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The moderating effect of career on the Development of Critical Thinking with the Chatbot in university students

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***Abstract*– The main objective of the research was to determine the moderating effect of the professional career on developing critical thinking with the chatbot in university students. A professional career in health sciences, such as human medicine, and another career in social sciences, such as advertising and multimedia, were chosen for the study. The proposed structural model had predictor variables such as effective chatbot interaction, chatbot problem resolution capability, autonomy fostered by chatbot use, chatbot response reliability and accuracy, and, as an endogenous variable, the development of critical thinking. The research was carried out in Arequipa, Peru. A quantitative approach with a non-experimental cross-sectional design was used, and a multivariate model was used to model structured equations based on variances. In conclusion, the structural model reveals that problem-solving ability and reliability in chatbot responses are crucial for developing critical thinking in college students, while perceived autonomy and quality of direct interaction do not play a significant role. Furthermore, the consistency of these effects across different career paths suggests that chatbots can be an effective educational tool without the need to tailor their features to specific fields of study such as professional careers. This highlights the utility of chatbots as versatile pedagogical tools in the higher education environment.**

***Keywords*— Chatbot, Problem Resolution, Autonomy by Chatbot Use, Response Reliability and Accuracy, Critical Thinking.**

I. Introduction

The study clarifies some doubts about the moderating role of the professional career in developing critical thinking using Chatbot tools. As has been observed, the role of professional careers also influences how students interact with these technological tools and may be different in health sciences and social sciences careers. Career guidance offered through chatbots can impact students' career decisions and career satisfaction by providing personalized advice that helps align their career paths with their personal interests and values, which can lead to greater satisfaction and better career outcomes [1]. This guidance can further mitigate the risk of students choosing careers based on external pressures, allowing for a more focused and authentic focus on their true interests.

While not directly explored in previous studies, career guidance offered by chatbots may also have a moderating effect on developing critical thinking. Chatbots allow students to focus more intently on developing critical skills by reducing stress and distractions related to career decisions. Furthermore, integrating career guidance with educational chatbots could offer a more holistic approach to student development, combining academic needs with career concerns, which can further enrich critical thinking by providing real-world contexts and applications for these skills [1, 2]).

Interacting with chatbots in educational settings has significantly improved college students' critical thinking skills [3]. These systems foster analytical and critical capabilities by encouraging students to actively evaluate the information provided [4]. Furthermore, in medical informatics, ChatGPT has motivated students to critically question and analyze the chatbot's responses, improving their critical thinking and problem-solving skills [4].

In the university educational context, the use of chatbots has proven to be an effective tool for developing critical thinking skills, an essential component in students' academic and professional training. Recent research indicates that integrating artificial intelligence chatbots in educational environments significantly improves higher-order thinking skills, including critical thinking, creativity, and problem-solving [5]. Additionally, Emran [6] highlight that the use of responses generated by ChatGPT as a teaching method has led to In terms of discussion facilitation, chatbots use persuasive rhetoric strategies that encourage students to reconsider their arguments and explore new perspectives, which is essential for the development of critical thinking [7, 8].

However, over-reliance on chatbots can lead to decreased critical thinking, as students may rely too much on automated responses without performing sufficient critical analysis [9]. This phenomenon underlines the importance of integrating these chatbots to foster a critical and reflective approach in students, thus ensuring their comprehensive cognitive development [9]. Chatbots have significantly impacted the development of critical thinking skills in educational contexts. The conscious use of chatbots such as ChatGPT, for example, has improved critical thinking capabilities in Italian students, particularly when they interact thoughtfully and experiencedly with technology [10]. Furthermore, Google Bard has contributed to academic literacy by offering robust fact-

checking and writing support features, improving critical thinking [11].

On the other hand, implementing chatbots in flipped classroom models has effectively fostered higher-order thinking skills by personalizing and energizing learning [5]. However, the integration of chatbots also poses challenges. There is concern that an over-reliance on tools such as ChatGPT to complete tasks may reduce the depth of students' cognitive engagement with the educational material, potentially diminishing the quality of education and the development of critical thinking [12]. In programming education contexts, ChatGPT has been shown to speed up task completion but often at the cost of deep understanding and critical thinking development, resulting in uniform and superficial solutions across users [13].

The impact of chatbots on critical thinking is not one-sided; a recent meta-analysis suggests that while some aspects of reasoning and knowledge retention may be improved, critical thinking and motivation may be negatively affected [14]. Especially in fields such as nursing education, over-reliance on chatbots may limit the development of critical skills, highlighting the need for clear guidelines and a focus on critical thinking in training [15]. Therefore, a balanced and thoughtful integration of these tools is crucial to maximize their benefits and minimize potential risks in developing critical thinking.

Effective interaction with chatbots is crucial in facilitating cognitive processes underlying critical thinking. When students actively interact with intelligent chatbots, such as ChatGPT, they engage in critical evaluations and profound analysis of the information received, essential for improving their critical thinking skills [3, 10]. This engagement involves receiving information and questioning it, analyzing its relevance and accuracy, and critically evaluating the chatbot's responses.

Regarding Chatbot Problem Resolution Capability, the chatbot's ability to effectively resolve queries is highlighted, directly fostering user problem-solving skills. This aspect of chatbots allows students to practice and improve their ability to think critically and creatively to find solutions to complex problems [16, 17]. Iteration in interactions with chatbots challenges students to refine their questions and consider multiple angles of a problem, thus promoting a critical and systematic approach to problem-solving.

Autonomy Fostered by Chatbot Use and Chatbot Response Reliability and Accuracy are key aspects that relate to how perceived autonomy and reliability of chatbot responses can reduce students' cognitive load. A lower cognitive load makes students more willing and able to engage in critical thinking as they can focus on analyzing and synthesizing information rather than worrying about the accuracy of the data provided by the chatbot [18]. Furthermore, confidence in the accuracy of the chatbot's responses can positively influence students' attitudes toward utilizing this technology, increasing their willingness to engage deeply and critically reflect on the topics discussed [3].

Finally, developing critical thinking with chatbots encapsulates the ultimate goal of these cognitive processes and interactions with chatbots. Bloom's taxonomy applied in this context suggests that interactions with chatbots can facilitate higher-order thinking skills such as analyzing, evaluating, and creating, which are foundational to critical thinking. However, it is also recognized that the more complex tasks become, the more students may fall back on lower-order thinking skills such as remembering and understanding, posing challenges to the sustained development of critical thinking [19].

While chatbots such as ChatGPT offer educational benefits, they also present significant disadvantages when relied upon for critical thinking tasks. One major limitation is their inability to synthesize ideas coherently, which can hinder users from developing well-founded conclusions [7]. Furthermore, chatbots can spread misinformation, negatively influencing users' critical thinking process – a severe risk in contexts where information accuracy is critical, such as during public health events [20].

Over-reliance on chatbots can also directly undermine critical thinking skills, leading students to a superficial understanding of complex topics and limiting the development of deep analytical skills [21, 22]. Biases in chatbot algorithms and the generation of content that lacks originality are other serious concerns, as they can distort the critical thinking process and lead to erroneous conclusions, as well as raise ethical issues related to the authenticity of academic work [23, 24]. Additionally, chatbots often lack the depth and nuance required for thorough critical analysis, which can result in insufficient exploration of complex issues [25]. The potential for these systems to facilitate academic dishonesty, such as cheating on exams and assignments, further undermines the integrity of the educational process and the development of authentic critical thinking skills [21, 23]. These challenges highlight the limitations of relying on chatbots for cognitively complex tasks and underscore the need for careful management and balanced technology integration into educational settings to foster genuine and critical learning. Furthermore, appropriate use of chatbots has demonstrated improved academic performance, information acquisition efficiency, and language proficiency [26, 27]. Based on these considerations, the following hypotheses are formulated:

Direct effects hypothesis:

H1: A higher level of autonomy fostered using the chatbot (AFCU) is positively associated with a more significant development of critical thinking through the chatbot (DCTC).

H2: A higher problem-solving ability of the chatbot (CPRC) is positively related to an increase in the development of critical thinking through the chatbot (DCTC).

H3: The reliability and accuracy of the chatbot's responses (CRRA) positively influence the development of critical thinking through the chatbot (DCTC).

H4: A more effective interaction with the chatbot (ECI) is positively linked to an increase in the development of critical thinking through the chatbot (DCTC).

Indirect effects hypothesis (Moderation)

H5: The professional career moderates the relationship between effective interaction with the chatbot (ECI) and the development of critical thinking through the chatbot (DCTC), such that this relationship varies depending on the student's professional career.

H6: Career path moderates the relationship between chatbot response reliability and accuracy (CRRA) and the development of critical thinking through the chatbot (DCTC), with this relationship varying depending on the student's career path.

H7: Career path moderates the relationship between chatbot problem-solving ability (CPRC) and the development of critical thinking through the chatbot (DCTC), indicating that the effect may be stronger or weaker depending on the student's career path.

H8: Career path moderates the relationship between chatbot autonomy fostered by use (AFCU) and the development of critical thinking through the chatbot (DCTC), suggesting that the influence of AFCU may vary depending on the student's career path.

II. Methodology

The study is quantitative and non-experimental and investigated whether the professional career, specifically in the areas of Health Sciences and Social Sciences, acts as a moderator in the impact of the use of chatbots on the development of critical thinking in university students. A cross-sectional design was selected, allowing the comparison of these moderating effects between the areas of study at a single point in time. This methodology is appropriate for establishing relationships and comparing groups without manipulating variables, providing an objective view of how disciplinary differences can influence the effectiveness of advanced educational technologies.

The sample consisted of 183 university students from a private university in Arequipa, Peru, who belong to the professional careers of Human Medicine with 95 (52%) and Advertising and Multimedia 88 (48%). With an equal representation of the sexes (51% women and 49% men), the ages are between 17 and 34 years, with a mean of 20.79 and a standard deviation of 3.07. Data collection was carried out in July 2024. Respondents were randomly selected and previously gave their consent.

The items and a 5-point Likert scale organize the instrument factors used to measure them, where (1) means strongly disagree, (2) disagree, (3) neither agree nor disagree, (4) agree, and (5) strongly agree. The study variables are Effective Interaction with the Chatbot (ECI), Problem-Solving Capacity with the Chatbot (CPRC), Autonomy Fostered by the Use of the Chatbot (AFCU), Reliability and Accuracy of Responses with the Chatbot (CRRA), and Development of Critical Thinking with the Chatbot (DCTC). Data processing was carried out with SmartPLS version 4.1.0.9.

III. Results

Table I presents the measurement model results for the study sample, including item factor loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) for each construct related to chatbot use and critical thinking development in college students. The Cronbach's alpha values for Autonomy Fostered by Chatbot Use (AFCU), Chatbot Problem Resolution Capability (CPRC), Chatbot Response Reliability and Accuracy (CRRA), and Effective Chatbot Interaction (ECI) are 0.780, 0.802, 0.850, and 0.813 respectively, all exceeding the acceptability threshold of 0.7, indicating good internal consistency within each set of items. Furthermore, the composite reliability (CR (rho_a)) values for each construct are 0.786, 0.805, 0.854, and 0.823, respectively, also exceeding the threshold of 0.7, reflecting the high reliability of the scales used in the research.

The AVE values for the AFCU, CPRC, CRRA, and ECI constructs are 0.603, 0.558, 0.626, and 0.642, respectively, all of them above the recommended threshold of 0.5. This indicates good convergent validity of the measures, suggesting that most of the variance of the items is explained by the corresponding factors. The factors loadings of the items vary between 0.718 and 0.854, demonstrating a strong and significant correlation of the items with their corresponding latent construct. These results underline the adequacy of the measurement tools used to assess how specific characteristics of the interaction with the chatbot impact the development of critical thinking. Thus, these findings validate the use of the scales for future research and more complex analyses, such as structural equation modelling, to explore the relationships between the variables studied and their moderation by the professional career.

The analysis presented does not include the items AFCU1, AFCU5, CPRC1, ECI1, ECI5, CRRA4, DCTC1, and DCTC4. This exclusion is because these items did not meet the quality criteria necessary for a good fit within the exploratory factor analysis, a critical process to ensure the accuracy and relevance of measurements in empirical studies. In an exploratory factor analysis, it is essential that each item adequately contributes to the intended factor structure, faithfully representing the underlying construct without ambiguities or redundancies.

The items that were eliminated from the model were because they showed low factor loadings or because their inclusion negatively affected the internal consistency of the scales, assessed by Cronbach's alpha and composite reliability. The elimination of these items is justified by the need to improve the clarity and unidimensionality of each construct, ensuring that the final scales effectively and accurately reflect the dimensions of users' behaviour and perceptions regarding chatbot use. This debugging process is essential to increase the construct validity of the measurement instrument, thus facilitating the interpretation and generalization of the study results to the target population.

TABLE I
MEASUREMENT MODEL RESULTS FOR THE STUDY SAMPLE

	Loading the item	Cronbach´s alpha	CR (rho_a)	AVE
AFCU2	0.724	0.780	0.786	0.603
AFCU3	0.782			
AFCU4	0.784			
AFCU6	0.813			
CPRC2	0.718	0.802	0.805	0.558
CPRC3	0.743			
CPRC4	0.792			
CPRC5	0.727			
CPRC6	0.753			
CRRA1	0.818	0.850	0.854	0.626
CRRA2	0.806			
CRRA3	0.747			
CRRA5	0.821			
CRRA6	0.760			
ECI2	0.829	0.813	0.823	0.642
ECI3	0.733			
ECI4	0.784			
ECI6	0.854			

Table II shows the Heterotrait-Monotrait (HTMT) ratio for the study sample, a criterion for assessing discrimination between constructs in structural equation analysis or factorial confirmatory modelling. The HTMT is an indicator of discriminant validity that compares the mean of the correlations between items of different constructs (heterotrait) with the mean of the correlations between items of the same construct (monotrait).

AFCU and CPRC: The HTMT between AFCU (Autonomy Fostered by Chatbot Use) and CPRC (Chatbot Problem Resolution Capability) is 0.802. This value, although high, is generally considered acceptable if it is below 0.85 or 0.90, according to the thresholds recommended by various authors to confirm discriminant validity. This suggests that, although AFCU and CPRC are related, they represent distinct constructs.

AFCU and CRRA: The ratio of 0.691 between AFCU and CRRA (Chatbot Response Reliability and Accuracy) indicates good discrimination between these constructs. This value is well below the threshold, reflecting that they measure different aspects of chatbot usage.

AFCU and ECI: An HTMT of 0.648 between AFCU and ECI (Effective Chatbot Interaction) shows excellent discrimination between these constructs, confirming that each contributes unique information to the model.

CPRC and CRRA: With an HTMT of 0.706, good discrimination is also confirmed between the chatbot's problem-solving ability and the reliability and accuracy of its responses, indicating that these constructs are conceptually distinct.

CPRC and ECI: The value of 0.775 suggests adequate but relatively closer discrimination, indicating a stronger connection between how users perceive the chatbot's effective interaction and problem-solving ability. CRRA and ECI: The ratio of 0.701 between CRRA and ECI also indicates adequate discrimination, validating that both constructs, although related to the chatbot's operation, are distinct in terms of what they specifically measure.

The results indicate that the assessed constructs possess good discriminant validity overall, as all HTMT values are below the commonly accepted critical threshold of 0.85 or even 0.90. This reinforces the structure of the measurement model used in the study, ensuring that each construct is unique and measures different aspects of the chatbot's impact on the development of critical thinking among university students. These results are fundamental to proceeding with causal or predictive analyses in future studies, trusting that the constructs do not significantly overlap in conceptual terms.

The absence of the variable "Development of Critical Thinking with Chatbot (DCTC)" in Table II, which presents the Heterotrait-Monotrait (HTMT) ratio, can be mainly explained by its formative nature in the measurement model used in the study. Unlike reflex variables, where items are manifestations of the construct and are expected to be highly intercorrelated, a formative variable comprises items that cause or define the construct. In other words, the items in a formative variable may not be correlated, as each contributes a unique aspect to the overall construct.

TABLE II
HETEROTRAIT-MONOTRAIT RATIO (HTMT) FOR STUDY SAMPLE

	AFCU	CPRC	CRR	ECI
AFCU				
CPRC	0.802			
CRRA	0.691	0.706		
ECI	0.648	0.775	0.701	

Figure 1 illustrates a structural equation model that assesses the influence of effective interaction with a chatbot (ECI), chatbot problem-solving ability (CPRC), chatbot autonomy fostered by use (AFCU), and chatbot response reliability and accuracy (CRR) on the development of critical thinking (DCTC) in university students. Specifically, CPRC is observed to have a significant and positive impact on DCTC, with a coefficient of 0.691 and a p-value of 0.000, which underlines the importance of the chatbot's ability to effectively solve problems in fostering critical thinking. On the other hand, AFCU also shows a positive relationship with DCTC, although with a more modest magnitude (coefficient of 0.195, $p = 0.012$), indicating that the perception of autonomy provided by the chatbot contributes favourably to the development of critical thinking skills in students. In the presented model, career is included as a moderating variable to explore whether differences in the field of study could influence the effectiveness of these interactions with the chatbot. However, the results of the moderation by career reveal that there are no significant effects in most interactions. For example, the moderating coefficients of career in the relationships between CPRC and DCTC and AFCU and DCTC are not statistically significant ($p = 0.343$ and $p = 0.666$, respectively). This

suggests that the chatbot's effectiveness in developing critical thinking does not vary significantly between different careers, such as Medicine and Advertising Multimedia, indicating that the benefits of chatbot use may be generalizable across diverse academic fields.

Finally, the lack of statistical significance in the moderating roles implies that, regardless of career, fundamental chatbot characteristics, such as problem-solving ability and fostering autonomy, are crucial for developing critical thinking. This highlights the potential universality of chatbots as pedagogical tools in the higher education setting. However, it is essential to recognize that study design and specific chatbot features could influence these results, so future research should consider exploring in more depth how variations in chatbot design and teaching methodologies may affect students from various professional disciplines differently.

In the structural equation model presented, the coefficient of determination R^2 for the dependent variable Development of Critical Thinking with Chatbot (DCTC) is 0.689, or 68.9%. This R^2 value is a key statistical indicator that measures the proportion of the variability in the dependent variable that is predictable from the independent variables in the model. In simpler terms, it explains how well the data for the independent variables fit the variation in the dependent variable DCTC.

An R^2 of 68.9% in this context means that approximately 69% of the variability observed in the development of critical thinking through the use of the chatbot can be explained by the predictor variables included in the model, such as effective interaction with the chatbot (ECI), the problem-solving ability of the chatbot (CPRC), the autonomy fostered by the use of the chatbot (AFCU), and the reliability and accuracy of the chatbot's responses (CRR). This is a considerably high level of explanation, suggesting that the model captures well the main factors that influence the development of critical thinking when students interact with the chatbot.

In educational and technological research, R^2 of 68.9% is remarkably high, indicating that the chatbot as a pedagogical tool significantly impacts the development of critical skills. This result strongly indicates the importance of optimizing and focusing on the chatbot features that contribute the most to critical thinking for educators and educational technology developers. Furthermore, it suggests that, although other variables not included in the model could contribute to explaining the development of critical thinking, the selected variables are the most relevant for this specific purpose in the context studied.

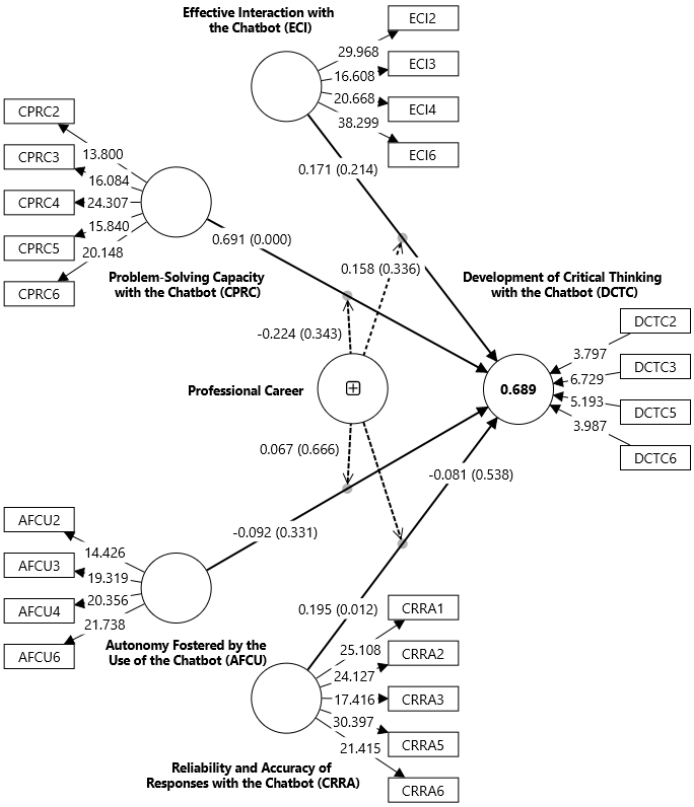

Figure 1 Results of the structural explanatory model and the moderating variable.

In the detailed analysis of Table IV, precise results are observed for the hypotheses of direct effects on developing critical thinking using chatbots. Hypothesis H2 (CPRC -> DCTC) shows a beta coefficient (β) of 0.691, with a mean of 0.658 and a t-value of 4.242, resulting in a p-value of 0.000, indicating that the problem-solving ability of the chatbot positively and significantly influences the development of critical thinking. Hypothesis H3 (CRRA -> DCTC) is also accepted with a β of 0.195, mean of 0.198, t-value of 2.527 and p-value of 0.012, underlining that the reliability and accuracy of the chatbot's response are important factors. On the other hand, hypotheses H1 (AFCU -> DCTC) and H4 (ECI -> DCTC) were rejected with coefficients of -0.092 and 0.171, respectively, and p-values of 0.331 and 0.214, indicating that neither fostered autonomy nor effective chatbot interaction have significant effects on critical thinking.

As for the hypotheses exploring the moderating effect of "career", all were rejected, indicating that career does not significantly modify the relationship between chatbot characteristics and the development of critical thinking. Hypothesis H5 (Professional Career x ECI -> DCTC) showed a β of 0.158 with a p-value of 0.336. At the same time, H6 (Professional Career x CRRA -> DCTC), H7 (Professional Career x CPRC -> DCTC), and H8 (Professional Career x AFCU -> DCTC) presented coefficients of -0.081, -0.224, and 0.067 with p-values of 0.538, 0.343, and 0.666 respectively. These results suggest that the impact of chatbot features on the

development of critical thinking is consistent regardless of students' career paths.

In conclusion, the structural model reveals that problem-solving ability and reliability in chatbot responses are crucial for developing critical thinking in college students, while perceived autonomy and quality of direct interaction do not play a significant role. Furthermore, the consistency of these effects across different career paths suggests that chatbots can be an effective educational tool without the need to tailor their features to specific fields of study. This highlights the utility of chatbots as versatile pedagogical tools in the higher education environment.

TABLE III
STRUCTURAL MODEL REGRESSION COEFFICIENTS FOR THE STUDY SAMPLE

Hypothesis	β	mean (M)	t vulues	p values	Result
H1: AFCU -> DCTC	-0.092	-0.071	0.973	0.331	Rejected
H2: CPRC -> DCTC	0.691	0.658	4.242	0.000	Accepted
H3: CRRA -> DCTC	0.195	0.198	2.527	0.012	Accepted
H4: ECI -> DCTC	0.171	0.191	1.242	0.214	Rejected
H5: Professional Career x ECI -> DCTC	0.158	0.153	0.963	0.336	Rejected
H6: Professional Career x CRRA -> DCTC	-0.081	-0.076	0.616	0.538	Rejected
H7: Professional Career x CPRC -> DCTC	-0.224	-0.234	0.947	0.343	Rejected
H8: Professional Career x AFCU -> DCTC	0.067	0.077	0.431	0.666	Rejected

IV. DISCUSSION AND CONCLUSIONS

Research on the moderating effect of a professional career on critical thinking development using ChatGPT in college students reveals significant variations that could depend on the field of study. Interaction with ChatGPT can strengthen general cognitive skills. However, the effectiveness of this technology can vary significantly across academic disciplines, which still requires further analysis in the educational context [16, 17].

Furthermore, the risks associated with reliance on chatbots and disseminating misinformation are particularly problematic in fields where accuracy is crucial. For example, in health sciences, the spread of incorrect information by chatbots could have serious consequences, negatively affecting the development of critical thinking and evidence-based clinical decision-making [12, 20]. On the other hand, biases in chatbot algorithms can lead to erroneous conclusions, which is especially worrying in disciplines where a high level of analysis and critical evaluation is required. The need for careful integration of chatbots that ensure complementarity with human judgment becomes evident, highlighting the importance of mitigating biases and encouraging critical and reflective use of this technology [23, 24].

Thus, the adaptation of the integration of ChatGPT and other chatbots in higher education should be specific to each degree program, ensuring that all students can benefit from their use without compromising their ability to develop independent and well-founded critical thinking. This approach personalizes the use of technology for different academic fields and promotes more equitable and practical education in developing essential critical skills [25, 28]. The study revealed significant findings on the impact of chatbot interaction on developing critical thinking among college students and assessed whether career path moderates this relationship. The results indicate that specific chatbot characteristics, such as its problem-solving ability and the reliability of its responses, are critical factors that significantly contribute to developing critical thinking. However, variables such as perceived autonomy and the effectiveness of chatbot interaction did not show a significant impact.

Furthermore, the career path was not a significant moderator in the relationship between chatbot interaction and critical thinking development. This suggests that the benefits of using chatbots to foster critical thinking skills are generalizable and not specific to a particular academic discipline, allowing educational institutions to implement these technological tools more uniformly across diverse fields of study.

In conclusion, this study underscores the importance of integrating advanced technologies such as chatbots into college education, highlighting their potential to enhance critical thinking skills across academic fields. Future research is also recommended that explores how different features and types of interaction with chatbots can more effectively influence the development of critical thinking, considering other contextual factors and student characteristics that could affect this dynamic.

REFERENCES

[1] N. Suresh, N. Mukabe, V. Hashiyana, A. Limbo, and A. Hauwanga, "Career Counseling Chatbot on Facebook Messenger using AI," in *ACM International Conference Proceeding Series*, 2021, pp. 65-73, doi: 10.1145/3484824.3484875.

[2] S. Agarwal, N. T. D. Linh, and G. J. R. Aponte, "Student Perception Regarding Chatbot for Counselling in Higher Education," in *Intelligent Systems Reference Library*, vol. 215, 2022, pp. 263-281.

[3] R. Suriano, A. Plebe, A. Acciai, and R. A. Fabio, "Student interaction with ChatGPT can promote complex critical thinking skills," *Learning and Instruction,* Article vol. 95, 2025, Art no. 102011, doi: 10.1016/j.learninstruc.2024.102011.

[4] S. M. Araujo and R. Cruz-Correia, "Incorporating ChatGPT in Medical Informatics Education: Mixed Methods Study on Student Perceptions and Experiential Integration Proposals," *JMIR Medical Education,* Article vol. 10, 2024, Art no. e51151, doi: 10.2196/51151.

[5] L. M. Silitonga, S. Suciati, and E. F. Prastikawati, "The Impact of Integrating AI Chatbots and Microlearning into Flipped Classrooms: Enhancing Students' Motivation and Higher-Order Thinking Skills," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 2024, vol. 14786 LNCS, pp. 184-193, doi: 10.1007/978-3-031-65884-6_19.

[6] A. Q. M. Emran, A. Aldallal, and A. Nadheer, "Investigating the Impact of ChatGPT on Enhancing University Students' Critical Thinking Skills," in *Studies in Systems, Decision and Control*, vol. 538, 2024, pp. 567-574.

[7] J. Haqbeen, S. Sahab, and T. Ito, "From Interactive Idea Development to Solution Planning: An AI-assisted Discussion Facilitation Timeline for Collaborative Planning," in *ACM International Conference Proceeding Series*, 2024, pp. 1026-1029, doi: 10.1145/3657054.3659120.

[8] T. Tanprasert, S. Fels, L. Sinnamon, and D. Yoon, "Debate Chatbots to Facilitate Critical Thinking on YouTube: Social Identity and Conversational Style Make A Difference," in *Conference on Human*

Factors in Computing Systems - Proceedings, 2024, doi: 10.1145/3613904.3642513.
[9] L. Farinetti and L. Canale, "Chatbot Development Using LangChain: A Case Study to Foster Critical Thinking and Creativity," in *Annual Conference on Innovation and Technology in Computer Science Education, ITiCSE*, 2024, vol. 1, pp. 401-407, doi: 10.1145/3649217.3653557.
[10] R. A. Fabio, A. Plebe, and R. Suriano, "AI-based chatbot interactions and critical thinking skills: an exploratory study," *Current Psychology,* Article 2025, doi: 10.1007/s12144-024-06795-8.
[11] M. H. Ali, M. Kainat, M. Maqsood, S. F. Fernandez, S. Ali, and M. Ahmad, "Chatbots in academic literacy exploring AI in education," in *Enhancing Higher Education and Research With OpenAI Models*, 2024, pp. 37-59.
[12] S. Murtiningsih, A. Sujito, and K. K. Soe, "Challenges of using ChatGPT in education: a digital pedagogy analysis," *International Journal of Evaluation and Research in Education,* Article vol. 13, no. 5, pp. 3466-3473, 2024, doi: 10.11591/ijere.v13i5.29467.
[13] N. Baláž, J. Porubän, M. Horváth, and T. Kormaník, "Using ChatGPT During Implementation of Programs in Education," in *OpenAccess Series in Informatics*, 2024, vol. 122, doi: 10.4230/OASIcs.ICPEC.2024.18.
[14] X. Deng and Z. Yu, "A Meta-Analysis and Systematic Review of the Effect of Chatbot Technology Use in Sustainable Education," *Sustainability (Switzerland),* Review vol. 15, no. 4, 2023, Art no. 2940, doi: 10.3390/su15042940.
[15] W. Tam, T. Huynh, A. Tang, S. Luong, Y. Khatri, and W. Zhou, "Nursing education in the age of artificial intelligence powered Chatbots (AI-Chatbots): Are we ready yet?," *Nurse Education Today,* Article vol. 129, 2023, Art no. 105917, doi: 10.1016/j.nedt.2023.105917.
[16] N. Pellas, "The role of students' higher-order thinking skills in the relationship between academic achievements and machine learning using generative AI chatbots," *Research and Practice in Technology Enhanced Learning,* Article vol. 20, 2025, Art no. 36, doi: 10.58459/rptel.2025.20036.
[17] Y. Qawqzeh, "Exploring the Influence of Student Interaction with ChatGPT on Critical Thinking, Problem Solving, and Creativity," *International Journal of Information and Education Technology,* Article vol. 14, no. 4, pp. 596-601, 2024, doi: 10.18178/ijiet.2024.14.4.2082.
[18] E. Y. Chou and W. C. Hsu, "Conversational Service Experiences in Chatbots: A Perspective on Cognitive Load," *Management Review (Taiwan),* Article vol. 40, no. 1, pp. 21-46, 2021, doi: 10.6656/MR.202101_40(1).CNI021.
[19] E. S. Y. E. Hui, "Incorporating Bloom's taxonomy into promoting cognitive thinking mechanism in artificial intelligence-supported learning environments," *Interactive Learning Environments,* Article 2024, doi: 10.1080/10494820.2024.2364237.
[20] H. Chin, A. Zhunis, W. Dong, C. Cha, and M. Cha, "Health Implications on the Excessive Use of AI Chatbots," *Journal of Institutional and Theoretical Economics,* Article vol. 180, no. 2, pp. 347-364, 2024, doi: 10.1628/jite-2024-0015.
[21] B. Mohammad *et al.*, "The Pros and Cons of Using ChatGPT in Medical Education: A Scoping Review," in *Studies in Health Technology and Informatics*, 2023, vol. 305, pp. 644-647, doi: 10.3233/SHTI230580.
[22] A. R. Vargas-Murillo, I. N. M. de la Asuncion Pari-Bedoya, and F. de Jesús Guevara-Soto, "Challenges and Opportunities of AI-Assisted Learning: A Systematic Literature Review on the Impact of ChatGPT Usage in Higher Education," *International Journal of Learning, Teaching and Educational Research,* Article vol. 22, no. 7, pp. 122-135, 2023, doi: 10.26803/ijlter.22.7.7.
[23] M. H. Elnagar *et al.*, "ChatGPT and dental education: Opportunities and challenges," *Seminars in Orthodontics,* Review vol. 30, no. 4, pp. 401-404, 2024, doi: 10.1053/j.sodo.2024.03.004.
[24] M. Sallam, "ChatGPT Utility in Healthcare Education, Research, and Practice: Systematic Review on the Promising Perspectives and Valid Concerns," *Healthcare (Switzerland),* Review vol. 11, no. 6, 2023, Art no. 887, doi: 10.3390/healthcare11060887.
[25] H. Hawk, M. Coriasco, and J. R. Jones, "Generative Artificial Intelligence: A Reflexive Thematic Analysis of Nursing Students' Perceptions Following a Guided Learning Activity," *Nurse Educator,* Article 2024, doi: 10.1097/NNE.0000000000001736.
[26] O. G. Aguilar, F. Delgado-Delgado, J. Meza-Málaga, O. Turpo-Gebera, and F. T. Apaza, "Predictors of Academic Performance through the Use Of Chatgpt in University Students," *Human Review. International Humanities Review / Revista Internacional de Humanidades,* Article vol. 21, no. 2, pp. 411-421, 2023, doi: 10.37467/revhuman.v21.5077.
[27] O. Guttierrez-Aguilar, E. Huarsaya-Rodriguez, and A. Duche-Pérez, "The Mediating Effect of Academic Performance on ChatGPT Satisfaction in University Students," in *Lecture Notes in Networks and Systems*, 2024, vol. 903, pp. 353-365, doi: 10.1007/978-3-031-52258-1_26.
[28] N. Karjanto, "Investigating difficulties and enhancing understanding in linear algebra: Leveraging SageMath and ChatGPT for (orthogonal) diagonalization and singular value decomposition," *Mathematical Biosciences and Engineering,* Review vol. 20, no. 9, pp. 16551-16595, 2023, doi: 10.3934/mbe.2023738.