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Can interaction with generative artificial intelligence enhance learning autonomy? A longitudinal study from comparative perspectives of virtual companionship and knowledge acquisition preferences

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Abstract

Background: With the development of artificial intelligence (AI) technology, generative AI has been widely used in the field of education and represents a groundbreaking shift in overcoming the constraints of time and space within educational activities. However, previous literature has not paid enough attention to AI-involved teaching patterns, and it is necessary to evaluate the effects of this learning pattern.

Objectives: Based on the social presence theory and the community of inquiry model, the main purpose of this study is to evaluate whether and how interaction frequency with chatbots (IFC) affects people's learning autonomy (LA) under two preferences: knowledge acquisition and virtual companionship, and whether social presence (SP) plays a mediating role.

Methods: The 1-year longitudinal study was designed to be conducted from May 2022 to May 2023 and included three rounds of surveys of 1155 undergraduate students on their use of robots for learning.

Results and Conclusions: For learners preferring virtual companionship, no direct correlation was found between IFC and LA. However, SP acted as a mediating factor, enhancing LA through increased chatbot interactions. This suggests that while direct interactions may not directly influence LA, the resulting SP can foster it. Conversely, for learners favouring knowledge acquisition, higher IFC negatively impacted both SP and LA. Despite this, a strong sense of SP consistently correlated positively with LA, indicating it could offset some negative effects of frequent chatbot use.

KEYWORDS
data science applications in education, distance education and online learning, human-computer interface, informal learning, mobile learning

1 | INTRODUCTION

With the continuous breakthroughs in artificial intelligence (AI) and deep learning technology, chatbots such as ChatGPT have changed the way people search for and obtain knowledge and information. Today, generative AI has amassed a large user base and is extensively applied across various fields including education and healthcare (Kasneci et al., 2023; Sallam, 2023a). The use of generative AI in personalized and interactive learning activities has become increasingly common (Firat, 2023). Different from traditional classroom teaching and online teaching, the participation of generative AI in teaching breaks the limitations of time and space, making it possible for people to learn

anytime and anywhere to meet their needs. In recent years, many studies in the field of education have discussed the unique advantages of AI technology in the teaching process, such as the personalized services and instant feedback it provides (Dempere et al., 2023; Rawas, 2023). However, few scholars explored the direct or indirect impact of generative AI on people's learning initiative. In the context of artificial intelligence, learners no longer passively accept knowledge, but can actively and freely learn and search for information. Learning autonomy is a very critical factor that affects learning effect and results (Chong & Reinders, 2022; Khan et al., 2022). Therefore, we focus on the impact of generative AI on learning autonomy.

Nowadays, AI chatbots can not only provide people with efficient information search services, but also provide people with emotional value and companionship (Bilquise et al., 2022). Therefore, we tried to explore whether the impact on people's learning autonomy is different when a chatbot participates in the learning process as a virtual companion versus as an ordinary knowledge acquisition tool. We will discuss this in two situations.

Past empirical research focusing on online learning performance has confirmed the importance of social presence. In learning environments where AI is involved, the role of social presence still requires further exploration. Social presence theory and the community of inquiry (CoI) model show that social presence is a key variable that affects teaching performance, and is usually an important factor mediating teaching presence and perceived presence (Garrison et al., 2010). Scholars have long debated whether social presence is determined by the properties of the medium itself or by sociological variables (Kreijns et al., 2011). We try to integrate two perspectives and discuss the impact of AI chatbots on social presence from both technical determinism and social determinism perspectives. We found that past empirical research on social presence, learning performance, and learning autonomy in the field of education were mostly limited to traditional teaching models or computer-mediated communication (CMC) models. Even though the perspective of online teaching is novel, the discussion is still limited to the interpersonal teaching model. Our research hopes to explore teaching activities from a complete human-computer interaction perspective. Considering that generative AI not only offer knowledge, but also provide emotional support and companionship, we distinguish two situations, virtual companionship, and knowledge acquisition, to explore the above issues. From 2022 to 2023, we conducted a three-wave longitudinal study exploring the relationship between interaction frequency with chatbots (IFC), social presence (SP), and learning autonomy (LA). Our research contributes to understanding how to enhance learning autonomy through AI and offers insights for refining algorithms in language models like GPT.

2 | LITERATURE REVIEW

2.1 | The effect of interaction with generative AI on learning autonomy

AI's ability to directly provide knowledge and information in various disciplines and its ability to participate in people's learning process as a virtual companion have been widely confirmed. The affordances of generative chatbots such as ChatGPT in assisting learning (especially language learning) have been well proven. These chatbots not only tailor educational content to individual needs but also interact in a dynamic, responsive manner that simulates human tutoring (Bin-Hady et al., 2023; Kohnke et al., 2023). Sallam (2023b)'s research has demonstrated significant benefits of chatbots in medical education, including aiding medical students with clinical illustrations, case formulation, data analysis, report generation, and exam preparation. Daun et al. (2023) discussed the potential of generative AI in software engineering education, mentioning the advantages of AI in providing automated assessment and developing personalized learning plans. A series of review studies and empirical studies have proven that generative AI also performs well in empowering higher education. In addition to providing knowledge, they can also provide flexible, personalized, and comprehensive teaching services (Dempere et al., 2023; Neumann et al., 2023). Basically, the ability to provide personalized guidance, instant feedback and interactive experience, and automatic scoring are the unique advantages of chatbots in education (Rawas, 2023). However, the above studies mostly focus on which aspects of the teaching process can be changed by AI technology or robots, or what are the pros and cons of this teaching model. Previous studies have largely overlooked the specific impact of generative AI, whether as virtual companions or tools for daily knowledge acquisition, on students' learning autonomy—a gap our research aims to address.

Learning autonomy, a concept introduced by Holec (1979) in the context of modern foreign language teaching, describes an individual's capacity to take charge of their own learning. Subsequent definitions by scholars like Little et al. (1991) and Nunan (1996) have emphasized critical thinking, independent decision-making, and the creation of learning opportunities, revolving around the themes of independence and self-direction. Regardless of whether it is defined in terms of ability or learning action, scholarly definitions consistently emphasize "independence" and "self-direction". (Chong & Reinders, 2022). This emphasis on autonomy represents a significant departure from traditional educational models, where knowledge distribution was often unilateral and passive. This shift subverts traditional teaching paradigms by moving away from rote learning towards a redistribution of power in knowledge construction (Ahakwa, 2024). Self-determination theory shows that learning autonomy can predict higher learning quality and happiness (Neufeld & Malin, 2024). A series of empirical studies in education and psychology are dedicated to finding ways to improve learners' autonomous learning abilities and increase opportunities for autonomous learning. From the perspective of educators, diagnostic writing has been shown to play a significant role in motivating students through feedback, helping them identify their strengths and areas for improvement in their learning processes (Kong & Pan, 2023). From the students' perspective, encouraging collaboration among peers has been demonstrated to enhance learning autonomy, as it allows learners to exchange knowledge and support each other in their educational journeys (Phan & Liu, 2023). Moreover, from a comprehensive viewpoint involving teachers and parents, allowing high-performing students to skip certain courses can further promote autonomy by enabling them to focus on areas that challenge them

and meet their learning needs, thus optimizing their educational path (Goulas et al., 2023). However, most of these studies focus on stimulating students' autonomous learning within traditional classroom settings. Even the exploration of the effects of online self-directed learning remains within the realm of interpersonal learning (Ji et al., 2023). Our study aims to explore the impact of generative AI such as ChatGPT or other chatbots on learners' learning autonomy.

It is worth mentioning that we consider two different preferences when exploring the impact of AI chatbots on learning autonomy. The first is taking a chatbot as a virtual companion. Nowadays, as a companion anytime and anywhere, generative AI can not only provide instant information and knowledge, but also provide companionship and emotional value to users (Chatterjee & Dethlefs, 2023). Previous studies have confirmed that students with poor grades have stronger emotional needs (Woolf et al., 2010), peer interaction may be beneficial to both learning outcomes and motivation (Yuan & Gao, 2023). The experimental research of Sinai and Rosenberg-Kima (2022) pointed out that chatbot participation in learning can provide students with positive feedback and incentives, help reduce anxiety, but its effect on improving autonomy is not significant. Many of these studies have treated chatbots primarily as mechanical entities. Our study aims to verify whether individuals are more motivated to engage actively in learning when they perceive chatbots as friends or peers, rather than just as machines.

> **RQ1.** Among learners who prefer virtual companionship, is there a relationship between interaction frequency with chatbots and students' learning autonomy?

The second is to use chatbots only as knowledge acquisition tools. Students may use chatbots to satisfy emotional needs or simply as daily knowledge acquisition tools. The ability of generative AI to provide information is unquestionable (Lund & Wang, 2023), but it is also a double-edged sword (Hisan & Amri, 2023). Studies exploring the advantages of artificial intelligence in education have invariably mentioned the risk of robots causing dependence on technology and degrading the quality of learning (Dempere et al., 2023; Neumann et al., 2023; Rawas, 2023). However, while most of these studies raise this concern narratively, there is a lack of empirical verification regarding these learning effects. Therefore, we wanted to explore whether when people only view chatbots as a tool, their reliance on technology will reduce their learning autonomy. As knowledge becomes more easily accessible, how might this affect individuals' initiative in learning?

> **RQ2.** Among learners who prefer knowledge acquisition, is there a relationship between interaction frequency with chatbots and students' learning autonomy?

2.2 | Relationship between interaction with generative AI and social presence

The concept of social presence was originally proposed by Short et al. (1976), which refers to the degree to which people are seen as real people in the process of communication using media. Later, the concept was widely used in sociological research to refer to the fact that people feel that their connections and interactions with others are real. Elyakim et al. (2023) posited that media technology plays a crucial role in determining social presence, suggesting that the nature and capabilities of the medium significantly influence this perception. In light of this, educational activities facilitated through computer-mediated communication (CMC) have faced criticism for a perceived lack of presence, which some argue may detract from the effectiveness of the learning environment (Ucok-Sayrak & Brazelton, 2022). Kreijns et al. (2022) challenged the view by arguing that social presence is not solely determined by the media used. Instead, they emphasized that in computer-mediated communication, social presence is defined by the perceived connection between participants, asserting that it is the user's perception that matters more than the technical properties of the medium. Kreijns proposed that this subjective experience of feeling connected and engaged with another intellectual entity is the true essence of social presence in digital interactions. In other words, although CMC has lower social context cues than traditional teaching, communicators can still create social presence by investing their identities and building online communities. Since then, the influencing factors of social presence have been divided into two voices: technological determinism and social determinism. The influencing factors of social presence have also been understood as situational factors (such as system functions, learning environment) and social factors (such as emotions, interaction, learners' personal social skills) (Bayram & Artan, 2024). Therefore, social presence theory, as a theory that connects technology and technology use situations with learning effects, has a unique contribution to our exploration and observation of the improvement of people's learning autonomy in the context of artificial intelligence.

We combine the two views, following the perspective of weak technological determinism (Appelgren, 2023), believing that technology affects the sense of presence, but technology is also relatively autonomous, and the sense of presence may be affected by both situational factors and social factors.

In the context of artificial intelligence, media and social factors change simultaneously. From the perspective of technological determinism, the emergence of generative AI has subversively changed the traditional teaching situation. Generally, online courses are taught by real teachers, but now learners are completely talking to machines. However, from the perspective of social factors, intelligent and humane chatbots may enhance users' sense of social presence. As chatbot technology continues to be updated and iterated, its ability to eliminate ambiguity, provide emotional support, develop personalized plans, and imitate "real people" is getting stronger and stronger (Chatterjee & Dethlefs, 2023; Kocoń et al., 2023; Zhao et al., 2023). Whether generative AI serve as a virtual companion or as a knowledge acquisition tool, the human-like interaction, humorous language, and emoticons they provide may enhance learners' perceived social presence. From the perspective of the interactive interface, the free input interface gives learners a richer interactive space; from the perspective of the actual interaction process, the immediate and humane responses of the chatbot may make learners feel as if they relate to a

"real teacher". Generative AI offers advantages over traditional computer-mediated teaching.

In the fields of education and psychology, empirical research based on social existential theory is already abundant. Many scholars have explored and verified the direct or moderating effects of social presence on teaching quality and course satisfaction (Andel et al., 2020; Zhong et al., 2022). There are also some scholars exploring the influencing factors and effectiveness of social presence in online learning (Yang et al., 2022; Zhang et al., 2023). However, the focus of these studies is still traditional interpersonal teaching. Research on new media only focuses on changes in the teaching field, and there is a lack of research on the impact of human-computer interaction on social presence. Today, chatbots, serving as fully intelligent, human-independent "electronic teachers," have created a new model for teaching interactions. Will this have an impact on learners' sense of social presence? Two preferences are again distinguished: using the chatbot as a virtual companion and using it solely for knowledge acquisition.

RQ3. Among learners who prefer virtual companionship, is there a relationship between interaction frequency with chatbots and students' sense of social presence?

RQ4. Among learners who prefer knowledge acquisition, is there a relationship between interaction frequency with chatbots and students' sense of social presence?

2.3 | Relationship between social presence and learning autonomy

The community of inquiry (CoI) model is a model created by Canadian scholar Garrison to describe the necessary components of a meaningful learning experience. Garrison identified teaching presence, cognitive presence, and social presence as key factors affecting the teaching experience and learning outcomes (Garrison et al., 2010). Teaching presence refers to the teacher's design and guidance of teaching activities, cognitive presence refers to the learner's integration and construction of meaning through reflection and dialogue. Social presence includes dimensions such as communication, interaction, and emotional expression in the community. Many empirical studies based on CoI theory have verified that the three senses of presence are closely connected with each other, demonstrating that each enhances the others to create a more immersive and effective learning environment (ElSayad, 2023; Teng et al., 2024). Furthermore, these dimensions are not only interconnected but also collectively contribute to significant predictive effects on learning outcomes. Research has shown that an effective integration of teaching, cognitive, and social presence can enhance blended learning performance (Yin & Yuan, 2022), improve the efficacy of online teaching (Sun & Yang, 2023), and increase students' online learning achievements (Na et al., 2024). Among them, social presence is particularly crucial, as it plays the most pivotal role in influencing learning efficacy (Tusyanah et al., 2023). Therefore, the CoI model can well explain why social presence is an important factor affecting learning experience and learning effects, and help us understand how exploring social presence affects people's learning autonomy in the context of human-computer interaction. Social presence acts as a mediating variable between teaching presence and cognitive presence, serving as a crucial link between teachers and students (Garrison et al., 2010). When AI technology and chatbots are used in the teaching process, the sense of teaching presence (led by teachers) and cognitive presence (led by students) do not undergo qualitative changes. However, the sense of social presence may experience significant shifts due to the transformation of the teaching environment—from traditional and virtual classrooms to entirely digital, "non-existent" classrooms. The virtual conversational learning process has blurred the boundaries between traditional teaching and learning, and immersive scenarios make virtual presence possible. Although interactions between individuals and robots may initially appear to be one-on-one, they are embedded within a broader learning community environment. For instance, multiple learners might interact with the same AI chatbot simultaneously, or they might share their experiences and insights from interacting with AI in classrooms, forums, or on social media. All of these can be considered parts of community interaction (Wang et al., 2022). Whether social presence has an impact on learning autonomy in the context of AI is the focus of our research.

The importance of social presence as an independent variable in teaching activities has also been proven by extensive empirical research in educational psychology. For example, Lim et al. (2021) and Oyarzun et al. (2018) proved that learning satisfaction is significantly positively related to teacher presence. An online survey by Lim (2023) showed that social presence, as a moderator variable, can significantly predict learning outcomes. Horzum (2015) verified that in the online learning model, social presence can also positively predict online learning satisfaction. However, the focus of these studies remains on face-to-face and online teaching within the realm of interpersonal teaching, lacking an exploration of human-computer interaction perspectives. Moreover, these studies focus primarily on learning performance and learning satisfaction, and pay insufficient attention to learners' learning autonomy. Many studies have proven that learning autonomy is an important reason that affects learning motivation and enhances learning performance (Mammadov & Schroeder, 2023; Nikou & Economides, 2018). Especially with the use of chatbots in teaching, the learning process is no longer confined to traditional settings such as schools or online classes. People can actively acquire knowledge anytime and anywhere, realizing the transformation from passive "students" to active "learners". Therefore, learning autonomy should be focused on as a very critical dependent variable. We aim to determine if the use of generative AI, whether as virtual companions or knowledge acquisition tools, can stimulate stronger learning autonomy through satisfying social presence experiences. On this issue, this study is also divided into two situations for exploration, that is, how does social presence affect people's learning autonomy in virtual companionship preferences and knowledge acquisition preferences?

H1. Among learners who prefer virtual companionship, social presence is positively related to students' learning autonomy.

H2. Among learners who prefer knowledge acquisition, social presence is positively related to students' learning autonomy.

In summary, we proposed four research questions and two research hypotheses, constructed our research model through social presence theory and CoI theory, and tried to explore how generative AI affects people's learning autonomy in the context of human-computer interaction, and whether social presence plays a mediating role in this process.

3 | METHOD

3.1 | Participants and procedure

The participants of our longitudinal study were 1155 undergraduate students, drawn from three universities located in Eastern China. These participants were chosen among students enrolled in elective computer courses, as they were more likely to adopt new technologies, thus providing a suitable population for our study. To distinguish between virtual companionship and knowledge acquisition preferences, participants self-reported their predominant mode of interaction with generative AI. Those who viewed chatbots as companions and derived emotional support from them were classified under the virtual companionship preference (Xie & Wang, 2024). This involves seeking solace, expressing feelings, or just having a heartfelt conversation with the chatbot (Ma & Huo, 2024). It is less about fulfilling a tangible need and more about emotional connection and mental well-being. It is in this mode that users may share their anxieties, fears, hopes, and more, hoping for understanding, comfort, or just a listening ear (Chaturvedi et al., 2023). Conversely, participants who primarily perceived chatbots as tools for obtaining information and knowledge were categorized under the knowledge acquisition preference. Their engagement with the chatbot was mainly utilitarian, focusing on acquiring specific information rather than seeking companionship (Jo & Park, 2023). Participants using chatbots for academic tasks, like paper drafting, information retrieval, or course-related queries, fall into this category (Al-Sharafi et al., 2023). To ensure clear differentiation, participants were presented with scenarios or use-cases representative of both modes. For instance: "I chatted with the bot when I felt lonely." (Virtual companionship preference). "I used the chatbot to help draft my assignment." (Knowledge acquisition preference). Finally, 657 participants were seen as preferring virtual companionship, and 498 participants were seen as preferring knowledge acquisition.

The longitudinal study was carried out in three waves, each of which was timed to coincide with significant events or developments. We developed a chatbot named Benny based on artificial intelligence generated content (AIGC) technology. As shown in Figure 1, users can interact with Benny for virtual companionship or knowledge acquisition through a chat interface.

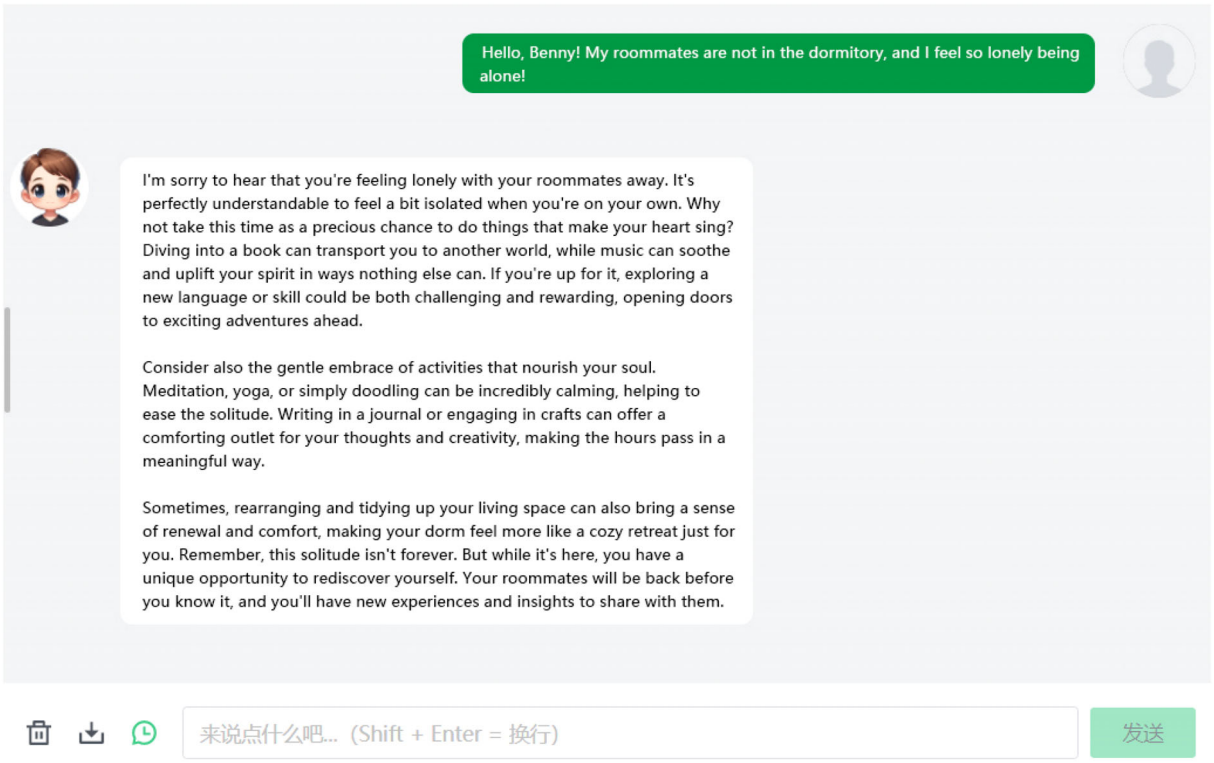

FIGURE 1 Interface of a user chatting with the virtual person Benny (the example in the figure is of a virtual companionship preference).

The first wave took place in May 2022. In the months leading up to this, China experienced a resurgence of COVID-19, leading to the implementation of strict control measures, including the lockdown of university campuses. To support students' well-being and alleviate both psychological distress and academic stress during this challenging period, the three universities collaboratively introduced a chatbot named Benny to their students, built upon Microsoft's Xiao Bing, also known as the Avatar Framework. This wave aimed to assess the initial impact of this chatbot on students' learning autonomy.

The second wave of the study took place in February 2023. By this time, China had adopted a more lenient approach towards COVID-19 management, easing many of the previous restrictions. Coinciding with advancements in AI chatbot technology, notably the ChatGPT model based on GPT3.5, the universities updated the Benny chatbot system to better support students in their studies and emotional well-being. This wave sought to determine the influence of the more technologically advanced AI chatbot on fostering learning autonomy among the participants.

The third and final wave of the study was conducted in May 2023, following the introduction of the GPT-4 model on March 15, 2023. With the widespread attention the GPT-4 model garnered, the universities offered Benny chatbots powered by this latest AI model to their students, presenting them with the newest advances in AI-driven support systems. The third wave's goal was to explore the implications of this state-of-the-art AI tool on enhancing students' learning autonomy.

Throughout all three phases, the chatbots, based on the respective contemporary artificial intelligence models of their time, were equipped to provide both text and voice assistance to the students, aiming to ease their academic challenges and emotional burdens.

Throughout the duration of the study, there was a decline in the number of participants in the virtual companionship preference. The retention rate stood at 87.98% in the second wave, accounting for 578 participants, and slipped to 86.15% in the third wave with 566 participants. This reduction primarily stemmed from the graduation of several students in June 2022, making subsequent data collection efforts challenging. However, despite this decrease, the retention rate for the virtual companionship preference remained commendably high, supplying a robust foundation for our longitudinal analysis. Among learners who prefer knowledge acquisition, the participant pool began at 560 in the first wave. By the second wave, the retention rate was 91.25% with 511 participants remaining, and this figure dwindled to 88.93% in the third wave, leaving 498 participants. It is crucial to note that our survey system retained the previous interaction preference selected by the participants. Any participant whose reported preference was inconsistent across the three waves had their samples excluded. This circumstance also resulted in a reduced sample size across the three waves of the study. However, based on our research findings, there was notable consistency in the participants' interaction preferences across all three waves, suggesting that transitions between the preferences occurred infrequently.

To handle the missing data, among learners who prefer virtual companionship preference, we first conducted a Little's Missing Completely at Random (MCAR) test. The results indicated that the missing values were randomly distributed ($\chi^2 = 101.726$, $p = 0.38$). Among learners who prefer knowledge acquisition, we similarly addressed the issue of missing data by initiating with a MCAR test. The results for this preference revealed that the missing data were randomly distributed as well ($\chi^2 = 94.382$, $p = 0.42$). Subsequently, we utilized the Maximum Likelihood (ML) method to handle these missing values, in line with the recommendation of Berry and Willoughby (2017).

This study collected data by distributing online surveys in the WeChat course groups of elective computer classes at three universities. The study was approved by the Institutional Review Board at the authors' institution (code B2022328I), and the participation of all subjects was based on informed consent. Participants who completed all three surveys were compensated with 15 RMB each, via WeChat Pay or Alipay.

For our data analysis, we utilized SPSS 26.0 to conduct descriptive statistics, while AMOS 25.0 facilitated multi-group confirmatory factor analysis (CFA) and the cross-lagged panel modelling (Su et al., 2022).

3.2 | Measures

The scales of this study are adapted from mature research. Survey questions can be viewed in Appendix.

3.2.1 | Interaction frequency with chatbots

In our investigation into the impact of two preferences for generative AI on participants' learning autonomy, we considered two dimensions: the frequency of use and the duration of use. Our survey findings reveal that participants with a preference for knowledge acquisition tend to engage with AI in a purpose-driven manner, frequently posing just a single question per interaction, which leads to relatively brief AI engagement periods. The variation in interaction duration across participants did not exhibit significant differences. We believe that the frequency of interactions serves as a more meaningful variable for our study, and thus we have chosen it as our independent variable. The predominant forms of interaction with chatbots are conveyed through AI-generated text and voice. To discern the frequency with which participants engaged with chatbots, we posed the question, "What is your interaction frequency with chatbots in the forms of AI-generated text and AI-generated voice?" Response options ranged from 1 to 5, where 1 represents "Less than once a week," 2 denotes "Once to twice a week," 3 signifies "Three to six times a week," 4 indicates "Once a day," and 5 corresponds to "Multiple times a day." We distinguished participants based on two different situations: virtual companionship and knowledge acquisition. Additionally, we included a "never" option. Participants who have never interacted with chatbots in either the virtual companionship or knowledge acquisition situations were excluded. In the questionnaire, participants were asked

whether they used chatbots other than those provided by the school. To better control for variables, those who indicated using external chatbots were also excluded.

In subsequent analysis, we found a strong correlation between interactions with AI-generated text and AI-generated voice (In all three waves of the analysis for both situations, the Pearson correlation between AI-generated text and AI-generated voice was greater than 0.68, with a p value less than 0.05.) This correlation can be attributed to the fact that AI-generated voice fundamentally operates on text recognition before converting it into speech, thus aligning it closely with AI-generated text. Given this strong correlation, we combined the frequency of interactions with both types of chatbots into a single score by calculating their mean value for further analysis.

The consistency of the measure for interaction frequency with chatbots remained high across all three waves. Among learners who prefer virtual companionship, Cronbach's alphas were 0.885 (T1), 0.901 (T2), and 0.891 (T3), underscoring a notable reliability over time. For learners who prefer knowledge acquisition, Cronbach's alphas registered at 0.873 (T1), 0.888 (T2), and 0.878 (T3), reflecting a similarly strong consistency.

3.2.2 | Social presence

Social presence was measured using a scale adapted from Kreijns et al. (2020). Participants were queried to consider their interactions with chatbots and express their agreement on various statements encompassing aspects such as perceived chatbot "personality", awareness of the chatbot during interactions, and the humanlike nature of their interactions. Responses were rated on a 5-point Likert scale, from 1 (Strongly Disagree) to 5 (Strongly Agree). Given the incorporation of a reverse-coded item (item number 6), care was taken to adjust scores appropriately before analysis. The mean score of all items was then computed to formulate a composite measure of social presence. A higher score corresponds to a heightened perception of social presence during chatbot interactions.

Among learners who prefer virtual companionship, the social presence scale displayed remarkable internal consistency across all three waves. For this situation, Cronbach's alphas were 0.912 (T1), 0.899 (T2), and 0.885 (T3), showcasing enduring reliability over time. Subsequently, we carried out a confirmatory factor analysis (CFA). The CFA for this preference across the three waves demonstrated a favourable model fit: χ^2/df was from 1.52 to 2.12, CFI was from 0.96 to 0.98, TLI was from 0.95 to 0.97, and RMSEA was from 0.02 to 0.03. Among learners who prefer knowledge acquisition, the social presence scale also exhibited robust internal consistency throughout the three waves. Cronbach's alphas were recorded at 0.905 (T1), 0.887 (T2), and 0.869 (T3), signifying a strong reliability. Results from the CFA across the three waves indicated a commendable model fit: χ^2/df was from 1.57 to 2.18, CFI was from 0.94 to 0.97, TLI was from 0.93 to 0.95, and RMSEA was from 0.03 to 0.04.

3.2.3 | Learning autonomy

Learning autonomy was assessed using a scale adapted from Macaskill and Taylor (2010). Participants were prompted to reflect upon their experiences and behaviours concerning self-directed learning and provide their level of agreement on statements highlighting elements such as the enthusiasm for new learning experiences, persistence in face of challenging tasks, and effective time management. Each response was evaluated on a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). With the inclusion of a reverse-coded item (item number 8), special attention was paid to correct the scores prior to any subsequent analytical procedure. The mean score across all items was calculated, offering a holistic measure of learning autonomy. A higher cumulative score is indicative of a stronger learning autonomy.

Among learners who prefer virtual companionship, the learning autonomy scale revealed remarkable internal consistency across the series of three waves. The Cronbach's alphas were as follows: 0.892 (T1), 0.906 (T2), and 0.884 (T3), illustrating sustained reliability over the duration of the study. A CFA was later conducted to affirm the structure of our measure in this specific preference. The CFA results across the three waves yielded an exemplary model fit with the χ2/df was from 1.50 to 2.10, the CFI was from 0.97 to 0.99, the TLI was from 0.96 to 0.98, and the RMSEA was from 0.02 to 0.03. Among learners who prefer knowledge acquisition, the learning autonomy scale showcased robust internal consistency through all three waves. The Cronbach's alphas recorded were: 0.867 (T1), 0.882 (T2), and 0.870 (T3). The CFA, when performed for this preference across the three waves, showed an excellent model fit. Specifically, the χ^2/df was from 1.55 to 2.15, the CFI was from 0.95 to 0.97, the TLI was from 0.94 to 0.96, and the RMSEA was from 0.02 to 0.04.

4 | RESULTS

4.1 | Common method bias test

Prior to delving into the outcome of our hypothesis tests, we first mitigated the possible issue of common method bias as our data was gathered from a single source. Common method variance could potentially pose a risk in studies like ours where self-report measures are employed for both the predictor and criterion variables. To examine this potential bias, we executed Harman's single-factor test, a broadly acknowledged method for scrutinizing common method bias (Podsakoff et al., 2003). This test administers an exploratory factor analysis where all survey items are included. If a solitary factor emerges or one factor is accountable for most of the covariance among the variables, it is suggestive of common method bias (Baumgartner & Weijters, 2012).

In our evaluation, the exploratory factor analysis yielded multiple factors each with Eigenvalues exceeding 1, suggesting that no single factor was responsible for the predominant part of the variance. Among learners who prefer virtual companionship, the principal factor

accounted for 28.5% of the variance in the first wave, decreased to 27.2% in the second wave, and slightly decreased to 26.8% by the third wave. Meanwhile, among learners who prefer knowledge acquisition, the primary factor represented 21.8% of the variance in the initial wave, rose to 22.1% in the subsequent wave, and settled at 21.9% in the final wave. Across all waves and both preferences, these percentages are well below the critical 50% threshold as suggested by Chin et al. (2012). This suggests that common method bias is not a major concern in our data.

4.2 | Descriptive statistics and correlations

The results of the descriptive statistics and correlations for the virtual companionship preference are depicted in Table 1. The table summarizes the means and standard deviations for the evaluated variables at all three intervals, coupled with the correlations among these variables.

The age of participants is denoted by an average age of 20.015 years and a standard deviation of 1.488. When it comes to gender, where 0 represents females and 1 signifies males, the mean stood at 0.565, accompanied by a standard deviation of 0.132. This demonstrates a fairly even gender distribution within the sample. Across all three waves, the interaction frequency with chatbots (IFC), social presence (SP), and learning autonomy (LA) showed considerable consistency over time, as evidenced by the significant correlations between the same constructs measured at different time points.

IFC and LA consistently showed no significant association throughout the three waves. This suggests that the frequency of interactions with chatbots does not have a clear relationship with participants' sense of learning autonomy among learners who prefer virtual companionship. On the other hand, IFC and SP displayed a persistently significant positive association across all three time intervals. This implies that participants who engaged more frequently with chatbots consistently perceived a heightened sense of social presence during their interactions among learners who prefer virtual companionship. Furthermore, SP and LA also demonstrated a consistently significant positive relationship throughout the three waves. This indicates that a greater sense of social presence during interactions with chatbots is associated with enhanced learning autonomy among participants.

The results of the descriptive statistics and correlations among learners who prefer knowledge acquisition are presented in Table 2. The average age of participants is illustrated with a mean of 20.428 years and a standard deviation of 1.502. As for gender representation, where 0 stands for females and 1 for males, the mean was 0.583, with a standard deviation of 0.137. This reflects a relatively balanced gender distribution within the study group. Across all three waves, IFC, SP, and LA showed considerable consistency over time, as evidenced by the significant correlations between the same constructs measured at different time points.

IFC and LA consistently showed a significant negative association across all three waves. This suggests that, among learners who prefer knowledge acquisition, as the frequency of interactions with chatbots increased, learning autonomy of participants decreased. Similarly, IFC and SP exhibited a significant negative relationship throughout the three time intervals. This indicates that higher interactions with chatbots were associated with a decreased sense of social presence for participants among learners who prefer knowledge acquisition. On the other hand, SP and LA demonstrated a consistently significant positive association across all three waves. This implies that a greater sense of social presence during interactions is associated with heightened learning autonomy among participants.

4.3 | Cross lagged analysis of the interaction frequency with chatbots, social presence, and learning autonomy among learners who prefer virtual companionship

In statistics, correlational analysis in descriptive statistics can only indicate that there is some statistical relationship between two

TABLE 1 The results of descriptive statistics and correlations (virtual companionship preference, $N = 657$).

Variables	*M*	SD	1	2	3	4	5	6	7	8	9	10
1. Age	20.015	1.488										
2. Gender	0.565	0.132	−0.021									
3. IFC (T1)	2.740	0.850	0.033	−0.131[a]								
4. IFC (T2)	2.802	0.833	0.041	−0.102[a]	0.650[b]							
5. IFC (T3)	2.931	0.879	0.042	−0.121[a]	0.608[b]	0.623[b]						
6. SP (T1)	3.602	0.832	0.033	−0.039	0.220[b]	0.241[b]	0.167[a]					
7. SP (T2)	3.596	0.816	0.018	−0.044	0.171[c]	0.249[b]	0.185[c]	0.661[b]				
8. SP (T3)	3.611	0.859	0.060	−0.050	0.169[b]	0.221[b]	0.218[c]	0.625[b]	0.638[b]			
9. LA (T1)	2.816	0.652	0.095	0.015	0.101	0.049	0.060	0.367[b]	0.305[b]	0.271[b]		
10. LA (T2)	2.958	0.668	0.067	0.026	0.078	0.061	0.082	0.295[b]	0.333[b]	0.296[b]	0.569[b]	
11. LA (T3)	3.014	0.680	0.058	0.017	0.084	0.054	0.039	0.288[b]	0.260[b]	0.343[b]	0.515[b]	0.580[b]

Abbreviations: Gender: 0, female; 1, male; IFC, interaction frequency with chatbots; LA, learning autonomy; *M*, means; SD, standard deviation; SP, social presence; T1, time 1; T2, time 2; T3, time 3.
[a]$p < 0.05$; [b]$p < 0.001$; [c]$p < 0.01$.

TABLE 2 The results of descriptive statistics and correlations (knowledge acquisition preference, $N = 498$).

Variables	*M*	SD	1	2	3	4	5	6	7	8	9	10
1. Age	20.428	1.502										
2. Gender	0.583	0.137	0.046									
3. IFC (T1)	2.913	0.735	0.050	0.055								
4. IFC (T2)	3.028	0.761	0.039	0.070	0.622[a]							
5. IFC (T3)	3.112	0.758	0.040	0.062	0.578[a]	0.601[a]						
6. SP (T1)	2.580	0.530	0.028	0.045	−0.202[a]	−0.165[b]	−0.144[c]					
7. SP (T2)	2.413	0.522	0.019	0.067	−0.151[b]	−0.216[a]	−0.170[b]	0.725[a]				
8. SP (T3)	2.459	0.561	0.031	0.028	−0.149[a]	−0.198[a]	−0.194[b]	0.642[a]	0.689[a]			
9. LA (T1)	2.902	0.601	−0.015	0.029	−0.181[b]	−0.178[b]	−0.161[b]	0.337[a]	0.264[a]	0.233[a]		
10. LA (T2)	3.033	0.635	−0.027	0.016	−0.168[b]	−0.204[b]	−0.180[b]	0.268[a]	0.308[a]	0.264[a]	0.532[a]	
11. LA (T3)	3.014	0.673	−0.019	0.054	−0.134[c]	−0.196[b]	−0.199[b]	0.270[a]	0.235[a]	0.325[a]	0.508[a]	0.540[a]

Abbreviations: Gender: 0, female; 1, male; IFC, interaction frequency with chatbots; LA, learning autonomy; *M*, means; SD, standard deviation; SP, social presence; T1, Time 1; T2, Time 2; T3, Time 3.
[a]$p < 0.001$; [b]$p < 0.01$; [c]$p < 0.05$.

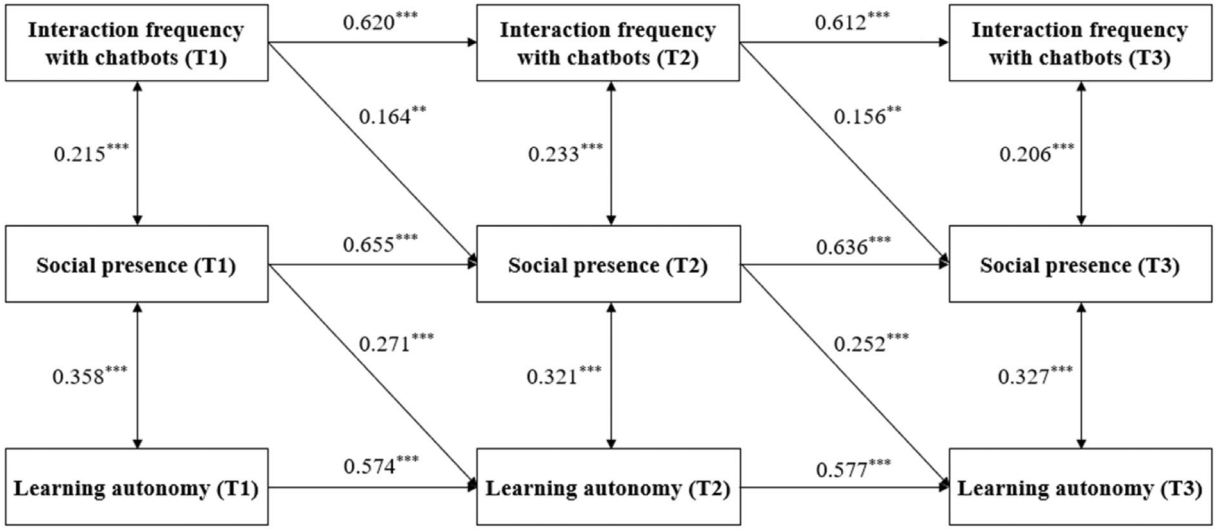

FIGURE 2 Three-wave cross-lagged model of the interaction frequency with chatbots, social presence, and learning autonomy in the virtual companionship preference. The measurement error and non-significant paths were omitted to enhance the clarity of the figure. Only the main paths of interest for this study are retained.

variables but cannot determine the directionality of this relationship. Cross-lagged analysis helps researchers explore potential causal relationships between variables, identifying which variable occurs first and which follows (Zyphur et al., 2020). Therefore, following our descriptive analysis, we conducted a cross-lagged analysis. We constructed a cross-lagged model with IFC serving as the independent variable, SP acting as the mediator, and LA being the dependent variable. The model and standardized path coefficients are depicted in Figure 2. In our SEM analysis within the same wave, we have employed double-headed arrows to denote the covariance between variables, reflecting our hypothesis that these constructs are interrelated within a single measurement period. This bidirectional representation is indicative of a correlational relationship, where changes in one construct are expected to relate to changes in another, without implying causality. Conversely, when examining relationships across different waves, we have utilized single-headed arrows. This is in line with the longitudinal nature of our study, where we aim to explore the directionality of influence—that is, how earlier measures might predict later outcomes. These single-headed arrows allow us to model the temporal precedence and potential causal influence of one variable on another over time.

Across all three waves, the relationship between IFC and SP, coefficients show a moderate positive association, ranging from 0.156 to 0.233 across the waves. There is also a consistent positive relationship over the three waves between SP and LA, with coefficients ranging from 0.252 to 0.358. The fit indices for the model were excellent: $\chi^2(df) = 145.24(90)$, $p < 0.001$, AGFI = 0.97, NFI = 0.95, RFI = 0.96, IFI = 0.97, TLI = 0.96, CFI = 0.98, RMSEA = 0.05.

In conclusion, the data suggest a stable and significant relationship between participants' frequency of interaction with chatbots and their subsequent sense of social presence and learning autonomy. As interactions with chatbots increased, there was a notable rise in the feeling of social presence, which in turn seemed to foster a heightened sense of learning autonomy. This consistent pattern observed across all three time points emphasizes the significant role of chatbots in enhancing both the perceived social presence and learning autonomy among learners who prefer companionship.

4.4 | Cross lagged analysis of the interaction frequency with chatbots, social presence, and learning autonomy among learners who prefer knowledge acquisition

We constructed a cross-lagged model with IFC serving as the independent variable, SP acting as the mediator, and LA being the dependent variable in the knowledge acquisition preference. The model and standardized path coefficients are depicted in Figure 3.

Across all three waves in the knowledge acquisition preference, direct relationship between IFC and LA indicate a persistently negative association, ranging from −0.111 to −0.172. Notably, the coefficient between IFC at T1 and LA at T3 signifies a prolonged negative effect, with an increased frequency of interactions with chatbots at T1 leading to a decline in learning autonomy by T3. The relationship between IFC and SP consistently shows negative coefficients, ranging from −0.131 to −0.203, implying a declining trend in social presence as participants interact more frequently with chatbots. SP and LA maintain a solid positive association throughout the three waves, with coefficients ranging modestly but staying robust, ranging from 0.219 to 0.320. The fit indices for this model in the knowledge acquisition preference were excellent: $\chi^2(df) = 132.87(90)$, $p < 0.001$, AGFI = 0.96, NFI = 0.95, RFI = 0.95, IFI = 0.96, TLI = 0.95, CFI = 0.97, RMSEA = 0.04.

In conclusion, among learners who prefer knowledge acquisition, as participants increased their interactions with chatbots, there was a noticeable negative correlation between IFC and LA, indicating that more frequent engagements led to a decline in learning autonomy. Concurrently, there is a discernible decline in the sense of social presence as participants engage more with chatbots. Despite this, the sustained positive relation between social presence and learning autonomy across the waves indicates a compensatory mechanism, where the perceived social presence might buffer the declining trend in autonomy.

5 | DISCUSSION

With the continuous advancement of AI and deep learning technology, it is now common for generative AI to participate in teaching activities (Baidoo-Anu & Ansah, 2023; Opara et al., 2023). However, past empirical research in education has mostly focused on the impact of online learning from the perspective of computer-mediated communication on learning performance or learning autonomy (Doo & Zhu, 2024; Sarfraz et al., 2022; Wu & Yu, 2022). Although online learning is a breakthrough for traditional classroom teaching, it is still limited to the scope of interpersonal teaching, and there is still a lack of empirical research focusing on a complete human-machine teaching model such as robot participation in teaching. Therefore, the purpose of this study is to explore whether and how interaction frequency with chatbots has an impact on learning autonomy. Considering that generative AI can not only directly provide information and knowledge along with personalized teaching services (Bin-Hady et al., 2023; Kohnke et al., 2023), it can also offer emotional value and companionship (Bilquise et al., 2022). We divide it into two situations to explore and discuss respectively: the situation where the chatbot is regarded as a virtual companion and the situation where it is only used as a daily knowledge acquisition tool.

In addition, based on the classic social presence theory and CoI theory, we regard social presence as a learning autonomy mediating variable between interaction frequency with generative AI. Previous literature has been controversial in exploring whether media or social

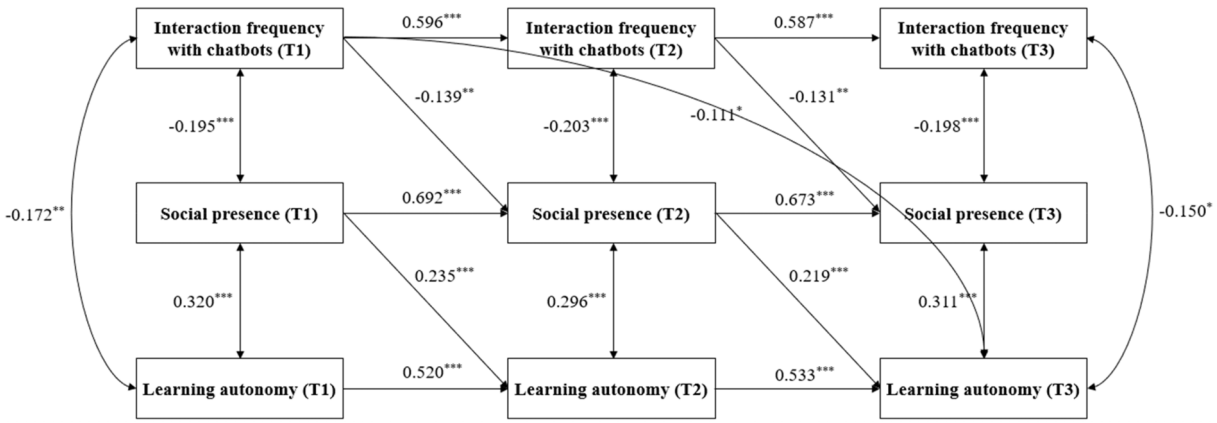

FIGURE 3 Three-wave cross-lagged model of the interaction frequency with chatbots, social presence, and learning autonomy among learners who prefer knowledge acquisition. The measurement error and non-significant paths were omitted to enhance the clarity of the figure. Only the main paths of interest for this study are retained.

factors play a decisive role in social presence. We combine the two perspectives and finds that AI chatbots have a negative impact on social presence when providing technical support as knowledge acquisition tools, but have a positive impact when providing emotional value as virtual companionship. Therefore, we also tried to explore whether social presence serves as a mediating variable to influence learners' learning autonomy under two situations.

Firstly, among learners who prefer virtual companionship, our research results reveal no significant correlation between IFC and LA. This finding is consistent with the conclusion of Sinai and Rosenberg-Kima (2022). Their research suggests that even when a social robot is perceived as a consistent virtual companion, it doesn't necessarily translate to heightened learning autonomy.

On the other hand, among learners who prefer knowledge acquisition, we observed a significant negative correlation between IFC and LA. Strikingly, as learners increase their use of intelligent robots for their studies, their sense of learning autonomy diminishes. This outcome, though unexpected, stimulates profound reflection on the role of technology in education. In everyday scenarios, these results suggest that virtual robots could potentially hinder learning autonomy. This aligns with concerns consistently raised by scholars. Dempere et al. (2023), Neumann et al. (2023), and Rawas (2023) posit that the direct and efficient services rendered by social robots might foster a dependency in students on these intelligent systems, leading them to be less proactive in their educational endeavours. This also echoes what Hisan and Amri (2023) pointed out that the ability of generative AI to provide information is a double-edged sword. Fuchs (2023) further contends that when knowledge becomes overly accessible, there is a risk of individuals becoming passive learners. This ease of access, as Lo (2023) suggests, could promote an uncritical acceptance of information, potentially encouraging academic complacency or even plagiarism.

Moreover, the deployment of intelligent robots invariably requires electronic terminals such as smartphones, tablets, computers, and other devices. These platforms, which seamlessly blend informational and entertainment features, might pose challenges to a learner's discipline and focus. Consequently, there is a pressing need for careful integration of these robots into educational settings, especially considering the potential pitfalls for younger learners. It is crucial to ensure they do not become overly reliant on these tools and that their capacity for independent, critical thought remains robust.

Secondly, among learners who prefer virtual companionship, as interactions with generative AI intensify, the sense of social presence also escalates. While chatbots, as intelligent robots, may physically eliminate the conventional "body" from the teaching process, they uniquely facilitate an emotional and interactive embodiment. The body becomes "absent but present" in an emotional and communicative sense. Advances in chatbot technology, with their growing ability to mimic human nuances, comprehend queries, and offer emotional resonance (as noted by Chatterjee & Dethlefs, 2023; Kocoń et al., 2023; Zhao et al., 2023), have transformed them from mere machines to virtual companions. Users begin to feel as if they are interacting with a genuine human entity, a sentiment which is intensifying over time. This is a distinctive capability that traditional computer-mediated teaching struggles to replicate, marking it as a unique advantage of intelligent robots in the educational arena.

Conversely, among learners who prefer knowledge acquisition, there is an inverse relationship: the higher the frequency of interaction with chatbots, the lower the perceived social presence. This finding is consistent with the principle of technological determinism, especially as expounded by Hallström (2022), that technology makes people physically absent from the scene, making it less easy to perceive social existence. The introduction of artificial intelligence in daily scenarios, especially in teaching, reduces the palpable cues of a social situation. The tactile presence of educators, classrooms, and even the tangible confines of the temporal and spatial dimensions of instruction fades away. Learners find it challenging to sense the existence of instructors or the teaching environment. Consequently, the degree to which they perceive the educators and even themselves as real entities diminishes. Similar to critiques often levied at the computer-mediated communication (CMC) teaching model, when learners and educators are geographically and temporally detached, the learner's bond with the educator weakens, causing the sensed presence during the learning process to wane. This decline underscores the inherent limitations of remote technology.

Thirdly, among learners who prefer virtual companionship, we observed that IFC doesn't directly relate to LA. However, we discovered a notable positive association between IFC and SP. Given the significant positive correlation between SP and LA, our results highlight the potential of SP as a mediator that can influence learning autonomy in this situation. This confirms the CoI model and echoes previous empirical research, proving that presence, especially social presence, is an important factor influencing learning effects (Fornara & Lomicka, 2019; Li, 2022; Sun & Yang, 2023). This aligns with Deci and Ryan (2013)'s assertion that successful learning experiences can bolster learning autonomy. While interaction with chatbots amplifies the sense of social presence, this consequently enhances learners' satisfaction with their learning journey. A fulfilling learning experience, in turn, invigorates learners' intrinsic motivation, an essential aspect of fostering active participation in human-computer interactive learning. In this context, it becomes evident that even if IFC doesn't directly bolster LA, it plays an indirect role by augmenting SP, thereby elevating learning autonomy.

In contrast, learners who prefer knowledge acquisition present a more complex landscape. Here, increased interaction with generative AI showed a direct negative impact on learning autonomy and concurrently led to a reduction in perceived social presence. However, the consistent positive correlation between SP and LA throughout our study is illuminating. It suggests a compensatory mechanism at play: despite the adverse impacts of higher IFC, the inherent positive relationship between SP and LA seems to provide a counteracting effect. This indicates that, even in scenarios where increased chatbot interaction might hinder autonomy, a robust sense of social presence could serve as a stabilizing factor. It highlights the potential of SP to counterbalance or perhaps even alleviate the negative implications of excessive IFC.

Our research has both theoretical and practical significance. From a theoretical point of view, firstly, this study is the first to incorporate the perspective of human-computer interaction into the research on learning performance, breaking new ground beyond the traditional focus. Previous research has primarily concentrated on learning autonomy within traditional classroom settings or human interactions in online environments. By shifting the focus to interactions between humans and AI, this research opens up new avenues for understanding how learning autonomy can be influenced in the context of technological advancements. Secondly, responding to the longstanding debate highlighted by Kreijns et al. (2011) on whether social presence is determined by the medium's properties or by sociological variables, this study synthesizes both perspectives. By investigating the role of AI chatbots in influencing social presence, and considering both their technological capabilities and the social interactions they enable, the research provides a nuanced understanding. This integrated approach leads to the conclusion that AI chatbots can enhance social presence through their interactive capabilities, which simultaneously engage technical and social determinants. Thirdly, this study recontextualizes the CoI framework within the realm of human-computer interaction in educational settings, with a particular focus on social presence—one of its core elements. By placing CoI in this innovative context, we expand the theoretical dimensions of the framework to adapt to new technological environments. This adaptation emphasizes how social presence, deeply influenced by interactions with AI technologies, plays a critical role in shaping learning autonomy. Fourthly, by distinguishing between two primary preferences of AI usage in education—virtual companionship and knowledge acquisition—this research adds granularity to our understanding of user interactions with AI. This distinction clarifies how different interaction preferences can lead to varied educational outcomes, offering specific perspectives and approaches for future research in human-computer interaction within the educational sector.

From a practical standpoint, our research underscores the potential of integrating generative AI into educational frameworks in ways that can significantly enhance individual learning autonomy. Firstly, our research demonstrates that virtual companionship provided by AI chatbots can enhance social presence, thereby positively influencing learning autonomy. Recognizing social presence encourages a more dynamic and self-directed learning approach, beneficial for learners irrespective of their preferences. Hence, creating an immersive learning environment that simulates interaction with a genuine teacher becomes crucial. Secondly, it is essential for educational technologists to refine AI chatbot responses to cultivate a sense of familiarity and provide the emotional support that users seek. However, our study also highlights the potential drawbacks of chatbot interactions, such as the risk of fostering dependency on technology, which can undermine autonomy and critical thinking in learning processes. Therefore, managing the use and application of tools like GPT and similar language models judiciously to prevent such dependency is vital. Thirdly, for educators, this study illustrates the utility of AI as a multifaceted tool that can elevate student engagement and autonomy, especially when it extends beyond mere provision of information to offering emotional support. To leverage these benefits, educators must adeptly incorporate AI-driven interactions that maintain or enhance social presence. Additionally, developers of educational technologies are encouraged to design AI interfaces and interactions that foster a sense of social presence, thus supporting more effective and autonomous learning experiences. Lastly, by aligning AI with pedagogical strategies, we pave the way for a synergistic relationship between technology and education, enriching the educational experience in the digital era. This approach ensures that digital learning environments facilitate not only knowledge acquisition but also social engagement, promoting the intrinsic motivation necessary for lifelong learning. The vision is for an educational landscape where AI serves as a complement to human interaction, fostering an ecosystem conducive to nurturing autonomous learners.

6 | CONCLUSION

This study explores the relationship between interaction with chatbots, social presence, and learning autonomy. This study opens new horizons for educational research in the context of artificial intelligence, and also provides improved reference for AI chatbots.

There are limitations of our study. First, the specific subject population, undergraduates from an eastern Chinese university, may limit the generalizability of our findings. Secondly, our research data comes from participants' self-reports, and intentional or unintentional reporting biases on the part of the subjects may affect the accuracy of the survey results.

Future research directions stemming from our study offer multiple avenues for enhancing the understanding and application of generative AI in educational contexts: Firstly, in our longitudinal study, to ensure the accuracy of the study, the system will retain the last preference filled in by the participants. If the preference is inconsistent among the three waves, this type of sample will be excluded. Future research can further explore the process and reasons of this preference conversion. Secondly, although in our study, participants mostly had clear preference tendencies (either for virtual companionship or knowledge acquisition), as evidenced by the high retention rate of participants, in real-world scenarios, users may have needs for both virtual companionship and knowledge acquisition simultaneously. Therefore, future research could consider including such mixed preferences in the studies. Thirdly, An essential area for future research is the exploration of generative AI's impact across diverse educational contexts and cultures, evaluating how different pedagogical approaches and learner backgrounds influence the effectiveness of AI-assisted learning. Fourthly, the development of strategies to mitigate potential dependencies on technology, as highlighted in our findings, warrants thorough investigation. This includes studying how educators can balance the use of generative AI to support, rather than replace, critical thinking and problem-solving skills in learners. Fifth, the integration of generative AI into hybrid learning models—combining face-to-face and online learning—presents an opportunity to investigate how AI can enhance social presence and learning

autonomy in blended educational settings. Investigating the balance between AI and human teacher interactions could provide a deeper understanding of how to optimally leverage technology to enrich the educational experience.

AUTHOR CONTRIBUTIONS

Zehang Xie: Research design, data analysis, method, results, discussion, writing, and paper revision. Xinzhu Wu: Introduction, literature review, discussion writing. Yunxiang Xie: Research design, data collection, paper revision, and funding acquisition.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of Shanghai Jiao Tong University (code B2022328I). The participants provided their written informed consent to participate in this study.

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APPENDIX A

A.1 | Survey questions

Interaction frequency with chatbots

What is your interaction frequency with chatbots?

Virtual companionship preference

AI generated text

(Never, less than once a week, once to twice a week, three to six times a week, once a day, multiple times a day)

AI generates voice

(Never, less than once a week, once to twice a week, three to six times a week, once a day, multiple times a day)

Or Knowledge acquisition preference

AI generated text

(Never, less than once a week, once to twice a week, three to six times a week, once a day, multiple times a day)

AI generates voice

(Never, less than once a week, once to twice a week, three to six times a week, once a day, multiple times a day)

Social presence (Kreijns et al., 2020)

To what extent do you agree with the following statement (*1 = Strongly Disagree and 5 = Strongly Agree*)

1. I can get a glimpse of the "personality" of the chatbot.
2. I'm aware of the chatbot's presence during our interaction.
3. My interaction with the chatbot doesn't feel robotic.
4. The chatbot interacts in a way that isn't entirely predictable.
5. The chatbot provides responses that are contextually relevant.
6. I can't really discern any "personality" from the chatbot. (R)
7. The chatbot feels like a real person to me.
8. I feel more aware of the chatbot than of other digital assistants.
9. Interacting with the chatbot feels like communicating with a real person.
10. It feels as if the chatbot understands my context.
11. I'm more aware of the chatbot than of traditional search engines.
12. The chatbot's responses feel personalized to me.
13. It feels like the chatbot is truly present during our interactions.
14. The chatbot understands my intentions well.
15. The chatbot is my primary choice for digital communication.

Learning autonomy (Macaskill & Taylor, 2010).

To what extent do you agree with the following statement (*1 = Strongly Disagree and 5 = Strongly Agree*)

1. I enjoy new learning experiences.
2. Even when tasks are difficult, I try to stick with them.
3. I enjoy finding information about new topics on my own.
4. I am open to new ways of doing familiar things.
5. I take responsibility for my learning experiences.
6. I enjoy being set a challenge.
7. I tend to be motivated to work by assessment deadlines.
8. I frequently find excuses to avoid studying. (R)
9. I plan my time for study effectively.
10. I am good at meeting deadlines.
11. My time management is good.
12. I am happy working on my own.