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Original Article

Exploring how ChatGPT adoption shapes student engagement, critical thinking, and academic achievement

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ABSTRACT

This study investigates how ChatGPT adoption intention influences academic performance among Business English undergraduates by integrating the Technology Acceptance Model (TAM) with Constructivist Learning Theory. Using convenience sampling, data from 243 students were analyzed via PLS-SEM. The results indicate that perceived convenience (PC), perceived usefulness (PU), and perceived ease of use (PEOU) positively shape attitudes (ATT) toward ChatGPT, with PC emerging as the strongest antecedent. Attitude significantly predicts adoption intention, which in turn drives actual usage. ChatGPT usage exerts positive effects on student engagement (ENG), critical thinking (CT), and knowledge sharing (KS); subsequently, ENG, CT, and KS each contribute positively to academic achievement (ACH). Theoretically, the study refines and extends TAM in a GenAI context by articulating a full pathway from technology beliefs → attitude/intention → use → learning outcomes, consistent with a constructivist perspective. Practically, the findings suggest learning designs that cultivate iterative prompting, verification, and critique, promote summarization, discussion, and peer sharing, and prioritize a convenient user experience (e.g., LMS integration, responsible-use guidelines) to maximize the educational value of ChatGPT in higher education.

Keywords: ChatGPT adoption, Engagement, Critical thinking, Academic achievements, Constructivist learning, Higher education

Introduction

Technology has long been integrated into education to leverage digital resources and pedagogical approaches that enhance teaching and learning processes [1]. A wide range of technologies—such as artificial intelligence (AI), virtual reality, augmented reality, simulation, and robotics—has been adopted in educational settings [2]. According to [3], the incorporation of ChatGPT into education has received substantial attention due to its potential to improve students' learning experiences. AI chatbots, as a key application of AI, employ natural language processing and machine learning techniques to simulate human-like conversations [4]. ChatGPT has gained widespread popularity owing to its advanced ability to generate coherent and contextually appropriate responses [5]. It can address students' individual needs, provide timely feedback, and support the comprehension of complex concepts.

Many studies have examined the acceptance of AI in education using the Technology Acceptance Model (TAM). For example, Sánchez-Prieto *et al*. [6] showed that ease of use, usefulness, and attitudes toward technology have significant effects on students' acceptance of automated assessment systems. Teachers with strong pedagogical beliefs and high levels of trust in AI are more likely to adopt AI tools. However, ethical concerns and the lack of transparency in AI may reduce teachers' acceptance [7]. Jiao *et al*. [8] demonstrated that AI can accurately predict students' learning outcomes based on their learning behavior data. According to [9], ChatGPT is crucial in enhancing students' learning experiences by allowing them to customize lessons and receive feedback tailored to their specific needs. As noted in [10],

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the use of ChatGPT—especially in higher education—highlights its relevance and importance. Therefore, ChatGPT is a valuable tool that helps students perform tasks such as providing information, summarizing, generating text, and other academic activities. According to [11], ChatGPT helps save time and improves the quality and efficiency of academic work in higher education.

The literature review indicates that there remains a scarcity of studies that comprehensively explain students' behaviors—particularly Business English majors—in accepting the use of ChatGPT and the benefits derived from employing this technology. To address this theoretical gap, the present study integrates the Technology Acceptance Model (TAM) and Constructivist Learning Theory to explain the behavior of Business English students by examining the factors influencing their attitudes and intentions to use ChatGPT, as well as the effects of adopting this technology throughout the learning process.

Theoretical background

Technology acceptance model (TAM) and constructivist learning theory

The Technology Acceptance Model (TAM) outlines the decision-making process through which users evaluate and adopt a specific technology. The model posits that an individual's actual usage behavior is shaped by their perceptions of the technology's usefulness and convenience, which subsequently determine their willingness to engage with that technology [12].

Constructivist learning theory, originally proposed by Vygotsky, emphasizes the active role of learners in constructing their own understanding [13]. Rather than merely receiving information, learners reflect on prior experiences and integrate new knowledge into their existing cognitive structures [14]. As an influential educational paradigm, constructivism has shaped many contemporary teaching and learning approaches [15]. Recent research highlights the effectiveness of constructivism in fostering higher-order learning skills, particularly critical thinking and problem solving [16]. The theory underscores the internal cognitive processes through which information is transformed into meaningful knowledge and skills. In technology-supported learning environments, students actively expand their understanding through interactive engagement with digital tools [17]. Educational technologies can enhance learning experiences by promoting interactivity, inquiry, and experimentation. Accordingly, constructivist theory aligns well with the present study, in which tools such as ChatGPT are considered capable of facilitating students' learning experiences [18], particularly by enabling questioning and providing immediate feedback.

Research hypotheses

According to [19], perceived usefulness (PU) is the extent to which students believe that using an AI tool (ChatGPT) can enhance their academic performance. [20] found that PU positively influences university students' attitudes toward using ChatGPT. Furthermore, [21] reported that PU has a positive impact on learners' attitudes toward adopting the technology in e-learning environments.

H1: PU has a positive effect on students' attitudes toward using ChatGPT.

Perceived ease of use (PEOU) refers to the degree to which an individual believes that using a particular system would be free of effort [22]. According to [20], PEOU positively affects students' attitudes toward adopting ChatGPT. In addition, [23] found that PEOU positively influences consumers' attitudes toward using 3G mobile services. Similarly, [24] argued that PEOU strongly shapes the attitudes of business students and instructors when adopting social media tools in e-learning. [21] also demonstrated that PEOU positively affects business students' attitudes toward using such technologies in e-learning contexts.

H2: PEOU has a positive effect on students' attitudes toward using ChatGPT.

According to [25], perceived convenience (PC) is the level of convenience related to time, location, and execution that individuals perceive when using wireless networks to complete a task. [26] found that PC is one of the key benefits of adopting technology in higher education for both staff and business students. Moreover, [20] discussed the positive influence of PC on business students' attitudes toward using ChatGPT. [27] also reported that PC positively affects university business students' attitudes toward using mobile technologies.

H3: PC has a positive effect on students' attitudes toward using ChatGPT [28-35].

Attitude refers to an individual's internal evaluation, viewpoint, and behavioral disposition [36]. A positive attitude toward a specific behavior is closely linked to perceived positive outcomes [37]. Students' attitudes reflect how they respond positively or negatively to the behavior in question [38]. According to [20], business students' attitudes toward ChatGPT have a significant positive impact on their intention to adopt the tool. In addition, [39] reported that attitude strongly influences e-learning adoption intentions in China. Based on [40] observed that business students in developed countries show positive influences on their e-learning adoption intentions. Furthermore, [21] indicated that learners' attitudes toward digital collaboration platforms positively affect their intention to use these platforms in e-learning environments.

H4: Students' attitudes have a positive effect on their intention to adopt ChatGPT.

A strong relationship exists between behavioral intention and actual usage of ChatGPT. Individuals with strong intentions to use the tool are more likely to engage with it more frequently. Behavioral intention to use ChatGPT is a strong predictor of its actual usage. Students who intend to use ChatGPT are more likely to incorporate it into their academic activities [41, 42].

H5: Intention to adopt ChatGPT has a positive effect on students' actual use of ChatGPT.

Student engagement reflects the extent to which students are behaviorally, emotionally, and cognitively involved in academic activities. As highlighted in the literature, ChatGPT acts as an interactive learning support tool by providing immediate feedback, clarifying complex content, and encouraging students to ask questions, thereby enhancing their engagement. Previous studies have shown that integrating ChatGPT increases intrinsic motivation, fosters an engaging learning environment, and encourages deeper participation in learning activities. Therefore, it is reasonable to expect that using ChatGPT will increase students' engagement in academic tasks.

H6: ChatGPT usage has a positive effect on students' engagement in learning activities.

Critical thinking is the capacity to analyze, evaluate, and synthesize information systematically, enabling learners to draw sound conclusions in problem-solving processes. Recent studies emphasize that the emergence of ChatGPT has opened new opportunities for developing students' critical thinking skills. According to [43], students tend to exercise analytical skills when assessing the accuracy of ChatGPT's responses, thereby strengthening their critical thinking. Similarly, v shows that using ChatGPT-generated outputs as sources for critique, comparison, and evaluation significantly improves critical thinking in problem-solving-oriented learning environments. In addition, [44] demonstrates that when students interact with ChatGPT by posing in-depth queries, verifying information, and comparing multiple perspectives, they further develop logical reasoning and argumentative skills. These studies underscore that ChatGPT not only provides answers but also creates an environment that stimulates students to think, question, and critically examine the information provided.

H7: ChatGPT usage has a positive effect on students' critical thinking.

Knowledge sharing refers to behaviors through which students exchange information, experiences, and insights to support one another during the learning process. In modern learning environments, AI tools such as ChatGPT play an important role in enabling rapid access to information, lowering barriers to academic communication, and thereby fostering knowledge-sharing behaviors. From a constructivist perspective, students construct knowledge through processes of exchange, discussion, and mutual critique. ChatGPT supports this process by providing instant information, suggesting content, clarifying complex concepts, and creating an environment that stimulates peer discussion. When students use ChatGPT to find solutions, understand course materials, or develop arguments, they tend to share the information obtained with classmates—constituting a collaborative form of knowledge sharing. Moreover, studies [41, 42] indicate that ChatGPT not only increases the intention to adopt technology but also promotes knowledge-sharing behaviors through collaborative learning activities, as students exchange content they have searched for or received as suggestions from AI. Likewise, recent higher-education research affirms that using AI tools enhances mutual support—especially when students discuss AI-generated responses, assess their accuracy, and share results with peers. Accordingly, both theory and empirical evidence provide grounds to expect that ChatGPT usage will strengthen knowledge-sharing tendencies in learning environments.

H8: ChatGPT usage has a positive effect on students' knowledge sharing.

Student engagement reflects the extent to which students are behaviorally, emotionally, and cognitively active, focused, and involved in academic activities. Prior research shows that higher engagement improves retention, increases learning motivation, and enhances overall academic performance. Findings in [12] indicate that highly engaged students achieve better academic outcomes in interactive learning environments. In the context of ChatGPT use, students receive immediate support, obtain timely feedback, and are encouraged to explore knowledge, thereby increasing their engagement in learning activities—an antecedent of improved academic achievement. Thus, the study proposes that greater engagement leads to better learning outcomes.

H9: Student engagement has a positive effect on academic achievement.

Critical thinking is one of the core competencies determining academic success. Students who effectively analyze, contrast, and evaluate information tend to achieve better results due to their deeper understanding of issues and more effective application of knowledge. Research shows that ChatGPT creates an environment that stimulates critical inquiry, including assessing information accuracy, comparing multiple viewpoints, and developing arguments. According to [45], cultivating critical thinking through interaction with AI enhances students' academic capacity and, in turn, improves performance. Consequently, critical thinking is considered a key predictor of academic achievement.

H10: Critical thinking has a positive effect on academic achievement.

Knowledge sharing is a collaborative academic behavior whereby students exchange information, experiences, and solutions to support one another. Under constructivist learning theory, knowledge is built through processes of exchange, discussion, and mutual critique. When students share information or content retrieved via ChatGPT with classmates, they broaden understanding, consolidate knowledge, and strengthen memory. Studies [41, 42] indicate that knowledge sharing is an important factor promoting academic outcomes in contexts where students use AI tools. Sharing knowledge thus helps students gain a deeper understanding, facilitates collaborative learning, and improves overall academic performance.

H11: Knowledge sharing has a positive effect on academic achievement.

Materials and Methods

This study was conducted using survey data collected from 243 undergraduate students. The sample comprised Business English majors who met two key criteria: (i) having foundational

knowledge relevant to their field of study, and (ii) having prior experience using ChatGPT. This group was selected because Business English students frequently engage with digital tools throughout their learning process, including translation-support software, grammar-checking applications, and online learning platforms. Moreover, AI-driven tools can assist these students in enhancing language proficiency and communication skills in international business contexts, thereby increasing their motivation and opportunities to experiment with AI-based learning technologies.

Data were collected through both online questionnaires and in-person distribution at several universities in Vietnam. A non-probability sampling method, specifically convenience sampling, was employed. This method was chosen because it allows researchers to easily access the targeted respondents, facilitates rapid data collection, and ensures an adequate number of observations for subsequent analysis. The dataset was analyzed using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach to examine the relationships among constructs in the proposed research model. PLS-SEM was considered appropriate because it is well-suited for studies with small to medium sample sizes and enables simultaneous estimation of complex structural relationships.

All constructs in the model were measured using established scales adapted from prior research. Perceived Usefulness (PU), Perceived Ease of Use (PEOU), and Perceived Convenience (PC) were measured using 3, 3, and 4 items, respectively, adapted from [20] and [46]. Attitude (ATT) was measured with 4 items adopted from [47]. The scales for ChatGPT usage intention, student engagement, critical thinking, and academic achievement were adapted from [48], consisting of 6, 4, 4, and 4 items, respectively. All measurement items used a five-point Likert scale ranging from 1 ("Strongly disagree") to 5 ("Strongly agree").

Results and Discussion

Sample characteristic

Among the 243 students who participated in the survey, 143 were male (55%), while female students accounted for the remaining 45%. The sample was collected from several universities, with proportions distributed relatively evenly across institutions, ranging from 12.3% at Van Lang University—the lowest participation rate—to 20.6% at Ho Chi Minh City University of Industry, which recorded the highest participation. In terms of academic year, second-year students represented the largest proportion (28.8%), followed by first-year students (24.7%). Third-year and fourth-year students accounted for 22.6% and 23.9%, respectively, indicating a fairly balanced distribution across cohorts, albeit slightly lower for the upper years compared to the first two. Regarding the frequency of ChatGPT usage, the group using the tool "occasionally" (1–2 times per week) constituted the highest proportion (41%). Approximately 34% reported using ChatGPT daily, while 25% indicated infrequent use (1–2 times per month).

Measurement model assessment

Table 1. Factor Loadings, Reliability, and Average Variance Extracted (AVE).

	Factor loadings	Cronbach Alpha	CR	AVE
Academic Achievement		0.825	0.83	0.74
ACH1	0.864			
ACH2	0.870			
ACH3	0.846			
Attitude		0.838	0.839	0.674
ATT1	0.788			
ATT2	0.876			
ATT3	0.816			
ATT4	0.801			
Critical thinking		0.826	0.856	0.739
CT1	0.873			
CT2	0.886			
CT3	0.818			
ChatGPT Usage Intention		0.882	0.883	0.681
ChatGPT1	0.867			
ChatGPT2	0.790			
ChatGPT3	0.836			
ChatGPT4	0.841			
ChatGPT5	0.789			
Actual ChatGPT Usage		0.831	0.732	0.764
UsageGPT1	0.767			
UsageGPT2	0.720			
UsageGPT3	0.846			
UsageGPT4	0.833			
UsageGPT5	0.721			
Engagement		0.9	0.904	0.768
Engagement1	0.869			
Engagement2	0.878			
Engagement3	0.870			
Engagement4	0.890			
Knowledge Sharing (KS)		0.822	0.754	0.868
KS1	0.769			
KS2	0.878			
KS3	0.880			
KS4	0.832			
Perceived Convenience (PC)		0.84	0.841	0.676
PC1	0.829			
PC2	0.827			
PC3	0.837			
PC4	0.795			
Perceived Ease of Use (PEU)		0.839	0.862	0.754
PEU1	0.881			
PEU2	0.836			
PEU3	0.888			
Perceived Usefulness (PU)		0.844	0.88	0.76

PU1	0.908
PU2	0.885
PU3	0.819

Based on the reliability and convergent validity criteria recommended by [49, 50], and [51], the results indicate that all measurement scales meet the required standards **(Table 1)**. Specifically, the Cronbach's Alpha values for all constructs exceed 0.7, which satisfies the acceptable reliability threshold proposed by [49]. Among them, the Engagement construct shows the highest reliability (0.9), indicating the strongest internal consistency. Likewise, the Composite Reliability (CR) values of all constructs are above 0.7, fulfilling the criterion suggested by [50] and confirming good internal consistency. In addition, the Average Variance Extracted (AVE) values are all greater than 0.6, surpassing the minimum threshold of 0.5 recommended by [51], demonstrating that the observed items adequately capture the latent constructs. Notably, Perceived Usefulness (PU) yields the highest AVE (0.76), reflecting the strongest convergent validity among the constructs. None of the constructs exhibit Cronbach's Alpha values below 0.7 or AVE values below 0.5, indicating that no observed variables need to be removed. Overall, the measurement scales demonstrate satisfactory reliability and convergent validity and are therefore suitable for subsequent analyses.

Table 2. Discriminant Validity Assessment Using the Fornell–Larcker Criterion

	ACH	ATT	CT	ChatGPT	ENG	PC	PEU	PU
ACH	0.86							
ATT	0.215	0.821						
CT	0.436	0.23	0.859					
ChatGPT	0.304	0.286	0.36	0.825				
ENG	0.208	0.264	0.248	0.281	0.877			
PC	0.19	0.402	0.221	0.283	0.215	0.822		
PEU	0.268	0.181	0.273	0.28	0.184	0.188	0.869	
PU	0.199	0.319	0.223	0.357	0.295	0.468	0.2	
UsageGPT	0.239	0.212	0.324	0.332	0.325	0.568	0.21	0.872

Based on the discriminant validity assessment using the criterion proposed by [51], the results in the table show that the square root of the AVE (values on the diagonal) is greater than the correlation coefficients between the constructs (values off the diagonal) **(Table 2)**. Since all diagonal values exceed the corresponding off-diagonal correlations, it can be concluded that the measurement scales achieve discriminant validity, meeting the standard of [51], and are therefore suitable for use in subsequent analyses.

Structural assessment

Table 3. Hypotheses testing

	β	P values
PU -> ATT	0.154	0.007
PEU -> ATT	0.091	0.028
PC -> ATT	0.313	0.000
ATT -> ChatGPT	0.286	0.000
ChatGPT -> UsageGPT	0.236	0.000
UsageGPT -> ENG	0.281	0.000
UsageGPT -> CT	0.304	0.000
UsageGPT -> KS	0.332	0.000
ENG ->ACH	0.321	0.000
CT->ACH	0.232	0.000
KS->ACH	0.123	0.000

The results of the structural model analysis show that all hypotheses are supported at the statistical significance level of $p < 0.05$ **(Table 3)**. Perceived convenience ($\beta = 0.313$), perceived usefulness ($\beta = 0.154$), and perceived ease of use ($\beta = 0.091$) all exert positive effects on students' attitudes. A positive attitude significantly predicts the intention to use ChatGPT ($\beta = 0.286$). This intention subsequently drives actual usage behavior ($\beta = 0.236$). ChatGPT usage has strong positive effects on student engagement ($\beta = 0.281$), critical thinking ($\beta = 0.304$), and knowledge sharing ($\beta = 0.332$). Finally, engagement ($\beta = 0.321$), critical thinking ($\beta = 0.232$), and knowledge sharing ($\beta = 0.123$) all positively contribute to academic achievement [52-57].

The PLS-SEM results indicate that perceived convenience (PC) is the strongest antecedent of attitude (ATT), surpassing both PU and PEU. This finding implies that in a digitally enriched learning environment, the benefits of ChatGPT's "instant access—anywhere—right when needed" serve as the primary emotional driver shaping students' positive attitudes toward AI tools. At the same time, PU and PEU continue to play fundamental roles within the TAM framework, as both exert significant positive effects on ATT. This reflects that learners perceive ChatGPT as useful (enhancing learning efficiency, saving time, and expanding knowledge sources) and easy to use (user-friendly interface, natural querying process).

The sequential relationships ATT → Intention and Intention → Actual Use are reaffirmed, demonstrating that the transformation from cognitive–affective evaluation to behavioral action occurs consistently in the higher-education context. Collectively, these findings reinforce the validity of TAM in the GenAI era: when convenience is highly perceived, usefulness and ease of use function as "amplifiers" that further strengthen positive attitudes, thereby increasing the likelihood of intention formation and actual system usage [58-63].

Compared to many traditional TAM studies that emphasize PU and PEU, the dominance of PC suggests a shift in TAM's focal point within the GenAI context—toward a "convenience-first TAM" for on-demand conversational platforms. (ii) Attitude continues to serve as a mediator between cognitive beliefs and behavioral intention, establishing a consistent cognition → affect → conation pathway in students' technology-acceptance behaviors. ChatGPT usage positively predicts, with medium to

relatively strong effect sizes, student engagement (ENG), critical thinking (CT), and knowledge sharing (KS). Three mutually reinforcing mechanisms help explain this chain of effects:

- Engagement mechanism (ENG): Immediate feedback, clarification of difficult concepts, and personalized learning tasks increase the frequency of academic interactions, drawing students into deeper learning activities rather than passive consumption.
- Higher-order cognitive mechanism (CT): When interacting with ChatGPT, students must assess credibility, compare perspectives, and engage in critical questioning—thereby strengthening reasoning, argumentation, and verification processes.
- Social–constructivist mechanism (KS): ChatGPT acts as an "idea launcher," enabling students to draft, synthesize, and systematize information for group discussions, thereby expanding their zone of proximal development in line with constructivist principles.

All three components—ENG, CT, and KS—positively predict academic achievement (ACH), suggesting a three-channel value-creation mechanism. Behavioral channel (ENG): higher engagement → more practice and feedback → stronger mastery of knowledge. Cognitive channel (CT): stronger analytical–evaluative–synthetic abilities → more effective transformation of knowledge into performance. Social channel (KS): sharing–dialogue–co-construction → reinforced memory and faster correction of misunderstandings. The findings show that ENG has the strongest effect on ACH, followed by CT and KS. This aligns with the view that maintaining stable engagement is a necessary condition for higher-order thinking and knowledge-sharing activities to effectively translate into performance gains [64-69].

Conclusion

This study examined the key factors proposed in the Technology Acceptance Model (TAM)—PU, PEU, and PC—to predict students' attitudes toward using ChatGPT, an AI-based tool. These TAM components clearly influence the attitudes and adoption intentions of Business English undergraduates at universities in Vietnam. The findings contribute to a deeper understanding of the factors that shape students' attitudes and intentions regarding the use of AI tools in educational settings, thereby providing important insights for the development and implementation of AI-based learning technologies. Additionally, the results offer detailed implications for the field of education by analyzing the impact of students' intention to adopt ChatGPT on their academic outcomes. By examining how ChatGPT adoption positively affects aspects such as engagement, critical thinking, and academic performance, the study highlights the practical effectiveness of integrating AI technologies into the learning activities of Business English majors.

Theoretical contributions

First, this study applies the TAM theory proposed by [70] to explain students' behavior in adopting ChatGPT. Students' attitudes are influenced by perceived usefulness, perceived ease of use, and perceived convenience, which subsequently shape their intention to adopt ChatGPT. By integrating the constructs of attitude and technology-use behavior (ChatGPT) from TAM, the study provides a clearer understanding of how technology is accepted.

Furthermore, the study employs Constructivist Learning Theory to highlight its effectiveness in enhancing students' participation in educational activities, fostering critical thinking, and improving academic performance. Thus, the integration of TAM and Constructivist Learning Theory offers a comprehensive explanation of Business English students' ChatGPT usage behavior—a topic that previous studies have not extensively examined, particularly in developing countries such as Vietnam. The combination of these two theories helps establish a more holistic model for investigating the influence of technology in education, especially regarding AI-powered tools such as ChatGPT.

Practical contributions

Learning design: Integrate multi-round prompting tasks—source verification—AI-response critique to foster critical thinking (CT); require summarization—interpretation—group presentations to promote knowledge sharing (KS); design micro-learning activities with rapid feedback to maintain engagement (ENG).

Tool implementation: Prioritize a convenient user experience (flexible access, subject-specific prompt templates, LMS integration) to strengthen the pathway from attitude → intention → actual usage; provide ethical and responsible-use guidelines to prevent AI over-dependence.

Policy and training: Organize digital-skills and AI-literacy workshops for students and instructors; issue guidelines on citation and disclosure of AI usage; encourage process-based assessment to measure ENG/CT/KS instead of relying solely on outcomes.

Limitations and research direction in the future

Although this study offers several valuable theoretical and practical contributions, a number of limitations should be considered when interpreting the findings.

First, the study employed a convenience sampling method, collecting data mainly from Business English students at several universities. The lack of probability sampling may limit the generalizability of the results to the wider population of Vietnamese students or to other academic disciplines. Moreover, focusing on a single major—one that typically has higher exposure to technology and foreign languages—may introduce bias in the observed patterns of ChatGPT acceptance and usage.

Second, the data were collected through self-reported questionnaires, which may lead to social desirability bias or self-perception bias. Students might overestimate or underestimate their actual usage levels or engagement in learning compared to their real behavior. In addition, although the Likert scale is widely used in technology-related behavioral research, it may not fully capture the complexity of academic behaviors.

Third, the study employed a cross-sectional design, which reflects behavioral patterns at only one point in time. As a result, causal relationships between ChatGPT use and academic outcomes cannot be fully confirmed. Future studies adopting longitudinal designs or quasi-experimental approaches would strengthen the causal inferences, particularly regarding mediating variables such as critical thinking and knowledge sharing.

Fourth, the study examined ChatGPT usage as a general behavioral construct without distinguishing between different types of usage (e.g., language support, solving assignments, content critique, or academic text generation). Different usage purposes may lead to varying impacts on engagement, critical thinking, and academic achievement—a point that future research should investigate in greater depth.

Finally, academic cultural factors and attitudes toward AI ethics were not incorporated into the model, even though these factors may significantly influence AI-use behavior in educational contexts. Issues such as overreliance on AI, academic integrity, transparency of information sources, and ethical standards in AI usage remain important gaps that should be addressed in future studies.

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