decisions (Adamopoulou & Moussiades, 2020).

In turn, the growth of knowledge and active engagement in AI directly contribute to the development of critical thinking. The growth of knowledge and active engagement in AI provides fertile ground for the cross-application of critical skills in other areas (Du et al., 2023). Analytical, synthetic, and problem-solving skills acquired can be applied in various situations. In summary, knowledge, and engagement in AI, although specific, act as catalysts for the development of broader cognitive and critical skills. AI, treated as a field of study and application, provides a platform to refine the ability to think critically, thereby contributing to a more reflective and analytical approach in problem-solving and information evaluation overall.

1.3. The present study

The main objective of this study is to explore the impact of interaction with ChatGPT on the complex critical thinking ability in a specific sample of Italian students. This investigation is based on the analysis of various variables, including attitudes, trust, engagement, knowledge, performance in critical thinking, and attitude. In more depth, it is hypothesized that: a) High levels of positive attitude and trust towards artificial intelligence will lead to higher levels of knowledge and engagement with AI. This is supported by research from Ajlouni et al. (2023) and Celik and Muukkonen (2023), which highlight how trust and a positive attitude towards AI influence openness to learning and active exploration of AI technologies. b) An increase in knowledge and experience gained through interaction with ChatGPT will be associated with a significant improvement in critical thinking. Studies such as those by Essel et al. (2024) and Guo and Lee (2023) demonstrate that interaction with ChatGPT can enhance critical, reflective, and creative thinking. c) Greater engagement in interactions with ChatGPT will be positively correlated with an increase in critical thinking. Minh (2024) and van Rensburg (2024) show how the use of ChatGPT can enhance the depth and structure of students' arguments, thereby improving their critical thinking abilities. d) Levels of engagement and knowledge may moderate the relationship between trust, attitude, and critical thinking. This exploratory hypothesis suggests that a positive attitude and greater trust in AI might not only promote higher engagement and knowledge acquisition but also enhance the effect of these variables on the improvement of critical thinking. While existing literature, such as that by Patel, Yadav, & Gaurav (2022) and St-Hilaire et al. (2022), indicates that trust in AI and engagement can positively influence learning, it remains unclear how and to what extent engagement and acquired knowledge interact with attitude and trust to affect critical thinking.

With these hypotheses, the aim is to provide a robust foundation for exploring the complex dynamics of interaction with ChatGPT and their possible correlations with critical thinking in educational contexts. The underlying logic is that, while interaction with other media, such as Instagram, TikTok, and Facebook, has been shown to reduce the use of System 2 by occupying cognitive resources with superficial and impulsive activities typical of System 1, thus impairing critical thinking (Arrivillaga et al., 2022; Dharmastuti et al., 2020; Dikarsa et al., 2020), the characteristics of AI-based chatbots, such as ChatGPT, could facilitate the activation of System 2. In line with cognitive load theory, the use of ChatGPT could reduce extraneous cognitive load, which represents cognitive resources required to manage irrelevant or poorly structured information. By reducing extraneous cognitive load, ChatGPT frees cognitive resources that can be allocated to germane cognitive load, which is directly related to learning and critical thinking activities.

2. Materials and methods

2.1. Participants

The study originally involved 241 participants, but some of them did not complete the task due to boredom, and consequently, they were excluded from the final analysis. The sample size was determined using established methodologies for sample estimation, based on the relevant population proportion specific to the study. Specifically, we employed a 95% confidence interval and calculated based on a university population percentage of 10% (=134). The final sample of the present study comprised 213 Italian university students, with a gender distribution of 94 males and 119 females. Participants' ages ranged from 18 to 30 years, with a mean age of 23.97 years (standard deviation = 5.02). These students were recruited from courses offered in the departments of economics, psychology, and sciences across various Italian universities, encompassing both undergraduate and graduate programs. The decision to involve students from diverse academic disciplines aimed to capture a broad range of perspectives and educational backgrounds and to ensure representativeness among participants and to avoid biases related to specific class or program characteristics. The recruitment process within the classes was implemented using a combination of approaches, including in-class announcements, informative emails sent to students, and project presentations during lectures. The researcher conducted direct visits to university classrooms during scheduled sessions, engaging personally with the attending students to deliver a detailed explanation of the ongoing survey. Students who were interested were then invited to participate, enabling them to decide based on their availability and interest.

2.2. Procedure

The research was conducted in accordance with the principles outlined in the Declaration of Helsinki. Each participant voluntarily agreed to take part in this study, and the investigation commenced only after obtaining written informed consent. Participants were welcomed in small groups in a quiet room near their classroom and underwent an assessment through self-report and performance tests lasting 100 min. All assessments were conducted between 9:00 a.m. and 12:00 a.m. An examiner provided each participant with the necessary materials, consisting of three dilemmas and their respective questions. Participants were asked to carefully read the first dilemma and respond to the corresponding questions after completing the reading. This process was then repeated for the second and third dilemmas.

2.3. Measurement

In this study, both self-report questionnaires and performance tests were employed. Specifically, to assess the participants' level of knowledge/experience with ChatGPT and their degree of engagement, two questionnaires were adapted from USEQ (Gil-Gómez et al., 2017). The Human-Computer Trust Measure (HCTM) developed by Gulati et al. (2019) was used to measure the level of trust, while the tool developed by Schepman and Rodway (2023) was used to measure General Attitudes towards Artificial Intelligence. Critical Thinking Attitude was measured using the Italian version of the Critical Thinking Attitude Scale (CTAS), and critical thinking performance was investigated through the administration of the Critical Reasoning Assessment (CRA).

2.3.1. General Attitudes towards Artificial Intelligence Scale

The General Attitudes towards Artificial Intelligence Scale (GAAIS) was developed by Schepman and Rodway (2023) to assess individual psychological predispositions towards Artificial Intelligence (AI). This measurement tool consisted of 20 statements, divided into two main factors: one positive and one negative, along with an attention check requiring the selection of "Strongly agree." Examples of statements from the positive scale included: "AI-based systems can contribute to making people happier" and "AI can have positive impacts on people's well-being." On the other hand, examples of statements from the negative scale were: "Organizations use AI unethically" and "I feel discomfort when thinking about future uses of AI." The scale utilized a 5-point Likert scale response mode, with the options: "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree". To calculate the

overall index of the scale, the negative items were reversed and summed with the positive ones.

The internal consistency analysis of the instrument demonstrated good reliability, highlighted by a Cronbach's alpha (α) value of .89.

2.3.2. Human-computer trust measure

The Human-Computer Trust Measure (HCTM) is a trust scale developed by Gulati et al. (2019) focusing on assessing trust in the relationship between the user and the computer (Cheng et al., 2022; Pinto et al., 2022). It is a self-assessment tool consisting of 11 statements, divided into four subscales: risk perception (3 statements – reversed in this subscale), competence (3 statements), benevolence (3 statements), and reciprocity (2 statements). Individuals are asked to respond to these statements using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). In this study, the goal was to assess trust in artificial intelligence systems, specifically, each placeholder was replaced with the term ChatGPT. To evaluate the internal consistency analysis, the Cronbach's alpha was used (α = .92).

2.3.3. Level of knowledge/experience with ChatGPT

To obtain a research instrument for estimating the level of knowledge/experience with ChatGPT, a questionnaire adapted from the USEQ instrument (Bernava et al., 2021; Gil-Gómez et al., 2017) was employed. The questionnaire comprised two sub-scales: the first investigated the level of knowledge about ChatGPT, presenting three questions such as "Indicate your level of knowledge regarding privacy and security factors in GPT"; the second scale with three items referred to the level of experience with ChatGPT. An example item was "Have you used ChatGPT as support in your academic/school activities?" Participants rated each item on a 5-point Likert scale, from 1 (not at all) to 5 (very much). Internal consistency was α = .89.

2.3.4. Level of engagement with ChatGPT

To assess the level of engagement during the use of ChatGPT, a questionnaire was adapted from the USEQ instrument (Bernava et al., 2021; Gil-Gómez et al., 2017) consisting of 4 items aimed at investigating the degree of active engagement and interest shown by users when interacting with the ChatGPT system. Examples of items were: "I am having a lot of fun using ChatGPT" and "I feel engaged using ChatGPT." Participants were asked to provide feedback on intensity, and the response mode was a 5-point Likert scale, ranging from 1 (not at all) to 5 (very much). From the internal consistency analysis, the Cronbach's alpha was α = .82.

2.3.5. Critical Reasoning Assessment (CRA)

The Italian version of the Critical Reflective Assessment (CRA) (Anghel et al., 2021; Fabio et al., 2024) was administered to objectively assess critical thinking abilities, reducing bias in responses and focusing on participants' actual performances rather than self-declarations. The CRA evaluates these abilities in complex and real-life situations, providing an accurate representation of challenges in daily life and moral decision-making. The CRA's structure is based on the Reflective Judgment Interview (King & Kitchener, 1985) and uses 3 specifically designed dilemmas on genetics vs. choice, fairness, and compassion. Participants respond to 5 questions for each dilemma, rated on a scale from 1 to 7. This approach provides a comprehensive analysis of the critical thinking process, exploring decision-making processes and the participant's perspective foundations. In the study context, responses were evaluated by two experts, achieving a high degree of agreement with a Cohen's Kappa agreement coefficient of .95. The CRA has demonstrated good reliability, with a Cronbach's alpha coefficient of α = .87. For the sample of the present study, the Cronbach's alpha coefficient from the internal consistency analysis was α = .89.

2.3.6. Critical Thinking Attitude Scale (CTAS)

Critical Thinking Attitude Scale (CTAS) (Fabio et al., 2024) was used to examine results and to assess participants' inclination to engage in a process of analytical, evaluative, and metacognitive reflection. The CTAS consists of 26 items, that measure 4 subscales "Systematicity" (nine items), "Search for Truth and Openness" (six items), "Analyticity" (four items) and "Inquisitiveness" (seven items). Participants responded on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), where higher scores indicated a better attitude. Example of items were: " I am able to think logically." and "I always try to delve deeper and understand things thoroughly". The CTAS demonstrated high internal consistency (Cronbach's alpha = .83) for all factors.

2.4. Statistical analysis

To analyses the findings, we utilized SPSS 28.0 statistical software (SPSS Inc., Chicago, IL, USA). Descriptive statistics, including means and standard deviations, were provided for each variable. Pearson correlation analysis was conducted to explore the relationships among attitudes toward artificial intelligence, trust, engagement, knowledge, performance, and attitude for critical thinking. Bonferroni's correction was applied to address multiple comparisons. To investigate the relationships between attitude and trust as predictive variables and engagement and knowledge as dependent variables, as well as between engagement and knowledge and critical thinking skills with critical thinking attitude, linear regression analyses were performed. Additionally, this study employed path analysis to examine the relationship among attitudes toward artificial intelligence, trust, engagement, knowledge, performance, and critical thinking attitude.

3. Result

Table 1 shows the means and standard deviations of the questionnaires related to attitudes and trust toward artificial intelligence, engagement, knowledge, performance, and attitude toward critical thinking.

In Table 2, Pearson correlations between attitude and trust toward artificial intelligence, engagement, knowledge, performance, and critical thinking attitude are presented. The Bonferroni correction has been applied, and the new significance level is set at (.05/15) .003. All variables show a positive and moderate correlation with performance in critical thinking (CRA). When it comes to the attitude toward critical thinking, only engagement and attitude towards AI exhibit correlations with it.

To investigate the relationship between attitudes towards artificial intelligence and trust in AI on levels of engagement, a linear regression was conducted, considering attitude and trust as predictor variables and engagement as the dependent variable. The data yielded significant results: respectively, $\beta = .491$, $t = 6.83$, $p < .001$, and $\beta = .282$, $t = 3.92$, $p < .001$. Together, attitude and trust explain 42.4% of the variance in predicting engagement (coefficient of determination R squared = 42.4%). The relationship between attitude and trust as predictor variables and knowledge as the dependent variable showed significant associations, with $\beta = .366$, $t = 4.94$, $p < .001$, and $\beta = .388$, $t = 5.24$, $p < .001$, respectively. Attitude and trust explain 39% of the variance in predicting knowledge (coefficient of determination R squared = 39%). Considering engagement as the independent variable and performance

Table 1
Descriptive statistics of AI attitude, AI trust, engagement, knowledge and critical thinking performance and attitude.

Measures	Means (±SD)
AI Attitude	62.25 (±13.96)
AI Trust	32.91 (±7.35)
Engagement	13.40 (±3.08)
Knowledge	12.99 (±5,77)
CT Performance	53.59 (±13.11)
CT Attitude	57.52 (±7.09)

Table 2
Pearson's correlations between AI attitude, AI trust, engagement, knowledge and critical thinking performance and attitude.

	1	2	3	4	5	6
1. CT Performance	–					
2. CT Attitude	.415[a]	–				
3. AI Trust	.392[a]	.016	–			
4. AI Attitude	.396[a]	.372[a]	.457[a]	–		
5. Engagement	.401[a]	.394[a]	.494[a]	.605[a]	–	
6. Knowledge	.230[a]	.057	.538[a]	.577[a]	.519[a]	–

[a] = $p < .001$.

in critical thinking as the dependent variable, the β coefficient was .381, $t = 4.73$, $p < .001$. When considering knowledge as the independent variable and performance in critical thinking as the dependent variable, the β coefficient was .188, $t = 2.16$, $p < .05$. Together, engagement and knowledge account for 13.4% of the variance in predicting performance in critical thinking (coefficient of determination R squared = 13.4%).

We conducted a path analysis to examine the relationships among AI attitude, AI trust, engagement, knowledge and critical thinking performance. The path model provided a good fit to the data ($\chi^2 = 26.32$, df = 8, $p < .001$; RMSEA = .05; CFI = .96), indicating an acceptable model fit. The path analysis illustrated in Fig. 1 indicates a direct relationship between attitude and trust on knowledge and engagement, and between engagement and knowledge on performance in critical thinking.

3.1. Inizio modulo

Assuming critical thinking artitudeas a dependent variable, the path model provided again a good fit to the data ($\chi^2 = 18.21$, df = 8, $p < .001$; RMSEA = .05; CFI = .96), indicating an acceptable model fit. The path analysis in Fig. 2 depicts a direct relationship between the same variables (trust and attitude on engagement). Knowledge, on the other hand, was found to be non-significant.

4. Discussion

The main objective of this study was to explore the complex dynamics of interaction with ChatGPT and their possible correlation with critical thinking in university students. Several variables were considered, such as attitudes and trust towards AI, engagement, knowledge, and experience, and their impact on both critical thinking attitude and performance.

4.1. Overview of findings

The study results confirmed the first hypothesis, which posited that a positive attitude and greater trust in AI directly influence knowledge, experience, and engagement with technology. The data showed that students with a favourable attitude and high trust in ChatGPT tended to acquire more knowledge and engage more actively with the chatbot. This suggests that a positive attitude toward AI not only enhances learning but also stimulates more active participation in interacting with technology.

The second and third hypotheses, which predicted a positive effect of knowledge and experience, as well as engagement on critical thinking, were confirmed. The data indicated that while the knowledge acquired was positively correlated with critical thinking performance, the effect of active engagement was more significant. This implies that although knowledge is important, active interaction with ChatGPT has a greater impact on students' critical thinking abilities.

Finally, the exploratory hypothesis that levels of engagement and knowledge may moderate the relationship between trust, attitude, and critical thinking was largely confirmed. Specifically, the results demonstrated that deep engagement with the chatbot was a crucial factor for the development of critical thinking skills, suggesting the importance of the quality of interaction for thinking processes. In contrast, the acquired knowledge and experience did not have a significant impact on critical thinking attitude, indicating that the level of engagement with the technology alone is decisive in the development of critical skills.

4.2. Comparison with previously studies

The results obtained in this study offer a complex and nuanced picture compared to the existing literature on interactions with AI-based technologies such as ChatGPT.

Firstly, the findings related to the influence of attitude and trust in AI on student engagement and critical performance corroborate the proposals of Ajlouni et al. (2023) and Celik and Muukkonen (2023). They suggest that a positive attitude and high trust in AI can facilitate the adoption and effective use of AI-based technologies, thereby enhancing user interaction and engagement. Our results support these observations, indicating that students with a favourable attitude towards ChatGPT and higher trust in this technology tend to be more engaged and perform better in critical thinking.

Consistent with studies such as Essel et al. (2024) and Guo and Lee (2023), which found a positive impact of interaction with ChatGPT on students' critical thinking, it emerged that knowledge and experience with ChatGPT can be influential in promoting critical thinking skills. However, engagement showed a stronger impact on critical thinking performance, supporting the conclusions of recent studies like those by Minh (2024) and Van Rensburg (2024), which indicated that deeper engagement is crucial for improving the quality of students' critical thinking and arguments.

While knowledge and experience enhance critical thinking performance by providing an informational foundation and advanced problem-solving practices, the results of this study found that these variables do not directly affect the attitude towards critical thinking, which appears to be more related to engagement. A high degree of

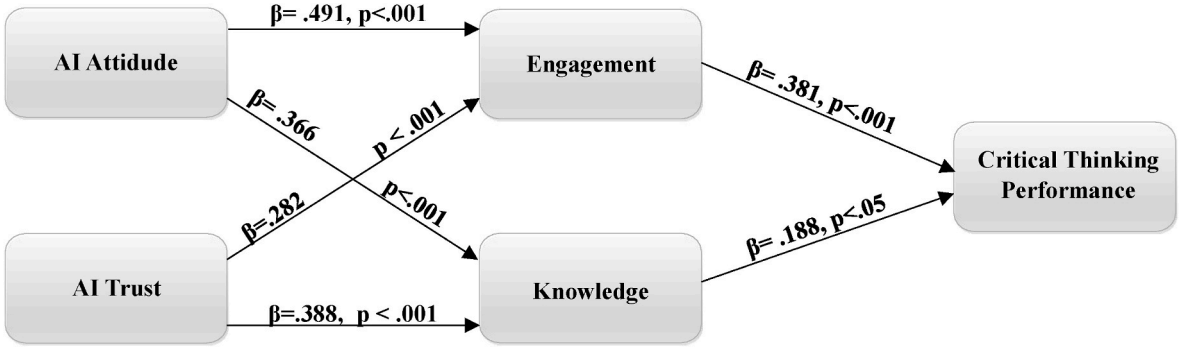

Fig. 1. Path Analysis related to Critical Thinking Performance.

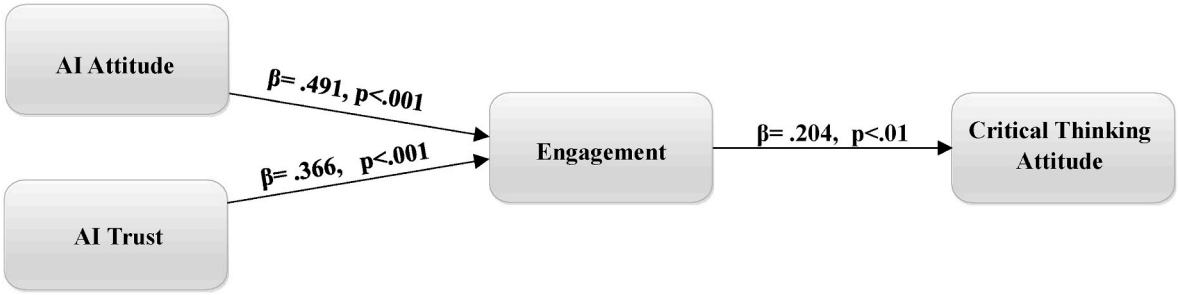

Fig. 2. Path Analysis related to Critical Thinking Attitude.

engagement might stimulate active participation and in-depth reflection, promoting not only effectiveness in critical performance but also a positive attitude towards critical thinking itself. Therefore, while knowledge seems essential for performing critical analyses, engagement may be crucial for developing and maintaining a favourable attitude towards critical thinking (Cheng et al., 2022; Ku et al., 2019).

The conflicting results reported by Krupp et al. (2024), who highlighted that many students accept inaccurate answers and use copy-paste without critical evaluation, suggest that while interaction with ChatGPT can facilitate critical thinking, it is insufficient without adequate engagement that stimulates deeper reflection, consideration of multiple perspectives, and the challenge of complex arguments, all essential elements for advanced critical thinking (Fabio & Suriano, 2023; Hartanto et al., 2023).

4.3. Theoretical explanations

These results can be explained considering the integration among various theories. Considering Bandura's (1986) social cognitive theory perspective, our findings suggest that positive attitude and trust toward artificial intelligence can be seen as influencing factors on students' engagement and knowledge construction during interaction with ChatGPT. Considering the dual-process theory perspective (Kahneman, 2011), our results suggest that engagement with ChatGPT, along with knowledge, representing a reflective and controlled process, has proven to play a more significant role in enhancing critical thinking performance.

This phenomenon can be analysed through the theory of cognitive load (Sweller & Chandler, 1994) which posits that the effectiveness of learning depends on the optimal management of available cognitive resources, dividing cognitive load into three main types: intrinsic load, extraneous load, and germane load dedicated to constructing knowledge schemas. ChatGPT appears to reduce both extraneous and intrinsic cognitive load, thereby facilitating the integration and application of tasks. This reduction allows students to allocate more cognitive resources to germane load, improving learning and understanding. Interestingly, ChatGPT could support students in processing complex information with less mental effort, thereby enhancing the overall effectiveness of the learning process.

4.4. Strengths, limitation and future direction

The strengths of this study lie in its relevance during a period of widespread AI adoption. These findings contribute to the understanding of the intricate dynamics characterizing human-AI interaction in educational contexts. While AI, such as ChatGPT, can provide real-time information and support, it is the users' attitudes, trust, and active engagement that play a key role in shaping complex critical thinking skills. The results underscore the importance of considering not only technological design but also the psychological and motivational aspects of users when developing AI-based educational tools. This study takes into account the complex interaction between different variables and assesses complex critical thinking, a crucial skill in contemporary society, through both self-report measures and performance tests, thus allowing for a more in-depth and objective understanding of real performance and reported information.

This study presents some significant limitations to consider in interpreting the results. Firstly, the analysis is based on a sample of university students, which, while promoting sample homogeneity, limits the generalizability of the results to other demographic groups. For instance, significant differences may emerge when examining the behavior of other age groups or different levels of education. Secondly, the cross-sectional nature of the study prevents establishing definitive causal relationships between the variables considered. Although it may be relevant for identifying correlations at a given moment, it does not allow tracing the direction or long-term effects of the interactions examined with certainty. Additionally, the assessment of interest, knowledge, and attitude to critical thinking relies on self-administered questionnaires, which could be influenced by participants' subjective perception. This introduces a potential risk of bias in the results, as responses may not fully reflect individuals' actual behavior or attitudes.

To further advance understanding of these dynamics, future research could explore how variables such as education and age influence such interactions. For example, focusing on different educational levels could reveal significant variations in learning modes and the use of digital resources like ChatGPT. A longitudinal approach could be particularly fruitful in studying the evolution of interaction dynamics over time, allowing observation of changes and developments in individuals' behavior in using digital educational tools. Finally, since this study primarily focuses on students' interaction with ChatGPT in formal educational contexts, future research could expand the investigation to include informal or professional contexts. This could reveal how interaction dynamics vary based on different motivations and objectives in diverse contexts, thereby enhancing understanding of the impact of such technologies in various aspects of daily and professional life.

4.5. Implications and recommendations

The current study provides a fundamental basis for further research on the interaction between humanity and Artificial Intelligence in the field of education. Understanding the dynamics involved in the use of AI-based tools, such as ChatGPT, can guide the development of more effective approaches to integrating them into education, thereby maximizing their positive impact on students' critical thinking skills. The results indicate that generative AI tools can enhance learning efficiency by facilitating access to diverse educational content tailored to individual student needs. However, it is essential to balance the benefits with the risks of this technology by establishing rigorous ethical guidelines to ensure transparency, data security, and algorithmic accountability. In the near future, it is likely that AI systems will become increasingly prominent mediators in the learning process, potentially assuming a more central role compared to traditional teachers. This perspective raises crucial considerations regarding the evolution of education and educational models. While AI systems have the potential to

improve access and personalize learning, it is equally important to examine the social, emotional, and cognitive impacts of learning primarily mediated by automated technologies.

Optimizing educational policies to systematically integrate AI-based tools like ChatGPT into the curriculum requires a targeted approach that actively promotes student engagement rather than merely fostering passive consumption of information. Teachers play a crucial complementary role as partners in the educational process, interpreting and guiding students' learning paths in a thorough and contextualized manner. Ongoing teacher training and structured governance of AI systems in education are essential for effectively integrating these tools into daily teaching activities. Actively involving families in the entire educational process is also crucial, for instance through targeted educational workshops that inform about the benefits and risks of using such tools. These meetings provide practical strategies to help parents actively support their children in using AI.

In conclusion, while the integration of AI systems in education promises to significantly transform the learning and teaching process, it is crucial to adopt a prudent, evidence-based approach in their implementation. Only then can the full potential of emerging technologies be leveraged to improve education sustainably and equitably for all students.

5. Conclusion

This study explored the dynamics of students' interaction with ChatGPT and their impact on complex critical thinking abilities. The results indicate that a positive attitude towards AI and trust play a key role in motivating students to actively engage with ChatGPT, influencing both knowledge and engagement. Engagement, in turn, emerges as a significant predictor of both critical thinking skills and students' attitude toward critical thinking.

The use of ChatGPT can represent a valuable resource for the development of students' critical thinking skills, offering them the opportunity to explore topics from various perspectives and deepen their understanding. However, it is essential to adopt an educational approach that promotes active engagement and in-depth comprehension to avoid passive dependence on AI chatbots. The educational implications of this study suggest the need to integrate the use of AI-based chatbots into educational settings, but with a particular focus on promoting active engagement and critical understanding. Crawford et al. (2023) argued that proper guidance is necessary to safeguard the ethical use of ChatGPT in education. Teachers can play a fundamental role in guiding students in the responsible and reflective use of such resources, encouraging independent research and critical evaluation of information provided by chatbots. Additionally, students' trust in AI can be strengthened through transparency in use and training on how to critically assess received responses.

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Ethics approval

Approval was obtained from the ethics committee of University of Messina. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Consent

Informed consent was obtained from all individual participants included in the study.

Data

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Rossella Suriano: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Alessio Plebe:** Supervision, Resources, Investigation, Data curation. **Alessandro Acciai:** Resources, Investigation, Data curation. **Rosa Angela Fabio:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare no conflict of interest. The authors have no financial or proprietary interests in any material discussed in this article.

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