

ARTICLE



## Students' emotions and cognitive loads in chatbot- versus peer-supported reading

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### Abstract

*Using a within-subject design, this study engaged 60 Chinese EFL university students in reading English academic passages either with GenAI chatbot support or with peer support. Employing questionnaires, we compared the levels of positive and negative emotions and intrinsic and extraneous cognitive loads reported by students in these two reading conditions. Additionally, semi-structured interviews were conducted with 16 students to delve into the factors affecting their emotions and cognitive loads in the two interactive reading conditions. The results of questionnaires show that students experienced a significantly higher level of positive activating and deactivating emotions such as hope and relief and a lower level of negative activating emotion such as anxiety, as well as significantly lower levels of intrinsic and extraneous cognitive load in chatbot-supported reading. The interviews further reveal that students attributed the observed advantages of reading with chatbot to its immediate support, high efficiency, convenience of tracking the discussion record, and the low-stress learning environment. In the meantime, they reported disadvantages in emotional communication and social dynamics when communicating with AI chatbot. Overall, this study has elucidated the mechanisms underlying differential effects of reading with GenAI chatbot support versus peer support on students' emotions and cognitive loads.*

**Keywords:** human-chatbot interaction; peer interaction; emotion; cognitive loads; academic reading

**Language(s) Learned in This Study:** English

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### Introduction

Reading English academic articles often arouses negative emotions and places a high level of cognitive load on English as a Foreign Language (EFL) university students. Collaborative reading has been proposed as a potential solution to alleviate negative emotions and lower the level of cognitive load. Yet, interactive reading with peers is often hampered by affective conflicts that may arise during collaboration (Fryer & Carpenter, 2006; Jehn et al., 2008) and cognitive pressure due to the lack of coordination (Kirschner et al., 2018). In this backdrop, AI-powered chatbots (e.g., ChatGPT), equipped with the ability to comprehend texts and the capacity to interact with human users, may serve as an intelligent collaborator to assist students in academic reading. However, there is limited understanding of readers' emotions and cognitive loads when interacting with chatbots during English academic reading. Additionally, it remains unclear whether reading with chatbots and with peers may have comparable or differential effects on EFL learners' emotion and cognitive load.

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In this study, we compared university EFL students' emotions and cognitive loads during chatbot-supported English academic reading to peer-supported reading. The findings will shed light on emotional responses and cognitive loads in different interactive reading conditions.

## Literature Review

### Collaborative Reading

Collaborative reading is a “socially contextualized” learning activity where participants work together through text-mediated interactions to co-construct meaning and knowledge (Kiili et al., 2012, p. 451). Collaborative reading finds its theoretical foundation in Vygotsky's (1978) sociocultural theory of learning. According to Vygotsky (1978), skill acquisition develops through mediated processes. In collaborative reading, interactive dialogues around a text become a mediated tool that enables readers to encounter diverse perspectives and varying levels of expertise, co-construct meaning, and gradually internalize sophisticated reading comprehension strategies, creating natural scaffolding opportunities that support individual growth in reading comprehension and strategy use (Reynolds, 2017; Vygotsky, 1978).

A plethora of studies have shown that collaborative reading with peers can enhance reading comprehension by leveraging the collective knowledge repertoire and perspectives to enhance text interpretation (Fuchs et al., 2001; Vaughn et al., 2011; Jin et al., 2020; Liu et al., 2024). Additionally, researchers have also observed that collaborative reading with peers can foster supportive “social partnerships” among students, encourage voluntary sharing, and cultivate inclusive learning environment (Coakley-Fields, 2018). Despite its advantages, collaborative reading has temporospatial constraints, and its effectiveness depends essentially on how students interact and collaborate with their peers (Chen & Chen, 2014). Researchers have found that students with heterogeneous levels of reading ability sometimes make uncoordinated efforts and disproportionate contributions during peer collaborative reading (Chen & Chen, 2014). Students' metacognitive knowledge (e.g., self-regulation and reflection), their degree of interpersonal familiarity, and peer relationships have significant impacts on their engagement during peer collaborative reading and the concomitant learning outcomes (Jin et al., 2022).

To overcome the temporospatial constraints of face-to-face peer collaborative reading, researchers have explored technological solutions, such as social annotation tools (Thoms & Poole, 2017; Zhang & Li, 2025), and chatbot as a reading companion (Zhang et al., 2024). Studies have shown that reading with AI-powered interactive chatbots may enhance learners' reading engagement and interest (Liu et al., 2022, 2024; Pan et al., 2024). For example, Liu et al. (2022) examined the effects of an AI chatbot that combines book talk and social affective cues (e.g., praise, asking about feelings, sharing feelings), and observed positive effects on students' engagement and interest in reading. Furthermore, Pan et al. (2025) showed that providing students with interactive personalized self-regulated reading support via a GenAI-powered chatbot, Readmate, significantly boosted students' self-regulated reading strategy use and reading engagement. Studies have further revealed that students who read with the support of chatbots achieved comparable reading comprehension as when reading with peers (Xu et al., 2021). Nonetheless, existing literature fails to shed light on students' emotions and cognitive load under the two interaction conditions, limiting our understanding of the emotional and cognitive mechanisms behind these two interactive reading contexts.

### Students' Emotional Responses to Collaborative Reading

Emotion is a significant factor linked to learners' behavioral, cognitive, and affective experience (Kleinginna & Kleinginna, 1981). According to Pekrun's (2006) Achievement Emotion Theory, learners' emotions can be categorized based on a valence-activation taxonomy. Valence consists of a continuum of positive emotions, like enjoyment and pleasure, and negative emotions, such as anxiety. Similarly, activation lies on a continuum of physiologically activating emotions, such as hopes, and physiologically deactivating emotions, like feelings of hopelessness. Thus, emotions can be classified into four types, namely positive-activating emotion (PAE, e.g., enjoyment, hope and pride), positive-deactivating emotion

(PDE, e.g., relaxation, assurance and relief), negative-activating emotion (NAE, e.g., anger, anxiety and shame), and negative-deactivating emotion (NDE, e.g., boredom, hopelessness and disappointment). Pekrun's (2006) four-dimensional framework of emotion has been adopted by researchers to explore students' emotions in various reading contexts (e.g., Chang & Chen, 2024; Chou, 2021), enabling their investigation of the multicomponent and dynamic nature of emotion with a hierarchical structure. His framework also guides the present study.

Studies demonstrate that reading with peers can enhance collaborative meaning-making and dialogic interactions among learners (Su & Guo, 2024), thereby reducing reading anxiety and improving emotional engagement (Timothy et al., 2023; Xiong, 2024). The positive emotional impact of peer collaborative reading extends to digital environments (e.g., Li & Li, 2023; Zhang & Li, 2025). Li and Li (2023) found that learners who participated in online interactive reading via social annotation tools experienced enhanced emotional engagement. However, other studies indicated that students experienced some negative emotions in computer-mediated collaborative reading due to low social presence of partners (Yashida, 2020), difficulties in empathizing with peers, and technical malfunctions (Su & Guo, 2024). Overall, existing literature has inconsistent findings on learners' emotional responses to interactive reading with peers. Research further revealed that several key factors affect students' emotions in peer collaborative reading, including individual-related factors like students' interests and willingness to communicate using foreign language (Xu, 2021), reading difficulties and quality of support from peers (Jin et al., 2022). Furthermore, degree of interpersonal interactions and technical issues can also affect students' emotions in computer-mediated peer collaborative reading (Su & Guo, 2024). However, so far, no study has explored students' emotional responses to interactive reading with AI chatbots.

### **Students' Cognitive Load during Collaborative Reading**

The cognitive load (CL) refers to the processing load imposed on the working memory system during a specific task (Sweller et al., 2019). The influential model of CL proposed by Sweller et al. (2019) underscores intrinsic cognitive load (ICL) and extraneous cognitive load (ECL). ICL is closely related to the intrinsic complexity of the information and learners' level of expertise in processing the information. ECL is the cognitive processing difficulty experienced by students related to interaction in teaching processes and instructional design. Sweller et al.'s (2019) model of CL, offering insights into the complex cognitive process of learning, has been leveraged by researchers to explore students' cognitive status in various reading contexts (e.g., Song et al., 2023; Yang & Hu, 2024). It is also adopted as a theoretical framework of CL in this study.

Scholars have argued for the "distribution advantage" of collaborative reading. This view has been supported by empirical findings that effective peer collaboration can reduce individual students' cognitive load (Janssen et al., 2010) through distributing the cognitive demands across group members and leveraging collective intellectual resources (Kirschner et al., 2009). But at the same time, peer collaborative learning may also incur additional cognitive loads due to "transaction costs" (Janssen et al., 2010; Janssen & Kirschner, 2020), arising from the need to monitor and evaluate both one's own and reading partners' epistemic progress during interactions, potentially leading to unproductive collaboration. When these transaction costs exceed the "distribution advantage", peer collaborative learning may adversely increase students' cognitive load compared to individual learning (Janssen & Kirschner, 2020). Studies have further revealed that the impact of peer collaborative reading on cognitive load is moderated by collaborative strategy use (Jin et al., 2022; Liu et al., 2024; Zhang & Li, 2025) and technological environments in computer-mediated collaboration (DeStefano & LeFevre, 2007; Zumbach & Mohraz, 2008). For example, Jin et al. (2022) indicate that effective collaborative reading strategies can enhance collective intellectual efforts of text comprehension, reducing individuals' CL.

The few studies that examine students' cognitive loads when reading with AI chatbots reported similarly mixed findings. Wang et al. (2024) found that students who read with a ChatGPT-empowered personalized support experienced higher CL than those who read with standardized questions to guide reading practice. However, other studies found lowered CL among students in AI-supported reading

activities (Koć-Januchta et al., 2022; Zhang et al., 2025). Koć-Januchta et al. (2022) reported that students who read the AI-enriched textbook experienced lower CL than those reading traditional ones, attributing the lower CL to students' perceived ease of use and effectiveness of the AI support. Similarly, Zhang et al. (2025) found that the powerful functions of the ChatGPT-based platform to support reading help alleviate students' CL by enhancing their understanding of complex content, improving efficiency and clarifying doubts. Overall, the existing literature has generated inconsistent findings regarding CL in AI-supported reading and lacks systematic investigations of the factors influencing students' CL in this context.

### **Studies Comparing the Effects of Peer Interaction and Interaction with AI**

The interactive capacities of AI chatbots emulating human-human interaction have fueled substantive interests among researchers in language education to explore whether and how learning with AI chatbots is similar to and different from learning with peers and teachers (Han, 2024). Jeon and Lee's (2024) systematic review of 11 comparison research published before March 2023 indicated that interaction with chatbots provides benefits comparable to those afforded by human-human interaction in some domains, such as eliciting utterances of similar sophistication, vocabulary, and grammar levels and facilitating improvements in speaking and listening proficiency. However, interaction with chatbots was less effective than human interaction in areas that may demand socially appropriate interpersonal elements, such as sustaining interactivity, providing sufficient information in elaborations, and maintaining a positive attitude toward target language conversations over the long term.

With regard to specific language skills, researchers have examined their comparative effects on speaking and writing. Studies on speaking have reported either comparable or more advantageous effects of collaborating with AI chatbots on speaking (Chen et al., 2025; Fathi et al., 2026; Kim & Su, 2024; Tai & Chen, 2024; Wang et al., 2024). Similarly, comparative research on writing has suggested that writing with AI chatbot is more advantageous than writing with peers in producing higher-quality essays because the AI tool outperformed peer collaboration in providing immediate and effective feedback to improve clarity and cohesion in their writing (Allen & Mizumoto, 2024; Wang, 2024).

Notably, however, there is a lack of comparative research on reading, to say nothing of revealing the emotional and cognitive mechanisms behind the two interaction conditions. Addressing these research gaps can deepen our understanding of the effect of interacting with AI chatbots versus with peers on students' emotions and cognitive loads in interactive reading activities, expanding insights into the unique strengths and weaknesses of each, and providing implications for the optimal design of collaborative reading. Thus, in this study, we compared students' emotions and cognitive loads when reading English academic articles with AI chatbot versus peer. The research questions (RQs) examined in this study are:

1. Are there any significant differences in students' emotions and cognitive loads when reading with a chatbot compared to reading with a peer?
2. What are the factors contributing to the differential effects on EFL students' emotions and cognitive loads, if any, between the two interactive reading conditions?

## **Methods**

### **Participants and Teaching Context**

60 English major sophomore students from two parallel classes, comprising 32 in Class A, and 28 in Class B, in an eastern Chinese university participated in this study. All participants were taught by the corresponding author in a sixteen-week reading-writing integrated course, aiming to develop their academic reading and writing skills. The participants were of upper-intermediate English proficiency.

The study was conducted in class from the 10th to 14th week of the semester. During the nine weeks prior to the study, the students in the two classes were taught to use Kimi, a text-based GenAI-powered chatbot (see section 3.2), to assist reading English articles and revising their English essays. Therefore, the

participants had gained sufficient experience in using Kimi before the study so that the novelty effect induced by new technology was minimized (see Fryer et al., 2017).

## Kimi

Kimi (see Figure 1), developed by Moonshot AI, is a free Generative AI tool supported by large language models. Compared to other GenAI chatbots accessible in mainland China such as iFlytek Spark (讯飞星火), Kimi excels in its advanced text processing capacity and its ability to handle long English articles, making it a suitable tool for this study that focused on academic reading. Kimi can analyze various parts of an article for the main ideas and their illustrative details, identify the key sentences in each part and analyze sentence structures and core vocabularies with specially designed prompts (see these prompts and examples of Kimi's analyzed results in Appendix C). These functions of Kimi were utilized in this study when students performed collaborative reading with the chatbot (see Research Design and Procedures).

### Figure 1

*The interface of Kimi*

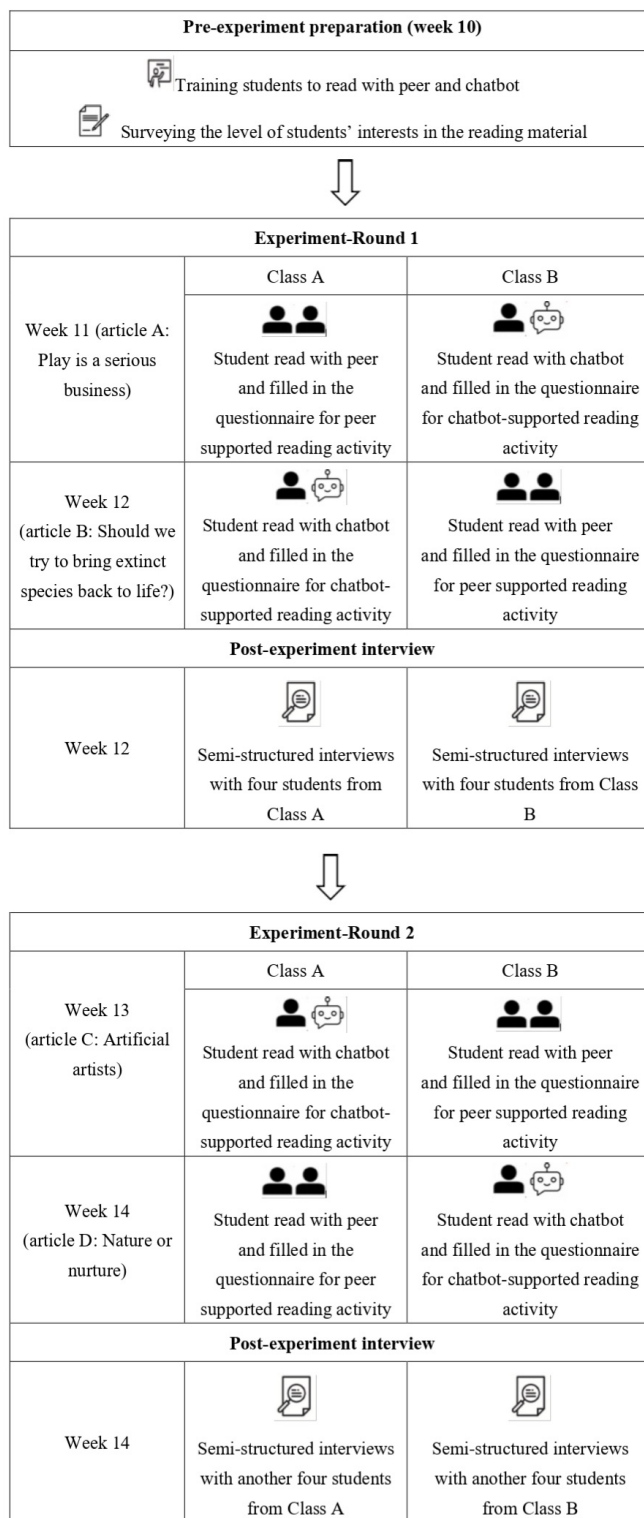


## Research Design and Procedures

This study adopts a within-subjects counter-balanced design to control for the influence of potential confounding variables (e.g., reading motivation) and mitigate task sequence effects. Specifically, we examined potential variations in the levels of emotion and cognitive loads experienced by the two classes of students in two peer-supported reading and two chatbot-supported reading activities during five weeks, as shown in Figure 2.

Figure 2

## Research Design



### ***Pre-Experiment Preparation***

In the 10th week, students in the two classes were informed of its objective and research design and invited to participate in this study on a voluntary basis. Additionally, they were asked to find a classmate to collaborate with in peer-supported reading activities, forming 16 dyads in Class A and 14 dyads in Class B. Furthermore, both classes received a 40-minute training (see [Figure 2](#)) on how to read collaboratively with a peer in peer-supported reading activities and with Kimi in chatbot-supported reading activities to ensure that all students were familiar with the processes in the two types of interactive reading activities. Moreover, students were asked to indicate, using a five-point Likert scale ranging from 1 (not interested) to 5 (very interested), their level of interest in reading seven articles drawn from the reading examination of IELTS academic tests, given the title and a 20-word brief summary as well as 5 keywords of each article. The four with the highest rankings were used for this study to enhance their motivation of reading. The two classes read these articles in class, one in a week, between the 11th and 14th weeks.

### ***The Two Interactive Reading Conditions***

The two classes of students read two articles with peers and the other two with Kimi in class between weeks 11 and 14 (see [Figure 2](#)). Each reading follows a pedagogical design consisting of the preparation stage, independent reading stage, collaborative discussion stage, and reflection & assessment stage ([Figure 3](#)). In the preparation stage, the teacher (i.e., the corresponding author) briefly informed students of the procedures in the interactive reading activity they were going to participate.

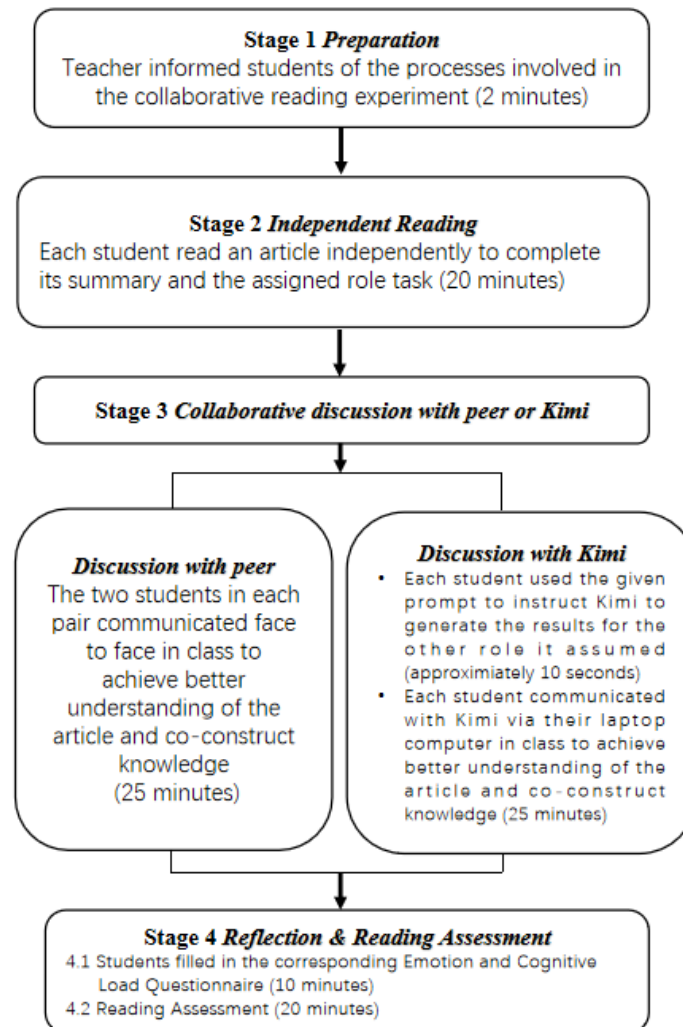
In the independent reading stage, first students were given 5 minutes to read the corresponding article independently to complete its summary report containing approximately 80 words by filling in the gaps with appropriate information from the article (see a summary example in [Appendix A](#)). Additionally, in this stage the two students in each pair were assigned two different roles, the content analyzer and the language analyzer, to read the article again independently and finish their assignments designed for the two roles respectively within 15 minutes (see [Appendix B](#)). A student who served as the content analyzer summarized the main ideas of various parts in an article and noted their illustrative details in each part, while the other student who served as the language analyzer identified the key sentences in each part and analyzed their structure and core vocabulary. On the other hand, when reading with Kimi chatbot each student could choose to serve one of the two roles (i.e., the content analyzer or the language analyzer) while Kimi played the other role, completing the same role assignments as in the peer-supported reading activity.

Next, in the collaborative discussion stage, the two students in each pair communicated face to face in class, while in chatbot-supported reading activity each student used the given prompt to instruct Kimi to generate the results for the other role it assumed (see [Appendix C](#)). They communicated with their peer or with Kimi via their laptop computers in class to resolve the problems they had in the independent reading stage when completing their role assignment and discuss other details to deepen their understanding of the article.

After that, in the final stage, students were asked to fill in the corresponding questionnaire to reflect on their emotions and cognitive load when they were interacting with their peer or Kimi (stage 3). Finally, a reading assessment using the original IELTS test items was administered to examine students' reading comprehension.

**Figure 3**

*Pedagogical Designs of Reading with Peer/Kimi Activity*



### **Questionnaires and Interviews**

Two 18-item questionnaires were developed to delve into students' emotions and cognitive loads when interacting with chatbot or peer (stage 3, Figure 3) in interactive reading activities (See Appendix D). The question items were the same, with the wording adjusted to the specific interactive reading context. In the questionnaires, emotions were assessed using adapted items from Pekrun et al.'s (2011) achievement emotion questionnaire, measuring hope (positive-activating emotion, PAE) with three items, relief (positive-deactivating emotion, PDE) with two items, anxiety (negative-activating emotion, NAE) with three items, and disappointment (negative-deactivating emotion, NDE) with three items. Cognitive load was assessed using adapted items from Leppink et al.'s (2013) cognitive load questionnaire, with four items on intrinsic cognitive load (ICL), and three on extraneous cognitive load (ECL). We adapted these two questionnaires by adding the context specification (i.e., "with the assistance of peer" or "with the assistance of chatbot"). All items in the questionnaires used a 5-point Likert scale from 1 "Strongly disagree" to 5 "Strongly agree". The Cronbach's  $\alpha$  values of the six dimensions (four on emotions and two on CL) in both questionnaires, ranging from 0.710 to 0.880, all surpassed the conventionally

acceptable standard of 0.7 (Nunnally, 1978), revealing adequate internal consistency among all dimensions.

In addition, 16 students, eight each from the two classes, voluntarily participated in the semi-structured interviews in Mandarin, their mother tongue, within 48 hours after each of the two rounds of experiment in the 12th and 14th weeks. Each interview lasted approximately 50 minutes. During the interviews, students were asked whether they experienced any positive and negative emotions when communicating with their peer and the chatbot, and the influencing factors contributing to their emotions in the two reading conditions (RQ 2). These open-ended questions used in the interviews allowed students to describe any emotions they experienced, including those not assessed in the questionnaires (e.g., enjoyment and boredom). Additionally, they were also asked whether and how interacting with peer and with chatbot can mitigate their comprehension difficulties (i.e., intrinsic CL) when reading academic passages, whether they experienced any communication problems when interacting with their peer or the chatbot (i.e., extraneous cognitive load) and how they cope with these problems (RQ 2). The interview questions translated into English are given in [Appendix E](#).

### Data Analysis

To address RQ 1, average scores of each dimension in emotions and CLs were calculated and compared across the two collaborative reading conditions. Given that Shapiro–Wilk test indicates that students' emotions and cognitive loads in the questionnaire data did not distribute normally, the non-parametric Wilcoxon signed-rank tests were used to examine RQ 1 regarding the differences in students' emotions and CL during the two types of interactive reading activities. The effect sizes ( $r$ ), calculated by  $Z / \sqrt{N}$  (Field, 2018), are interpreted according to Plonsky and Oswald (2014), as an effect size of .20 as small, .40 as medium, and .60 as large.

To address RQ 2, students' interview responses were transcribed verbatim, translated from Chinese into English, and analyzed using thematic analysis (Braun & Clarke, 2006) in the following ways. First, the first author carefully examined the interview transcripts of five participants thoroughly to identify codes (e.g., “low level of trust on peer”, “high level of trust on the chatbot”) and grouped similar codes to derive themes (e.g., “trust on collaborator”). Then, the coding scheme was checked and refined by the corresponding author. After that, the first author continued to code the remaining transcripts with the refined scheme, followed by his reiterative examination and refinement of the identified codes and themes to ensure the coding results truthfully represented interviewees' ideas. To ensure inter-rater reliability, 25% of the transcribed responses were analyzed by the first author and the corresponding author, with inter-rater agreements reaching 95%. Any disagreements were resolved through discussion between the two authors to reach a consensus.

## Results

### Comparison of Students' Emotions and CL when Reading with Peer versus with Chatbot

Regarding differences in students' emotions and CL in the two interactive reading settings (RQ1), Wilcoxon signed-rank tests indicated significant differences in three types of emotions, namely positive activating emotion (PAE), positive deactivating emotion (PDE), as well as negative activating emotion (NAE), and both intrinsic cognitive loads (ICL) and extraneous cognitive loads (ECL) between the two interactive reading conditions ([Table 1](#)). Specifically, students experienced a significantly higher level of PAE ( $z = 2.941$ ;  $p = 0.003$ ;  $r = 0.404$ ) and PDE ( $z = 2.846$ ;  $p = 0.004$ ;  $r = 0.391$ ), but a significantly lower level of NAE ( $z = 3.474$ ;  $p = 0.001$ ;  $r = 0.477$ ) when reading with chatbot. However, students experienced a similar level of negative deactivating emotion (NDE) in the two interactive reading conditions ( $p = 0.216$ ). Additionally, students experienced a significantly lower level of ICL ( $z = 2.253$ ;  $p = 0.024$ ;  $r = 0.309$ ) and ECL ( $z = 2.827$ ;  $p = 0.005$ ;  $r = 0.388$ ) when reading with chatbot.

**Table 1**

*Comparison of Students' Emotion and CL when Reading with Peer versus with Chatbot*

Dimensions	Reading with peer		Reading with Kimi chatbot		$z$	$p$	$r$
	Median	IQR	Median	IQR			
PAE	3.750	0.750	4.000	0.583	2.941	0.003*	0.404
PDE	3.750	0.750	4.000	0.750	2.846	0.004*	0.391
NAE	2.500	0.917	2.000	0.917	3.474	0.001*	0.477
NDE	2.500	1.000	2.333	1.000	1.238	0.216	0.170
ICL	3.125	0.813	2.875	1.063	2.253	0.024*	0.309
ECL	2.000	1.000	2.000	0.667	2.827	0.005*	0.388

*Note.* Positive Activating Emotion (PAE), Positive Deactivating Emotion (PDE), Negative Activating Emotion (NAE), Negative Deactivating Emotion (NDE), Intrinsic Cognitive Load (ICL), Extraneous Cognitive Load (ECL).  
\* $p < 0.05$

### **Factors Affecting Students' Emotions when Reading with Peer Versus with Chatbot**

Concerning the influencing factors (RQ2), the interview responses indicated that the observed differences in emotions under these two interactive reading conditions could be attributed to the quality of support, the degree of emotional exchange, as well as some social factors such as peer judgement and interpersonal relationships.

#### ***The Quality of Collaborator's Support***

12 students indicated that they received limited support from peer students in peer interactive reading activities to comprehend sophisticated vocabulary, complicated sentences and unfamiliar concepts in English academic passages, owing to their less developed English proficiency. In this circumstance, students experienced helplessness (e.g., Wu), concern (e.g., Shuo, Huang), frustration (Shuo), and anxiety (Huang), as the quote from Wu illustrates below:

During the process of peer interactive reading, both of us may encounter some common problems, and probably won't be able to solve them well. We both feel rather helpless. When two people are at a similar level and stay together, they may not be able to make progress. (Wu)

In contrast, students experienced sense of trust (Huang) and relief (Liu and Xiang) in chatbot-supported reading activities, because they found that Kimi could provide rich and effective supports to help students better understand English academic passages by summarizing the main ideas of long paragraphs (Wen), analyzing complex discourse structures (Meng), and providing in-depth explanations of unfamiliar concepts (Xiang). Meng's chatlog extract (Figure 4) illustrated the chatbot's ability to analyze text.

## Figure 4

### Extract of Meng's Query and Kimi's Response

In part g, the first sentence talks about people's awareness of brain activation, tell me what's the function of this sentence, why it was posed in the beginning of part



Search for brain activation in argume...

在文本的第G部分中，第一句话“People have not paid enough attention to the amount of the brain activated by play”（人们没有足够重视玩耍激活的大脑区域）具有重要的作用。以下是这句话的功能和它为什么被放在第G部分开头的原因：

1. **引入新观点**：这句话引入了一个新的观点，即玩耍对大脑激活的影响，这是之前部分未详细讨论的。它为读者提供了一个新的视角，即玩耍不仅仅是身体活动，它还涉及到大脑的广泛激活。
2. **强调重要性**：通过指出人们“没有足够重视”，这句话强调了玩耍激活大脑的重要性，暗示这是一个被忽视的研究领域，需要更多的关注和研究。
3. **过渡到细节**：这句话作为引入，为接下来更详细的讨论和证据铺垫，即玩耍如何激活大脑的不同部分，以及这种激活如何影响行为和认知发展。
4. **引起好奇心**：它激发读者的好奇心，使他们想要了解更多关于玩耍和大脑激活之间的联系，从而增加对后续内容的兴趣。
5. **设定研究背景**：这句话设定了研究的背景，表明尽管玩耍在发展和学习中扮演着重要角色，但我们对其神经机制的理解仍然有限。
6. **引导论证方向**：在一篇议论文中，这句话可以作为引导，指向作者将要展开的论证方向，即玩耍对大脑的积极影响及其在发展中的作用。

综上所述，这句话在第G部分的开头起到了承上启下的作用，既总结了前文的讨论，又为深入探讨玩耍与大脑激活之间的关系奠定了基础。这种结构在议论文中非常常见，有助于保持文章的连贯性和逻辑性。

Kimi's text comprehension and analysis capacities induced positive emotions for Xiang: "I felt more relaxed when reading with the chatbot than with my peer, because the chatbot's level of understanding and English proficiency are higher than ours. I'm quite at ease and think it's rather reliable."

The more effective chatbot supports can account for higher levels of positive-activating emotion (e.g., enjoyment) and positive-deactivating emotion (e.g., relaxation) as well as a lower level of negative activating emotion (e.g., anxiety) among students in chatbot-supported reading activities.

### **The Degree of Emotional Exchange**

Whether students had emotional exchange with their partner in interactive reading activities influences their emotions. Wu noted the rich emotional exchange with peers in peer-supported reading activity, such as expressions of sympathy, approval, and encouragement or through nonverbal means like eye contact and nodding:

While talking with peer, he had some slight movements, such as nodding or summarizing the information I had just provided. In this way, I could tell that he was paying attention.

Acknowledgement and emotional connections with peers boosted Meng's self-efficacy: "When I came up with a great idea and shared it with my peer, he would give me timely feedback and praise, and then I felt like I was really good at this."

On the other hand, students reported that chatbot seldom provide any emotion cues in their interactions, resulting in their feelings of some negative-deactivating emotions such as boredom, demotivation and frustration when interacting with Kimi in chatbot-supported reading activities, as indicated by Guo:

The chatbot is really quiet. When I shared some of my understandings with my peer student, he would affirm some of them. However, the chatbot seldom gives affirmation. It made me feel really bored, and it made me reluctant to continue asking questions. I also felt a bit frustrated. Since it didn't give me any affirmation, it seemed that all of my understandings were wrong.

### **Other Social Factors**

Several students indicated that the sense of responsibility of helping peers made them feel pressured for good performance. They felt stressed or frustrated when they could not do well to help their partner in peer interactive reading activities. In contrast, students were free from this concern when reading with Kimi because chatbot is not real human.

Additionally, peer judgement influenced students' emotions in peer-supported reading activities. Several students indicated that the concerns about being judged by their peers aroused their feelings of nervousness and anxiety. In contrast, Kimi chatbot was not judgmental, creating a stress-free learning environment and making students feel relieved when making mistakes. The quotes of Wen below illustrate the advantage of interacting with chatbot in creating a low-stress learning environment:

When having a conversation with peers, if I mispronounce a word or say something wrong, they may have some opinions about you. However, when talking with the machine, this situation won't happen, because the machine will first answer your questions and then correct your mistakes. (Wen)

Furthermore, students also expressed concerns about interpersonal relationships in peer-supported reading activities. They needed to be very careful with what they said to maintain a harmonious relationship with peer students when they had different opinions in discussions. In contrast, students had no concern about maintaining a good relationship with chatbot, contributing to greater relaxation among students when interacting with chatbot, as Meng indicated:

I don't need to worry that chatbot will be unhappy due to different opinions. On the contrary, when I communicate with peer student, I am concerned about whether my peer is psychologically sensitive when I have different ideas and when I want to refute him. (Meng)

Overall, students' concerns of peer judgement, interpersonal relationships with peer collaborator and their responsibility of helping them resulted in feelings of some negative-deactivating emotions (e.g., anxiety, nervousness) when interacting with peer students, accounting for a higher level of negative-activating emotions among students when interacting with peers in interactive reading activities.

### **Factors Affecting Students' ICL when Reading with Peer versus with Chatbot**

Students' responses in the interview indicated that the observed differences in intrinsic cognitive load under these two interactive reading conditions could be mainly attributed to the quality of collaborator's support. The limited peer support due to their less developed English proficiency and knowledge made students experience a higher level of ICL (Median<sub>peer-supported</sub> = 3.125, see Table 1) when understanding the English academic passages than in the chatbot-supported reading activities (Median<sub>chatbot-supported</sub> = 2.875). On the other hand, Kimi chatbot could provide rich and effective support to enhance students' understanding of the challenging English academic passages, significantly reducing their intrinsic cognitive load in chatbot-supported reading activities, as indicated by Wu:

These articles are quite professional. I think they are a bit beyond our reading proficiency. Some of the nouns and concepts mentioned may actually require us to search online before we can understand them. So, Kimi can help us conduct searches more quickly and then provide quicker feedback to assist comprehension. (Wu)

## Factors Affecting Students' ECL when Reading with Peer versus with Chatbot

Students' interviews indicated that modes of interaction, ease of repairing communication breakdown and keeping discussion record can affect their extraneous cognitive loads when interacting with their collaborator.

### ***Modes of Interaction***

The different modes of interaction with peers and Kimi caused different levels of ECL among students during the discussion stage in the two types of interactive reading activity. Oral communication with peers contains simple sentences that are easy to understand, while chatbots' written communication often contains long sentences with complicated structure and condensed information, imposing additional cognitive burdens for comprehension, as Fang indicated:

Chatbot generates too much content at one time in long sentences, and I have to read slowly and might get a bit tired after reading. (Fang)

### ***Ease of Repairing Communication Breakdowns***

Communication breakdowns sometimes occurred when students interacted with peer or with chatbot. Students reported that repairing communication was easier when communicating with their peers than with chatbot, because they shared much in common with their peers (e.g., similar age and backgrounds, studying the same subjects, etc.), as indicated by Wang:

My peer also had similar learning experiences and the directions that we can think of are similar. He can understand where there might be questions, especially when it comes to some difficult and complicated problems. Thus, when I raise this question, they will be more likely to choose that way of answering. (Wang)

In contrast, repairing communication breakdowns when interacting with chatbot was deemed more complicated as it required students to refine their prompts in appropriate ways, such as adding descriptions of contexts (Wen) and objectives (Guang) as well as specifying aspects of queries (Wang), so that chatbot's feedback can better cater to their needs. The quote of Guang below illustrated that composing appropriate prompts to repair communication imposed additional ECL on students:

Sometimes when I asked a question, the answer chatbot gave me was not what I wanted. It may give me a long string of data, and I needed to modify it, that is, input more precise instructions to get what I want. (Guang)

### ***Ease of Keeping Discussion Record***

The chatlog of interaction between students and Kimi can facilitate students' recall of their discussion, whereas there were no written records of their oral discussion with partner, adding cognitive loads to students when they recalled the details of the discussed content in peer discussion. The following quote from Wen illustrated the advantage of interaction with chatbot in keeping discussion record to facilitate their recall of details.

When communicating with peer, since we present ideas by speaking, there may be some content that we might not remember after we've said it. In contrast, when the chatbot generates a piece of message, it will stay on the computer all the time. And if there's something you don't understand, you can go back and read it again. (Wen)

In general, interacting with Kimi in written mode can cause some extraneous cognitive loads (ECL) among students when they encountered breakdown of communicating with Kimi and deliberated on appropriate prompts to repair communication breakdown. However, the advantage of keeping a detailed discussion record can reduce the ECL experienced by students when they recall the details of discussed contents, leading to a relatively low level of overall ECL (Median<sub>chatbot-supported</sub> = 2.000, see [Table 1](#)) among students when interacting with Kimi.

## Discussions

This mixed-method study sheds light on the emotional and cognitive mechanisms that help explain the reasons behind the reported facilitative roles of GenAI-powered interactive chatbots on reading in existing literature (Liu et al., 2022, 2024; Pan et al., 2025). The results of questionnaires indicated that reading with GenAI-powered interactive chatbots promoted positive emotions (hope, relief), reduced negative emotions (anxiety, disappointment), and lowered cognitive loads during academic reading. The interview data added more insights by revealing both advantages (e.g., high efficiency, convenience of tracking the discussion record, and the low-stress learning environment) and limitations (restricted emotional communication and social dynamics) in chatbot-supported reading compared to reading with peer support. Overall, the findings suggest that GenAI shows strong potential as a useful pedagogical tool to overcome some of oft-reported cognitive and socio-emotional challenges of collaborative reading with peers (Chen & Chen, 2014; Jin et al., 2021), while still requiring strategic integration with peer interaction to achieve optimal effects on learners' cognitive-emotional well-being.

Adding a comparative lens to the existing literature on cognitive loads during collaborative reading, this study found that reading with AI was associated with lower ICL and ECL than reading with peers. The finding suggests that cognitive loads during collaborative reading are impacted not only by collaborative strategy use and technological features identified in previous literature (e.g., DeStefano & LeFevre, 2007; Jin et al., 2022; Liu et al., 2024; Zhang & Li, 2025) but also by collaborative reading partners. The finding that GenAI-powered chatbots, as a reading partner, significantly reduced college EFL students' cognitive loads during academic reading corroborates the findings of Koć-Januchta et al. (2022) and Zhang et al. (2025). This study further revealed that the lower ICL was due to the cognitive capacity of GenAI in enhancing students' comprehension of complex content and improving reading efficiency. In this light, teachers could design more challenging tasks involving higher-order thinking skills (e.g., synthesizing information, critical reflection) in chatbot-supported reading activities to develop students' advanced cognitive ability. The impact of GenAI on ECL was mixed. On the one hand, the written records of interaction served as cognitive cues for students, hence reducing ECL. On the other hand, potential complexity of the language and density of information in GenAI outputs as well as the difficulty of repairing communication problems with chatbot may increase ECL for some students, especially those with weaker language proficiency. To overcome these issues, teachers can ask two or more students to read academic articles collaboratively with the assistance of chatbot, capitalizing on the cognitive support of chatbot while also promoting their cognitive engagement through peer interaction.

Adding to the limited research on students' emotions when reading with AI tools, this study contributed nuanced insights into the effect of chatbot versus peer support on a wide array of positive and negative emotions during academic reading. Reading together with chatbots was found to elevate positive-activating emotion (e.g., hope as indicated in the questionnaires and enjoyment in the interviews) and positive-deactivating emotion (e.g., relief in the questionnaires and relaxation in the interviews), and lower negative deactivating emotion (e.g., anxiety indicated in both questionnaires and interviews) among EFL university students, compared to reading with peers. The greater emotional support from chatbots was due to not only the cognitive capacity of GenAI in enhancing text comprehension and improving reading efficiency but also its affordances of creating stress-free learning environment and low social pressure interaction. These findings underscored the potential pedagogical values of using GenAI chatbots to support reading academic texts to assist students coping with emotional challenges in academic reading, concurring with other AI chatbot-mediated speaking or writing research that indicates the positive effects of interaction with chatbot on enhancing learners' motivation and lowering anxiety (e.g., Fathi et al., 2026; Guo et al., 2024; Kim & Su, 2024). But at the same time, the participants in the interview reported limited emotional bonding with the chatbot, describing occasional boredom and a lack of affirmation owing to low social dynamics. The above mixed findings are due to the different foci of negative emotions assessed in the questionnaires (anxiety, disappointment) and those in interviews (any negative emotions including others like boredom). To mitigate these negative emotions, teachers should

balance between reading with chatbot and with peers or ask two or more students to interact with chatbot collaboratively so as to better assist students to engage emotionally in academic reading.

## Conclusions, Limitations, and Future Research Directions

This study has elucidated the mechanisms underlying differential effects of reading with GenAI chatbot support versus peer support on EFL university students' emotions and cognitive loads in academic reading. Our findings indicate that GenAI chatbots such as Kimi can better elevate EFL university students' emotional status and lower their CLs in academic reading than peer interaction. At the same time, the findings emphasize the importance of strategic balance between and integration of the two types of interactive reading conditions to optimize students' emotional and cognitive well-beings in academic reading.

However, this study only examined upper-intermediate students who are English majors in a single Chinese university and can use Kimi chatbot adequately, limiting the generalizability of the findings. Future studies could be conducted among EFL learners from various backgrounds with varied levels of AI literacy. Additionally, in this study, we did not investigate the associations between learners' emotions and their CLs as well as their relationships to students' reading achievements in chatbot-supported reading and peer-supported reading activities. Future research may investigate their relationships to deepen our understanding of whether and how learners' cognition and their emotions are correlated in collaborative reading conditions and how they may be connected to students' reading achievements.

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## Appendix A. Summary Example

The article explores attitudes towards \_\_\_\_\_ and its role in \_\_\_\_\_. Despite AI's capabilities, there is a lack of \_\_\_\_\_ in its predictions, with people often preferring \_\_\_\_\_. To benefit from AI, \_\_\_\_\_ must be established. However, this is hindered by people's \_\_\_\_\_ with AI and its \_\_\_\_\_ algorithms that are difficult to comprehend. The article proposes solutions such as increasing \_\_\_\_\_ about AI's algorithms and allowing for some \_\_\_\_\_ over AI decisions to foster trust.

## Appendix B. Task Sheets Given to Students

### Task Sheet Used by the Student Serving as the Content Analyzer

Parts	Main idea	Illustrative details
Part A (example)	AI's predictive capabilities and public trust issues.	AI is used in crime prediction and medical prognosis. People tend to distrust AI predictions and prefer human experts.
Part B		
Part C		

*Note.* Student can add rows in the table to analyze all parts of the article.

### Task Sheet Used by the Student Serving as the Language Analyzer

Parts	Key Sentences	Important Structures and/or Vocabulary
Part A (example)	Yet for all these technological advances, we still seem to deeply lack confidence in AI predictions.	Concessive structure. Expressions like "yet" can indicate concessive or contrastive relationship between two adjacent clauses.
Part B		
Part C		

*Note.* Student can add rows in the table to analyze all parts of the article.

## Appendix C. Prompts Used by Students when Interacting with Kimi

### Prompt Used by Students to Instruct Kimi when It Served as the Content Analyzer

Role: You are a professional analyst.

Task: Summarize the main idea and corresponding Illustrative details from the article for EFL students.

Requirements: The summary should be presented in a table format, clearly outlining each main idea alongside its Illustrative details. Ensure the table is concise yet comprehensive, highlighting key points from the article.

Instructions: Extract the main idea of each part from the article, identify the Illustrative details provided for main idea of each part, and organize this information into a well-structured table. Make sure the table is easy to read and suitable for academic discussion.

Example for output format:

| Parts | Main idea | Illustrative details |

| --- | --- | --- |

| Part A | Artificial intelligence (AI) can already predict the future. | - Police are using AI to detect when and where crime is likely to occur.<br>- Doctors use AI to predict when a major disease is likely to occur in a patient.<br>- Researchers use AI equipped with imagination to plan for unexpected consequences. |

*Note.* View a sample report generated by Kimi via <https://kimi.moonshot.cn/share/ct80rffbaqmplhgs10>.

### Prompt Used by Students to Instruct Kimi when It Served as the Language Analyzer

Role: You are a professional analyst.

Task: Analyze the component parts of a text for a group of EFL students.

Requirements: Summarize the key sentences, important structures, and vocabulary of each part in a table format.

Instructions: Break down the text into its main components, identifying significant sentences, structures, and vocabulary. Organize this information into a clear and concise table, ensuring it's educational and easy to understand.

Example for output format:

| Parts | Key Sentences | Important Structures and/or Vocabulary |

| --- | --- | --- |

| Part A | - Artificial intelligence (AI) can already predict the future.<br>- Yet we still seem to deeply lack confidence in AI prediction. | Expressions like yet, however, can indicate controversy |

*Note.* view a sample report generated by Kimi via <https://kimi.moonshot.cn/share/ct80shr4ukfclarq1ak0>.

### Appendix D. Questionnaires on Emotion and Cognitive Load when Interacting with Kimi/Peer in Interactive Reading Activities

Questionnaires	Construct	Item	Mean	SD
Questionnaire on Emotion and Cognitive Load when Interacting with Chatbot	PAE ( $\alpha=0.761$ )	I am hopeful that I will perform well in reading articles with the assistance of AI chatbot.	4.264	0.622
		I have great hope that I have sufficient ability to read articles with the assistance of AI chatbot.	3.925	0.836
		I sense a feeling of hope that I will be successful in reading articles with the assistance of AI chatbot.	4.113	0.708
	PDE ( $\alpha=0.710$ )	I feel relieved because I succeeded in reading articles with the assistance of AI chatbot.	3.925	0.752
		I feel relieved when I have been able to understand difficult articles with the assistance of AI chatbot,	4.142	0.654
	NAE ( $\alpha=0.794$ )	I feel nervous when reading articles with the assistance of AI chatbot.	2.104	1.023
		I worry it might be too difficult to read articles with the assistance of AI chatbot.	2.245	0.924
		I feel queasy(心神不定的) when I think about reading articles with the assistance of AI chatbot.	2.198	1.064
	NDE ( $\alpha=0.863$ )	I feel disappointed that I did not succeed in reading articles with the assistance of AI chatbot.	2.745	0.996
		I am disappointed that I did not perform well in reading articles with the assistance of AI chatbot.	2.557	1.043
		I am disappointed about my lack of accomplishments in reading articles with the assistance of AI chatbot.	2.651	1.042
	ICL		The articles covered topics that I perceived as very complex.	3.292

	( $\alpha=0.768$ )	The articles covered argumentative strategies that I perceived as very complex.	3.425	0.936
		The articles used language that I perceived as very complex.	3.208	0.973
		The articles covered concepts and definitions that I perceived as very complex.	3.462	0.938
	ECL ( $\alpha=0.744$ )	The chatbot's explanations were unclear.	2.547	0.947
		The chatbot's explanations were not useful.	2.321	0.834
		The chatbot's language during the communication was too difficult to understand.	2.038	0.872
Questionnaire on Emotion and Cognitive Load when Interacting with Peer	PAE ( $\alpha=0.721$ )	I am hopeful that I will perform well in reading articles with the assistance of peer	3.754	0.931
		I have great hope that I have sufficient ability to read articles with the assistance of peer.	3.544	1.036
		I sense a feeling of hope that I will be successful in reading articles with the assistance of peer.	2.875	1.045
	PDE ( $\alpha=0.814$ )	I feel relieved because I succeeded in reading articles with the assistance of peer.	3.702	0.906
		I feel relieved when I have been able to understand difficult articles with the assistance of peer.	3.842	0.841
	NAE ( $\alpha=0.854$ )	I feel nervous when reading articles with the assistance of peer.	2.596	1.067
		I worry it might be too difficult to read articles with the assistance of peer.	2.912	1.074
		I feel queasy (不安的) when I think about reading articles with the assistance of peer	2.614	1.082

NDE ( $\alpha=0.799$ )	I feel disappointed that I did not succeed in reading articles with the assistance of peer.	2.632	1.080
	I am disappointed that I did not perform well in reading articles with the assistance of peer.	2.860	0.972
	I am disappointed about my lack of accomplishments in reading articles with the assistance of peer.	2.842	1.099
ICL ( $\alpha=0.871$ )	The article covered topics that I perceived as very complex.	2.877	0.983
	The article covered argumentative strategies that I perceived as very complex.	2.895	0.838
	The articles used language that I perceived as very complex.	2.667	0.809
	The articles covered concepts and definitions that I perceived as very complex.	2.807	0.875
ECL ( $\alpha=0.880$ )	My peer's explanations were unclear.	2.053	0.934
	My peer's explanations were not useful.	2.386	0.978
	The language of my peer during the communication was too difficult to understand.	2.035	0.886

## Appendix E. Interview Questions

### Part 1: Emotional Experiences when Interacting with Peer/Kimi

1. When interacting with a peer:
  - a. Did you have any positive emotional experiences?
  - b. What factors contributed to these positive emotions?
  - c. Did you have any negative emotional experiences?
  - d. What factors led to these negative emotions?
2. When interacting with Kimi:
  - a. Did you have any positive emotional experiences?
  - b. What factors contributed to these positive emotions?
  - c. Did you have any negative emotional experiences?
  - d. What factors led to these negative emotions?

3. What were the factors contributing to the different emotional experiences when interacting with peer versus with Kimi chatbot?
4. Which type of interaction, interacting with peer versus with chatbot, gave you a better emotional experience? Why?

## Part 2: Cognitive Load when Interacting with Peer/Kimi

1. Did interacting with a peer help reduce the difficulty of understanding the article? If yes, how?
2. Did interacting with Kimi help reduce the difficulty of understanding the article? If yes, how?
3. Which type of interaction, interacting with peer versus with Kimi, was more effective in reducing the difficulty of understanding the article? Why?
4. Did you encounter any problems when communicating with your peer? If yes, what factors led to these problems?
5. Did you encounter any problems when communicating with Kimi? If yes, what factors led to these problems?
6. Which type of interaction, interacting with peer versus with Kimi, had a better communication effect between you and your collaborator? Why?

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