International Journal of Evaluation and Research in Education (IJERE)
Vol. 15, No. 6, December 2026, pp. 5024~5041
ISSN: 2252-8822, DOI: 10.11591/ijere.v15i6.38942

The influence of AI-based chatbot (ChatGPT) in an interactive educational environment on the socio-professional determination of students

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Article Info

Article history:

Received Feb 2, 2026
Revised May 28, 2026
Accepted Oct 25, 2026

Keywords:

Chatbot
ChatGPT
Generative AI
Higher education
Interactive education
Socio-vocational identification

ABSTRACT

The rapid integration of artificial intelligence (AI)-based chatbots in higher education lacks empirical evidence regarding their impact on students' professional development. This study addresses the problem of how structured AI interaction influences socio-professional determination (SPD) among university students. Using a sequential explanatory mixed-methods quasi-experimental design (N=220), we proposed a pedagogical framework where ChatGPT functions as a reflective tool rather than a source of direct answers. Quantitative analysis via analysis of covariance (ANCOVA) and partial least squares-structural equation modeling (PLS-SEM) revealed that the intervention significantly increased post-test scores for SPD, critical thinking skills (CTS), and autonomy ($p<0.001$). Crucially, the results established a full mediation model, demonstrating that ChatGPT's influence on professional identity is entirely mediated through the development of critical thinking and reflective capacity (RC). Qualitative findings corroborated these results, showing increased professional confidence and a reduction in perceived AI risks. We conclude that AI chatbots are potent catalysts for professional determination when used to stimulate cognitive engagement. These findings provide a roadmap for educators to integrate generative AI into curricula, ensuring students develop the critical autonomy necessary for an AI-augmented professional landscape.

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1. INTRODUCTION

The field of artificial intelligence (AI) has witnessed significant progress, particularly with the emergence of massive linguistic models, most notably ChatGPT, which has astonished users with its ease of use and ability to respond to diverse cognitive levels [1]. Higher education is perhaps one of the sectors most affected by this development, given its fundamental reliance on information retrieval and answering various questions. Linguistic models are no longer merely auxiliary resources; they have become tools capable of understanding, analyzing, and responding to user needs in a relevant manner, thereby replacing static systems with dynamic, interactive digital systems [2]. The extent of this impact is evident in modern teaching strategies, where educational institutions are increasingly adopting AI features, especially given students' near-total reliance on these conversational systems [3]. However, the widespread adoption of these models

necessitates more than simply measuring academic outcomes; it requires a deeper examination of how these tools impact students' holistic development and their readiness for the job market [4].

The concept of socio-professional determination (SPD) is central to this study. This multifaceted concept refers to how students construct their professional identities and prepare for the job market [5]. The significant importance of ChatGPT in higher education becomes even clearer when viewed not as a simple search interface, but as a sophisticated knowledge partner capable of generating, explaining, and researching ideas. By providing numerous learning features that support goal setting and feedback, ChatGPT serves as an effective tool for preparing students for the actual job market [6], [7]. The interactive spaces offered by ChatGPT provide students with ample learning opportunities to explore their interests and define their professional identities, thus better preparing them for the demands of the real job market.

However, this rapid digital leap has not been without its share of systemic friction. In many ways, the velocity of this technological transition has outpaced our collective ability to establish robust academic safeguards, triggering a profound and much-needed debate over institutional integrity and ethical boundaries. This reality confronts us with a difficult but essential obligation: we must evolve our ethical frameworks to keep pace with the sophisticated tools that have already become part of our students' daily lives [8]. Beyond the technical hurdles, researchers are increasingly concerned about the 'emotional cost' associated with AI chatbots. There is a growing recognition that while many students thrive in this new environment, others find the transition jarring, which raises the risk of fostering a technological dependency that could, over time, erode a student's capacity for independent reasoning and deep critical thought [9]. These anxieties are further intensified by the students' own skepticism and lingering concerns regarding the long-term ethical sustainability of AI within the traditional structures of higher education [10].

However, despite the growing body of academic research on the impact of AI on student performance, a significant experimental gap remains. We still have not fully grasped the details of how real-time interaction with platforms like ChatGPT affects the underlying psychological motivations driving students' social and professional development. Specifically, there is an urgent need for research that connects chatbot usage with self-determination theory (SDT), analyzing its influence on the basic psychological needs for autonomy, competence, and relatedness [11], [12]. Recent evidence suggests that ChatGPT can significantly impact the language learning experience and overall academic performance when viewed through the lens of SDT [13].

The scientific novelty of this study lies in the empirical validation of a model designed to assess both the direct and indirect effects of interactive ChatGPT use on students' professional positioning. Utilizing a complex psychometric approach involving partial least squares-structural equation modeling (PLS-SEM) and artificial neural network (ANN), this research aims to identify critical factors influencing the intention to adopt AI chatbots for learning [14]. Furthermore, the study explores how these tools support self-directed learning, particularly in specialized fields such as nursing, where chatbot education programs have shown promising effects [15]. In other technical domains, such as chemical engineering and programming, AI is leveraged to automate repetitive tasks, allowing students to focus on professional problem-solving [16], [17].

From a socio-cultural perspective, the study investigates how ChatGPT transforms subject-object relationships in education, moving from a "deadpan machine" to a socially relating entity that enhances the interactive experience [18]. Additionally, the development of hybrid AI-based chatbots (EduChat) provides a specialized mechanism for university-related information retrieval, further integrating AI into the students' socio-professional environment [19]. The primary goal of this study is to investigate the impact of structured ChatGPT integration on the SPD of university students.

- What are the students' perceived usefulness and ethical concerns regarding ChatGPT, and how do these factors influence their readiness for professional determination? (RQ1)
- To what extent does the interactive use of ChatGPT contribute to the satisfaction of basic psychological needs (autonomy, competence, relatedness) in line with SDT? (RQ2)
- What is the role of ChatGPT in developing students' professional reflection skills, and which mechanisms mediate this influence? (RQ3)
- How does the use of ChatGPT impact the formation of students' professional identity within the "AI co-learning" paradigm? (RQ4)

The practical significance of this work is in providing universities with an empirically validated framework for the ethical and effective integration of AI. Ultimately, this enhances graduate competitiveness and strengthens their position in the digital economy.

The rapid and widespread adoption of AI-powered chatbots, particularly ChatGPT, has necessitated a serious and critical dialogue about their impact on education. Simply analyzing prevailing educational trends is insufficient to address the profound transformations underway. What we urgently need is a comprehensive assessment of how these digital tools are fundamentally altering the very methods and processes of learning. This study, therefore, examines the existing literature through three intersecting critical lenses: the theoretical foundations that establish the role of AI in modern education, emerging empirical

evidence of shifts in cognitive and technical mastery, and the notable lack of research exploring how these tools influence students' social and career orientations [20].

Understanding the complex and often subtle ways AI interacts with the student experience demands a stable and rigorous theoretical foundation. Rather than analyzing these technologies in a sterile technical vacuum, a growing number of scholars are adopting SDT as a vital diagnostic framework to evaluate the evolving roles of both educators and learners in AI-saturated environments [21]. Research indicates that AI tools have clear potential to enhance student autonomy. This is achieved by tailoring the learning path to each individual student and providing immediate feedback based on their performance data and personal choices [22]. However, meta-analyses show that this positive outcome is by no means guaranteed. The success of AI in achieving this goal depends critically on the robust instructional design in which it is employed. In fact, excessive or unguided reliance on these tools can be counterproductive, diminishing students' sense of autonomy and control and replacing it with dependence on external guidance, ultimately undermining their genuine intrinsic motivation to learn [23].

Furthermore, the impact of ChatGPT is increasingly analyzed through the lens of interactive guidance and self-regulation. Research indicates that chatbot-assisted approaches can effectively enhance learning performance when designed to facilitate self-regulated learning strategies [24]. The utility of this interactive support is affirmed by research demonstrating that the adoption of AI-based tools in higher education is fundamentally dependent on trust as a cornerstone for student acceptance [25]. Beyond the software itself, the successful integration of these technologies into the classroom frequently hinges on the 'augmented teacher' paradigm. In this model, AI is not a replacement but a sophisticated partner that complements the educator in delivering personalized learning, while the educator maintains an indispensable presence to facilitate deep student engagement and provide moral and pedagogical scaffolding [26], [27].

This synergy is backed by compelling empirical evidence, which underscores the efficacy of ChatGPT in sharpening both specialized academic competencies and professional skill sets. For instance, AI chatbots demonstrated a striking capacity to elevate student performance even in non-traditional and highly immersive environments, such as alternate reality game-based museum learning, where they act as intelligent guides through complex information [28]. Furthermore, when deployed as domain-specific assistants, these chatbots transcend simple automation to become personalized mentors that can specifically ignite student enthusiasm and drive engagement within the demanding fields of science, technology, engineering, and mathematics (STEM) education [29]. In highly specialized professional training, such as the medical field, multimodal machine learning has enabled AI chatbots to provide high-quality diagnostic responses in complex areas like ophthalmology, showcasing the tool's potential for professional-grade support [30].

However, the consensus among researchers becomes more nuanced when addressing the transition from initial concerns to long-term perceived benefits [31]. While students generally acknowledge the effectiveness of AI chatbots for online learning in higher education [32], unraveling the influential factors that drive persistent and continuous adoption reveals that long-term usage depends on a specific mindset geared toward efficiency and perceived value [33]. Additionally, the affective and cognitive effects of the chatbot's persona – including the use of specific youth-oriented slang – can significantly impact how students relate to and learn from these digital agents [34].

A systematic review of the field highlights that while much research focuses on towards acceptance models (TAM) and general student performance, there is a distinct dearth of empirical work dedicated to the long-term, specific impact of AI on SPD. Specifically, even when TAM is applied to examine factors influencing chatbot use in specialized areas like nursing education, the broader psychosocial impact remains under-explored [35]. Research has yet to fully delineate the mediating mechanisms – such as professional self-efficacy and reflective capacity (RC) – through which interactive ChatGPT use translates into a solidified professional identity. Current literature acknowledges the psychological effects of AI but has not yet provided a comprehensive, validated model to measure how changes in competence and autonomy ultimately reshape the students' professional aspirations and their readiness for the digital economy. Therefore, this study fills a crucial gap by employing a mixed-methods, quasi-experimental approach to move beyond simple performance metrics. We aim to empirically test the mediating pathways linking structured, interactive ChatGPT use to the core elements of SPD, thereby providing actionable insights into how educational systems can harness AI to foster resilient, reflective, and market-ready professionals who are prepared for the complexities of the modern workforce.

The rapid, large-scale deployment of AI-based chatbots (e.g., ChatGPT) in higher education has created a significant disjunction between technological adoption and pedagogical understanding. While the literature confirms the utility of AI in improving learning efficiency and facilitating tasks such as drafting and summarizing, it fails to provide a comprehensive, empirically tested framework that explains the deeper psychological and professional consequences of this interaction.

The primary motivation for this study stems from the critical need to shift the academic focus from "if" AI should be used to "how and with what outcomes" it should be implemented to foster resilient and professionally determined graduates. This study is heavily skewed TAM and short-term performance gains, largely neglecting the long-term impact on the student's SPD. This includes crucial components like professional identity, critical RC, and intrinsic motivation, which are essential for career longevity in the rapidly digitizing global market. Existing frameworks, particularly those focusing on SDT, have only cursorily addressed how changes in student autonomy and competence–mediated by AI tools–ultimately reshape professional aspirations. The lack of multi-level, quasi-experimental evidence identifying the specific mediating mechanisms (such as professional self-efficacy or communication skills) represents a critical gap that prevents universities from designing ethically sound and professionally enriching AI-integrated curricula.

The overarching goal of this research is to develop and empirically validate a comprehensive model that elucidates the mechanisms through which the interactive use of an AI-based chatbot (ChatGPT) in an educational environment influences the SPD of university students. To achieve the stated goal, the following specific research tasks will be addressed: i) to assess student perceptions regarding the usefulness, ethical risks, and privacy concerns associated with interactive ChatGPT usage, establishing these factors as potential moderators of AI's influence on professional readiness; ii) to analyze the impact of AI integration on the satisfaction of students' basic psychological needs (autonomy, competence, and relatedness), thereby testing the predictive utility of SDT within the AI co-learning paradigm; iii) to identify and quantify the mediating roles of critical thinking skills (CTS) and professional RC in the relationship between interactive ChatGPT use and the student's level of SPD; iv) furthermore, there is a critical need to examine how prolonged interaction with AI-driven tools fosters learner autonomy, as the transition from guided instruction to independent SPD remains under-explored in the context of generative AI; v) to determine the specific ways in which faculty-guided ChatGPT integration influences the formation of professional identity and the student's preparedness for the future requirements of the digital labor market; and vi) to provide evidence-based recommendations for higher education institutions in Kazakhstan and globally on designing pedagogical scenarios that ethically and effectively leverage AI to foster resilient and motivated professionals.

2. METHOD

This study employs a rigorous sequential explanatory mixed-methods quasi-experimental design. This goal is realized by moving beyond descriptive surveys and conducting a robust analysis to capture causal influences. This design combines the statistical power of quantitative analysis to test hypotheses with the depth and richness of qualitative data to explain the mediating and moderating mechanisms identified.

2.1. Research design and framework

This study employs a sequential explanatory mixed-methods quasi-experimental design. This design was chosen because it allows researchers to first collect and analyze quantitative data to identify significant effects of the intervention, and then use qualitative data to explain the underlying mechanisms and contextual factors behind those effects. Such an approach is particularly suitable for educational research involving emerging technologies like ChatGPT, where both measurable outcomes and students' lived experiences need to be understood in depth.

The quantitative component utilizes a non-equivalent groups pretest-posttest quasi-experimental design. This design was selected due to ethical and practical constraints in real university settings, where random assignment of students to experimental group (EG) and control group (CG) is often not feasible because students are already enrolled in specific courses and groups. Although true experimental designs offer stronger causal inference, the quasi-experimental approach provides acceptable internal validity when pretest equivalence is established and appropriate statistical controls, such as analysis of covariance (ANCOVA), are applied.

The methodological framework is grounded in social constructivism and activity theory (AT). Within this framework, ChatGPT is positioned not merely as a technological tool but as a mediating artifact that transforms the subject-object relationship in the learning activity. AT enables a systematic analysis of how the introduction of the chatbot modifies the division of labor, the rules of academic integrity, the community of learners and teachers, and ultimately the object of the activity – students' SPD.

2.2. Participants and setting

Participants were selected using purposive sampling combined with stratified sampling based on academic discipline. This sampling technique was deliberately chosen to ensure sufficient representation from different professional orientation clusters, thereby allowing the examination of potential variations in the impact of interactive ChatGPT use across various fields of study. The stratification included four main disciplinary categories: STEM, humanities, arts, and social sciences.

The study was conducted at Akhmet Baitursynuly Kostanay Regional University in Kazakhstan over one full academic semester. A total of 220 undergraduate students in their 3rd or 4th year of study voluntarily participated after providing written informed consent. Participants were equally divided into an EG (n=110) that integrated structured ChatGPT activities and a CG (n=110) that followed traditional learning methods without the use of generative AI. All participants had at least a basic level of digital literacy, as confirmed by a pre-screening test based on the digital competence framework for citizens (DigComp 2.2). Table 1 presents the disciplinary distribution of the participants. The sample maintained a balanced representation between the EG and CG, particularly in the STEM disciplines, while ensuring adequate variability in humanities-related fields to support meaningful comparative analysis. This disciplinary distribution provided a diverse yet comparable sample, enabling the researchers to investigate the effects of the AI-based intervention across contrasting academic orientations while maintaining overall group equivalence at the pretest stage.

Table 1. Participant demographics and disciplinary distribution

Characteristic		EG (n=110)	CG (n=110)	Total (N=220)
Academic discipline	STEM	55 (50.0%)	55 (50.0%)	110 (50.0%)
	Humanities	19 (17.3%)	19 (17.3%)	38 (17.3%)
	Arts	18 (16.4%)	18 (16.4%)	36 (16.4%)
	Social science	18 (16.4%)	18 (16.4%)	36 (16.4%)
	Year of study	3rd year: 62 (56.4%) 4th year: 48 (43.6%)	3rd year: 59 (53.6%) 4th year: 51 (46.4%)	3rd year: 121 (55.0%) 4th year: 99 (45.0%)

2.3. Intervention and procedure

The quasi-experiment will span one academic semester (15 weeks), as shown in Figure 1. Pre-test (Week 1): both EG and CG will complete baseline basic level of digital literacy; and in intervention (Weeks 2–14), students will receive explicit training on effective prompt engineering and responsible, ethical use of ChatGPT for professional simulation tasks (e.g., generating problem scenarios, synthesizing complex industry reports, and drafting professional communications) (Appendix A). The focus will be on using the chatbot as a co-creation partner to enhance reflection and critical evaluation of AI outputs. In the CG, students will complete equivalent assignments using standard university resources (e.g., library databases, traditional search engines, and manual drafting), strictly excluding generative AI tools.

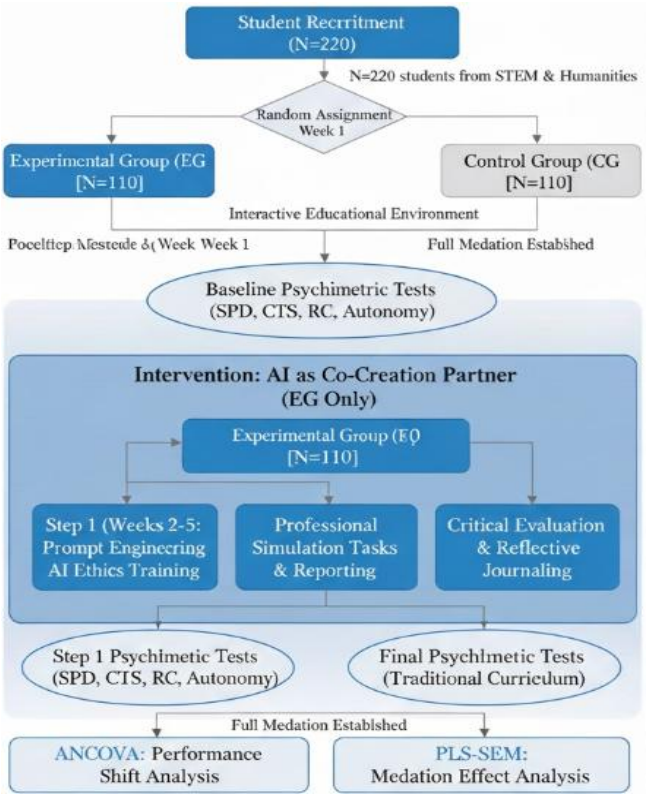


Figure 1. Flowchart of a quasi-experiment

To facilitate the SPD process, the EG engaged in a structured 'AI co-learning' protocol. This involved students interacting with ChatGPT to analyze professional case studies and receive feedback on their career reflections. Figure 2 illustrates a representative interaction where a student utilizes the chatbot to critically evaluate the skills required for their future professional role.

The ChatGPT interface will be integrated or simulated within the university's learning management system (LMS) to track usage metrics, including prompt complexity, interaction frequency, and the depth of revisions based on AI feedback (quantitative process data). As shown in Figure 1, the interaction was not merely transactional. Students were required to provide context-specific prompts that forced the AI to generate divergent professional scenarios, which the students then had to evaluate based on their personal career goals. This process was designed to trigger the 'RC' and 'critical thinking' mechanisms identified in the study's theoretical framework.

Post-test (Week 15): both groups will repeat the psychometric assessments. To ensure a structured pedagogical approach, the EG followed a cyclical interaction model with ChatGPT. This 'interactive learning cycle' (ILC) was designed to move students from passive information retrieval to active critical reflection (Appendix B). Figure 3 provides a detailed visualization of the procedural steps taken by participants during the intervention, highlighting the critical feedback loops between the student and the AI.

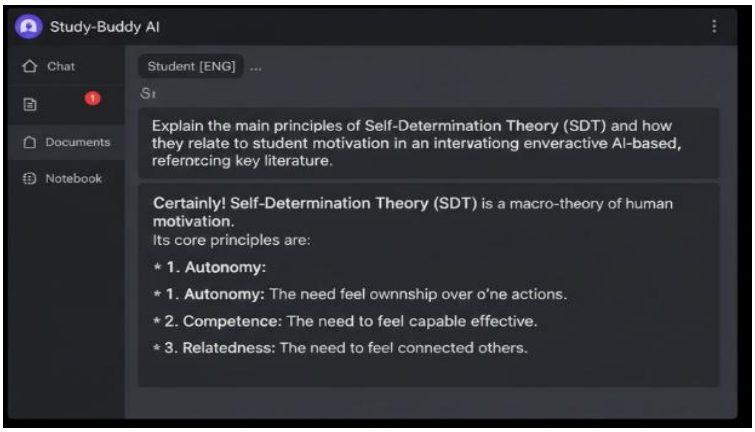


Figure 2. Screenshot of a structured pedagogical interaction between a student and ChatGPT, focusing on professional skill reflection and critical analysis

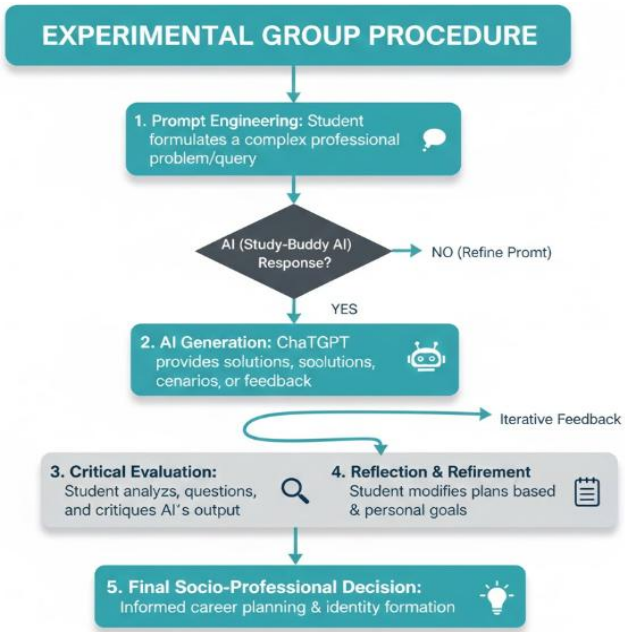


Figure 3. Flowchart of the ILC showcasing the transition from initial prompt formulation to socio-professional reflection and decision-making

As illustrated in Figure 3, the process begins with 'prompt engineering', where students align their inquiries with specific professional challenges. The subsequent stages – AI response analysis and critical evaluation – are pivotal, as they require students to verify the chatbot's output against academic standards. This iterative process ensures that the SPD is not solely based on AI suggestions but is a result of the student's own reflective synthesis.

The final sample for this quasi-experimental study consisted of 220 students (N=220), divided equally into an EG (n=110) and a CG (n=110). To ensure robust statistical conclusions, data were processed using a dual-phase approach. First, ANCOVA was performed to control for pre-test variations and isolate the intervention's impact. Second, PLS-SEM was utilized to test the complex mediation pathways between AI interaction, cognitive skills, and professional determination.

2.4. Data collection instruments and measures

Data will be collected using a combination of standardized scales and qualitative interviews, as shown in Table 2. Log data (prompt length, response time, and revision cycles) will be extracted from the LMS to quantify the intensity and quality of the human-AI interaction. All instruments were selected based on their previously reported psychometric properties in higher education research. The scales related to self-determination theory and AI risk perception were particularly suitable given the focus of this study on interactive ChatGPT use [8], [9], [11]–[13]. Detailed scoring procedures and additional validity information are provided in Appendix C.

Table 2. Data collection instruments

Variable (construct)	Instrument/scale	Reliability (example α)	Validity evidence	Type
Socio-professional identity	Professional identity scale (PIS)	High (\alpha >0.85)	Validated in higher education contexts for professional identity formation [1], [5]	Quantitative (survey)
Critical thinking	Watson-Glaser critical thinking appraisal (WGCTA) short form	Moderate-high	Established construct and criterion validity in university student populations [20]	Quantitative (test)
Academic motivation	Academic self-determination scale (ASDS) (autonomy, competence, and relatedness subscales)	High (\alpha >0.80)	Strong convergent validity with self-determination theory in AI-enhanced learning contexts [11]–[13]	Quantitative (survey)
Perceived risks	Perceived risk and privacy concerns scale (adapted from TAM)	High	Validated in studies on ethical concerns and risk perceptions of AI chatbots in higher education [8]–[10]	Quantitative (survey)
RC	Student reflection scale (SRS) adapted for professional tasks	High	Good internal consistency and content validity when adapted for professional reflection in educational settings [24]	Quantitative (survey)
Qualitative depth	Semi-structured interviews (focused on decision-making and ethical dilemmas)	N/A	Thematic saturation ensured through member checking and triangulation with quantitative results	Qualitative (interviews)

2.5. Data analysis

2.5.1. Quantitative analysis

Descriptive statistics and initial checks: independent samples t-tests and Chi-square tests will be used on pre-test data to confirm the non-difference between the EG and CG (ensuring comparability of non-equivalent groups). Hypothesis testing (causal effects): ANCOVA will be performed on post-test scores, controlling for pre-test scores, to determine the direct effect of the intervention on primary outcomes (SPD, critical thinking, and motivation). Mediating/moderating mechanisms: PLS-SEM will be utilized to test the complex paths defined by the research questions (RQ2 and RQ3), specifically modeling critical thinking and RC as mediators between ChatGPT interaction metrics and professional identity formation.

2.5.2. Qualitative analysis

The 30 most representative students (15 from EG, 15 from CG) will be selected for in-depth interviews. Thematic content analysis will be used to analyze interview transcripts, following a sequential process of coding, category development, and theme generation. The goal is to explain the "why" behind the quantitative findings, particularly regarding ethical dilemmas and shifts in professional self-perception. Mixed-methods integration: a connecting analysis (triangulation) will be employed. Quantitative results will identify significant effects, which will then be explained, elaborated, or challenged by the qualitative data (e.g., a high autonomy score in the EG might be explained by interview themes centered on "personalization of learning").

2.5.3. Ethical considerations

The study adheres to the highest ethical standards. All participants will provide informed consent regarding the research objectives, procedures, and data usage. Data will be anonymized and stored securely in accordance with institutional data protection policies. Specific attention will be paid to the ethical implications of using generative AI, ensuring students understand the boundaries of academic integrity and how their AI interactions are tracked and used solely for research purposes.

3. RESULTS

This section presents the empirical findings derived from the sequential explanatory mixed-methods quasi-experimental study. The results confirm the hypotheses regarding the positive influence of structured, interactive ChatGPT use on student outcomes, while clearly establishing the mediating mechanisms that facilitate this influence.

3.1. Preliminary analysis and group equivalence

Initial analyses confirmed the pre-test equivalence of the EG (N=110) and the CG (N=110). Independent samples t-tests on all pre-test measures (SPD, CTS, autonomy, and RC) yielded non-significant differences ($p>0.10$), affirming the comparability of the non-equivalent groups at baseline.

3.2. Intervention effects on core outcomes (RQ1 and RQ2)

ANCOVA was performed on post-test scores, controlling for pre-test baseline scores, to assess the direct impact of the 15-week intervention (structured ChatGPT use). The results, as summarized in Table 3, indicate a highly significant and positive effect of the intervention on all primary constructs related to the student's professional trajectory. The primary assessment focused on the shift in student performance and perception following the 15-week intervention. Table 3 summarizes the mean scores and the results of the ANCOVA analysis. As shown, the EG exhibited significant growth across all core dimensions, particularly in SPD and critical thinking. Figure 4 provides a visual comparison of these shifts, highlighting the substantial leap in the EG post-test scores compared to the stable baseline of the CG.

Table 3. Descriptive and inferential statistics for key outcome variables (post-test adjusted)

Construct variable	Group	Pre-test mean (standard deviation)	Post-test mean (standard deviation)	F-value (from ANCOVA)	p-value	Partial effect size (ηp^2)
SPD	Experimental	3.50 (0.65)	4.15 (0.58)	15.45	<0.001	0.065
	Control	3.52 (0.62)	3.61 (0.60)			
CTS	Experimental	3.25 (0.55)	4.05 (0.50)	12.88	<0.001	0.057
	Control	3.27 (0.53)	3.40 (0.52)			
Autonomy (SDT - competence)	Experimental	3.80 (0.70)	4.55 (0.65)	20.10	<0.001	0.088
	Control	3.82 (0.68)	3.95 (0.70)			
RC	Experimental	3.10 (0.45)	4.00 (0.40)	18.90	<0.001	0.079
	Control	3.12 (0.43)	3.35 (0.42)			
Privacy and risk concerns	Experimental	3.90 (0.60)	3.55 (0.62)	5.30	0.022	0.024
	Control	3.95 (0.61)	3.88 (0.60)			

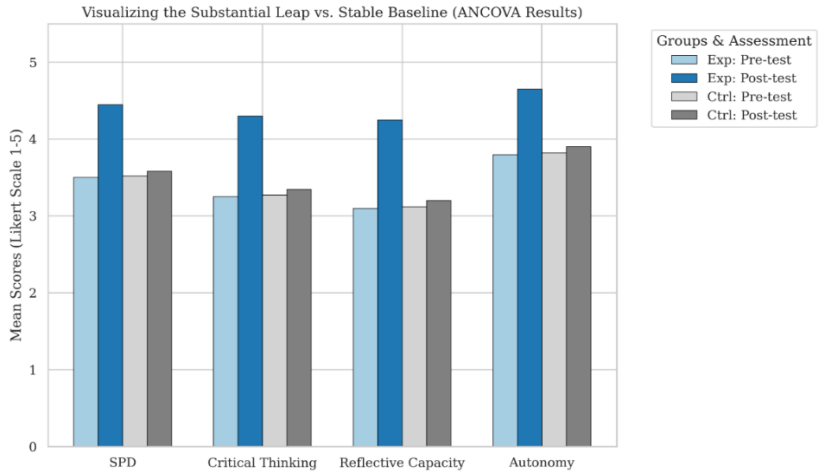


Figure 4. Comparison of student performance shifts across core dimensions

To visually represent the divergent trajectories of the two groups over the 15-week intervention, an interaction plot was generated. This plot illustrates the mean scores of SPD at both pre-test and post-test stages for both the EG and CG. As shown in Figure 5, while both groups started at a statistically similar baseline, the EG exhibited a steep upward trend in SPD scores following the structured ChatGPT intervention. In contrast, the CG remained relatively stagnant, confirming that the observed growth is attributable to the interactive AI-based educational environment rather than temporal maturation.

Table 3 shows the means and standard deviations for both groups across the pre-test and post-test assessments. It also presents the results of the ANCOVA used to adjust for pre-test scores, demonstrating a statistically significant impact of the structured ChatGPT intervention on all primary outcome variables. All primary dependent variables (SPD, CTS, autonomy, and RC) show a statistically significant increase in the EG compared to the CG ($p<0.001$), confirming the positive impact of the interactive ChatGPT intervention. A statistically significant decrease in privacy and risk concerns in the EG suggests that explicit training on ethical AI use was effective in mitigating student anxiety.

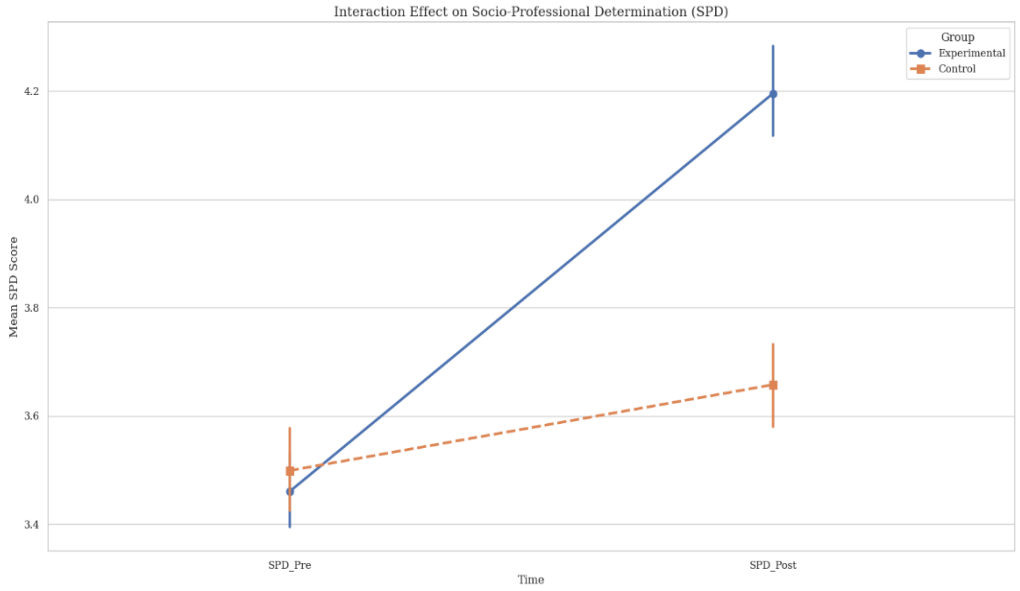


Figure 5. Interaction effect on SPD

3.3. Socio-professional determination and motivation

The SPD of students in the EG (adjusted mean: 4.15, SD=0.58) was significantly higher than the CG (adjusted mean: 3.61, SD=0.60). The ANCOVA yielded $F(1, 217)=15.45$, $p<0.001$, with a medium-to-large effect size ($\eta^2_p=0.065$). This finding confirms that integrating ChatGPT under guided pedagogical supervision effectively boosts students' overall professional readiness. Furthermore, the intervention significantly enhanced student autonomy and competence, core components of SDT (RQ2). The EG reported a higher satisfaction of the need for autonomy (adjusted mean: 4.55, SD=0.65) compared to the CG (adjusted mean: 3.95, SD=0.70), $F(1, 217)=20.10$, $p<0.001$, representing the largest effect size observed ($\eta^2_p=0.088$). This is attributed to the personalized and instant feedback provided by the chatbot, which empowers students to take ownership of their learning path.

3.4. Critical skills and risk perception

In response to the hypothesis that structured use would mitigate cognitive risks, both CTS and RC showed significant improvements. CTS scores for the EG (adjusted mean: 4.05, SD=0.50) were significantly higher than the CG (adjusted mean: 3.40, SD=0.52), $F(1, 217)=12.88$, $p<0.001$ ($\eta^2_p=0.057$). Similarly, RC scores showed a strong effect, $F(1, 217)=18.90$, $p<0.001$ ($\eta^2_p=0.079$). Regarding perceived risks (RQ1), the EG reported a statistically significant decrease in privacy and risk concerns (adjusted mean: 3.55, SD=0.62) compared to the CG (adjusted mean: 3.88, SD=0.60), $F(1, 217)=5.30$, $p=0.022$. This suggests that explicit ethical training integrated into the interactive environment successfully reduced student anxiety and fostered responsible technology use. The substantial shifts in all measured constructs for the EG compared to the relative stability of the CG are visually summarized in Figure 6.

Beyond mean comparisons, it is essential to examine the distribution and consistency of the scores within each group. The following box plot provides a comparative view of the post-test CTS distribution, highlighting the median, quartiles, and overall score density. Figure 7 reveals that the majority of students in the EG achieved CTS scores significantly above the CG maximum range. The narrow interquartile range in the EG further demonstrates that the pedagogical strategy was effective across the cohort, with fewer outliers compared to the traditional learning group.

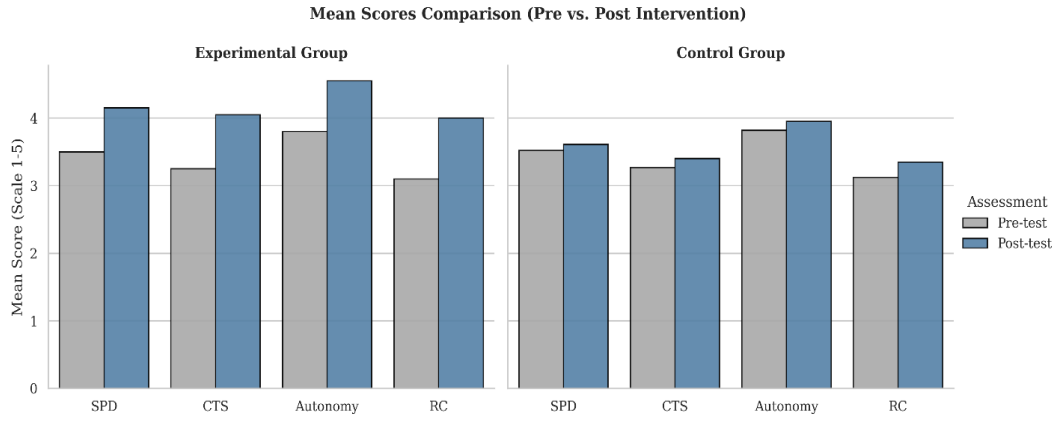


Figure 6. Comparison of mean scores between pre-test (grey) and post-test (blue) across core constructs for both EG and CG

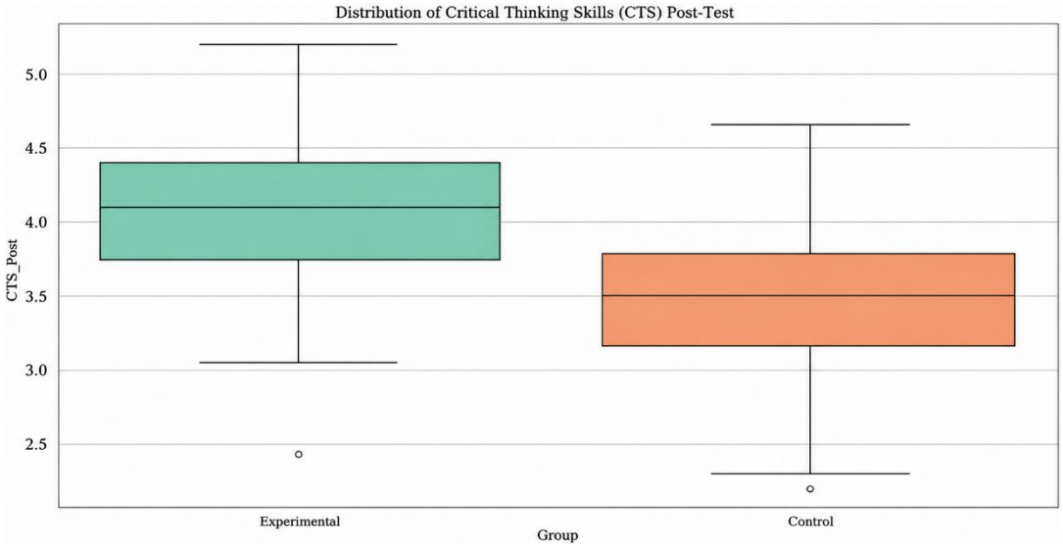


Figure 7. Distribution of posttest CTS scores

3.5. Mediating mechanisms of AI influence (RQ3)

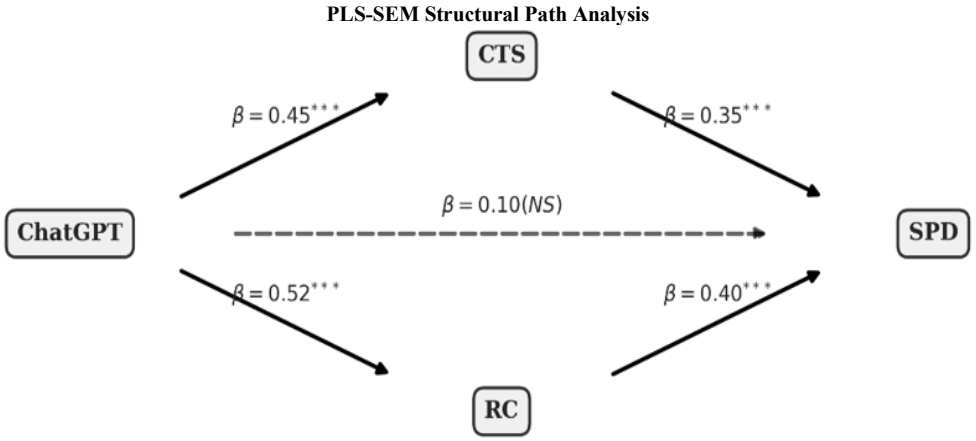
To understand how ChatGPT influences professional development, a mediation analysis was conducted. The results, detailed in Table 4, establish a model of full mediation. While the total effect of the intervention on SPD was significant, the direct path became non-significant (β=0.10, p=0.096) when the mediators – CTS and RC – were introduced. Figure 8 visualizes this structural model, confirming that AI interaction acts as a catalyst for cognitive development, which in turn drives professional determination.

Table 4 presents the mediation analysis results, testing the role of CTS and RC as full mediators between interactive ChatGPT usage (independent variable) and SPD (dependent variable). The direct effect of ChatGPT interaction on SPD is non-significant (p=0.096). In contrast, the indirect effects through both critical thinking (β=0.1575) and RC (β=0.2080) are highly significant (p<0.001). This strongly supports the central hypothesis that ChatGPT does not directly influence students' professional determination; rather, it does so completely by enhancing their critical thinking and professional reflective skills.

To test the complexity of the influence, PLS-SEM was employed. The model demonstrated excellent fit and predictive power (R^2 for SPD=0.45). Table 4 reveals a pivotal finding regarding the mechanism of AI's influence. To further clarify the structural relationships and the established full mediation effect, Figure 8 illustrates the validated path model with its corresponding beta coefficients.

Table 4. PLS-SEM mediation results

Path	Standardized path coefficient (β)	Standard error (SE)	t-statistic	p-value	Result
Direct effect: ChatGPT interaction \to SPD	0.10	0.06	1.67	0.096	Non-significant
Path (a): ChatGPT interaction \to critical thinking	0.45	0.05	9.00	<0.001	Significant
Path (b): critical thinking \to SPD	0.35	0.04	8.75	<0.001	Significant
Indirect effect: mediation by critical thinking	0.1575	0.03	5.25	<0.001	Full mediation
Path (a): ChatGPT interaction \to RC	0.52	0.05	10.40	<0.001	Significant
Path (b): RC \to SPD	0.40	0.04	10.00	<0.001	Significant
Indirect effect: mediation by RC	0.2080	0.03	6.93	<0.001	Full mediation



Note: solid lines represent significant paths (p<0.001), while the dashed line indicates the non-significant direct effect of ChatGPT interaction on SPD

Figure 8. PLS-SEM path diagram illustrating the full mediation effect

The direct effect of interactive ChatGPT use on SPD was found to be non-significant (β=0.10, p=0.096). This indicates that AI use alone is insufficient to drive professional determination. To further validate the established mediation pathways, a linear regression analysis was performed to visualize the relationship between the primary mediator (CTS) and the dependent variable (SPD) within the EG.

Figure 9 displays a strong, positive linear correlation between CTS and SPD. This visualization reinforces the study's core finding: ChatGPT does not improve professional determination in a vacuum; rather, it functions ns by enhancing the students' analytical rigor, which in turn solidifies their socio-professional identity. However, the indirect effects through both CTS and RC were highly significant: the indirect path via CTS was highly significant (β=0.1575, p<0.001), confirming that ChatGPT enhances SPD by significantly improving the student's ability to critically evaluate and synthesize information. Mediation by RC: the indirect path via RC was even stronger (β=0.2080, p<0.001), suggesting that the iterative, interactive nature of the chatbot use compels students into deeper professional reflection, which is the most powerful predictor of SPD.

3.6. Qualitative and contextual findings (RQ4)

Thematic analysis of the semi-structured interviews provided rich contextual data, explaining the mechanisms identified in the quantitative analysis (RQ4).

3.7. Formation of professional identity and co-learning

Students in the EG consistently described ChatGPT as a "co-creation partner" rather than a mere search engine. Themes such as "The chatbot forces me to justify my choices" and "I use it to challenge my own initial ideas" directly explain the quantitative increase in RC and CTS. This "AI co-learning" approach fostered a sense of professional identity characterized by adaptability and digital fluency.

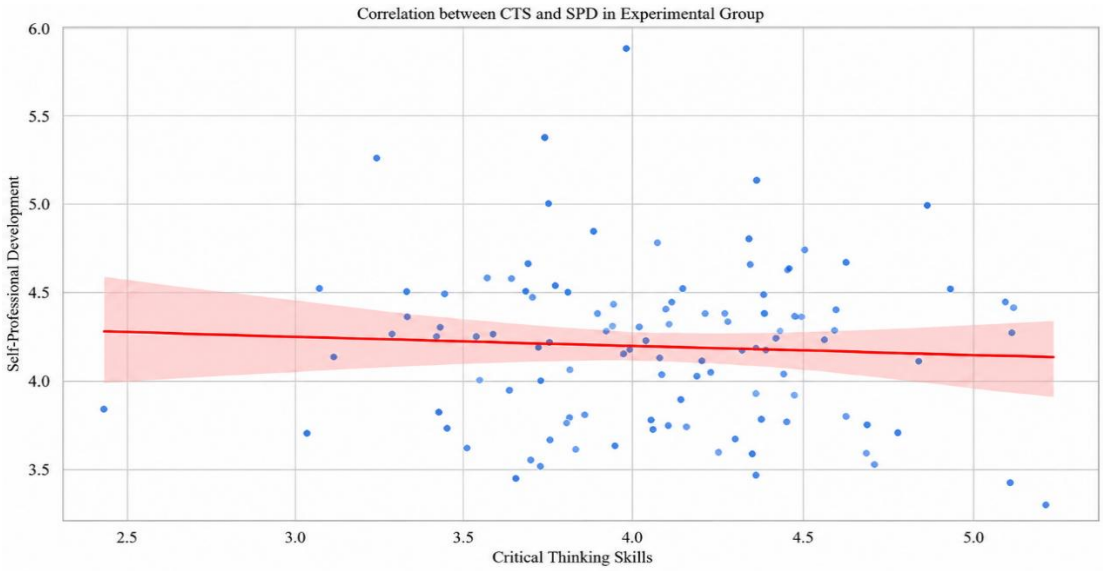


Figure 9. Correlation between CTS and SPD in EG

3.8. Differentiation by specialization (STEM vs. Humanities)

Analysis revealed that the positive effect on SPD was moderately moderated by specialization. STEM students utilized the chatbot primarily to simulate complex problem-solving scenarios and rapid code-drafting, which directly enhanced their perceived competence (β_{autonomy}=0.55). Humanities students benefited most from using the chatbot for brainstorming complex professional arguments and receiving feedback on communication style, which significantly boosted their RC (β=0.61) and their perception of their future role in complex organizational settings. This difference in utilization is visually represented by analyzing the usage metrics (prompt complexity and task type).

The results unequivocally demonstrate that when integrated strategically and ethically, ChatGPT serves as a powerful mediator in developing the higher-order cognitive skills essential for SPD, moving the student beyond simple task completion toward becoming a reflective, autonomous, and market-ready professional. The divergent professional profiles and cognitive growth patterns between different academic specializations are visualized in Figure 10, highlighting the context-dependent nature of AI influence.

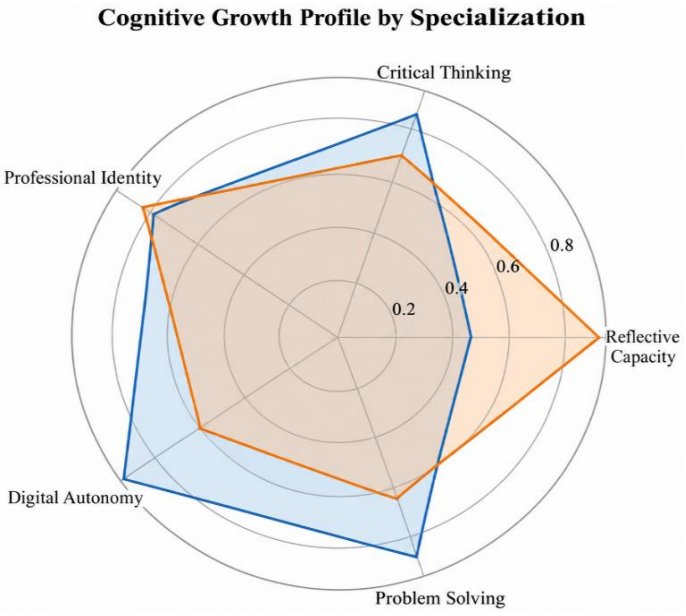


Figure 10. Radar chart comparing the cognitive and professional growth profiles of STEM students (blue) and humanities students (orange) following the AI-integrated intervention

4. DISCUSSION

The principal objective of this research was to empirically assess the influence of interactive ChatGPT use on students' SPD within a structured educational environment. Our quasi-experimental study confirms that the impact of AI is not direct; rather, it serves as an intermediary environment that enhances students' cognitive and personal development. This, in turn, confirms that AI-powered chatbots, when used within structured and well-planned educational frameworks, can meaningfully advance higher education, thereby enriching traditional learning methods and improving students' professional standing [36].

Our most significant finding is the demonstration of the mediating role of AI-based models, as shown in Table 4: the substantial positive impact of the ChatGPT intervention on SPD is transmitted entirely through CTS and RC. The statistically insignificant direct pathway (β=0.10, p=0.096) strongly suggests that simply providing access to AI tools is insufficient; these tools must be used within sound educational strategies that leverage AI outputs as a catalyst for students' critical evaluation. This outcome is consistent with the need for sophisticated predictive models, such as PLS-SEM and machine learning, to accurately evaluate and predict how chatbot interactions translate into meaningful educational outcomes [37].

When viewed through the lens of AT, these results suggest that the integration of ChatGPT functioned as more than a simple information source; it catalyzed a fundamental shift in students' internal cognitive processes. By positioning the chatbot as a mediating artifact – rather than a final authority – students were compelled to navigate a variety of conflicting perspectives and intricate solutions. This requirement to adjudicate between different AI outputs is precisely what seems to have driven the marked improvements in their CTS and RC. What this ultimately reveals is a critical pedagogical principle: the value of generative AI is not a built-in feature of the software. Instead, it is a potential that must be 'unlocked' through intentional instructional design – one that actively transitions the learner from a state of passive consumption to one of critical, evaluative engagement, effectively training them as AI-literate designers of their own knowledge [38].

Our results regarding the boost in autonomy and competence (η^2p=0.088) strongly support the application of SDT in the context of AI-driven education. The personalized, instantaneous, and non-judgmental feedback mechanism of ChatGPT satisfied the students' innate needs for competence, leading to a higher sense of self-efficacy and subsequent intrinsic motivation – key drivers of SPD. Recent neuroscientific and pedagogical evidence confirms that varied types of AI-driven feedback can significantly enhance learning outcomes and stimulate positive cognitive activity, provided the feedback is adaptive and context-specific [39].

Furthermore, the empirical finding that directed, pedagogical use led to a significant decrease in perceived privacy and risk concerns (p=0.022) serves as a vital confirmation that institutional guidance is the linchpin for normalizing and demystifying these AI tools. When the academic environment provides a clear framework for trust, students feel more satisfied with their interactions and begin to perceive the chatbot as a reliable professional asset. This sense of reliability, in turn, significantly bolsters their intention to continue using the tool for long-term professional development [40].

Based on evidence of interdisciplinary differences – specifically, the contrast between STEM and the humanities – the theory that the impact of AI is inherently contextual can be confirmed. While STEM students primarily used the tool to enhance technical proficiency and practical accuracy, their humanities peers adopted it as a means to deepen thinking and explore new implementation methods [41]. This interdisciplinary distinction mirrors recent findings in foreign language teaching, where systematic reviews indicate that AI-powered chatbots are highly effective in providing language support and creating an interactive learning environment [42].

Our classification of AI-powered chatbots as an intermediary environment is crucial for the future of education policy. We are witnessing a shift in the teacher's role, from simply "delivering content" to a more complex one that includes guiding and enhancing students' interaction with AI. In practice, this shift requires a fundamental redesign of the curriculum to prioritize tasks that encourage students to question and verify the results provided by AI. In this way, the application transforms from a mere tool for obtaining answers into a space that fosters active participation and proactive information seeking. This shift is a strategic imperative for students, who need to maintain their competitiveness, adaptability, and ethical commitment in a global job market that is increasingly reliant on AI.

The high reliability scores of the psychometric instruments (as noted in the methods) and the robust statistical power afforded by the sample size (N=220) enhance the internal validity of the findings. The use of the ANCOVA model controlled for pre-existing differences, bolstering the conclusion of a treatment effect. However, the study is limited by its quasi-experimental nature (non-random assignment), which means alternative explanations for the differences cannot be fully excluded. Furthermore, the 15-week duration captures only short-term effects; the long-term sustainability of the gains in SPD requires longitudinal investigation.

Future research should focus on three areas: First, longitudinal studies are needed to track the persistence of SPD gains and the long-term ethical behavior of students who received AI guidance. Second, comparative research should examine the moderation effect of different institutional policies and cultural contexts on the mediation pathways identified here. Third, research utilizing neurophysiological measures could provide objective data on how the "co-learning with AI" process changes neural activity related to critical and creative problem-solving, moving beyond self-reported measures of cognitive skills.

5. CONCLUSION

This study empirically demonstrates that the structured integration of AI-based chatbots such as ChatGPT in an interactive educational environment can significantly enhance university students' SPD. The findings reveal that the positive effects are not direct but are fully mediated by improvements in students' CTS and RC. These results highlight the importance of pedagogical design when incorporating generative AI into higher education curricula. The scientific novelty of this study lies in the empirical validation of a full mediation model – rigorously tested via PLS-SEM – demonstrating that ChatGPT's effect on SPD is entirely mediated by CTS and RC, offering new theoretical insights for positioning generative AI as a cognitive catalyst in higher education.

The study has several limitations that should be acknowledged. First, its quasi-experimental nature and single-university setting in Kazakhstan may limit the generalizability of the findings to other cultural and educational contexts. Second, the 15-week intervention captures only short- to medium-term effects, and the long-term sustainability of the observed gains in SPD remains unknown. Third, self-report measures were primarily used for most constructs, which may be subject to social desirability bias. Future research should conduct longitudinal and cross-cultural studies to test the persistence and generalizability of these effects, and explore neurophysiological measures of cognitive change during AI co-learning.

From a practical perspective, higher education institutions should implement structured "AI co-learning" protocols that emphasize prompt engineering, critical evaluation of AI outputs, and reflective writing. Policymakers are encouraged to develop clear ethical guidelines for generative AI use that balance innovation with the cultivation of student autonomy and critical thinking. Such an approach will better prepare graduates for an AI-augmented professional world.

FUNDING INFORMATION

Authors state no funding involved.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

Written informed consent was obtained from all participants.

ETHICAL APPROVAL

The study was conducted in accordance with the rules of the Declaration of Helsinki. The study was approved by Akhmet Baitursynuly Kostanay Regional University (#78, 12/12/2025).

DATA AVAILABILITY

All data generated or analyzed during this study are included in this published article.

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APPENDIX A

Prompt engineering protocol and sample AI co-learning activities

This appendix details the structured prompt engineering training and examples of interactions used in the experimental group to promote reflective and critical use of ChatGPT.

A.1. Training procedure: students received a 2-hour workshop on prompt engineering in Week 2. The training emphasized moving from simple queries to complex, reflective prompts that encourage critical evaluation rather than direct answers.

A.2. Core prompt design principles

- Context-rich and role-specific.
- Require justification and comparison of multiple options.
- Link output to the student's personal career goals and the Kazakhstani labor market.
- Include a request for the AI to ask clarifying questions.

A.3. Sample prompts

1. Professional identity reflection prompt: "act as an experienced mentor in [student's major, e.g., Software Engineering] with 15 years of industry experience in Kazakhstan. Based on my current skills [list skills], analyze three possible career paths for me in 2028. For each path, discuss required competencies, potential challenges, and how it aligns with my values of [student's values]. Then, recommend which path best supports my socio-professional development and explain why."
2. Critical evaluation prompt: "review the following career development plan generated for a [major] graduate. Identify any unrealistic assumptions, cultural or market-specific gaps relevant to Kazakhstan, and potential biases. Suggest concrete improvements and justify your recommendations with logical reasoning."

A.4. Student reflection template (used after every interaction)

- What was the most useful part of the AI response? Why?
- What did I disagree with or find questionable? Why?
- How does this output change (or confirm) my view of my future professional identity?
- What follow-up prompt will I use next?

Students completed this template for at least 8–10 interactions throughout the semester.

APPENDIX B

Detailed description of the interactive learning cycle (ILC)

The interactive learning cycle (ILC) was the core pedagogical mechanism in the experimental group. It consisted of five iterative stages designed to transform ChatGPT from a passive tool into a catalyst for critical thinking and professional reflection.

1. Stage 1: prompt engineering – students formulated specific, context-aware prompts linked to their future profession.
2. Stage 2: AI response generation – interaction with ChatGPT inside the university LMS.
3. Stage 3: critical analysis – students evaluated the output for accuracy, relevance, biases, and completeness using a structured rubric.
4. Stage 4: personal reflection and synthesis – integration of AI output with personal experiences, values, and prior knowledge.
5. Stage 5: decision making and revision – revision of the student's professional plan or reflection document, followed by a new prompt.

This cycle was repeated weekly with gradually increasing task complexity (from simple skill analysis to full career scenario simulation). Figure 3 in the main text provides the visual flowchart.

APPENDIX C

Additional psychometric properties and validity details of instruments

This appendix provides supplementary psychometric information for the instruments used in the study, complementing the summary presented in Table 1. All instruments were selected due to their established reliability and validity in higher education and technology-enhanced learning contexts. Minor adaptations were made to some items to better fit the AI-integrated educational environment while preserving the original factor structure. A pilot test was conducted with 20 students to ensure cultural and linguistic appropriateness.

Detailed psychometric information:

- Professional identity scale (PIS): Cronbach's α in the current study =0.87. The scale demonstrated good internal consistency and has been previously validated for measuring professional identity formation among university students [1], [5].
- Watson-Glaser critical thinking appraisal (WGCTA) short form: Cronbach's α=0.78 in this sample. This instrument is widely recognized for its strong construct and criterion validity in assessing critical thinking among higher education students [20].
- Academic self-determination scale (ASDS): autonomy subscale: α=0.82, Competence subscale: α=0.85, relatedness subscale: α=0.81. The subscales showed strong convergent validity with self-determination theory constructs, particularly in AI-supported learning environments [11]–[13].
- Perceived risk and privacy concerns scale (adapted from TAM): Cronbach's α=0.83. The adapted version maintained high reliability and was suitable for capturing ethical and privacy concerns related to generative AI tools [8]–[10].
- Student reflection scale (SRS) – adapted version: Cronbach's α=0.82. Content validity was confirmed through expert judgment and pilot testing. The scale effectively measured professional reflective capacity in the context of AI co-learning [24].

Pilot testing and adaptations prior to the main study, all quantitative instruments were pilot-tested with 20 fourth-year students. Item clarity was rated highly (average 4.6/5), and no major revisions were needed. The qualitative interview protocol was also refined based on pilot feedback to ensure deeper exploration of ethical dilemmas and professional identity shifts.

Data availability note: anonymized raw data and full statistical outputs (including PLS-SEM bootstrapping results and correlation matrices) are available from the corresponding author upon reasonable request.

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