Non-academic learner socialisation with ChatGPT and its influences on learning English argumentative writing logic

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Abstract

ChatGPT-assisted learning has been increasingly implemented and shown effectiveness at cognitive and affective levels. In this learning approach, learners may have non-academic socialisation with ChatGPT behaviourally by producing non-academic prompts and emotionally by developing a sense of relatedness with it, which, considering the reported benefit of non-academic learner socialisation, may contribute to the effectiveness of ChatGPT-assisted learning. So far, research on such non-academic socialisation and its impact remains limited. To fill in the gap and thereby enhance the understanding of ChatGPT-assisted learning, we explored the extent and nature of non-academic socialisation with ChatGPT among EFL learners and its effects on learning outcomes in English argumentative writing. We developed a GPT-4-powered bot for learning English argumentative writing logic and asked 40 EFL university students to use it for a 45-to-75-min period. We analysed their prompts and surveyed their senses of relatedness to measure their behavioural and emotional non-academic socialisation with ChatGPT. Pre-post tests, writing tasks, and questionnaire surveys were administered to assess their learning outcomes regarding logical knowledge, logical quality, and self-efficacy in English argumentative writing. Semi-structured interviews were also conducted. Findings indicate that EFL learners had upper-intermediate levels of non-academic socialisation with ChatGPT due to ChatGPT's excellent capabilities of language understanding and generation, fostering social presence and homophily, and stimulating positive emotions among learners. The socialisation enhanced learning outcomes in English argumentative writing, especially logical knowledge, by improving feedback acceptance, motivating strategy application, and triggering a flow. Based on the findings, we recommend long-term ChatGPT-assisted learning of English argumentative writing logic with spontaneous non-academic socialisation and a distinct, engaging bot persona.

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1 Introduction

In recent years, chatbots, i.e., computer programs designed for natural language conversations with humans, have gained increasing attention and application in education (Zhang et al., 2023b). Among these, ChatGPT has emerged as a prominent tool (Shaikh et al., 2023). Developed by OpenAI, ChatGPT is a large language model renowned for understanding user intents and contextual nuances in complex conversations, providing coherent responses across diverse topics (Achiam et al., 2023), having demonstrated effectiveness in assisting the development of knowledge and skills (Songsiengchai et al., 2023). When assisting learning, ChatGPT can generate personalised materials and tasks (Kohnke et al., 2023), evaluate learner proficiency and offer personalised feedback (Shaikh et al., 2023), and ask and answer open-ended questions (Guo & Lee, 2023). According to Deng and Yu's (2023) criteria, these capabilities qualify ChatGPT as a teaching assistant, learning partner, and personal tutor.

Beyond academic roles, ChatGPT may also serve as a companion with whom learners can socialise without academic purposes (Oktawirawan, 2022). Research has documented non-academic learner socialisation with educational chatbots and Chat-GPT from both emotional and behavioural dimensions: Emotionally, learners report feeling a sense of relatedness, perceiving chatbots as "real friends" (Yang et al., 2022); Behaviourally, learners produced prompts to greet chatbots, express gratitude (Kane, 2019), and share personal issues (Goda et al., 2014). Such non-academic socialisation is facilitated by the capabilities of chatbots, including ChatGPT, to detect user emotions and intents (Cheng et al., 2023), adopt distinct personas (Ruan et al., 2020; Zhang et al., 2023b), provide social cues, such as addressing users by names (Huang et al., 2022), and offer emotional support through agreement, empathy, encouragement, and praise (Brandtzaeg et al., 2022). The socialisation can elicit enjoyment and comfort (Brandtzaeg et al., 2022) and promote intimacy and self-disclosure (Croes & Antheunis, 2021). Furthermore, ChatGPT's capability to personalise responses based on extensive conversation histories (Brown et al., 2020) enables appropriate replies and fosters shared experiences with users (Oktawirawan, 2022). Consequently, Chat-GPT has the potential to elicit non-academic learner socialisation from both emotional and behavioural dimensions while assisting learning.

Despite this potential, few studies have investigated non-academic learner socialisation, specifically in the context of ChatGPT-assisted learning. Exploring this area could deepen our understanding of learner behaviours and emotions in ChatGPT-assisted learning, which is crucial for designing effective technology-enhanced learning environments and providing better support for future learners (Lai et al., 2018; Su et al., 2021). Therefore, it is meaningful to examine the extent and nature of learners' socialisation with ChatGPT in both emotional and behavioural dimensions.

Moreover, although research on ChatGPT-assisted learning remains limited, non-academic learner socialisation in other educational contexts has demonstrated substantial positive influences on academic and affective outcomes. In traditional learning environments, non-academic socialisation with peers and teachers encourages learners to apply cognitive and metacognitive strategies, enhances emotional well-being, increases motivation, and improves academic performance (Ma et al.,

2018; Shao et al., 2024). In chatbot- and robot-assisted learning contexts, non-academic socialisation with educational technology has been associated with increased learner enjoyment (Ruan et al., 2020) and heightened willingness to engage in practice (Ayedoun et al., 2015). These empirical findings indicate the positive impacts of non-academic learner socialisation on learning outcomes, which may also apply to ChatGPT-assisted learning. Investigating these effects could illuminate the effectiveness and underlying mechanisms of ChatGPT-assisted learning, providing valuable insights for future research and implementation.

To address these gaps, we developed a GPT-4-powered bot to assist learning English argumentative writing logic, a critical component English as a Foreign Language (EFL) proficiency (Murray, 2012). By analysing learner prompts, surveys, knowledge tests, writing tasks, and interviews, we aim to explore the extent and nature of non-academic socialisation with ChatGPT among EFL learners from both emotional and behavioural perspectives, as well as its impact on learning outcomes in terms of logical knowledge, logical quality, and self-efficacy in English argumentative writing. This study seeks to deepen understanding of learner experiences, effectiveness, and mechanisms of ChatGPT-assisted learning, offering insights for future design and implementation. Two questions guided this study:

> RQ1: To what extent do EFL learners socialise with ChatGPT for non-academic purposes in learning English argumentative writing logic? How and why?
> RQ2: Does EFL learners' non-academic socialisation with ChatGPT influence the development of logical knowledge, logical quality, and self-efficacy in English argumentative writing? How and why?

2 Literature review

2.1 Developing logical knowledge, logical quality, and self-efficacy in English argumentative writing

English argumentative writing is writing that presents and supports a stance on a particular issue (Murray, 2012). It is an essential skill for EFL learners (Murray, 2012), who generally demonstrate low proficiency (Nejmaoui, 2019) and low self-efficacy in English argumentative writing, defined as learners' belief in their ability to write argumentative texts successfully (Tsao, 2021).

A significant challenge faced by EFL learners is the development of sound logic in their writing (El Khoiri & Widiati, 2017). Sound logic in English argumentative writing refers to the structured and coherent connection of premises and evidence to conclusions (DeLancey, 2017). It is crucial for the persuasiveness and validity of the primary argument, widely recognised as a key criterion for assessing English argumentative writing quality (de Swart, 2018). Nevertheless, EFL learners frequently commit logical fallacies in their argumentative writing, which significantly diminishes the overall quality of their work (El Khoiri & Widiati, 2017). El Khoiri and Widiati (2017) analysed the English argumentative essays of 40 university EFL students and identified low logical quality. Similarly, Lismay (2020) examined essays

written by 28 university students and found that over 76% contained logical fallacies, which considerably reduced their writing quality. Given the positive correlation between writing quality and self-efficacy (Busse et al., 2023), low logical quality in EFL learners' English argumentative writing may contribute to their low self-efficacy.

To enhance EFL learners' logical quality and self-efficacy in English argumentative writing, it is essential to develop their logical knowledge, encompassing concepts, principles, and structures for constructing clear and persuasive arguments (Murray, 2012). Researchers argue that most logical problems in EFL argumentative writing are fundamental and can be addressed once learners understand relevant logical concepts and principles (Murray, 2012; Oaksford & Chater, 2020). For example, Nejmaoui (2019) instructed EFL learners on logical concepts relevant to English argumentative writing, and pre- and post-writing assessments showed significant improvements in logical quality. Thus, developing EFL learners' logical knowledge is beneficial for improving their logical quality and self-efficacy in English argumentative writing (Murray, 2012).

Researchers and educators have proposed various strategies to enhance EFL learners' logical knowledge, logical quality, and self-efficacy in English argumentative writing. For instance, Nejmaoui (2019) provided EFL learners with instruction. Song and Sparks (2019) integrated logical knowledge exercises into educational digital games for middle school students, with test and survey results indicating the effectiveness of these exercises in improving reasoning error identification skills. Selpia et al. (2020) investigated the logical knowledge of high school EFL students and found that their overall proficiency levels were low. They recommended that teachers guide students to analyse logic in authentic English texts and encourage questioning and discussion of logical principles to enhance understanding.

In sum, developing logical knowledge is essential for EFL learners to improve logical quality and self-efficacy in English argumentative writing. Exercises, instructions, and analysis of authentic English texts from a logical perspective are effective approach to developing logical knowledge.

2.2 Chatbot-assisted learning, generative AI, and ChatGPT-assisted learning

In recent years, chatbot-assisted learning has gained recognition as an effective educational approach. Kuhail et al. (2023) systematically reviewed 36 studies and found that educational chatbots could offer academic recommendations, support academic discussions, answer questions, and provide emotional support. Zhang et al. (2023b) reviewed 46 studies on chatbot-assisted learning, highlighting its usefulness in enhancing learner knowledge and affection through knowledge presentation, practice facilitation, activity supervision, encouragement, personalised address, humour, emojis, and informal conversation.

The landscape of chatbot-assisted learning has been largely changed by generative AI, which are AI models capable of learning from data and generating original, meaningful, personalised content. As a prime example of generative AI, GPT has been increasingly applied as the core of chatbot-assisted learning, demonstrating significant potential. Baidoo-Anu and Ansah (2023) conducted an exploratory synthesis study on ChatGPT-assisted learning, identifying its advantages over traditional

chatbot-assisted learning in personalising learning materials, promoting interaction, and providing assessments with feedback. In another synthesis study, Kasneci et al. (2023) identified the usefulness of ChatGPT in understanding learner prompts, generating diverse instructions and exercises, assessing academic performance, enhancing student engagement and interaction, and personalising learning experiences.

Specifically, ChatGPT has demonstrated usefulness in writing education. For example, Baskara (2023) argued that ChatGPT could provide personalised, real-time feedback on writing in terms of vocabulary, grammar, and syntax. It may also sustain learner motivation in EFL writing by creating an authentic, immersive and interactive writing environment. Han et al. (2023) developed a ChatGPT-assisted programme for learning EFL writing where ChatGPT analysed students' writing and provided suggestions. The focus group results revealed learners' positive experiences with the programme.

So far, no research has examined ChatGPT-assisted learning of English argumentative writing logic, although existing studies have suggested its great potential. Guo and Lee (2023) asked university students to develop critical thinking skills by discussing and writing an argumentative essay with ChatGPT. They found significant effectiveness of ChatGPT-assisted learning in enhancing learners' perceived critical thinking skills in English argumentative writing. Zhang et al., (2023a, 2023b) developed a chatbot-assisted programme for learning English argumentative writing logic. Based on a conventional decision tree, their chatbot delivered instructions, examples, and exercises on logical concepts and demonstrated usefulness in enhancing EFL learners' logical knowledge and quality in English argumentative writing. They argued that the programme would be more effective if integrated with ChatGPT.

2.3 Non-academic learner socialisation and its influences in language learning

Non-academic learner socialisation can be defined as learner engagement with others within a learning community that is not directly related to educational content or specific educational outcomes (De Silva & Garnaut, 2011). Driven by individuals' inherent need to understand the world and establish social bonds, such socialisation arises from the tendency to attribute human-like characteristics—such as emotions, mental states, and behaviours—to non-human entities. This phenomenon is known as anthropomorphisation, to which non-academic socialisation also contributes (Airenti, 2015; Epley et al., 2007). Unlike affective feedback acceptance, which emphasises learners' passive acceptance of comments from educational resources (Van der Pol et al., 2008), non-academic learner socialisation is characterised by learners' proactive use of social cues, such as addressing peers by name and smiling, as well as developing emotional attachments, including feelings of relatedness and community (Frisby & Martin, 2010).

This form of socialisation is prevalent in traditional language educational settings with teachers and peers (Gan, 2021; Martinot et al., 2022) and can positively influence learners' cognition and emotions, as explained by various theories. For instance, self-regulated learning theory (Zimmerman, 2013) can elucidate the benefits of non-academic learner socialisation, which emphasises the importance of learners' proactive management of their learning through cognitive and metacognitive strategies,

such as elaboration and planning. Empirically, Ma et al. (2018) conducted a questionnaire Survey involving 11,036 Chinese EFL students and found that learners who engaged in stronger non-academic socialisation with teachers tended to employ more cognitive and metacognitive strategies in their EFL learning, leading to improved academic performance.

Another theoretical perspective that supports the positive influences of non-academic learner socialisation is attachment theory (Bowlby, 1980), which underscores the significance of forming strong, healthy interpersonal bonds in fostering feelings of security and enhancing academic performance. Ma et al. (2020) investigated the non-academic socialisation of 4,900 Chinese EFL students with their teachers and identified significant positive impacts on the development of EFL proficiency. Drawing on Attachment Theory, Ma et al. explained that learners experiencing more extensive and positive non-academic socialisation felt safer, more valued, and more supported in their EFL learning, motivated to invest greater effort in academic tasks.

Furthermore, the positive influences of non-academic learner socialisation can also be interpreted through the lens of self-determination theory (Deci & Ryan, 2012), which posits that motivation plays a crucial role in learning experiences and outcomes. For example, Shao et al. (2024) explored non-academic socialisation among 717 Chinese students with their peers and found significant positive impacts on academic achievements. They argued that improved non-academic socialisation with peers fostered increased motivation in learning, further enhancing academic outcomes.

However, it is important to note that non-academic learner socialisation does not always lead to improved learning outcomes. Frisby and Martin (2010) found that non-academic socialisation with peers was not significantly related to learning outcomes, arguing that fulfilling learners' social needs may not necessarily align with their educational needs. This perspective aligns with constructivist learning theory (Vygotsky & Cole, 1978), which contends that learning is most effective when learner actions are directly aligned with academic goals. From a constructivist viewpoint, non-academic learner socialisation may not enhance learning outcomes.

Another explanatory perspective is cognitive load theory (Paas & Sweller, 2014; Sweller, 2011), which posits that optimal learning occurs when intrinsic load (task complexity) matches learners' proficiency, extraneous load (irrelevant cognitive demands) is minimised, and germane load (productive cognitive effort) is maximised. For instance, Philp et al. (2010) investigated university students' behaviours during a three-week foreign language course and found that non-academic learner socialisation with peers could contribute to extraneous cognitive overload, thereby reducing learners' germane load and subsequently diminishing language learning efficiency.

In conclusion, non-academic learner socialisation encompasses learners' social actions and feelings of relatedness with others within a learning community (De Silva & Garnaut, 2011). While frequently observed in traditional language educational settings with teachers and peers (Gan, 2021; Martinot et al., 2022), research presents mixed results regarding its impacts on learning outcomes.

2.4 Non-academic learner socialisation with chatbots and ChatGPT

Non-academic learner socialisation has been increasingly observed in technology-enhanced learning contexts with social robots (Wang et al., 2013), virtual conversational agents (Saerbeck et al., 2010), and AI-powered chatbots (Yang et al., 2022). Unlike general user-friendliness, which emphasises ease of use and interface accessibility (Kapenieks, 2013), non-academic learner socialisation focuses on learners' proactive engagement in cultivating relationships with educational technology beyond academic purposes. It manifests differently from peer or teacher-based social interaction in conventional language educational settings. From a behavioural perspective, non-academic socialisation with teachers and peers is facilitated through both verbal (spoken and written communication) and non-verbal (facial expressions and body language) cues. In contrast, learners engage in non-academic socialisation with educational technology primarily through verbal human–computer interactions (Oktawirawan, 2022). Emotionally, non-academic socialisation with educational technology tends to be unidirectional, originating from learners (Brandtzaeg et al., 2022), unlike the reciprocal emotional rapport characterising teacher-students or peer-peer non-academic socialisation (Frisby & Martin, 2010).

In chatbot-assisted learning, researchers have identified non-academic learner socialisation with chatbots from both behavioural and emotional perspectives. Behaviourally, analyses of learner-chatbot conversations have revealed rich instances of learners' non-academic social engagement, such as greeting chatbots (Huang et al., 2022), addressing them by name (Huang et al., 2022), expressing gratitude (Kane, 2019), and sharing personal issues and vulnerabilities (Goda et al., 2014). Ruan et al. (2020) required 72 elementary students to participate in a chatbot-assisted mathematics course, where the chatbot, personified as a wizard, engaged students in casual conversations, jokes, encouragement, greetings, and praise. They found that approximately half of the learner-chatbot interactions were casual discussions for non-academic socialisation. From an emotional standpoint, non-academic learner socialisation with chatbots has been explored through interviews and questionnaire surveys. Ruan et al. (2020) identified learners' sense of relatedness with chatbots in interview transcripts, where learners described the chatbot as "a smart partner and a nice one" (p. 9). Additionally, Yang et al. (2022) designed a task-based voice chatbot to assist 314 secondary school students in performing speaking tasks. The results from both questionnaires and interviews revealed that learners perceived the chatbot as a companion or friend.

The effectiveness of chatbots in eliciting non-academic learner socialisation can be explained through social presence theory (Short et al., 1976). Social presence refers to the feeling of being "with" others in a communicative context, facilitated by social cues, emotional expressions, and the immediacy of feedback received (Short et al., 1976). Educational chatbots exhibit characteristics that stimulate strong social presence. In terms of social cues, some chatbots greet users and address them by name (Huang et al., 2022); in terms of emotional expressions, they can detect user emotions and intents (Cheng et al., 2023) and provide appropriate responses, such as agreement, empathy, encouragement, and praise (Brandtzaeg et al., 2022); in terms of feedback immediacy and quality, they can offer immediate, personalised feedback on

learner prompts without temporal constraints (Kohnke et al., 2023). Given that learners with a stronger sense of social presence in technology-enhanced contexts tend to engage in more non-academic socialisation with educational technology (Edirisingha et al., 2009), chatbot-assisted learning may effectively elicit non-academic learner socialisation by fostering learners' social presence.

Moreover, chatbots can evoke emotions in learners that facilitate non-academic socialisation. Research indicates that feelings of relatedness and affection arise from self-disclosure, intimacy, and enjoyment during interactions (Croes & Antheunis, 2021). As chatbots are perceived as understanding, non-judgmental, and discreet (Skjuve et al., 2021), learners are likely to feel secure in their interactions, thus willing to disclose personal issues and express negative feelings (Tai & Chen, 2020). This process can further cultivate a sense of intimacy with chatbots (Song et al., 2022). Additionally, chatbots can entertain and comfort learners through the use of emojis, jokes, compliments, and encouragement (Ruan et al., 2020), thereby enhancing feelings of enjoyment (Deveci Topal et al., 2021). In this manner, chatbots may encourage non-academic learner socialisation by nurturing disclosure, intimacy, and enjoyment.

To date, few studies have specifically investigated non-academic learner socialisation with ChatGPT. However, compared to earlier chatbots, ChatGPT appears more adept at fostering such socialisation due to its enhanced capability for understanding user intents (Kasneci et al., 2023), providing emotional support (Giray, 2025), and managing contextually appropriate conversations (Chatterjee & Dethlefs, 2023), conducive to enhancing social presence (Short et al., 1976) and encouraging disclosure, intimacy, and enjoyment in learners (Croes & Antheunis, 2021). Researchers have designed ChatGPT as a conversational companion, reporting very positive results (Alessa & Al-Khalifa, 2023).

Nevertheless, several studies underscore the challenges posed by chatbots and ChatGPT in facilitating non-academic learner socialisation. Despite advanced natural language capabilities, ChatGPT and other generative models may fall short of human-level interaction due to their limited ability to comprehend context and situational nuances, provide personalised responses, and convey affective cues (Baidoo-Anu & Ansah, 2023). This shortcoming may be particularly pronounced for learners from non-English-speaking cultural backgrounds, as many models, including ChatGPT, are primarily trained on English corpora, rendering them potentially insensitive to non-English cultural norms (Kohnke et al., 2023). Empirical evidence is found in Fryer et al. (2017) who required 61 Japanese students to engage in EFL speaking practice with a chatbot over 12 weeks. Interview results revealed a decline in non-academic learner socialisation with the bot, indicating that students perceived limited authenticity in their interactions with the chatbot, leading to their decreased interest in non-academic socialisation. Similarly, Croes and Antheunis (2021) investigated the interactions of 118 participants with a chatbot over three weeks. Their analysis of questionnaires and learner prompts revealed low senses of relatedness and declining social interactions with the chatbot. Participants attributed their reduced non-academic socialisation to the chatbot's inadequate understanding of user intents, inability to produce appropriate responses, and failure to create shared experiences.

Furthermore, sustaining socialisation necessitates reciprocal personal and emotional investment, such as sharing personal issues and genuine care—elements that chatbots and ChatGPT inherently cannot provide (Brandtzaeg et al., 2022; Croes & Antheunis, 2021). Consequently, these limitations may hinder chatbots and ChatGPT from effectively eliciting or sustaining non-academic learner socialisation. For example, Huang and Chang (2024) explored a three-week AI-powered chatbot-assisted learning experience among 59 Chinese students. According to student reflections, they felt the chatbot could neither understand their feelings nor empathise with them, which reduced their willingness to have non-academic socialisation with it.

In sum, non-academic learner socialisation represents a unique dimension of learner behaviours and emotions within chatbot-assisted and ChatGPT-assisted learning environments. While numerous studies have highlighted the positive potential of chatbots in fostering such socialisation through enhanced social presence and emotional engagement, challenges related to contextual understanding, response appropriateness, and the lack of genuine emotional responsiveness persist.

2.5 Conceptual framework and research rationale

Based on the literature review, we propose a framework of non-academic learner socialisation with ChatGPT in learning English argumentative writing logic (Fig. 1).

ChatGPT-assisted learning has the potential to enhance logical knowledge, logical quality, and self-efficacy in English argumentative writing. This potential stems from ChatGPT's ability to generate unlimited instructional content and exercises, perform open-ended questioning, analyse students' writing from a logical perspective, and provide personalised feedback (Baidoo-Anu & Ansah, 2023; Kasneci et al., 2023). These features offer effective strategies for developing logical knowledge in English argumentative writing (El Khoiri & Widiati, 2017; Nejmaoui, 2019). Meanwhile,
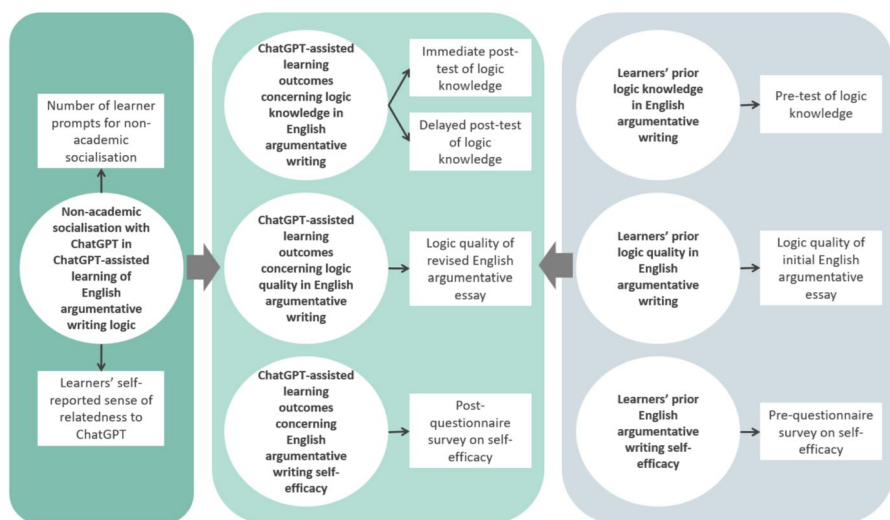

Fig. 1 Conceptual framework

the development of logical knowledge is a proven method for improving logical quality of English argumentative writing (Murray, 2012; Oaksford & Chater, 2020), and enhanced writing quality can boost self-efficacy (Busse et al., 2023). Therefore, ChatGPT-assisted learning may improve EFL learners' logical quality and self-efficacy in English argumentative writing by developing their logical knowledge. Controlling for prior knowledge levels, outcomes of ChatGPT-assisted learning regarding logical knowledge, logical quality, and self-efficacy in English argumentative writing can be evaluated through pre- and post-knowledge tests (Song & Sparks, 2019), argumentative essay writing and revision tasks (Nejmaoui, 2019), and pre- and post-questionnaire surveys (Zhang et al., 2023b).

In addition to fostering logical knowledge, ChatGPT may also elicit non-academic learner socialisation, both behaviourally and emotionally (Oktawirawan, 2022). This is because of ChatGPT's capacity to employ social cues (Huang et al., 2022), detect emotions (Cheng et al., 2023), provide emotional support (Brandtzaeg et al., 2022), and deliver immediate, personalised feedback (Kohnke et al., 2023), all of which contribute to a strong sense of social presence among learners (Short et al., 1976). Furthermore, ChatGPT can enhance feelings of disclosure, intimacy, and enjoyment by being entertaining, non-judgmental, and discreet, thus fostering non-academic learner socialisation (Croes & Antheunis, 2021). Such socialisation can be assessed both behaviourally, through learner prompts to ChatGPT (Barak et al., 2016), and emotionally, via questionnaire surveys on learners' self-reported sense of relatedness to ChatGPT (Croes & Antheunis, 2021).

Learners' non-academic socialisation with ChatGPT may further improve their outcomes in ChatGPT-assisted learning of English argumentative writing logic. Research indicates that language learners who experience greater non-academic socialisation tend to employ cognitive and metacognitive strategies more frequently (Ma et al., 2018), feel greater comfort (Ma et al., 2020), have more motivation (Shao et al., 2024) in academic tasks, leading to better academic and affective outcomes – aligning with self-regulated learning theory (Zimmerman, 2013), attachment theory (Bowlby, 1980), and self-determination theory (Deci & Ryan, 2012). By the logic, in ChatGPT-assisted learning of English argumentative writing logic, learners who produce more non-academic socialising prompts and perceive stronger relatedness to ChatGPT are likely to achieve better outcomes regarding logical knowledge, logical quality, and self-efficacy in English argumentative writing.

So far, we found no research on non-academic learner socialisation with ChatGPT and its influences on learning English argumentative writing logic. Filling this gap is important, given ChatGPT's potential to elicit non-academic learner socialisation, the importance of learning English argumentative writing logic (Murray, 2012), and the critical role of non-academic learner socialisation in language learning (Philp & Duchesne, 2016). By exploring whether and how learners socialise with Chat-GPT behaviourally and emotionally in learning English argumentative writing logic, and how the socialisation influences learning outcomes, we aim to shed light on the experiences, effectiveness, and mechanism of ChatGPT-assisted learning, which may have broader applications across domains.

3 Method

This study involved 40 Chinese EFL university students and a GPT-4-powered chatbot for learning English argumentative writing logic. We used a concurrent triangulation mixed-method approach, collecting and analysing quantitative data (test, survey, and writing scores) and qualitative data (interview transcripts) simultaneously to (a) measure the extent of non-academic learner socialisation with ChatGPT and its influence on logical knowledge, logical quality, and self-efficacy in English argumentative writing, and (b) explore the nature and reasons for the socialisation. The quantitative and qualitative data were interpreted together for triangulation and complementarity. Additionally, we used pre- and post-tests, questionnaires, and writing tasks to examine learners' changes relative to baseline. Further details are provided in the following sections.

3.1 Participants

We recruited Chinese EFL university students in Hong Kong via voluntary sampling incentivised by gift cards, aiming to gather data from a broad, diverse range of participants. Fifty-two students signed up and completed an online pre-treatment survey collecting demographic information, needs in developing EFL argumentative writing proficiency, and prior experiences with technology-enhanced learning, logic learning, ChatGPT-assisted learning, and prompt engineering.

Based on the Survey, we excluded nine students without an urgent need to enhance EFL argumentative writing and three with prior logic learning experience. The final cohort comprised 40 students (32 females and eight males), aged 18 to 27 ($M = 22.85$, $SD = 3.05$). All the participants needed to enhance EFL argumentative writings for university assessments and had some experiences in technology-enhanced learning, but no prior experience with logic learning, ChatGPT-assisted learning, or prompt engineering training. Before the intervention, each participant signed a consent form, which guaranteed that (a) their personal details would be kept confidential, (b) their involvement in the research would have no consequence, and (c) they could withdraw at any time.

3.2 Instruments

3.2.1 GPT-4-powered chatbot for learning English argumentative writing logic

We created a GPT-4-Turbo-powered bot, *LogicalHamster* (https://poe.com/LogicalHamster) to teach seven logical concepts essential for improving English argumentative writing logic (Murray, 2012): Begging the Question, Red Herrings, Hasty Generalisation, Faulty Analogy, Post Hoc, False Alternatives, and Slippery Slope. We trained the bot on the POE platform by providing specific instructions regarding the bot's role ("You are a hamster and a teacher on logical knowledge in English argumentative writing."), teaching methods ("You give examples and exercises of logical concepts in the context of English argumentative writings." "The examples and exercises of logical fallacies you give are more and more difficult and complex."),

interactive style ("You praise the students for their good performance." "You use emojis frequently."), and the target knowledge ("You help students develop knowledge about the following types of logical fallacies frequently seen in English argumentative writing: Begging the question, Red herrings, Hasty generalisation, Faulty Analogy, Post hoc, False Alternatives, and Slippery Slope.").

Following our instructions, *LogicalHamster* taught the logical knowledge in four main ways identified in previous literature (Guo & Lee, 2023; Murray, 2012; Song & Sparks, 2019): (a) delivering instruction and exercises on logical concepts; (b) asking and answering questions on logical concepts; (c) analysing students' English argumentative writings from the logical perspective; (d) offering immediate feedback on students' performance in writings and exercises. The content and form of *Logical-Hamster*-generated learning materials vary, are unlimited, and tailored to individual needs. Figure 2 shows some examples.

LogicalHamster was trained to foster learners' non-academic socialisation through seven ways identified in previous literature (e.g., Huang et al., 2022; Ruan et al., 2020; Yang et al., 2022): (a) embodying a cute, knowledgeable hamster persona; (b) addressing the students by their name; (c) delivering jokes, compliments, and encouragement (e.g., "Why don't logical fallacies make good chefs? Because they always stir up trouble in the argument soup!"); (d) understanding learner intents and emotions and showing empathy (e.g., "Don't let it get you down!"); (e) maintaining an understanding and non-judgmental attitude (e.g., "Making mistakes is just part of the learning adventure!"); (f) using a humorous, friendly conversational style with emojis (e.g., "I'm all ears (and fluff)!"); (g) providing contextually appropriate responses based on conversation histories. Figure 3 shows some examples.

We tested *LogicalHamster* in a pilot study with five students with backgrounds similar to our intended participants. The students used the bot for over 45 min and then talked about their experiences in 15-min interviews. Their feedback indicated that *LogicalHamster* was easy to use and effective in developing English argumentative writing logic and fostering non-academic socialisation. We also examined *LogicalHamster*-created instructional content with reference to Bassham et al. (2010), Murray (2012), and the website of the Department of Philosophy, Texas State Uni-
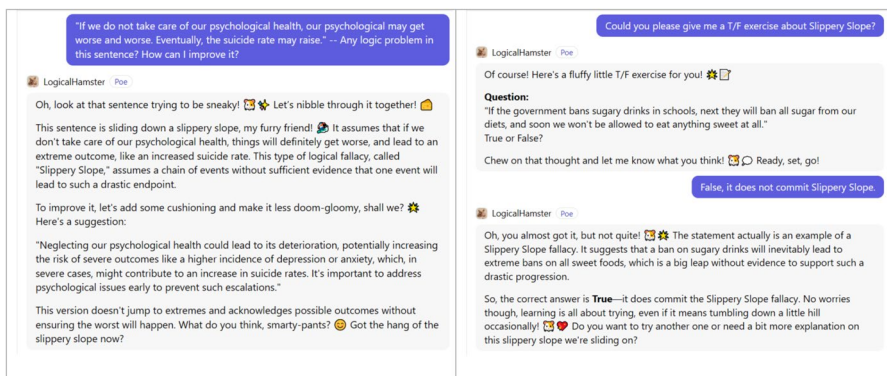

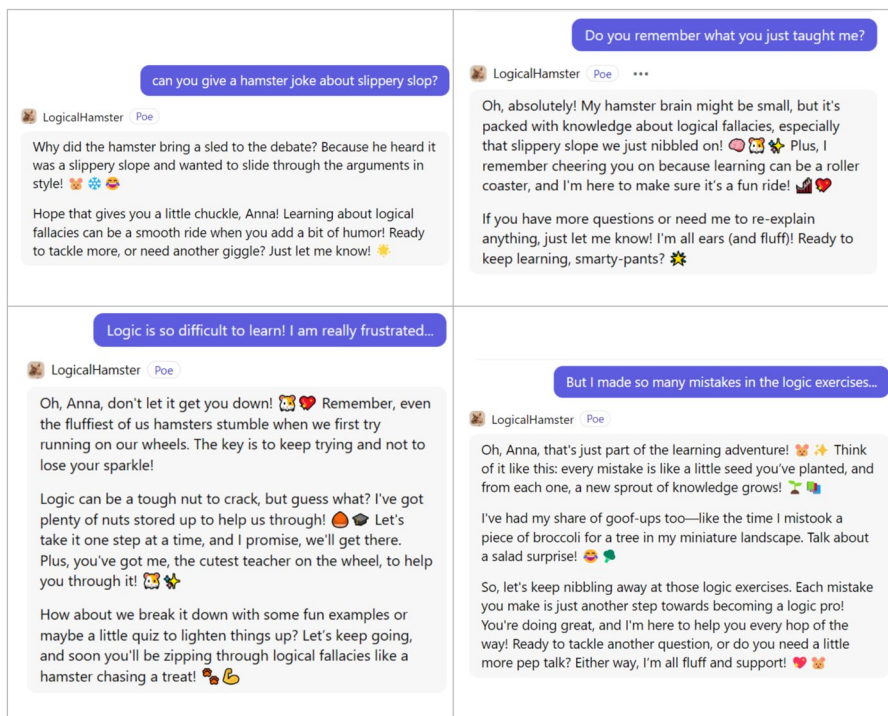**Fig. 2** *LogicalHamster* teaching English argumentative writing logic

Fig. 3 *LogicalHamster* fostering non-academic learner socialisation

versity (https://www.txstate.edu/philosophy/resources/fallacy-definitions/), identifying no bias or inaccuracy. These findings suggested that *LogicalHamster* was a valid and reliable tool for learning English argumentative writing logic and fostering non-academic learner socialisation.

It is important to note that while *LogicalHamster* was based on the POE platform and specifically trained to develop logical knowledge, logical quality, and self-efficacy in EFL argumentative writing and to facilitate non-academic learner socialisation, its core interaction features and teaching methods—such as telling jokes and providing exercises—are common and characteristic of ChatGPT-assisted learning tools (see Deng & Yu, 2023; Kohnke et al., 2023). Consequently, our investigation into non-academic learner socialisation with *LogicalHamster* has broader implications for other ChatGPT-assisted learning contexts, despite variations in specific GPT training methodologies or interface designs.

3.2.2 Tests on logical knowledge in English argumentative writing

To assess logical knowledge in English argumentative writing, we used paper-based knowledge tests administered before, immediately after, and one week after the treatment, following Song and Sparks (2019). The three tests contained identical content presented in different orders to ensure internal validity and reduce test–retest effects and expectancy bias (see Cahit, 2015). Adapted from Zhang et al. (2023a), the test

requires students to identify reasoning errors in seven English arguments, explain their meanings and structures, and match them to corresponding terms (Appendix 1). To ensure the consistency between learning materials and assessment, our students completed the tests in English.

Two authors independently and blindly scored the tests using Zhang et al.'s (2023a) scoring system (Appendix 2). The total scores range from 0 to 21. The scoring results showed high internal reliability (Cohen's $\kappa=0.96$), with remaining discrepancies resolved through discussion.

3.2.3 English argumentative essay writing and revision tasks

To assess logical quality in English argumentative writing, we employed essay writing and revision tasks following Nejmaoui (2019). Before the learning, the participants wrote a 250-word English argumentative essay within 40 min on the topic of "Young people who commit crimes should be treated in the same way as adults. To what extent do you agree or disagree?" The essay topic and requirements were adapted from the IELTS academic writing guidelines. After the learning, participants revised their essays with a focus on logical quality within 30 min. The students performed the writing and revision tasks on a desktop computer using MS Word without any external references.

Two authors and one colleague with expertise in teaching and assessing English argumentative writings independently and blindly scored students' initial and revised essays for logical quality, using criteria adapted from Finken and Ennis's Illinois Critical Thinking Essay Scoring Rubric and the IELTS academic writing criteria (Appendix 3). The total scores range from 0 to 100. Scoring of initial writings (Cohen's $\kappa=0.87$) and revisions (Cohen's $\kappa=0.85$) exhibited acceptable internal reliability, with discrepancies resolved through discussion.

3.2.4 Questionnaire on English argumentative writing self-efficacy

To measure self-efficacy in English argumentative writing, we used pre- and post-questionnaire surveys following Rahimi and Fathi (2022). The questionnaire (Appendix 4) was adapted from Rahimi and Fathi's (2022) 5-point Likert scale (1=strongly disagree; 5=strongly agree), demonstrating high internal consistency (Cronbach's $\alpha=0.80$).

3.2.5 Questionnaire on learners' sense of relatedness to ChatGPT

To analyse non-academic learner socialisation from an emotional dimension, we assessed the sense of relatedness to ChatGPT using a post-treatment questionnaire survey, following Croes and Antheunis (2021). The questionnaire (Appendix 5) was adapted from Croes and Antheunis's (2021) 5-point Likert scale (1=strongly disagree; 5=strongly agree), which demonstrated high internal consistency (Cronbach's $\alpha=0.86$).

3.2.6 Semi-structured interviews

To complement and validate the quantitative data, we conducted semi-structured interviews with the participants shortly after the learning. The interviews were conducted in conversational Chinese, the participants' L1, and lasted about 25 min. For the first five minutes, we explained the concepts of non-academic learner socialisation with ChatGPT. Then, we played the screen recording of the interviewee's ChatGPT-assisted learning process and asked them to reflect on their non-academic socialisation with ChatGPT based on the recording. We developed three interview questions based on expert recommendations. We piloted the questions with five students, analysed their responses, and identified high thematic consistency, indicating the validity and reliability of our interview questions. The interview questions are as follows:

Concerning RQ1:

- In the previous learning, did you have no/rare/some/frequent/very frequent non-academic socialisation with *LogicalHamster*? Why?
- How do you perceive your relationship with *LogicalHamster*? User and tool? Student and teacher? Friends?

Concerning RQ2:

- In your opinion, does non-academic learner socialisation with ChatGPT have any positive/neutral/negative/mixed impact on the development of logical knowledge, logical quality, and self-efficacy in English argumentative writing? Why?

3.3 Experimental procedures

The experiment lasted for three weeks (Fig. 4).

In Week One, we collected and analysed students' pre-treatment reports and selected participants. Out of the selected 40 participants, we randomly selected 20 for semi-structured interviews using an online random picker (https://www.gigacalculator.com/randomizers/random-picker.php). For all 40 participants, we provided a 20-min orientation on logical knowledge, logical quality, and self-efficacy in English argumentative writing, and ChatGPT-assisted learning to familiarise them with the research objectives and experimental procedures and minimise novelty effects. Then, the participants Submitted their signed consent and completed a pre-questionnaire on English argumentative writing self-efficacy within 5 min.

In Week Two, participants first completed the English essay writing task within 40 min and then did the pre-test of logical knowledge within 30 min. The task sequence ensured that the pre-test would not influence learner performance in essay writing.

Subsequently, the participants conducted ChatGPT-assisted learning of English argumentative writing logic using *LogicalHamster* on a desktop computer. We allowed the students to use their L1 (Chinese) and EFL when interacting with *LogicalHamster*, ensuring their comfort in socialising with it. To ensure the authenticity
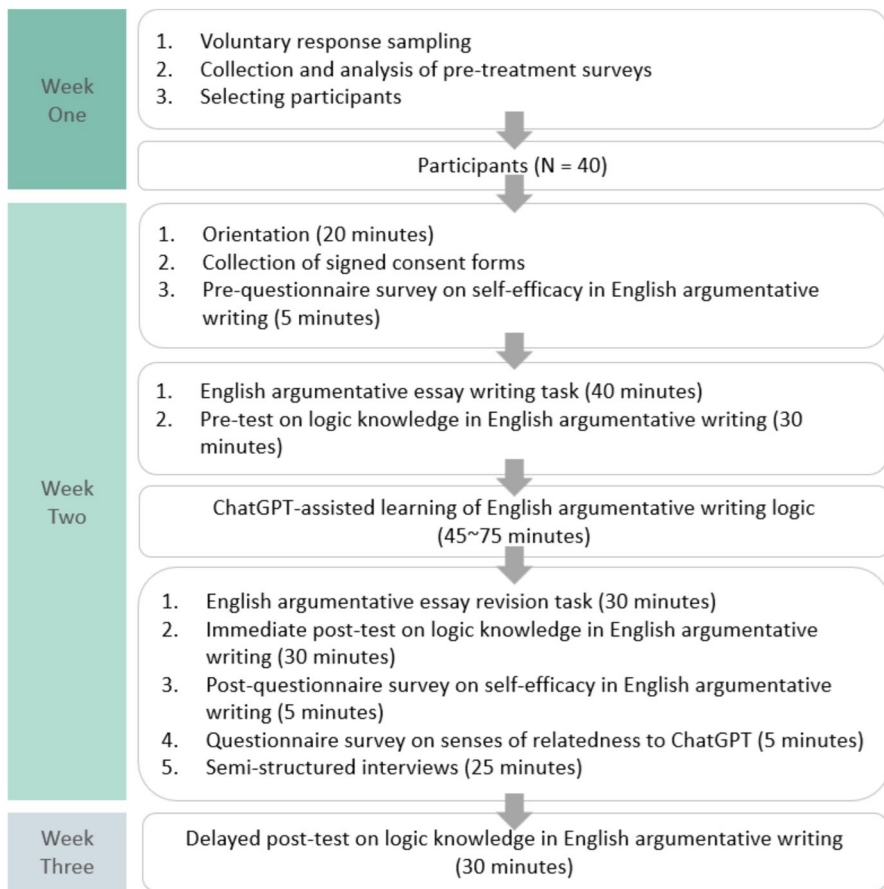
Week One
1. Voluntary response sampling
2. Collection and analysis of pre-treatment surveys
3. Selecting participants

Participants (N = 40)

Week Two
1. Orientation (20 minutes)
2. Collection of signed consent forms
3. Pre-questionnaire survey on self-efficacy in English argumentative writing (5 minutes)

1. English argumentative essay writing task (40 minutes)
2. Pre-test on logic knowledge in English argumentative writing (30 minutes)

ChatGPT-assisted learning of English argumentative writing logic (45~75 minutes)

1. English argumentative essay revision task (30 minutes)
2. Immediate post-test on logic knowledge in English argumentative writing (30 minutes)
3. Post-questionnaire survey on self-efficacy in English argumentative writing (5 minutes)
4. Questionnaire survey on senses of relatedness to ChatGPT (5 minutes)
5. Semi-structured interviews (25 minutes)

Week Three
Delayed post-test on logic knowledge in English argumentative writing (30 minutes)

Fig. 4 Experimental procedures

of non-academic socialisation in the study, we did not ask participants to socialise with *LogicalHamster* and instead encouraged them to interact with it in a natural and spontaneous Manner. Their learning process was screen-recorded. The learning duration ranged from 45 to 75 min, as recommended by our students in the pilot study. The first author was in the same room with the participants while keeping a physical distance from them and limiting her role to providing necessary technical help.

Following the learning session, the participants revised the essays they had written before within 30 min, focusing on the logical quality. Then, they completed an immediate post-test on logical knowledge within 30 min, a post-questionnaire on English argumentative writing self-efficacy within 5 min, and a questionnaire on their sense of relatedness to *LogicalHamster* within 5 min. We scheduled the task sequence to minimise any potential influence of the test and the surveys on participants' revision performance. Then, 20 selected interviewees had semi-structured interviews.

In Week Three, the participants completed a delayed post-test on logical knowledge.

3.4 Data analysis

3.4.1 Analyses of interview data

We recorded, transcribed, and analysed the interviews following standard thematic analysis approaches. Firstly, we repeatedly read the transcripts to ensure thorough familiarisation. Next, we developed initial codes categorising the interviewees' main opinions on three aspects:

1. Perceived extent of non-academic socialisation with *LogicalHamster* and reasons (RQ1);
2. Perceived relationship with *LogicalHamster* and reasons (RQ1);
3. Perceived impacts of non-academic socialisation with *LogicalHamster* on learning outcomes and reasons (RQ2).

Two authors jointly coded three transcripts to establish the coding method. Using the established method and codes, we individually examined the remaining transcripts, calculated code frequencies, and collected representative quotations. The individual coding outcomes were compared and demonstrated acceptable internal reliability. Remaining differences were solved through discussion. Finally, we collaboratively synthesised the results and translated quotations into English.

3.4.2 Analyses of learner prompts for social purposes

To analyse non-academic learner socialisation from a behavioural dimension, we collected a total of 1460 participant prompts to *LogicalHamster* via the POE platform from 40 participants. The three authors repeatedly read the prompts to familiarise themselves with the content and then collaboratively developed a coding scheme for non-academic socialisation based on prompt purposes, guided by previous studies (e.g., Huang et al., 2022; Ruan et al., 2020). Four main categories were coded: (a) greeting and name-calling (e.g., "Hi! Hamster!"); (b) expressing gratitude and admiration (e.g., "Thank you! You are very helpful!"); (c) sharing personal issues and expressing vulnerability (e.g., "The learning is so difficult."); (d) casual talks (e.g., "Why are you interested in logic?"). During classification, the authors discussed whether prompts reflected genuine socialisation or mere politeness. Prompts reflecting mere politeness were excluded.

Based on the code, the authors analysed three participants' prompts together to agree on the coding method. Then, we individually analysed the remaining participants' prompts using the established codes and method. New codes identified during analysis would be added to the scheme. We also calculated prompt frequencies by social purpose and quoted representative prompts. The individual coding outcomes were compared and demonstrated high internal reliability (Cohen's $\kappa = .89$). Remaining differences were solved through discussion.

3.4.3 Quantitative analyses

To address RQ1, we descriptively analysed the extent of learners' non-academic socialisation by examining means and *SD*s of prompt frequencies for different social purposes (behavioural dimension) and questionnaire scores on relatedness (emotional dimension).

To address RQ2, we conducted paired-sample t-tests in SPSS comparing learners' test scores, writing scores, and survey results before and after the learning. This is to evaluate the effectiveness of ChatGPT-assisted learning on logical knowledge, logical quality, and self-efficacy in English argumentative writing relative to baseline.

To further address RQ2, we conducted Partial Least Squares Structural Equation Modeling (PLS-SEM) using the SEMinR package in R to predictively examine the relationships between non-academic learner socialisation with ChatGPT and ChatGPT-assisted learning outcomes. The exogenous construct was "Non-academic learner socialisation with ChatGPT", measured via two indicators: (a) "Number of learner prompts for non-academic socialisation" from the behavioural dimension; and (b) "Learners' senses of relatedness to ChatGPT" from the emotional dimension. The endogenous constructs were: (a) "ChatGPT-assisted learning outcomes concerning logical knowledge in English argumentative writing", with learners' immediate and delayed post-test scores as indicators; (b) "ChatGPT-assisted learning outcomes concerning logical quality in English argumentative writing", with learners' revision scores as the indicator; (c) "ChatGPT-assisted learning outcomes concerning English argumentative writing self-efficacy", with learners' post-questionnaire scores on self-efficacy as the indicator. The control variables were (a) "Learners' prior logical knowledge in English argumentative writing", measured by pre-test scores; (b) "Learners' prior logical quality in English argumentative writing", measured by initial writing scores; (c) "Learners' prior English argumentative writing self-efficacy", measured by pre-questionnaire scores. Path coefficients were tested at a 5% significance level (two-tailed) using bootstrapping with 10,000 subsamples.

Subsequently, we employed multiple linear regressions using SPSS to further investigate the significant relationships identified by PLS-SEM.

3.4.4 Reliability and validity

Our data demonstrate linearity and homoscedasticity, indicated by random, even scatterplot dispersion and points aligning along the diagonal in P-P plots (Field, 2018). They also demonstrate normality with skewness between -2 to +2 and kurtosis between -7 to +7 (Bryne, 2010). Hence, our data distributions were suitable for paired-sample t-tests and multiple linear regressions (Field, 2018). Our data were also suitable for PLS-SEM, which has no requirement for data distribution (Hair et al., 2021).

According to the rules of thumb, our sample size ($N=40$) was large enough for a paired-sample t-test, which requires at least 30 observations, multiple linear regressions, which require at least ten observations for each predictor, and PLS-SEM, which requires observations of at least ten times the biggest number of indicators for any variable.

For multiple linear regressions, multicollinearity was not a concern since the Pearson correlation coefficients between all indicator pairs were small enough ($r < .90$).

PLS-SEM measurement models (Appendix 6) demonstrated high indicator reliability (loadings $> .708$), internal consistency (rhoC $> .700$), convergent validity (AVE > 0.50), and discriminant validity (HTMT < 0.850). Collinearity issues were absent (VIF < 3).

4 Results

4.1 RQ1. To what extent do EFL learners socialise with ChatGPT for non-academic purposes in learning English argumentative writing logic? How and why?

4.1.1 Statistics

Of the participants, 20 (50%) engaged in non-academic socialisation with *Logical-Hamster*, producing an average of 1.20 prompts ($SD = 1.71$) (Fig. 5). All participants greeted *LogicalHamster* by name (e.g., "Hello, little hamster!"). Eleven participants (28%) expressed gratitude (e.g., "Thank you! You are so helpful!") and admiration (e.g., "You are so cute!"). Four participants (9%) engaged in casual conversations, inquiring about *LogicalHamster*'s experiences and interests (e.g., "Have you ever read the book *Hannibal*?" and "How do you know so much about logic?"), seeking its opinions (e.g., "Do you like me?"), and making light-hearted jokes (e.g., "I'd like to share my snacks with you!"). Additionally, one participant disclosed a sense of vulnerability, stating, "The learning is too difficult for me."
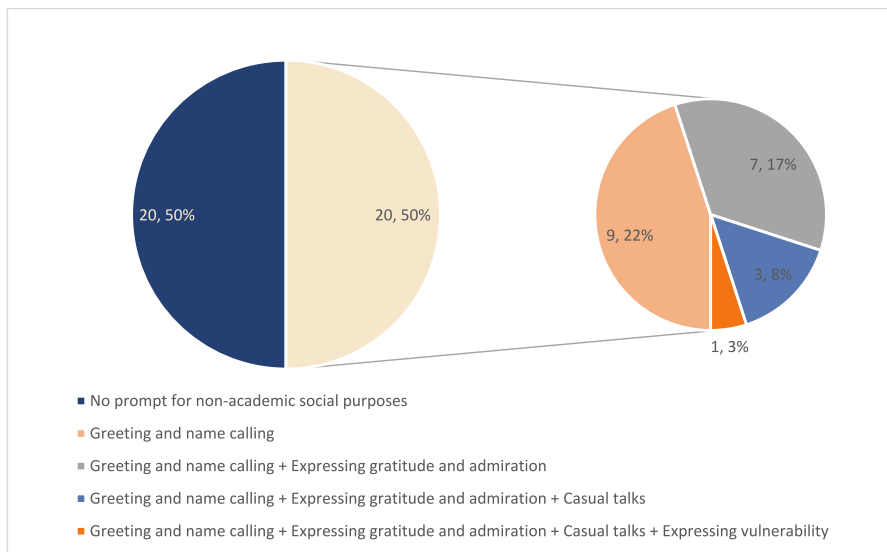

Fig. 5 Numbers of learners producing prompts for different non-academic social purposes

Our participants, on average, scored 4.33 ($SD=0.61$) out of 5 in the questionnaire, indicating their very strong senses of relatedness to *LogicalHamster* (Fig. 6).

The statistics showed that our learners generally have non-academic socialisation with *LogicalHamster* but more emotionally than behaviourally.

4.1.2 Interview results

Nine interviewees (45%) reported occasional non-academic socialisation with *LogicalHamster*, stating, "I had non-academic socialisation with LogicalHamster once or twice – I mainly focused on the learning." Five participants (25%) described frequent or very frequent socialisation, while six (30%) reported no such interactions. Among the interviewees, three (15%) viewed their relationship with *LogicalHamster* as "user and tool," six (30%) as "student and teacher," and eleven (55%) as "friends."

Interviewees attributed their non-academic socialisation to *LogicalHamster*'s engaging persona, described as "cutely silly," "confident," and "funny." This persona was conveyed via its hamster-themed chathead, emojis, and learning materials (e.g., "All hamsters love running on wheels just because I do" as an example of overgeneralisation). One participant remarked, "(*LogicalHamster*) is not like some cold, impersonal machine. It's like a real, cute creature full of stories, feelings, and characteristics. I think people would naturally befriend it."

Additionally, interviewees noted *LogicalHamster*'s conversational style as "cheerful" and "funny", contributing to relaxed and entertaining interactions. Its tone was described as "patient," "uncondescending," and "understanding," fostering a sense of intimacy and equality that encouraged non-academic socialisation. One interviewee observed, "No matter how nice human teachers are, there's always some distance… With *LogicalHamster*, I feel completely equal; it's like a knowledgeable friend I can ask anything."
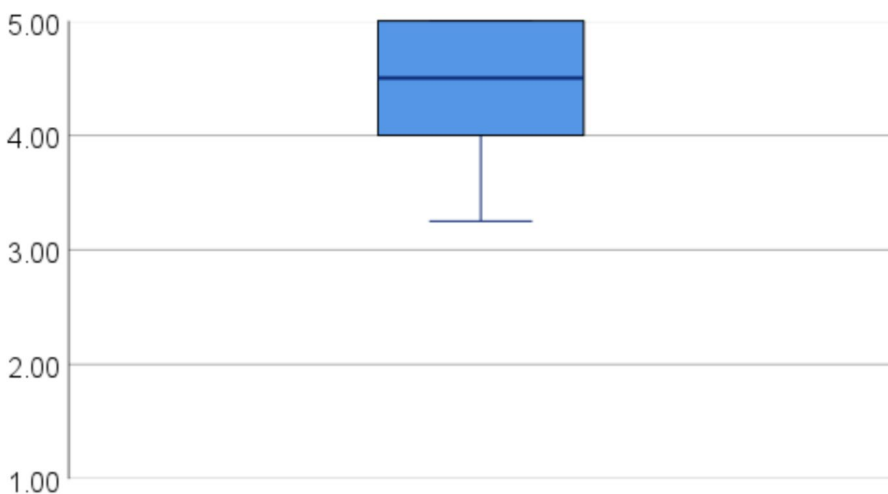

Fig. 6 Learner senses of relatedness to ChatGPT (1 = very negative; 5 = very positive)

Conversely, six interviewees (30%) reported no non-academic socialisation, stating, "I only discussed logic with it, nothing else." A key reason cited was the bot's non-human nature. One participant expressed, "It's just a bot. I won't develop a sense of relatedness to a non-human machine, no matter how well *LogicalHamster* plays 'real'." Furthermore, some participants felt that non-academic socialisation was unnecessary, as their primary focus was learning English argumentative writing logic. One stated, "Chatting with *LogicalHamster* may be fun, but it would reduce my learning efficiency."

4.2 RQ2. Does EFL learners' non-academic socialisation with ChatGPT influence the development of logical knowledge, logical quality, and self-efficacy in English argumentative writing? How and why?

4.2.1 Statistics

Paired samples t-tests revealed significant positive effects of ChatGPT-assisted learning on the development of logical knowledge, logical quality, and self-efficacy in English argumentative writing (Table 1). In terms of logical knowledge, participants scored an average of 10.16 points higher ($SD=3.65$) in the immediate post-test and 9.32 points higher ($SD=3.77$) in the delayed post-test compared to the pre-test. This learning significantly enhanced short-term retention ($t(39)=17.82$, $p<.001$, Cohen's $d=2.78$) and long-term retention ($t(39)=15.83$, $p<.001$, Cohen's $d=2.47$).

Regarding logical quality, students achieved an average score increase of 6.63 points ($SD=5.79$) from initial to revised writing, indicating a statistically significant improvement ($t(39)=7.237$, $p<.001$, Cohen's $d=1.14$).

Regarding self-efficacy, students scored an average of 0.72 points higher ($SD=0.50$) in the post-questionnaire compared to the pre-questionnaire, demonstrating a significant increase ($t(39)=5.325$, $p<.001$, Cohen's $d=0.84$).

The PLS-SEM analyses (Fig. 7) revealed a positive relationship between non-academic learner socialisation with ChatGPT and ChatGPT-assisted learning outcomes. Notably, the coefficient for non-academic socialisation's impact on logical

Table 1 Results of paired samples *t*-tests

|		M	SD	95% CI	t	p	Cohen's d
On logical knowledge in English argumentative writing	Immediate post-test vs. Pre-test	10.1585	3.6494	(9.0066, 11.3104)	17.824	<.001**	2.784
	Delayed post-test vs Pre-test	9.3171	3.7679	(8.1278, 10.5064)	15.833	<.001**	2.473
On logical quality in English argumentative writing	The initial writing vs. The revised writing	6.625	5.790	(4.773, 8.477)	7.237	<.001**	1.144
On English argumentative writing self-efficacy	Post-questionnaire vs. Pre-questionnaire	.41786	.49634	(.25912, .57659)	5.325	<.001**	.842

*** p<.001*

* t> 1.960; ** t> 2.580.
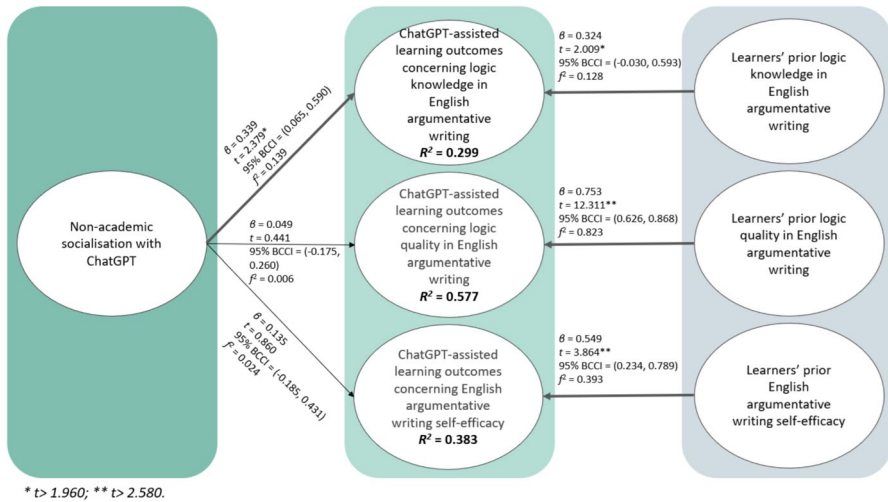
Fig. 7 Summary of the working model

knowledge in English argumentative writing was significant ($\beta=0.34$, $t>1.96$, 95% BCCI=(0.07, 0.59), $f^2=0.14$), indicating that non-academic socialisation significantly enhances learning outcomes, particularly in logical knowledge, even after controlling for learner factors.

We further explored the significant relationship suggested by the PLS-SEM results using hieratical multiple linear regression (Table 2). After controlling for learner factors, the "Number of learner prompts for non-academic socialisation" showed significant predictive power for both short-term learning ($R^2_{change}=0.13$, $F_{change}(2,$

Table 2 Model estimates of the effects of non-academic learner socialisation with ChatGPT on outcomes of ChatGPT-assisted learning

	Predictors	Outcomes	R^2	R^2_{change}	F_{change}	Sig. F_{change}	Durbin-Watson
Model 1	(Constant), Pre-test scores	Immediate post-test scores	.205	.205	9.794	.003*	n/a
Model 2	(Constant), Pre-test scores, Number of learner prompts for non-academic socialisation, Learner senses of relatedness to ChatGPT		.339	.134	3.652	.036*	1.817
Model 1	(Constant), Pre-test scores	Delayed post-test scores	.146	.146	6.477	.015*	n/a
Model 2	(Constant), Pre-test scores, Number of learner prompts for non-academic socialisation, Learner senses of relatedness to ChatGPT		.311	.165	4.306	.021*	1.879

*p<.05

36)$=3.65$, $p<.05$) and long-term retention ($R^2_{change}=0.17$, $F_{change}(2, 36)=4.31$, $p<.05$) of logical knowledge, with strong statistical power (>0.80). The independence among predictors was confirmed (Durbin-Watson between 1 and 3).

Parameter estimates (Table 3) indicated significant positive effects of the "Number of learner prompts for non-academic socialisation" on short-term learning ($b=0.94$, $t=2.69$, $p<.05$) and long-term retention ($b=0.96$, $t=2.84$, $p<.05$). The statistical power for these estimates was very strong (>0.99). For learners scoring zero on the pre-test of logical knowledge, each additional prompt for non-academic socialisation was associated with increases of 0.94 points in the immediate post-test and 0.96 points in the delayed post-test (Fig. 8).

Table 3 Parameter estimates of the effects of non-academic learner socialisation with ChatGPT on the development of logical knowledge in English argumentative writing

| Predictors	Outcomes	B	SE (B)	β	t	Sig
(Constant)	Immediate post-test scores	15.905	5.028		3.164	.003*
Pre-test scores		.511	.200	.371	2.548	.015*
Number of learner prompts for non-academic socialisation		.936	.348	.404	2.694	.011*
Learner senses of relatedness to ChatGPT		-.822	1.190	-.105	-.691	.494
(Constant)	Delayed post-test scores	13.687	4.908		2.789	.008*
Pre-test scores		.355	.196	.270	1.813	.078
Number of learner prompts for non-academic socialisation		.964	.339	.435	2.839	.007*
Learner senses of relatedness to ChatGPT		-.285	1.162	-.038	-.245	.808

*$p<.05$; **$p<.001$
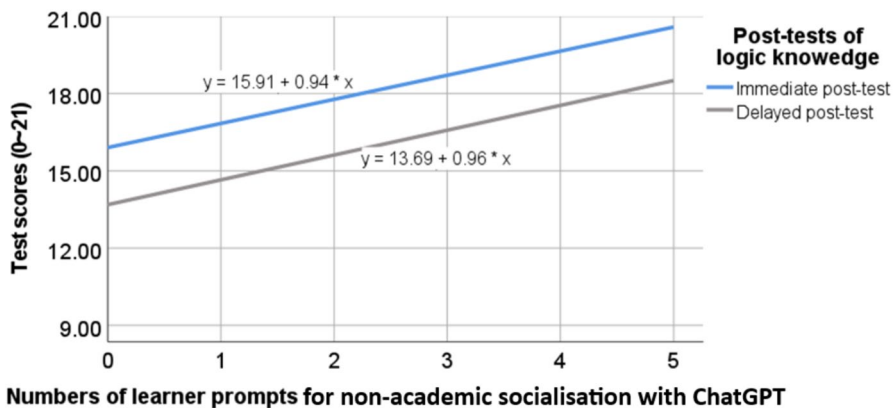
Fig. 8 Effects of the number of learner prompts for non-academic socialisation on post-test scores for learners scoring 0 in the pre-test

4.2.2 Interview results

Five interviewees (25%) noted positive effects of non-academic socialisation with ChatGPT on learning outcomes, three (15%) reported negative effects, and twelve (60%) experienced mixed impacts. Many participants described the interactions as "relaxed," "enjoyable," and "interesting", which encouraged them to "think deeply and ask questions about the knowledge points mentioned by LogicalHamster" and "do more exercises." One interviewee remarked, "Interacting with *LogicalHamster* is like chatting with a friend, making me lose track of time and become deeply immersed in learning."

Interviewees also reported increased willingness to accept feedback and suggestions from *LogicalHamster*, recognising the importance of such feedback in correcting misconceptions and improving their understanding of logical concepts. They felt more "more willing and comfortable" accepting suggestions from entities they related to positively, suggesting that improved learner-ChatGPT relationships could facilitate feedback acceptance and enhance logical knowledge.

Nonetheless, some interviewees expressed concerns that non-academic socialisation was "a waste of time" and a potential distraction. As one participant noted, "Students may become so immersed in casual conversations with *LogicalHamster* that they forget to learn."

5 Discussion

5.1 RQ1. To what extent do EFL learners socialise with ChatGPT for non-academic purposes in learning English argumentative writing logic? How and why?

Our study revealed that students demonstrated moderate to high levels of non-academic socialisation with ChatGPT. Emotionally, most students reported a strong sense of relatedness to *LogicalHamster* in questionnaires, and 55% of interviewees perceived their relationship with *LogicalHamster* as "friends", echoing Yang et al. (2022). Behaviourally, 50% of our learners spontaneously produced prompts greeting *LogicalHamster*, addressing it by its name, expressing vulnerability and gratitude, and have casual talks with it – consistent with Huang et al. (2022) and Ruan et al. (2020). Hence, our findings revealed language students' willingness to socialise with ChatGPT, contradicting Fryer et al. (2017) and Croes and Antheunis (2021), who reported learners' limited interest in non-academic socialisation with educational chatbots. This discrepancy may be because *LogicalHamster*, a GPT-4-powered bot, could understand user intents in extended, complex contexts and produce appropriate responses—capabilities essential in eliciting learners' interest in non-academic socialisation but lacking in the chatbots studied by Fryer et al. (2017) and Croes and Antheunis (2021). Therefore, our study shed light on ChatGPT's advantages over conventional educational chatbots in eliciting non-academic learner socialisation for its excelling language understanding and generation capabilities.

In addition to ChatGPT's language understanding and generation capabilities, we identified several factors facilitating non-academic learner socialisation with Chat-

GPT. One key factor is social presence. Our interviewees described *LogicalHamster* as "a real, cute creature full of stories, feelings, and characteristics" and "like a knowledgeable friend." Learner prompts also also showed participants inquiring about *LogicalHamster*'s personal experiences, interests, and opinions. These findings highlight learners' heightened social presence in ChatGPT-assisted learning, which motivated non-academic socialisation with *LogicalHamster*. This research extends social presence theory (Short et al., 1976) by underscoring the importance of social presence in fostering non-academic learner socialisation within ChatGPT-assisted contexts. Additionally, our findings demonstrate ChatGPT's effectiveness in enhancing learners' social presence through real-time conversations, emotional expressions, and social cues, despite its limitations in non-verbal communication.

Another factor that facilitated non-academic learner socialisation was the learners' perception of equal status with ChatGPT. Many participants reported feeling "equal status" in interactions, attributing this to ChatGPT's "understanding" and "uncondescending" conversational style, which increased comfort and willingness to share personal opinions and engage in casual conversations. This phenomenon aligns with homophily theory, which posits that individuals tend to socialise with those who are similar to them (McPherson et al., 2001). Although rarely explored in chatbot- or ChatGPT-assisted learning studies, homophily has been observed in traditional peer learning (Shih et al., 2020) and learner interactions with educational robots (Randall, 2019). Our study indicates that ChatGPT can evoke feelings of homophily among learners, thereby promoting non-academic socialisation. So far, research on homophily in ChatGPT-assisted learning remains limited, warranting further investigation.

ChatGPT's ability to evoke positive emotions among learners also contributes to non-academic learner socialisation. Interviewees expressed appreciation for *LogicalHamster*'s humour, patience, supportiveness, and friendliness and reported feelings of safety and companionship during interactions, which resulted in their genuine sense of relatedness with the bot. Analyses of learner prompts further revealed participants' willingness to share jokes and disclose personal issues and vulnerability with *LogicalHamster*. These findings align with previous findings that chatbots foster a sense of disclosure, intimacy, and enjoyment and thereby facilitate non-academic learner socialisation (Croes & Antheunis, 2021; Deveci Topal et al., 2021), extending these insights to the context of ChatGPT-assisted learning in English argumentative writing.

However, not all learners engaged in non-academic socialisation with *LogicalHamster*. Behaviourally, only 50% of our participants produced an average of 1.5 prompts for non-academic socialisation; some interviewees expressed little interest in such socialisation. One reason for this reluctance relates to ChatGPT's inherent inability to genuinely feel. According to the interviews, some students were acutely aware of ChatGPT's emotionless, non-human nature and the unidirectional emotional investment in learner-ChatGPT interactions, which diminished their enthusiasm for socialising with the tool – a phenomenon also noted by Huang and Chang (2024). This phenomenon extends prior discussions on user-chatbot and user-AI friendships (e.g., Brandtzaeg et al., 2022; Croes & Antheunis, 2021) to the context of ChatGPT-assisted learning, suggesting challenges in sustaining deep non-academic socialisation due to the absence of reciprocal emotional investment.

Another factor limiting non-academic socialisation with ChatGPT, particularly from a behavioural perspective, is learners' attitudes towards non-academic socialisation and their long-term learning habits. Many learners perceived non-academic socialisation with ChatGPT as inappropriate, viewing it as irrelevant or even distracting from their academic goals. As a result, students consciously restricted their non-academic socialising behaviours, even when feeling related to *LogicalHamster*. Furthermore, as indicated in the pre-treatment survey, all participants lacked experience with ChatGPT- or chatbot-assisted learning, suggesting that their non-academic socialisation with ChatGPT was not well-established. Consequently, despite their strong feelings of relatedness to *LogicalHamster*, they may not have naturally engaged in the socialisation via prompts. Our findings align with Zhang et al. (2024), highlighting the significant impact of learner beliefs and long-standing learning habits on educational technology use.

5.2 RQ2. Does EFL learners' non-academic socialisation with ChatGPT influence the development of logical knowledge, logical quality, and self-efficacy in English argumentative writing? How and why?

Our quantitative and qualitative analysis results triangulated each other and revealed the effectiveness of ChatGPT-assisted learning for enhancing logical knowledge, logical quality, and self-efficacy in English argumentative writing. Interviews indicated that students developed logical knowledge and awareness through ChatGPT-assisted learning, which in turn improved their ability to address logical fallacies, enhance logical quality, and increase self-efficacy in English argumentative writing. This study provides empirical evidence for previous claims regarding the potential of ChatGPT-assisted learning (Baskara, 2023; Zhang et al., 2023a) and extends its potential to writing and logic education. Based on our findings, we recommend practitioners adopt ChatGPT-assisted learning of English argumentative writing logic.

Our PLS-SEM and interview results further highlights the significant contribution of non-academic learner socialisation with ChatGPT to the effectiveness of this learning approach, particularly in developing logical knowledge. Specifically, we found that increased prompts for non-academic socialisation with *LogicalHamster* led to higher post-test scores in logical knowledge, regardless of learners' prior knowledge in this area. This finding underscores the benefits of non-academic socialisation with ChatGPT in logic education and English argumentative writing education, generalising Van den Berghe et al.'s (2019) findings on traditional educational chatbots. Based on these results, we recommend spontaneous non-academic socialisation with ChatGPT to improve outcomes in ChatGPT-assisted English argumentative writing logic learning.

Several factors underlie the positive impacts of non-academic learner socialisation with ChatGPT on learning English argumentative writing logic. One significant factor is the reception of feedback. Our interview results indicated that learners generally felt more comfortable accepting academic suggestions and feedback from entities with whom they had established non-academic interactions and personal

relationships. Consequently, they were more inclined to learn from ChatGPT during such socialisation. This phenomenon aligns with attachment theory (Bowlby, 1980) and extends previous findings in traditional peer learning contexts (e.g., Ma et al., 2020; Sato & Ballinger, 2012), emphasising the benefits of strong, healthy non-academic learner-ChatGPT relationships for improving feedback acceptance. Given the importance of constructive feedback in both writing education (Hyland & Hyland, 2006) and logic education (Guo & Lee, 2023), the positive influence of non-academic learner socialisation with ChatGPT on feedback acceptance is conducive to learning English argumentative writing logic. Hence, non-academic learner socialisation may improve outcomes of ChatGPT-assisted learning of English argumentative writing logic by enhancing learners' feedback acceptance.

Another factor underlying the positive effects of non-academic learner socialisation with ChatGPT on learning outcomes is increased motivation to apply learning strategies. According to our interviewees, learners engaging in more non-academic socialisation with *LogicalHamster* felt more motivated and interested in academic tasks, extending Shao et al.'s (2024) findings on peer non-academic socialisation to ChatGPT. Furthermore, our interviews revealed a positive correlation between learner motivation and their efforts to "think deeply and ask questions about the knowledge points" and "do exercises." This finding generalises Ma et al.'s (2018) observations of increased learning strategy application among learners with greater non-academic socialisation with teachers. Thus, our study suggests that the benefits of non-academic socialisation found in traditional contexts—between teachers and students and among peers—generalise to ChatGPT-assisted learning environments. Our findings also highlight motivation and learning strategies as essential in ChatGPT-assisted learning of English argumentative writing logic. This aligns with self-determination theory (Deci & Ryan, 2012) and self-regulated learning theory (Zimmerman, 2013), suggesting that non-academic socialisation with ChatGPT can enhance logical learning by boosting motivation and encouraging strategic application.

Flow theory can also explain the effectiveness of non-academic learner socialisation with ChatGPT. Flow is a mental state characterised by intense focus on the activity at hand, distorted senses of time-passing, and high levels of enjoyment and excitement (Csikszentmihalyi, 1991). Learners experiencing flow tend to concentrate on learning materials and devote great effort to academic tasks, likely to obtain satisfactory outcomes (Hong et al., 2017). Interviews suggest *LogicalHamster* appeared to induce flow in learners of English argumentative writing logic ("[Chatting with *LogicalHamster*] made me lose sense of time-passing and deeply immersed in the learning."), thereby enhancing their learning efficiency. Hence, our findings provide empirical evidence for the usefulness of chatbot-assisted learning in triggering flow (e.g., Zhang et al., 2023b) and generalise these theories to ChatGPT-assisted learning of English argumentative writing logic. Based on the findings, we recommend practitioners foster flow in learners of English argumentative writing logic through ChatGPT.

However, non-academic learner socialisation with ChatGPT is not universally beneficial. Our interviews revealed that some students perceived non-academic

socialisation with ChatGPT as "a distraction," which detracted from their focus on developing the target knowledge and skills. This finding is consistent with cognitive load theory (Sweller, 2011) and supports Philp et al.'s (2010) view that non-academic socialisation can cause extraneous cognitive overload, thereby diminishing learners' germane load and learning efficiency. Additionally, some interviewees viewed non-academic socialisation with ChatGPT as irrelevant to their academic goals and unhelpful to learning efficiency, echoing constructivist learning theory (Vygotsky & Cole, 1978). These findings suggest that non-academic socialisation with ChatGPT could be cognitively demanding and distracting for some learners in a ChatGPT-assisted learning environment. Given the high cognitive complexity associated with understanding logical concepts and developing logical quality in English argumentative writing (El Khoiri & Widiati, 2017), practitioners should take learners' cognitive capacities into account when implementing ChatGPT-assisted learning methods.

Moreover, the learning duration may influence the effectiveness of non-academic learner socialisation with ChatGPT. Our PLS-SEM results indicated that non-academic socialisation with ChatGPT had no statistically significant effects on logical quality and self-efficacy in English argumentative writing. This may be due to the high cognitive complexity required to apply logical knowledge in enhancing the logical quality of authentic English argumentative writing, which surpasses the demands of developing logical knowledge. According to Bloom's taxonomy of learning objectives (Bloom et al., 1969), academic goals with higher cognitive complexity requires more time to develop. Thus, improving logical quality in English argumentative writing may be inherently difficult through a single session of non-academic socialisation. Similarly, self-efficacy is often deeply rooted in learners' prior, long-term experiences (Schmidt & DeShon, 2009), and a single session may not suffice to effect significant changes in self-efficacy, as acknowledged by our interviewees. These findings align with Zhang et al. (2024), who discussed the null results of short-term technology-enhanced language learning and highlighted the importance of long-term interventions. Previous research has demonstrated that long-term training can lead to statistically significant improvements in argumentative writing quality (Nejmaoui, 2019) and writing self-efficacy (Wilby, 2022). Therefore, we advocate long-term implementation of ChatGPT-assisted learning to better understand how non-academic socialisation with ChatGPT affects the development of logical quality and self-efficacy in English argumentative writing.

Notably, our findings indicate that logical knowledge fully mediates the effect of non-academic socialisation with ChatGPT on logical quality and self-efficacy in English argumentative writing. According to our interview data, many students attributed their improvements in logical quality and self-efficacy to their mastery of logical knowledge and successful resolution of logical issues in their writing. This finding is consistent with El Khoiri and Widiati (2017) and Oaksford and Chater (2020), who emphasise the direct influence of logical knowledge on argumentative writing quality and self-efficacy. Accordingly, non-academic learner socialisation with ChatGPT appears to exert an indirect effect on logical quality and self-efficacy via logical knowledge. In the statistical model, once the significant effect of non-

academic learner socialisation with ChatGPT on logical knowledge is controlled for, the remaining direct effects on the other two outcomes may be minimal. This is evidenced by our PLS-SEM results, which show that the direct effects of non-academic learner socialisation with ChatGPT on neither logical quality nor self-efficacy in English argumentative writing were statistically significant. Hence, non-academic learner socialisation with ChatGPT may have limited effects on logical quality and self-efficacy in English argumentative writing due to the mediating role of logical knowledge.

6 Conclusion and implications

This study explored non-academic learner socialisation with ChatGPT and its influences on the development of logical knowledge, logical quality, and self-efficacy in English argumentative writing. In addressing RQ1, we identified upper-intermediate levels of non-academic learner socialisation with ChatGPT: Emotionally, learners expressed a strong sense of relatedness to ChatGPT, viewing it as both a friend and a tutor; Behaviourally, they produced prompts greeting ChatGPT, addressing it by its name, expressing vulnerability and gratitude, and engaging in casual talks. Overall, ChatGPT showed effectiveness in eliciting non-academic learner socialisation by fostering social presence, homophily, and positive emotions. In addressing RQ2, our findings demonstrated a positive influence of non-academic learner socialisation with ChatGPT on learning outcomes—particularly logical knowledge—by enhancing feedback acceptance, motivating learners to apply learning strategies, and facilitating flow.

Our findings illuminate ChatGPT's potential as both a supportive companion and an effective educational tool that enhances non-academic learner socialisation in learning English argumentative writing logic, thereby improving learning outcomes. Previous studies have highlighted the benefits of non-academic learner socialisation with chatbots in language learning (Van den Berghe et al., 2019) and the considerable potential of ChatGPT in supporting English argumentative writing logic (Zhang et al., 2023a) and serving as a conversational companion (Chatterjee & Dethlefs, 2023). This study generalises these theories within ChatGPT-assisted learning and deepens our understanding of the experiences and effectiveness of this approach, with implications that may extend across domains.

Our study offers several important implications for the implementation of Chat-GPT-assisted learning. First, we recommend conducting orientations to inform students about the benefits and limitations of non-academic socialisation with ChatGPT prior to implementation. Our interview results revealed that many students deliberately restricted non-academic socialisation with ChatGPT, believing such interactions were unproductive or harmful to knowledge and skill development, despite feelings of relatedness to ChatGPT. Our statistical findings challenge this belief, demonstrating the significant positive effects of spontaneous learner prompts for non-academic socialisation with ChatGPT on learning outcomes. Therefore, educa-

tors should address misconceptions about non-academic socialisation and encourage spontaneous interactions with ChatGPT. For example, before implementing ChatGPT-assisted learning, teachers may provide an orientation session including: a presentation of data and case scenarios showing the improved learning outcomes associated with spontaneous non-academic prompts; a demonstration where students engage in casual, non-academic conversations with ChatGPT; and a reflection activity illustrating how these interactions can build relatedness and indirectly support academic motivation. However, teachers should avoid mandating or excessively encouraging non-academic learner socialisation, as it may be cognitively demanding and distracting for some learners, potentially reducing their learning efficiency, as indicated in our interviews. Moreover, orientations should clarify the unidirectional nature of non-academic socialisation with ChatGPT and ChatGPT's inherent inability to possess genuine personality or emotional investment. This aims to minimise the risk of learners over-anthropomorphising ChatGPT, which may lead to excessive dependency and cognitive disorientation (Deshpande et al., 2023). For example, educators could include disclaimers or discussions in orientations emphasising that, unlike human peers, ChatGPT does not possess emotions or true understanding, thus cautioning learners against forming emotional attachments that could impede autonomous learning. Thus, educators should support spontaneous non-academic socialisation while mitigating the risks of over-anthropomorphisation through pre-learning orientations.

Furthermore, we advocate for the development of a distinct and engaging persona for ChatGPT, one that embodies qualities such as humour and patience. In our study, *LogicalHamster*, a GPT-4-powered chatbot, was designed to present itself as a hamster, featuring a hamster-themed, humours conversational style and a chat head of a hamster image. This design proved effective, as our interviewees described *LogicalHamster* as a "cutely silly," "confident," and "funny" friend. The persona fostered non-academic learner socialisation by enhancing social presence and, consequently, academic development. Given these findings, future instructional designers should consider creating vivid, distinct personas for GPT-powered bots to support logical and English argumentative writing education, probably drawing inspiration from *LogicalHamster*. It is important to note, however, that while the design elements of *LogicalHamster* are common to GPT-powered bots, non-academic learner socialisation with ChatGPT may vary across disciplines, GPT model versions, and prompt-engineering approaches. For example, while *LogicalHamster*'s persona was effective in English argumentative writing contexts, a GPT-powered bot designed for STEM education might require a different persona emphasising precision and analytical rigour rather than humour. Therefore, researchers and practitioners should exercise caution when generalising our findings to other GPT-powered bots.

Our study has several limitations. The first limitation concerns our sample. We investigated a single cohort of Chinese EFL students, predominantly female, from one higher educational institution who had experience with technology-enhanced learning but lacked prior exposure to logic learning, chatbot-assisted learning, or prompt engineering. This highly homogeneous cohort, while representative of learn-

ers with similar backgrounds, limited the exploration of variables such as gender, digital literacy, training experiences, educational backgrounds, and cultural identities. These factors may influence the nature and extent of non-academic learner socialisation with ChatGPT, as individuals' situational, developmental, and cultural contexts play a considerable role in shaping their socialisation (Epley et al., 2007). For instance, younger students generally exhibit greater willingness to interact with conversational agents (Randall, 2019), suggesting that middle school students could experience more non-academic socialisation with ChatGPT than students with higher educational backgrounds. Additionally, native speakers of Chinese and English adhere to different social norms regarding politeness (Zheng, 2021), which may lead to divergent patterns of non-academic socialisation with ChatGPT in learning contexts. To broaden the scope of research in this area, future studies should consider various situational, developmental, and cultural factors when investigating non-academic learner socialisation with ChatGPT. Furthermore, our sample size was relatively small ($N=40$), which warrants caution in generalising our findings to a larger, more diverse population.

Secondly, our investigation of non-academic learner socialisation with ChatGPT was conducted during a single session lasting 45 to 75 min. Due to the relatively short treatment, our results may be influenced by novelty effects, although we attempted to mitigate these through pre-treatment orientations and observed no instances of such effects in our analysis of learner prompts or interview transcripts. Additionally, learner behaviours and emotions are dynamic and can evolve over time (Ning & Downing, 2010), suggesting that the nature, extent, and effects of non-academic learner socialisation with ChatGPT in a one-session context may differ from those in long-term learning scenarios. For instance, previous research has documented a decline in learners' non-academic socialisation with chatbots over time (Fryer et al., 2017), a trend that may also be applicable to ChatGPT-assisted learning. Moreover, our study evidenced significant positive impacts of non-academic learner socialisation with ChatGPT on logical knowledge development within a single session. However, in a long-term learning context, frequent non-academic socialisation with ChatGPT could lead to over-anthropomorphisation and excessive dependence on it, which may result in cognitive disorientation and negatively affect academic development (Deshpande et al., 2023). Therefore, to gain a more comprehensive understanding of non-academic learner socialisation with ChatGPT while minimising novelty effects, we call for long-term research in this area.

The third limitation pertains to our data collection methods. We evaluated learners' ChatGPT-assisted learning outcomes in terms of logical knowledge through pre-, post-, and delayed tests, following Song and Sparks (2019) and Zhang et al. (2023a). Although the questions in these three tests were presented in varying orders, they contained the same content to enhance internal validity, which leaves room for potential test–retest effects and expectancy bias. Future researchers might employ tests with varied content to assess logical knowledge, thus further mitigating scoring bias.

Additionally, we explored non-academic learner socialisation with ChatGPT based on learner prompts, questionnaire responses, and interview results, but did not anal-

yse *LogicalHamster*'s responses. However, a systematic evaluation of the complete learner-ChatGPT dialogue could have triangulated our data, provided richer insights and enabled a more comprehensive, robust exploration of our research questions. For example, during the process of analysing learner prompts, we identified non-academic prompts that appeared to stem from social norms of politeness rather than authentic social engagement, which we subsequently excluded from further analysis. Nevertheless, the robustness of our analyses could be enhanced by employing a systematic evaluation of the complete learner-ChatGPT dialogues, guided by an established coding scheme. Furthermore, we observed instances of learners disclosing personal issues and expressing vulnerability towards *LogicalHamster* in their prompts, alongside interviewees describing the bot as "patient and non-judgmental." By holistically examining learner-ChatGPT dialogues, we could identify specific GPT cues that triggered these behaviours and feelings, thereby enhancing our understanding of the mechanisms underlying non-academic learner socialisation with ChatGPT. Thus, we recommend critical evaluations of complete learner-ChatGPT dialogues using systematic coding schemes in future studies.

Finally, our model of non-academic learner socialisation with ChatGPT in the context of learning English argumentative writing logic could be further refined. In this model, non-academic learner socialisation was examined using two distinct reflective measures—behavioural and emotional dimensions. Together, these dimensions influence learning outcomes in terms of logical knowledge, logical quality, and self-efficacy in English argumentative writing. Despite the high validity and reliability of our model at both the measurement and structural levels (see Appendix 6), there is potential for further refinement by considering additional interactions among various factors and isolating the impacts of individual factors. For instance, beyond their individual effects, behavioural and emotional dimensions of non-academic learner socialisation may interact in influencing ChatGPT-assisted learning outcomes, given the interconnected nature of different dimensions of learner engagement in technology-enhanced learning (Plass et al., 2015). Additionally, our interview results suggest the mediating role of logical knowledge on logical quality and self-efficacy in English argumentative writing, echoing previous arguments (e.g., Busse et al., 2023; El Khoiri & Widiati, 2017). However, the mediating effect of logical knowledge has yet to be incorporated into the model. Also, our study did not involve a control group, making it infeasible to isolate the effects of non-academic learner socialisation alone. Future researchers may enrich and refine our framework of non-academic learner socialisation with ChatGPT by investigating various dynamics, interactions, and mediations at a micro-level and applying an experimental-control group design.

In recent times, we have witnessed growing investigation and implementation of ChatGPT-assisted learning across domains. This study sheds light on non-academic socialisation with ChatGPT for English argumentative writing education, offering insights into its mechanisms that may be applicable in other fields. To realise the full potential of ChatGPT-assisted learning, we encourage further research into this approach, including ChatGPT-assisted collaborative learning and educational games.

Appendix 1 Logical knowledge assessment (Zhang et al., 2023a)

Seven common logical fallacies in English argumentative writings		
A. Begging the Question	B. Red Herring	C. False Alternatives
D. Post hoc fallacy	E. Hasty Generalization	F. Slippery Slope
G. Faulty Analogy		

In *Column A* of the following table, there list seven sentences from English argumentative writings, each committing one of the above seven types of logical fallacies. Please complete the following table by:

1. Explaining the meanings and structures of the fallacies of each sentence in *Column B*.
2. Matching the terminology of the fallacies of each sentence in *Column C*.

[A] Example sentences	[B] Meanings and structures of the fallacy in the sentence	[C] Terminology of the fallacy
1 All the world's top technical companies are working on the development of AI technology because AI technology is the hottest topic in this field		
2 Either we allow cars in the city centre, or the local businesses will suffer		
3 Students' learning efficiency significantly declined after they had online learning. Hence, online learning has negative effects on students' learning efficiency		
4 If we do not solve the problem of air pollution today, the problem may continue being delayed day after day. In the end, this problem will never be solved		
5 To say humans are immortal is like saying a car can run forever		
6 According to our interviews of 200 students in Hong Kong, Asian students are overall reluctant to ask their teachers for help		
7 It is true that the quality of second language education is not good in our country. However, the native language education is a bigger problem and in more need of our attention		

Appendix 2. Scoring system of the tests on logical knowledge (Zhang et al., 2023a)

Categories		Score for each type of logical fallacy
Fallacy meaning	The student does not provide any correct information concerning the structure and meaning of the logical fallacy in the example sentence	0
	The student provides some correct but incomplete, inaccurate information concerning the structure and meaning of the logical fallacy in the example sentence	1
	The student provides correct, complete, clear explanations for the structure and meaning of the logical fallacy in the example sentence	2
Fallacy terms	The student matches the meaning and term of the fallacy correctly	0
	The student fails to match the meaning and term of the fallacy	1
Total		3

Appendix 3. Scoring system of English essay logic (adapted from Finken and Ennis's Illinois Critical Thinking Essay Scoring Rubric and IELTS's academic writing assessment criteria)

Categories		Scores
Supporting Reasons	The accuracy, relevance and sufficiency of the evidence students used to support their arguments	0~25
Reasoning	The clarity of arguments and convincingness of reasoning	0~25
Commitment of logical fallacies	The frequencies and depths of logical fallacies	0~25
Coherence	The linking of ideas through logical sequencing throughout the students' writings	0~25
Total		0~100

Appendix 4. Questionnaire on English argumentative writing self-efficacy (Rahimi & Fathi, 2022)

Statements	To which degree do you agree with the statements?				
	Strong-ly disagree [1]	Dis-agree [2]	Neu-tral [3]	Agree [4]	Strong-ly agree [5]
I feel confident about English argumentative writing					
I know how to perform well in English argumentative writing					
I can perform English argumentative writing with an under-lying logical organisation					
If I put in the needed effort, I am sure I can become a good writer in English argumentative writing					
I can perform English argumentative writing tasks that are relevant and appropriate to the assignment					
I present my point of view or arguments accurately and effectively in English argumentative writing					
I am sure I can do well in English argumentative writing even if they are difficult					

Appendix 5. Questionnaire survey on learners' sense of relatedness to ChatGPT (Croes & Antheunis, 2021)

Statements	To which degree do you agree with the statements?				
	Strong-ly disagree [1]	Dis-agree [2]	Neu-tral [3]	Agree [4]	Strong-ly agree [5]
I would be upset if I could not interact with *LogicalHamster* again					
I feel like *LogicalHamster* is my friend/ partner/ companion					
I will continue to interact with *LogicalHamster* in the future					
I think *LogicalHamster* could be a friend/ partner/ compan-ion of mine					
LogicalHamster and I could never establish a personal friendship with each other.*					
I could become close friends with *LogicalHamster*					

*Reverse item

Appendix 6. Indicators of the validity and reliability of the PLS-SEM analysis

Table 4 Indicators for the reliability and validity of the PLS-SEM measurement model

Variables	Indicators	Factor loadings	rhoC	AVE
Non-academic learner socialisation with ChatGPT	Number of learner prompts for non-academic socialisation	0.854	0.817	0.691
	Questionnaire scores on the senses of relatedness to ChatGPT	0.807		
Learners' prior logical knowledge in English argumentative writing	Pre-test scores	1.000	1.000	1.000
Learners' prior logical quality in English argumentative writing	Scores of the initial writing	1.000	1.000	1.000
Learners' prior English argumentative writing self-efficacy	Pre-questionnaire scores on self-efficacy	1.000	1.000	1.000
ChatGPT-assisted logical learning outcomes concerning logical knowledge in English argumentative writing	Immediate post-test scores	0.935	0.932	0.872
	Delayed post-test scores	0.932		
ChatGPT-assisted logical learning outcomes concerning logical quality in English argumentative writing	Scores of the revised writing	1.000	1.000	1.000
ChatGPT-assisted logical learning outcomes concerning English argumentative writing self-efficacy	Post-questionnaire scores on self-efficacy	1.000	1.000	1.000

Table 5 The heterotrait-monotrait ratio of correlations (HTMT) indicating the discriminant validity of the measurement models of PLS-SEM

	Non-academic learner socialisation with ChatGPT	Learners' prior logical knowledge in English argumentative writing	Learners' prior English argumentative writing self-efficacy	Learners' prior logical quality in English argumentative writing	ChatGPT-assisted logical learning outcomes concerning logical knowledge in English argumentative writing	ChatGPT-assisted logical learning outcomes concerning English argumentative writing self-efficacy	ChatGPT-assisted logical learning outcomes concerning English argumentative writing self-efficacy
Non-academic learner socialisation with ChatGPT							
Learners' prior logical knowledge in English argumentative writing	0.487						
Learners' prior English argumentative writing self-efficacy	0.599	0.355					
Learners' prior logical quality in English argumentative writing	0.194	0.038	0.002				
ChatGPT-assisted logical learning outcomes concerning logical knowledge in English argumentative writing	0.648	0.483	0.158	0.180			
ChatGPT-assisted logical learning outcomes concerning English argumentative writing self-efficacy	0.520	0.371	0.607	0.268	0.107		
ChatGPT-assisted logical learning outcomes concerning logical quality in English argumentative writing	0.155	0.055	0.027	0.758	0.208	0.323	

Table 6 Variance inflation factors (VIF) indicating the collinearity of the PLS-SEM structural model

Outcomes	ChatGPT-assisted logical learning outcomes concerning logical knowledge in English argumentative writing	ChatGPT-assisted logical learning outcomes concerning English argumentative writing self-efficacy	ChatGPT-assisted logical learning outcomes concerning logical quality in English argumentative writing
Predictors			
Non-academic learner socialisation with ChatGPT	1.15	1.238	1.01
Learners' prior logical knowledge in English argumentative writing	1.15	n/a	n/a
Learners' prior English argumentative writing self-efficacy	n/a	1.238	n/a
Learners' prior logical quality in English argumentative writing	n/a	n/a	1.01

Data availability The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research, supporting data is not available.

Declarations

Ethics I confirm that all the research meets ethical guidelines and adheres to the legal requirements of the study country.

Conflict of interest None.

Declaration of generative AI in scientific writing During the preparation of this work, the authors used *Grammarly* to polish the language. After using this tool, the authors meticulously reviewed and edited the content and take full responsibility for the content of the publication.

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