Roles and functionalities of ChatGPT for students with different growth mindsets: Findings of drawing analysis

Yun-Fang Tu
Department of Educational Technology, Wenzhou University, Wenzhou, China // sandy0692@gmail.com

ABSTRACT: With the rapid development of generative artificial intelligence (GAI), the performance and usability of related tools, such as ChatGPT, have significantly improved. The advancement has fostered researchers to increasingly focus on students' perceptions and application of the roles, functionalities, and interaction patterns of these tools in higher education. The present study adopted the draw-a-picture technique to explore the viewpoints and conceptions of undergraduates with different growth mindsets regarding the roles and functionalities of ChatGPT in learning. It also analyzed their interaction process with ChatGPT, especially their interaction skills and question types. The results showed that there were significant differences in the conceptions of "locations," "learning content," and "learning activities" of students with different growth mindsets. In the interaction process between undergraduates and ChatGPT, significant differences existed in the interaction skills and question types of students with different growth mindsets. Besides, students with different growth mindsets also had different learning achievements and critical thinking tendencies. The findings revealed the conceptions of students with different growth mindsets regarding the roles and functionalities of ChatGPT in learning, and also provided valuable insights for teachers. These findings are beneficial for educators to more accurately adjust and optimize the application of these tools in teaching activities based on students' different growth mindsets.

Keywords: Draw-a-picture technique, Growth mindsets, Generative artificial intelligence, GAI, Undergraduates

1. Introduction

As generative artificial intelligence (GAI) continues to evolve, ChatGPT has had a significant influence on teaching approaches in higher education. Most educational studies have indicated that ChatGPT has the ability to promote personalized learning and higher-order thinking (Baidoo-Anu & Owusu Ansah, 2023; Chan, 2023). GAI plays multiple significant roles in education, such as teacher/tutor, student/tutee, learning peer/partner, domain expert, administrator, and learning tool (Hwang & Chen, 2023). GAI technologies (e.g., ChatGPT) not only attract attention in the field of education but also prompt educational practitioners to actively explore their potential application in teaching and learning (Lim et al., 2023; Strzelecki, 2023). Specifically, researchers have pointed out that ChatGPT can enhance the flexibility, autonomy and comprehensiveness of the learning environment, which are believed to bring various benefits to learners (Heimans et al., 2023; Mohamed, 2023; Rospigliosi, 2023). For instance, Jeon and Lee (2023) specified that chatbots (e.g., ChatGPT) not only served as content providers, teaching assistants, and evaluators, but also acted as partners for learners to practice conversation with. However, the influence of ChatGPT goes far beyond this, as it has been applied in various fields of education, such as medicine, science, engineering, and computing education (Arif et al., 2023; Berdanier & Alley, 2023; Cooper, 2023; Firat, 2023).

In the field of higher education, the main function of ChatGPT is to generate highly innovative output through interaction with users, thereby enriching students' learning experience. This includes serving as a writing assistant, teaching art and design methods, as well as acting as a research support tool (Chan & Hu, 2023; Kasneci et al., 2023). Some researchers have disclosed that information literacy plays a crucial role in the operation of ChatGPT. Especially when seeking and evaluating information, learners need to apply their critical thinking skills to determine whether the information provided by ChatGPT is accurate and credible (Lund & Agbaji, 2023; Yan, 2023). Lo (2023) introduced the CLEAR framework as a guiding methodology for prompt engineering in educational settings. This framework encapsulates five core principles: conciseness, logical coherence, explicitness, adaptability, and reflectiveness. The application of the CLEAR framework is posited to facilitate more effective student engagement with AI-generated content, particularly in ChatGPT. The study argues that this approach fosters the development of critical thinking skills, which are increasingly essential in this era of advanced conversational agents. Besides, ChatGPT emphasizes question-oriented dialogue and in-depth exploration of knowledge, combines real-time interaction, adaptability and personalization, and can enhance student engagement. This has caused ChatGPT to attract increasing attention in the field of higher education (Chan, 2023; Mohamed, 2023). While ChatGPT-related research mainly focuses on social implications, technological development and application, how learners in higher education perceive and utilize ChatGPT in learning contexts has received little attention. Researchers have revealed that in terms of the roles

and functionalities of ChatGPT in learning, exploring and investigating learners' perceptions, learning performance, and communication modes is crucial to assist learners' effective learning (Hwang & Chen, 2023; Wu et al., 2023). In addition, researchers have uncovered that learners' growth mindset may affect their acceptance or performance in new technological environments (Liu et al., 2022; Yeh et al., 2023). A few studies have also verified that possessing a growth mindset can not only affect learners' engagement, motivation and learning behaviors, but also improve their information literacy and academic achievements (Cheng et al., 2021; Tewell, 2020). Based on the situations and needs of students in higher education, it is necessary to understand their expected learning modes, conceptions and communication skills for the roles and functionalities of ChatGPT in learning (Hsieh & Tsai, 2018; Hwang et al., 2023; Lai, 2021).

Previous research mainly adopted questionnaires to understand learners' attitudes towards the use of ChatGPT, with limited focus on exploring undergraduates' perceptions and conceptions of the roles and functionalities of ChatGPT in learning based on their experiences. Moreover, mixed methods have attracted increasing attention from researchers in educational research (Chang et al., 2022a). For instance, Gal (2023) used multiple analysis methods (including drawing analysis, reflection analysis, and analysis of course summary work) to evaluate the impact of pedagogy in university education. The use of the draw-a-picture technique allows participants to express their viewpoints through a combination of visual and textual elements. It also provides researchers with a comprehensive and in-depth way to understand learners' perceptions and interpretations of specific concepts (Chang & Tsai, 2023; Hsieh & Tsai, 2017; Hsieh & Tsai, 2018). Above all, this study employed the draw-a-picture technique to explore the viewpoints and conceptions of students with different growth mindsets regarding the roles and functionalities of ChatGPT in learning. This study also analyzed the interaction between students with different growth mindsets and ChatGPT, with a focus on interaction skills and question types. Additionally, it further examined the influences of different growth mindsets on students' learning achievement and critical thinking tendency. These research findings not only provide researchers with new insights into the application of ChatGPT in educational contexts, but also serve as valuable guidance for educational practitioners on how to more effectively integrate ChatGPT into higher education learning environments.

2. Literature review

2.1. Students' conceptions of roles and functionalities of ChatGPT in learning

ChatGPT, a GAI-based chatbot, has achieved widespread recognition and significant influences in the field of higher education (Chan & Hu, 2023; Farazouli et al., 2023; Fauzi et al., 2023). It not only provides an innovative learning environment, but, more importantly, creates a way for students to deeply engage with and explore various types of information (Baidoo-Anu & Owusu Ansah, 2023). Engaging in personalized and in-depth conversations with ChatGPT not only helps students to understand various academic conceptions from more diverse perspectives, but also effectively stimulates their thinking ability and creativity (Rospigliosi, 2023). In terms of language teaching, particularly in English writing, Yan (2023) specified that ChatGPT played an auxiliary role in grammar checking and feedback. Furthermore, it stated that due to academic integrity and plagiarism during the training stage, most scholars still had reservations about the application of ChatGPT in this field. Therefore, integrating ChatGPT into the teaching process is not only a technological innovation, but also an important means to enhance education quality and AI literacy (Chan, 2023; Farrokhnia et al., 2023).

Nonetheless, the conceptions of roles and functionalities of ChatGPT in learning are multifaceted and complex. In the field of language education, it can not only serve as an interlocutor and content provider, but also as a teaching assistant and evaluator. Educators need to use professional teaching knowledge to integrate various resources, inspiring students to become more proactive researchers and enhancing students' AI ethics awareness when using AI tools (Cotton et al., 2023; Jeon & Lee, 2023). Farrokhnia et al. (2023) examined the application of ChatGPT in the field of education by using the SWOT (i.e., Strengths, Weaknesses, Opportunities, and Threats) framework. They highlighted that ChatGPT could provide personalized learning and alleviate teachers' burden. Yet, it might also result in a deficiency in students' in-depth understanding and critical thinking, which potentially increased the risk of academic dishonesty. Several researchers have clearly defined ChatGPT in learning, illustrated how it can be applied in education (e.g., Farrokhnia et al., 2023; Hwang & Chen, 2023; Lim et al., 2023), proposed the CLEAR framework (Lo, 2023), and adopted a survey to investigate the influencing factors of using ChatGPT (Liu & Ma, 2023; Strzelecki, 2023). For example, Chan and Hu (2023) revealed that understanding students' attitudes and concerns about using GAI tools was particularly critical for educational practitioners, which could help promote students' learning motivation and learning outcomes. Liu and Ma (2023) pinpointed that attitudes played an extremely important role in predicting learners' behavioral intentions of using

ChatGPT. This finding implied that if EFL learners had a positive attitude towards ChatGPT, they were more likely to use this tool for learning in informal or leisure activities.

However, in the field of higher education, there has been a lack of exploration into how students perceive and utilize the roles and functionalities of ChatGPT in learning from various perspectives, particularly concerning students with different growth mindsets. Understanding these conceptions and perspectives is of crucial importance for the design and integration of this tool in educational practices. To fill this research gap, this study mainly adopted the draw-a-picture technique as a research method and focused on students with different growth mindsets. Moreover, to provide a good reference for designing and developing ChatGPT-integrated learning and training activities, this study also analyzed students' interaction processes with ChatGPT, as well as their learning achievement, and the critical thinking tendency of students with different growth mindsets in the ChatGPT-integrated learning activities. These research results can serve as guidance and a reference for the integration of ChatGPT or similar tools in future teaching and training activities.

2.2. Drawing as a research approach

Drawing is not only a means of visual expression, but it has various other functions, including perception, communication, invention, and action (Adams, 2017; Tu et al., 2021). With regard to educational evaluation, drawing has been verified as an effective formative assessment tool, which is particularly valuable for capturing and assessing learners' conceptual understanding in specific domains (Chang & Tsai, 2023; Chang et al., 2020; Hsieh & Tsai, 2017; Selwyn et al., 2009). Additionally, scholars such as Lai (2021) and Zhang et al. (2023) have indicated that the draw-a-picture technique serves as a research tool for gaining a deeper understanding of participants' thought processes and personal experiences. This technique is particularly useful in situations where language or writing skills are limited. It serves as an alternative based on emotional and economic considerations, and can reveal nuances that other research methods cannot capture (Haney et al., 2004; Hsieh & Tsai, 2017). Besides, the draw-a-picture technique can guide learners to express their opinions freely and to demonstrate their cognitive structure through free drawings, texts, symbols and visual expressions, so that researchers can understand their perceptions (Chang & Tsai, 2023; Liou, 2017; Yeh et al., 2019). For example, Zhang et al. (2023) used the draw-a-picture technique to analyze elementary school students' stereotypes about robots. Barak et al. (2023) employed multiple dimensions to explore teachers' understanding of nature of science, which included focus – the central image/s (i.e., the central element or main message of the image), details – the particulars in each image (i.e., each single element in the image or specific details in the image), interactions – the links between images (i.e., relationships or connections between the images), context – the drawing setting (i.e., the broader situation or context of the image, including time, place, or other elements relevant to the topic), and written explanation.

In addition, questionnaires, interviews, and experiments are the most commonly used methods in the field of educational research to understand learners' learning perceptions, attitudes, and experiences (Chang et al., 2022b; Liu et al., 2022). Nevertheless, even though these research methods have their own advantages, they also have certain limitations. For example, while questionnaires have the advantage of being structured and quantifiable, they may have difficulty capturing certain implicit or less quantifiable information. On the other hand, interviews can provide more layers and depth of data, but the implementation involves higher costs and time investment. The quality of the data may also be affected by the language ability of interviewees (Hsieh & Tsai, 2018; Tu et al., 2021). Some researchers have corroborated that understanding learners' multiple perspectives and conceptions of specific learning contexts can not only promote teachers to adjust their teaching strategies to better meet the needs of students, but can also enhance students' learning motivation and engagement (Chang et al., 2022b; Hwang et al., 2017; Vermunt & Vermetten, 2004). In addition, some scholars have employed the draw-a-picture technique to explore learners' perceptions of the use of emerging technologies (i.e., AI, smart technology, and the metaverse) in education, such as AI-assisted learning (Lai, 2021), smart healthcare technology contexts (Chang et al., 2022b), and the metaverse in higher education (Hwang et al., 2023).

Regarding students' conceptions of the roles and functionalities of ChatGPT in learning, it involves their inherent perceptions through exploration and actual experience of the ChatGPT-assisted learning process (Hwang & Chen, 2023; Tu et al., 2021). In order to gain a deeper understanding of participants' perceptions of and perspectives on the roles and functionalities of ChatGPT in learning, this study used the draw-a-picture technique. This allowed the participants to express their perspectives and opinions using images within the constraints of time and vocabulary, enabling the investigation of information that was difficult to measure (Chang & Tsai, 2023; Haney et al., 2004; Hsieh & Tsai, 2018).

3. Research questions

The research questions are listed as follows:

- What is the overall conceptual framework of undergraduates regarding the roles and functionalities of ChatGPT in learning? Are there differences in the conceptions (including roles, participants involved, locations, learning content, learning activities, objects, and emotions and attitudes) of the roles and functionalities of ChatGPT in learning of students with different growth mindsets?
- During the interaction between undergraduates and ChatGPT, are there differences in the interaction skills and question types of students with different growth mindsets?
- What are the information literacy and critical thinking tendencies of students with different growth mindsets?

4. Method

4.1. Participants

A total of 67 students from a university in northern Taiwan voluntarily joined the information literacy project which included search tools and retrieval techniques, Internet resource evaluation and utilization, and information quality assessment. Referring to the suggestions of previous research (Lo, 2023), this study incorporated the CLEAR framework for prompt engineering into information literacy learning activities as a guiding structure for students to interact with ChatGPT. As four of the students did not fully participate in the project, only 63 valid data were collected from 29 male and 34 female students, with an average age of 20.3 years. Each participating student had previous experience using ChatGPT. The Research Ethics Committee from the institution with which the study is affiliated granted ethical approval. Participants were also advised that they were free to discontinue their involvement in the study at any time without any negative consequences.

4.2. Data collection and instruments

In order to deeply understand the differences in the learning effectiveness of learners with different growth mindsets, a growth mindset questionnaire was administered before the learning activities. Afterwards, the students were required to complete four tasks, that is, taking an information literacy test (ILT), filling out a critical thinking tendency questionnaire, drawing their perceptions of ChatGPT-supported learning activities, as well as completing a learning sheet with the assistance of ChatGPT.

The questionnaire assessing growth mindset was adapted from the original instrument developed by Bai et al. (2019). This modified version incorporated three items, that is, “I learned a lot of knowledge and skills when using ChatGPT from this project,” “I hope to learn how to use ChatGPT to challenge my information literacy in this project,” and “I believe that putting in more effort can improve my information literacy.” The questionnaire adopted a 5-point Likert scale (5 = *strongly agree*; 1 = *strongly disagree*). The Cronbach’s alpha value of the original scale was .75.

The ILT was modified from Boh Podgornik’s et al. (2015) ILT for higher education. The test design and content included information sources and databases, search strategies, intellectual property and ethics, and heuristics and critical evaluation. It consisted of 40 multiple-choice items, with a perfect score of 100. The reliability of the ILT in Šorgo’s et al. (2017) study was .71, calculated with a Cronbach’s alpha value. The ILT test paper was reviewed and modified by two library and information science professors with more than 5 years of teaching experience.

The critical thinking tendency questionnaire was modified from Chai et al. (2015). It consisted of six items, for example, “I will reflect on whether the knowledge I have learned through ChatGPT is accurate,” “I will judge the value of new information or evidence provided by ChatGPT in the learning activities,” and “In the learning activities, I will try to understand the information provided by ChatGPT from different perspectives.” The questionnaire adopted a 5-point Likert scale (5 = *strongly agree*; 1 = *strongly disagree*). The Cronbach’s alpha value was .80, showing adequate reliability.

Finally, the students were mandated to complete two principal activities: drawing a picture and completing a learning sheet with the assistance of ChatGPT. They were made to create a painting on A4 paper to demonstrate their conceptions of the roles and functionalities of ChatGPT in learning (Haney et al., 2004; Lai, 2021). In order

to deeply understand how the students perceived the ChatGPT-facilitated learning context, a specific prompt was provided, "According to your comprehension and experience of using ChatGPT, please draw a picture to describe your perspectives regarding the roles and functionalities of ChatGPT in learning." The students were encouraged to express their conceptions in any way (including symbols, text, concept maps, and other creative forms). Moreover, they were asked to write down three to five short sentences to describe their drawings. As for the learning sheet, the students were required to submit their communication/interaction content with ChatGPT, so as to understand how they utilized this tool to support learning. Among 67 students, the data of four students were invalid because they did not complete the drawing and related learning activities. Thus, a total of 63 valid questionnaires, drawings, and learning sheets were collected as the data to understand students' conceptions and situations of using ChatGPT for learning from different perspectives.

4.3. Coding scheme

This study employed the draw-a-picture technique to explore undergraduates' conceptions of the roles and functionalities of ChatGPT in learning. Referring to previous scholars, such as Haney et al. (2004) and Hsieh and Tsai (2018), a coding scheme for drawings was developed, consisting of the seven categories of roles, participants involved, locations, learning content, learning activities, objects, and emotions and attitudes (see Table 1). It's important to highlight that each drawing wasn't confined to a single category; that is to say, an individual drawing could display various characteristics. However, recurring instances of the same subcategory within a single drawing were tallied only once for analysis. Figure 1 shows the coding of a HGM student's drawing. It demonstrated that through the personal computer and mobile phone, a learner happily consulted/discussed some information and completed assignments with ChatGPT, and used it for translation and English learning.

Table 1. The coding scheme developed from students' drawings

Categories	Subcategories			
1. Roles	1.1	Tutee	1.3	Tools
	1.2	Tutor		
2. Participants involved	2.1	Teachers	2.3	Robot
	2.2	Learners	2.4	No human drawn
3. Locations	3.1	Home	3.3	Unspecified
	3.2	In-class activities		
4. Learning content	4.1	Specific learning content	4.2	Non-specified
5. Learning activities	5.1	Search information	5.3	Discussions and consultations
	5.2	Reports/assignments	5.4	Translation
6. Objects	6.1	Personal computer (PC) / Notebook (NB)	6.5	Tables and chairs
	6.2	Tablet	6.6	Traditional classroom equipment
	6.3	Mobile phone	6.7	Others
	6.4	Books		
7. Emotions and attitudes	7.1	Positive	7.3	No use of affective words or symbols
	7.2	Negative		

In order to obtain a comprehensive understanding of the different communication ways when the undergraduates were using ChatGPT, including interaction skills (e.g., role-play, styles, polite responses, be specific, and output formatting) and question types, this study referred to previous studies (i.e., Hwang & Chen, 2023; Lo, 2023) to develop a coding scheme to analyze their interaction with ChatGPT. The same subcategory that appeared in the same conversation was counted only once. Table 2 shows the detailed coding scheme.

In addition, to ensure the accuracy and appropriateness of the coding schemes in Table 1 and Table 2, two senior experts from the field of technology-assisted learning were invited to assess and revise the coding scheme, which included all elements of the student drawings. Two independent coders coded the drawings according to the coding scheme with a Cohen's kappa value of .83 (Lavrakas, 2008), showing a high level of agreement on the coding results. Besides, inconsistent coding was discussed by the experts to reach a consensus.

Figure 1. An example of the coding of a participant's drawing

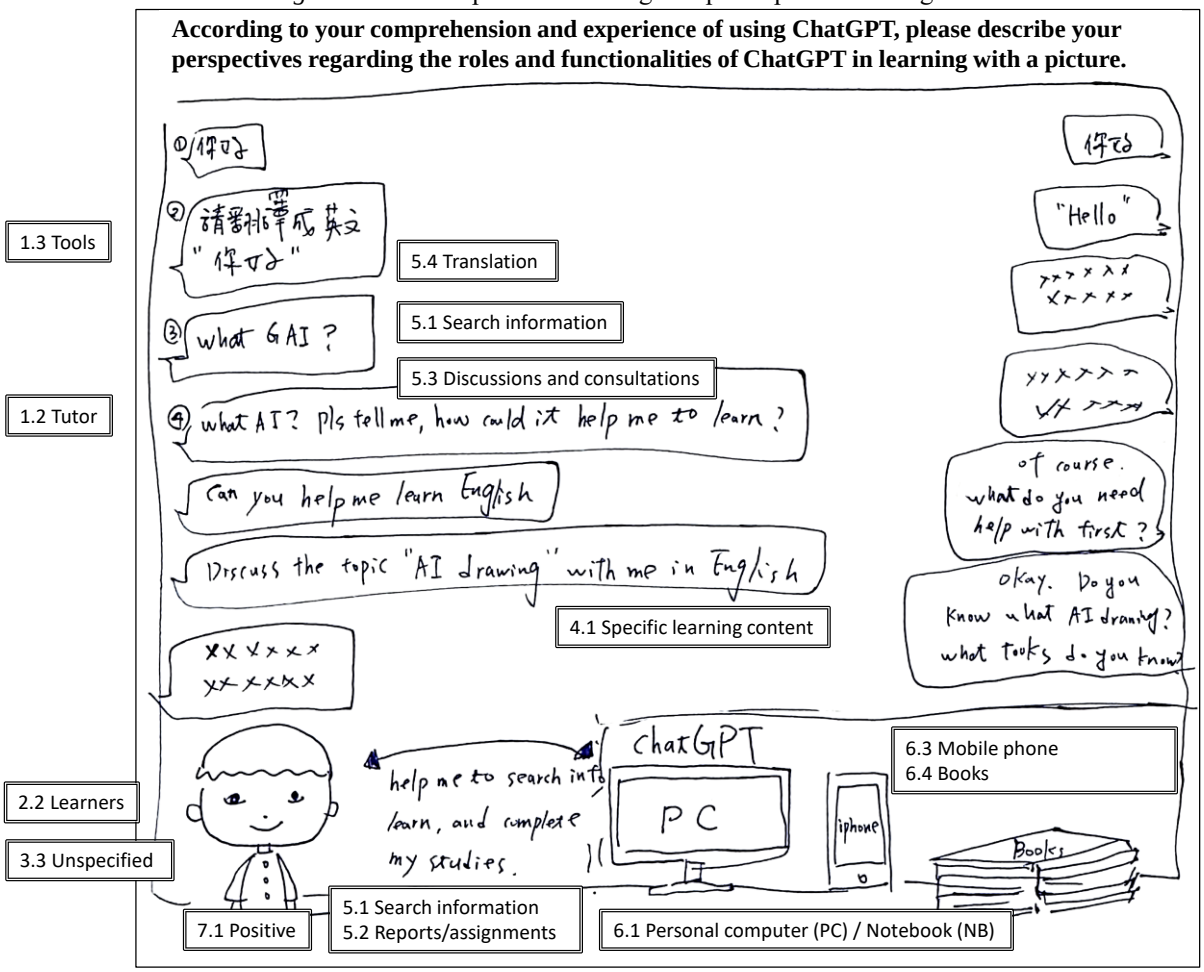


Table 2. The coding scheme developed from students' interaction skills and question types with ChatGPT

Categories	Subcategories	Description
Interaction skills	Role-play	When interacting with ChatGPT, students may play a specific role to better simulate specific situations or emotional reactions, such as asking ChatGPT to act as a digital learning expert.
	Styles	The language style or writing style used in the communication process, such as formal, informal, colloquial, etc.
	Polite responses	Polite responses to ChatGPT, such as expressing gratitude after obtaining the necessary information or completing a task.
	Be specific	When using ChatGPT to perform a certain task, the task is clearly and specifically defined and described for students to achieve the goal more accurately.
	Output formatting	The format of information output requested by students to ChatGPT, such as specific document types, formatting requirements, etc.
Question types	Test questions	There is one or one set of correct answers. The answers to the questions (e.g., What is information literacy?) can often be found in relevant books or textbooks.
	Authentic questions	Uptake questions: Uptake means that a person's question is related to a previous conversation. Uptake questions should be relevant to the ongoing conversation and can be directed towards an individual or the entire group, for example, "Based on your previous response, could you please explain the second point in more detail?"
		Higher-level thinking questions include speculation questions, generalization questions, and analysis questions, for instance,

		"Given what we've just said about a and b, what's your viewpoint?"
	Exploratory talk	Exploratory talk takes place when learners share, evaluate and build knowledge. Learners reason, challenge, and respond to challenge with reasons and evidence, for example, "Based on your answer, I disagree with the first point. Could you please explain why you think so?"

4.4. Data analysis

This study adopted a mixed methods approach, incorporating quantitative and qualitative research methods. First of all, referring to Hwang et al. (2023), this study used the mean score of the growth mindset questionnaire to determine the high growth mindset group (HGM group) and the low growth mindset group (LGM group). On this basis, the independent *t* test was used to analyze the data of learning achievement (i.e., ILT) and critical thinking tendency, so as to explore the differences between students with different growth mindsets.

Furthermore, to explore the perceptions of students with different growth mindsets regarding the roles and functionalities of ChatGPT in learning, this study systematically coded students' drawing and performed a Chi-square test to report the differences in each category. This revealed students' diverse and complex conceptions and attitudes towards the roles and functionalities of ChatGPT in learning. Also, this study coded and analyzed the interaction content between students and ChatGPT, with a particular emphasis on interaction skills and question types. Through this series of in-depth analysis, this study expected to achieve a more comprehensive and in-depth understanding of students' conceptions and practices regarding the roles and functionalities of ChatGPT in learning.

5. Results

5.1. Undergraduates' conceptions of roles and functionalities of ChatGPT in learning

As delineated in Table 1, the drawings submitted by 63 undergraduates were subjected to analysis. The coding process yielded a cumulative total of 714 codes. Of these, 386 codes were attributed to students categorized in the HGM and 328 group to those in the LGM group. Table 3 shows the results of the item frequency and percentage of students' drawings. Overall, in terms of their conceptions of the roles and functionalities of ChatGPT in learning, the most to least drawn categories were learning activities (29.13%), objects (18.07%), roles of ChatGPT (16.53%), participants involved (9.80%), locations (8.82%), learning content (8.82%), and emotions and attitudes (8.82%). This implied that, for the majority of students, the roles and functionalities of ChatGPT in learning involved learning activities (i.e., reports/assignments, search information, and discussions and consultations), objects (i.e., PC/NB, mobile phone, and tablet), roles of ChatGPT (i.e., tools and tutor), and participants involved (i.e., learners, no human drawn, teachers, or robots).

As shown in Table 3, when the undergraduates were asked to describe their conceptions and experience regarding the roles and functionalities of ChatGPT in learning, most of them viewed ChatGPT as learning "tools" or media. To be more specific, students in both the HGM group and the LGM group believed that ChatGPT could play the role of a tool in the learning process. Besides, in comparison with those in the LGM group, students in the HGM group were significantly more inclined to regard ChatGPT as a "tutor" ($\chi^2 = 16.91$, $p < .001$). This implied that both groups shared a common understanding of viewing ChatGPT as a learning tool or medium. However, there was a significant difference between the two groups in terms of ChatGPT as a tutor. In particular, the LGM group did not think of ChatGPT as a "tutee" when using ChatGPT for learning.

Concerning the "participants involved" category, students most frequently drew "learners," followed by "no human drawn," "teachers," and "robots." There was no significant Chi-square difference in this category between the drawings of students in both groups ($\chi^2 = 6.02$, $p > .05$). This indicated that they shared common conceptions; that is, the conceptions of students in both the HGM group and the LGM group involved learners.

As shown in Table 3, in the "locations" category, students from the HGM group most frequently drew "unspecified," followed by "in-class activities." On the other hand, students from the LGM group most frequently drew "unspecified," followed by "in-class activities" and "home." There was a significant Chi-square difference in this category between the two groups ($\chi^2 = 8.92$, $p < .05$). In comparison with the LGM group, the

HGM group was significantly more inclined to draw "unspecified" locations when describing the roles and functionalities of ChatGPT in learning ($\chi^2 = 18.79$, $p < .001$). In contrast, in comparison with those in the HGM group, more students in the LGM group focused on "home" ($\chi^2 = 9.46$, $p < .01$) and "in-class activities" ($\chi^2 = 6.61$, $p < .05$) when describing the role and functionalities of ChatGPT in learning.

Table 3. Distribution of perceptions of undergraduates regarding the roles and functionalities of ChatGPT in learning by the categories and subcategories

Categories and subcategories	HGM students *N* (% = *N*/32)	LGM students *N* (% = *N*/31)
Roles		
Tutor	**32 (100%)[1]**	**18 (58.06%)[2]**
Tutee	**5 (15.63%)[2]**	0 (0%)
Tools	**32 (100%)[1]**	**31 (100%)[1]**
Participants involved		
Teachers	**1 (3.13%)[3]**	**3 (9.68%)[3]**
Learners	**29 (90.63%)[1]**	**24 (77.42%)[1]**
Robots	**3 (9.38%)[2]**	0 (0%)
No human drawn	**3 (9.38%)[2]**	**7 (22.58%)[2]**
Locations		
Home	0 (0%)	**8 (25.81%)[2]**
In-class activities	**1 (3.13%)[2]**	**8 (25.81%)[2]**
Unspecified	**31 (96.88%)[1]**	**15 (48.39%)[1]**
Learning content		
Specific learning content	**21 (65.63%)[1]**	**8 (25.81%)[2]**
Non-specified	**11 (34.38%)[2]**	**23 (74.19%)[1]**
Learning activities		
Search information	**32 (100%)[1]**	**29 (93.55%)[2]**
Reports/assignments	**32 (100%)[1]**	**31 (100%)[1]**
Discussions and consultations	**30 (93.75%)[2]**	**24 (77.42%)[3]**
Translation	**25 (78.13%)[3]**	5 (16.13%)
Objects		
PC/NB	**32 (100%)[1]**	**24 (77.42%)[1]**
Tablet	**11 (34.38%)[3]**	**8 (25.81%)[3]**
Mobile phone	**12 (37.50%)[2]**	**11 (35.48%)[2]**
Books	7 (21.88%)	7 (22.58%)
Tables and chairs	1 (3.13%)	6 (19.35%)
Traditional classroom equipment	1 (3.13%)	7 (22.58%)
Others	2 (6.25%)	0 (0%)
Emotions and attitudes		
Positive	**22 (68.75%)[1]**	**23 (74.19%)[1]**
Negative	0 (0%)	0 (0%)
No use of affective words or symbols	**10 (31.25%)[2]**	**8 (25.81%)[2]**

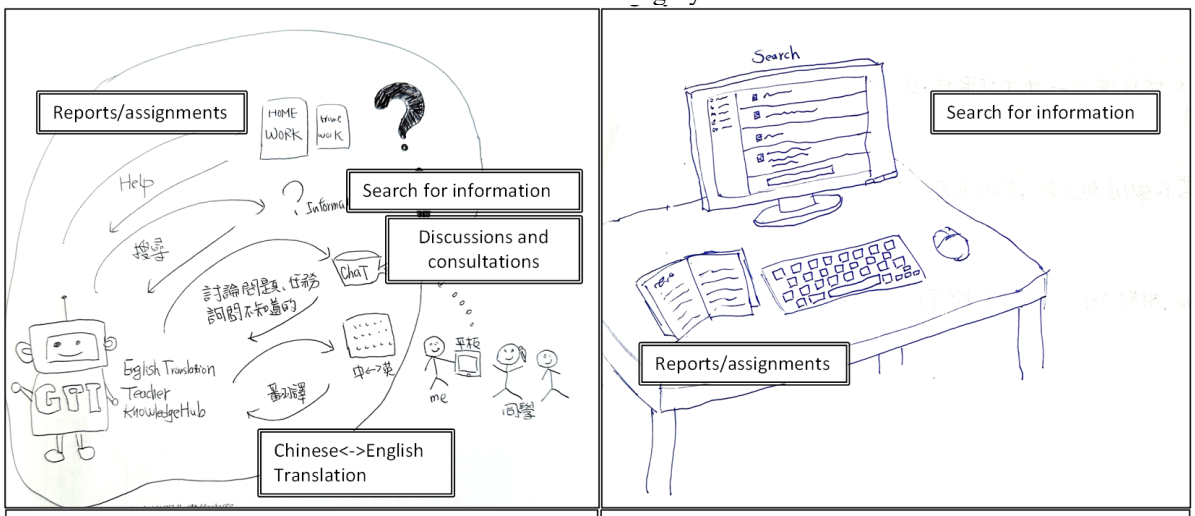
Note. The top three subcategories are marked in bold face, and the superscript denotes ranking within each category.

In addition, a significant difference existed in the "learning content" of the drawings between the HGM group and the LGM group according to the Chi-square analysis ($\chi^2 = 10.05$, $p < .01$). In comparison with those of the LGM group, "specific learning content" appeared more frequently in the drawings of the HGM group ($\chi^2 = 10.05$, $p < .01$, see Figure 1). On the other hand, in comparison with those in the HGM group, more students in the LGM group focused on "non-specified" learning content ($\chi^2 = 10.05$, $p < .01$, see Figure 2).

Figure 2 illustrates sample drawings of students in the LGM group and the HGM group. As for the "learning activities" category, students mostly drew "reports/assignments," followed by "search information," "discussions and consultations," and "translation." The Chi-square test uncovered a significant difference in this category between the HGM group and the LGM group ($\chi^2 = 10.05$, $p < .01$). In comparison with those of the LGM group, "translation" appeared more frequently in the drawings of the HGM group ($\chi^2 = 24.26$, $p < .05$). Nonetheless, there were significant differences between the two groups in the subcategories of "reports/assignments," "search information" and "discussions and consultations." This implied that among the conceptions of the roles and functionalities of ChatGPT in learning of the two groups, "reports/assignments," "search information" and "discussions and consultations" were the most frequently drawn learning activities; yet, a significant difference

was observed in the subcategory of "translation." In the drawing of the LGM student, ChatGPT was described as a tool used to search for information and to assist with assignments (see Figure 2).

Figure 2. Examples of the "reports/assignments" and "search for information" subcategories in the "learning activities" category



A HGM student's drawing | A LGM student's drawing

As shown in Table 3, in the "objects" category, the most common object drawn by students was "PC/NB," followed by "mobile phone," "tablet," "books," "traditional classroom equipment," "tables and chairs," and "others." There was no significant difference in this category between the two groups according to the Chi-square test (χ^2 = 11.67, p > .05). This implied that the HGM group and the LGM group shared common conceptions of the roles and functionalities of ChatGPT in learning in terms of "object."

As for the "emotions and attitudes" category, students often mostly drew "positive," followed by "unspecified." It is worth noting that the students did not display any negative emotions or attitudes in their drawings. There was no statistically significant disparity in this category among the drawings produced by students with different growth mindsets (χ^2 = 0.22, p > .05). This specified that the undergraduates held similar emotions and attitudes regarding the roles and functionalities of ChatGPT in learning; they mainly expressed positive emotions and attitudes in their drawings.

5.2. Undergraduates' interaction skills and question types with ChatGPT

Utilizing the coding scheme shown in Table 2, the interaction skills and question types of 63 undergraduates with ChatGPT were analyzed. Table 4 displays the occurrence and percentage distribution of the item in the students' drawings. In terms of interaction skills, the most to least applied skills were "role-play," "be specific," "styles," "output formatting," and "polite responses." In comparison with the LGM group, the HGM group adopted "role-play," "be specific," "output formatting," "styles," and "polite responses" more frequently, and the results showed significant Chi-square differences in these subcategories (χ^2 = 16.28, p < .01). This implied that the HGM group demonstrated more diverse and professional skills when interacting with ChatGPT.

As for question types, both groups of students most frequently employed "test questions," followed by "authentic questions" and "exploratory talk." A significant Chi-square difference existed in this category between the two groups (χ^2 = 14.64, p < .01). Also, there was a significant Chi-square difference in the subcategory of "authentic questions" between the HGM group and the LGM group (χ^2 = 14.64, p < .01). This revealed that the HGM group demonstrated question-posing and higher-level abilities when interacting with ChatGPT. They might be better at using questions to explore, analyze, and reflect on knowledge rather than merely to assess and confirm.

Figure 3(a), (b) and (c) demonstrate the coding of the interaction between a student from the HGM group and ChatGPT. First of all, the student posed a specific question, "Does information literacy refer to a person's ability to use information technologies?" and requested that ChatGPT act as an undergraduate (i.e., role-play) to answer the question. Then, the student asked further questions based on ChatGPT's answers (see Figure 3(a)). Figure 3(b) further shows that the student politely expressed gratitude and asked ChatGPT to provide the answers in a

table. Afterwards, ChatGPT was requested to rewrite the content in an interesting style. Figure 3(c) illustrates that the student posed a higher-level thinking question, “A learner asks ChatGPT when he has a problem, and he learns from the content provided by ChatGPT. Is ChatGPT a learning tool and tutor in this case?” Regarding this question, the student also questioned and challenged ChatGPT’s responses.

Table 4. Distribution of interaction skills and question types between undergraduates and ChatGPT by the categories and subcategories

Categories	Subcategories	HGM students *N* (% = N/32)	LGM students *N* (% = N/31)
Interaction skills	Role-play	**32 (100%)[1]**	**26 (83.87%)[1]**
	Styles	**28 (87.50%)[2]**	**11 (35.48%)[3]**
	Polite responses	**9 (28.13%)[3]**	1 (3.23%)
	Be specific	**32 (100%)[1]**	**18 (58.06%)[2]**
	Output formatting	**32 (100%)[1]**	3 (9.68%)
Question types	Test questions	**32 (100%)[1]**	**31 (100%)[1]**
	Authentic questions	**32 (100%)[1]**	**18 (58.06%)[2]**
	Uptake questions	**32 (100%)[1]**	**18 (58.06%)[2]**
	High-level thinking questions	14 (43.75%)[3]	0 (0%)
	Exploratory talk	4 (12.50%)	0 (0%)

Note. The top three subcategories are marked in bold face, and the superscript denotes ranking within each category.

Figure 3(a). An example of the coding for interaction skills and question types in a HGM student’s conversation with ChatGPT

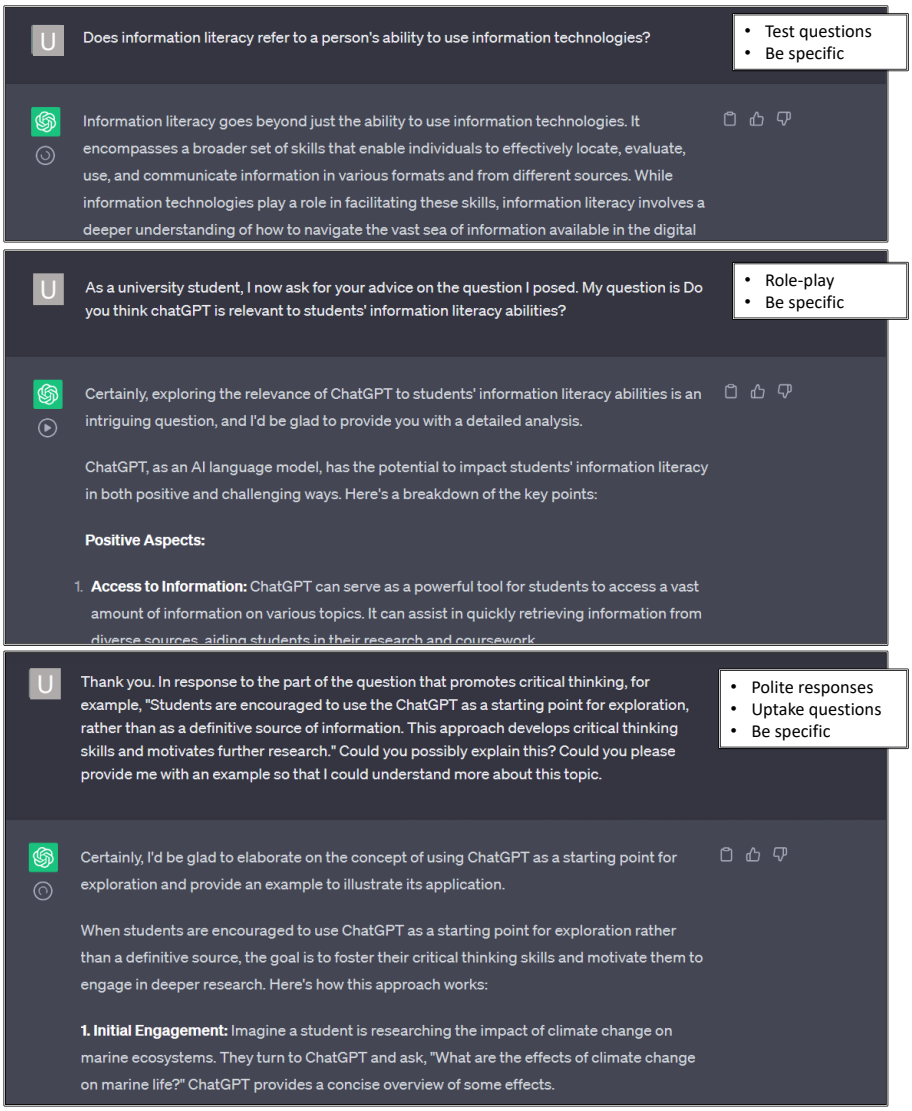


Figure 3(b). An example of the "output formatting," "polite responses," "styles," and "be specific" subcategories in a HGM student's conversation with ChatGPT

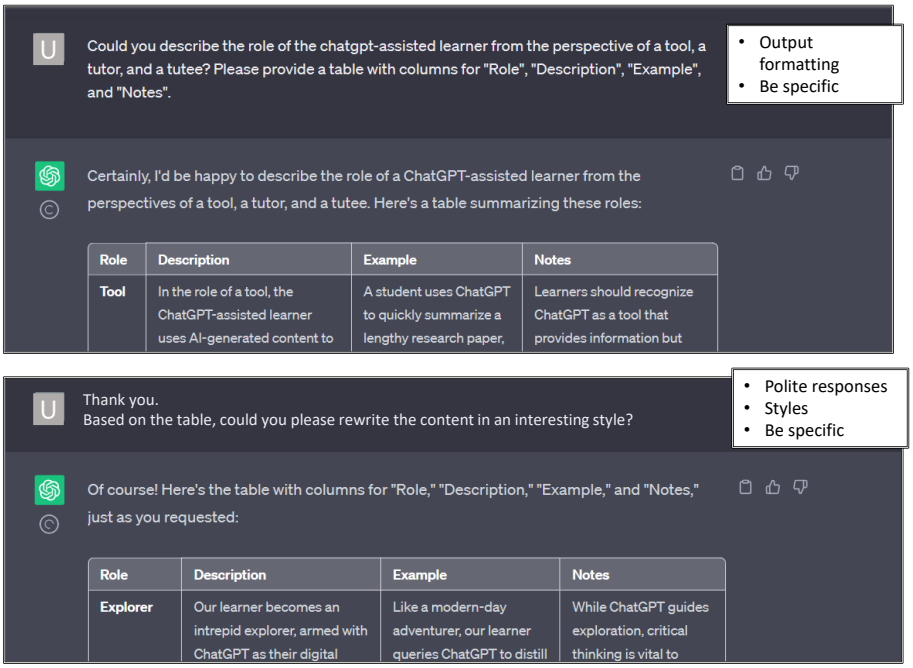
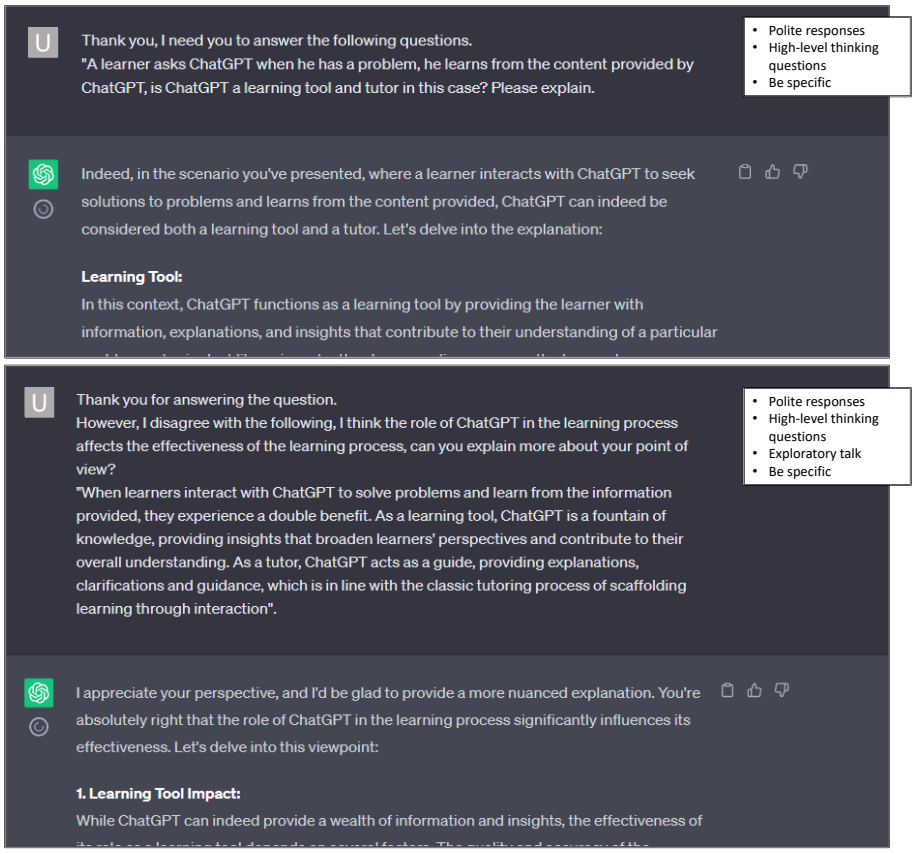


Figure 3(c). An example of the "output formatting," "polite responses," "styles," and "be specific" subcategories in a HGM student's conversation with ChatGPT



5.3. Learning achievement and critical thinking tendency

Table 5 shows the independent sample *t*-test results of learning achievement and critical thinking tendency of the two groups. In terms of learning achievement, the mean score and standard deviation of the HGM group were 88.98 and 2.97, while those of the LGM group were 81.13 and 3.22. The *t*-test results (t = 10.08, p < .001)

disclosed that the HGM group significantly outperformed the LGM group, with a large effect size (d = 2.54) (Cohen, 1988). As for critical thinking tendency, the mean score and standard deviation of the HGM group were 4.54 and 0.28, while those of the LGM group were 3.75 and 0.34. The t-test results (t = 9.948, p < .001) revealed that the HGM group had significantly better critical thinking tendency than the LGM group, with a large effect size (d = 2.51) (Cohen, 1988).

Table 5.*t*-test results

Variable	Group	*N*	Mean	*SD*	*t*	*d*
Learning achievement	HGM group	32	88.98	2.97	10.08***	2.54
	LGM group	31	81.13	3.22		
Critical thinking tendency	HGM group	32	4.54	0.28	9.948***	2.51
	LGM group	31	3.75	0.34		

Note. ***p < .001.

6. Discussion and conclusions

6.1. Discussion

This study compared the viewpoints of students with different growth mindsets regarding the roles and functionalities of ChatGPT in learning through drawing. Even though the two groups of students shared similar conceptions in terms of "roles," "participants involved," "objects," and "emotions and attitudes," significant differences were found in "locations," "learning content" and "learning activities." During the interaction with ChatGPT, there were significant differences in interaction skills and question types between students with different growth mindsets. This study also analyzed the differences in learning achievement, and critical thinking tendency between students with different growth mindsets. The findings not only revealed the conceptions, attitudes, interaction skills, learning achievement, and critical thinking tendency of students with different growth mindsets regarding the roles and functionalities of ChatGPT in learning, but also provided insights into how to more effectively integrate ChatGPT into learning activities.

Regarding the first research question, the results uncovered that when the undergraduates were prompted to describe the roles and functionalities of ChatGPT in learning, most of them focused on "learners" themselves. They viewed ChatGPT as a learning tool and tutor, and employed mobile devices (e.g., NB, mobile phone, and tablet) to engage in learning activities without a specific location. These activities included "reports/assignments," "search for information," and "discussions and consultations," and can be incorporated with specified or non-specified learning content. The students also demonstrated positive emotions and attitudes in the learning process. This indicated that most undergraduates regarded ChatGPT as a personalized learning tool and tutor, thus highlighting the importance of independent learning. This might also be related to their understanding of existing educational tools and teaching approaches. Besides, students could learn through mobile devices without the restraint of location. This flexible and adaptable learning mode allowed ChatGPT to be combined with specified or non-specified learning content, thus underscoring the application potential of ChatGPT in different disciplines and topics. Chan (2023) reported that neither students nor teachers believed that AI would replace teachers in the future. She suggested that teachers and students required a balanced approach/mechanism to adopt AI technology, and that AI should be used as a complementary teaching approach rather than an alternative one. Similarly, some studies have pinpointed that when students encounter challenges in learning tasks, GAI technology (e.g., ChatGPT) can act as a virtual tutor to provide immediate and personalized learning support, thereby promoting learners' cognitive development and understanding (Chan & Hu, 2023). As indicated in previous research, ChatGPT can help students engage in individual learning, and further enhance their learning experience by providing personalized and interactive support (Berdanier & Alley, 2023; Cooper, 2023; Firat, 2023; Hwang & Chen, 2023). Furthermore, some researchers have also emphasized the importance of different roles such as tutors, tutees, and tools to contribute to the educational process in technology-enhanced environments (Hwang & Chien, 2022; Lai, 2021).

Based on the coding results, significant differences existed in the categories of "locations," "learning content," and "learning activities" between students with different growth mindsets. In the "locations" category, most of the undergraduates, especially those in the HGM group, did not specify a location in their drawings. Also, in comparison with those in the HGM group, students in the LGM group were significantly more inclined to adopt ChatGPT at "home" and during "in-class activities" to facilitate their learning. This suggested that the HGM group might pay more attention to the learning process and outcomes rather than specific learning locations. On the other hand, the LGM group tended to learn in familiar and comfortable environments (e.g., homes and

classrooms) rather than broader or diverse learning venues (Liu et al., 2022). As for the "learning content" category, students with different growth mindsets demonstrated different learning trends. Students in the HGM group were inclined to adopt ChatGPT for "specified" learning content, reflecting their goal orientation and focus; they might regard ChatGPT as a tool to achieve specific learning goals. In contrast, students in the LGM group utilized ChatGPT for "non-specified" learning content, which illustrated their openness to exploring various topics. Yu et al. (2022) pointed out that in a learning environment that employed the guided inquiry approach and focused on students' social-emotional development, students tended to recognize their growth mindsets. For instance, teachers could provide students in the HGM group with more challenging tasks for them to delve into specific topics. On the other hand, students in the LGM group might need more guidance and support to focus their exploration on specific learning goals, so as to build confidence and promote active learning experience. Finally, in the "learning activities" category, both groups shared similar conceptions in terms of "reports/assignments," "search information," and "discussions and consultations." It is worth noting that the "translation" subcategory appeared more frequently in the drawings of the HGM group in comparison with those of the LGM group. The results disclosed that although the two groups had similar conceptions in most learning activities, a significant difference in "translation" could be found. This might be closely related to the design mechanism of learning activities, which had the potential to shape and influence students' cognitive structures and conceptual models. In addition, this finding also implied that the HGM group engaged in more diverse learning activities when using ChatGPT to assist their learning (Tewell, 2020; Tseng et al., 2020).

As for the second research question, this study analyzed the interaction skills and question types between the undergraduates and ChatGPT. The results indicated significant differences in these two categories between the HGM group and the LGM group. Table 4 shows that the HGM group performed more diverse interaction skills (i.e., "role-play," "be specific," "styles," "output formatting," and "polite responses") than the LGM group. This might be because students with a high growth mindset generally had a more positive and proactive attitude toward learning; they were more inclined to explore and challenge themselves so that they could perform richer and more diverse interaction skills from different angles and perspectives. The results implied that students in the HGM group were more goal-oriented, attentive, and proficient in inquiry and critical thinking during the learning process, and they were also more effective in using ChatGPT as a learning tool. With regard to the "question types" category, "test questions" were commonly used by both groups, probably because this was the basic way of learning and understanding knowledge. Also, the HGM group mainly used "uptake questions" in the "authentic questions" subcategory. On the other hand, the two groups seldom used "higher-level thinking questions" and "exploratory talk." In particular, both groups rarely employed "exploratory talk." This pointed out that the undergraduates were less likely to actively put forward their own opinions or evidence during the interaction process, and that they seldom questioned or challenged the content provided by ChatGPT during the conversation. Previous research has pinpointed that putting emphasis on specific conceptions or questions during the training phase has the potential to shape and guide learners' cognitive structures and thinking patterns (Yan, 2023). Based on this finding, instructional design should comprehensively consider learners' knowledge and skill gaps in relevant fields, and adopt corresponding teaching strategies to further strengthen their knowledge and skills in exploratory talk. As mentioned by Hwang and Chen (2023), to effectively utilize GAI in the field of education, two key conceptions should be understood and realized. The first is "knowing why," which is a key element to foster learners' in-depth understanding. The second is the conception of "It's all about prompts," which abandons the traditional search mindset and employs the programming prompt instead.

With regard to the third research question, the HGM group had significantly higher learning achievement (i.e., ILT) and critical thinking tendency than the LGM group. These findings were in line with previous studies, indicating that students with a high growth mindset are usually more open and motivated to learn and explore new knowledge. This may prompt them to believe that abilities can be improved through hard work, thereby enhancing their learning motivation and achievement (Dweck, 2006; Hwang et al., 2023; Lai & Hwang, 2014). Students with a high growth mindset may tend to analyze and evaluate information and be more willing to engage in critical thinking, thus improving their learning motivation (Liu et al., 2022). This was in accordance with the findings of the second research question, highlighting the critical thinking and analytical abilities of the HGM group. They asked questions to facilitate deeper understanding through active exploration, analysis and reflection, which underscored their active learning attitudes and pursuit of mastery of knowledge. Furthermore, appropriate learning tools and teaching strategies could increase students' willingness to learn and alleviate their negative emotions during the information search process (Guo et al., 2015). The positive correlations between high growth mindsets and motivation, learning achievement and critical thinking tendency seemed intuitive; however, they might involve quite complex interaction and influencing factors (Miller & Srougi, 2021), which requires further research to enhance understanding. In addition, several studies have specified the importance of critical thinking and have recommended its integration into instructional design and the evaluation of learning effectiveness. This can prompt students not only to accept information, but also to effectively deconstruct and analyze it. Also, digital literacy and information literacy are regarded as a core interdisciplinary competence,

which involves the retrieval, verification and application of information in online and physical environments (Chan, 2023; Lo, 2023; Lai & Hwang, 2014; Lund & Agbaji, 2023).

6.2. Research limitations and recommendations

This study has some limitations. First, this information literacy project only lasted 6 hours, and the data were collected from undergraduates at a single university; therefore, generalizability is limited, and the results may not represent all undergraduates in Taiwan. Second, this study adopted questionnaires to evaluate undergraduates' growth mindsets and critical thinking tendency, while other aspects (e.g., learning motivation, cognitive load, and learning anxiety) were not investigated. Third, this study utilized the draw-a-picture technique as the principal method for data collection, aiming to investigate the conceptions held by students with different growth mindsets regarding the roles and functionalities of ChatGPT in learning. Students' drawings were coded into seven categories (i.e., roles, participants involved, locations, learning content, learning activities, objects, and emotions and attitudes). However, further research is needed to better understand how to accommodate the needs of students with different growth mindsets. To gain a more comprehensive understanding, it is recommended that future research broaden the scope of investigation to include schools at different grade levels and a larger number of undergraduates. In addition, a combination of questionnaires, interviews and behavioral analysis can be adopted to understand learners' conceptions of the roles and functionalities of ChatGPT in learning, as well as their interaction with ChatGPT from multiple perspectives. Based on the findings, the following recommendations were made for future studies:

- It is recommended that future studies incorporate teaching strategies to explore the changes in quality and learning effectiveness at different time intervals. In addition, future research can further investigate the conceptions and perceptions of students at different educational stages (e.g., elementary school, high school, university, and graduate school) regarding the roles and functionalities of ChatGPT in learning, as well as their behavioral characteristics when using ChatGPT in learning.
- Future research is recommended to adopt multiple research methods (e.g., interviews, and behavioral analysis) and interdisciplinary empirical research, as well as to explore the effects of ChatGPT-integrated learning activities on students' learning motivation, cognitive load, learning anxiety and higher-level thinking skills.
- In order to promote students' higher-level thinking skills, it is recommended to include learning activities involving practical challenges and projects in the instructional design. Additionally, it is recommended that future studies continue to evaluate students' interaction with ChatGPT, so as to gain insights into how the interaction impacts their higher-level thinking skills.
- In order to enhance students' learning effectiveness and problem-solving ability in ChatGPT-assisted learning, it is recommended to incorporate learning strategies for active engagement and problem solving (e.g., computers as Mindtools, project-based learning, and inquiry-based learning). Moreover, future research can further explore the correlation between growth mindset and self-regulated learning, and delve into the effects of some variables (e.g., learning strategies, self-regulated learning) on learners' effectiveness in using ChatGPT to assist learning.
- It is recommended that future research delve into the influences of ChatGPT's role as teacher/tutor, student/tutee, learning peer/partner, domain expert, administrator, and learning tool in learning activities on students' knowledge and abilities, for instance, exploring students' acceptance and feedback on different roles of ChatGPT and evaluating how different roles can improve learning effects.

References

Adams, E. (2017). Thinking drawing. *International Journal of Art & Design Education, 36*(3), 244-252. https://doi.org/10.1111/jade.12153

Arif, T. B., Munaf, U., & Ul-Haque, I. (2023). The future of medical education and research: Is ChatGPT a blessing or blight in disguise? *Medical education online, 28*(1), 2181052. https://doi.org/10.1080/10872981.2023.2181052

Baidoo-Anu, D., & Owusu Ansah, L. (2023). Education in the era of generative artificial intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning. *SSRN*. http://dx.doi.org/10.2139/ssrn.4337484

Barak, M., Yachin, T., & Erduran, S. (2023). Tracing preservice teachers' understanding of Nature of Science through their drawings and writing. *Research in Science Education, 53*(3), 507-523. https://doi.org/10.1007/s11165-022-10069-3

Berdanier, C. G., & Alley, M. (2023) We still need to teach engineers to write in the era of ChatGPT. *Journal of Engineering Education*. https://doi.org/10.1002/jee.20541

Boh Podgornik, B., Dolničar, D., Šorgo, A., & Bartol, T. (2015). Development, testing, and validation of an information literacy test (ILT) for higher education. *Journal of the association for Information Science and Technology, 67*(10), 2420-2436. https://doi.org/10.1002/asi.23586

Chan, C. K. Y. (2023). A comprehensive AI policy education framework for university teaching and learning. *International Journal of Educational Technology in Higher Education, 20*(1), 1-25. https://doi.org/10.1186/s41239-023-00408-3

Chan, C. K. Y., & Hu, W. (2023). Students' voices on generative AI: Perceptions, benefits, and challenges in higher education. *International Journal of Educational Technology in Higher Education, 20*, 43. https://doi.org/10.1186/s41239-023-00411-8

Chang, C. C., Hwang, G. J., & Tu, Y. F. (2022a). Roles, applications, and trends of concept map-supported learning: A systematic review and bibliometric analysis of publications from 1992 to 2020 in selected educational technology journals. *Interactive Learning Environments.* https://doi.org/10.1080/10494820.2022.2027457

Chang, C. C., Hwang, G. J., Tu, Y. F., Lai, C. L., & Huang, B. (2022b). Perceptions and conceptions of learning in smart healthcare technology contexts: A draw-a-picture analysis of the differences between nurses and nurse preceptors. *Interactive Learning Environments.* https://doi.org/10.1080/10494820.2022.2160469

Chang, H. Y., & Tsai, C. C. (2023). Epistemic network analysis of students' drawings to investigate their conceptions of science learning with technology. *Journal of Science Education and Technology, 32*(2), 267-283. https://doi.org/10.1007/s10956-022-10026-9

Chang, H. Y., Lin, T. J., Lee, M. H., Lee, S. W. Y., Lin, T. C., Tan, A. L., & Tsai, C. C. (2020). A systematic review of trends and findings in research employing drawing assessment in science education. *Studies in Science Education, 56*(1), 77-110. https://doi.org/10.1080/03057267.2020.1735822

Cheng, M. W., Leung, M. L., & Lau, J. C. H. (2021). A review of growth mindset intervention in higher education: The case for infographics in cultivating mindset behaviors. *Social Psychology of Education*, 1-28. https://doi.org/10.1007/s11218-021-09660-9

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). L. Erlbaum Associates.

Cooper, G. (2023). Examining science education in ChatGPT: An exploratory study of generative artificial intelligence. *Journal of Science Education and Technology*. https://doi.org/10.1007/s10956-023-10039-y

Cotton, D. R., Cotton, P. A., & Shipway, J. R. (2023). Chatting and cheating: Ensuring academic integrity in the era of ChatGPT. *Innovations in Education and Teaching International.* https://doi.org/10.1080/14703297.2023.2190148

Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random House.

Farazouli, A., Cerratto-Pargman, T., Bolander-Laksov, K., & McGrath, C. (2023). Hello GPT! Goodbye home examination? An exploratory study of AI chatbots impact on university teachers' assessment practices. *Assessment & Evaluation in Higher Education*. https://doi.org/10.1080/02602938.2023.2241676

Farrokhnia, M., Banihashem, S. K., Noroozi, O., & Wals, A. (2023). A SWOT analysis of ChatGPT: Implications for educational practice and research. *Innovations in Education and Teaching International.* https://doi.org/10.1080/14703297.2023.2195846

Fauzi, F., Tuhuteru, L., Sampe, F., Ausat, A. M. A., & Hatta, H. R. (2023). Analysing the role of ChatGPT in improving student productivity in higher education. *Journal on Education, 5*(4), 14886-14891. https://doi.org/10.31004/joe.v5i4.2563

Firat, M. (2023, January 12). How chat GPT can transform autodidactic experiences and open education? https://doi.org/10.31219/osf.io/9ge8m

Gal, A. (2023). From recycling to sustainability principles: The perceptions of undergraduate students studying early childhood education of an education for sustainability course. *International Journal of Sustainability in Higher Education, 24*(5), 1082-1104. https://doi.org/10.1108/IJSHE-05-2022-0165

Guo, Y. R., Goh, D. H. L., Luyt, B., Sin, S. C. J., & Ang, R. P. (2015). The effectiveness and acceptance of an affective information literacy tutorial. *Computers & Education, 87*, 368-384. https://doi.org/10.1016/j.compedu.2015.07.015

Haney, W., Russell, M., & Bebell, D. (2004). Drawing on education: Using drawings to document schooling and support change. *Harvard Educational Review, 74*(3), 241-272. https://doi.org/10.17763/haer.74.3.w0817u84w7452011

Heimans, S., Biesta, G., Takayama, K., & Kettle, M. (2023). ChatGPT, subjectification, and the purposes and politics of teacher education and its scholarship. *Asia-Pacific Journal of Teacher Education, 51*(2), 105-112. https://doi.org/10.1080/1359866X.2023.2189368

Hsieh, W. M., & Tsai, C. C. (2017). Exploring students' conceptions of science learning via drawing: A cross-sectional analysis. *International Journal of Science Education, 39*(3), 274-298. https://doi.org/10.1080/09500693.2017.1280640

Hsieh, W. M., & Tsai, C. C. (2018). Learning illustrated: An exploratory cross-sectional drawing analysis of students' conceptions of learning. *The Journal of Educational Research, 111*(2), 139-150. https://doi.org/10.1080/00220671.2016.1220357

Hwang, G. J., & Chen, N. S. (2023). Editorial position paper: Exploring the potential of generative artificial intelligence in education: Applications, challenges, and future research directions. *Educational Technology & Society, 26*(2). https://www.jstor.org/stable/48720991

Hwang, G. J., Chu, H. C., & Lai, C. L. (2017). Prepare your own device and determination (PYOD): A successfully promoted mobile learning mode in Taiwan. *International Journal of Mobile Learning and Organisation, 11*(2), 87-107. https://doi.org/10.1504/IJMLO.2017.084277

Hwang, G. J., Tu, Y. F., & Chu, H. C. (2023). Conceptions of the metaverse in higher education: A draw-a-picture analysis and surveys to investigate the perceptions of students with different motivation levels. *Computers & Education, 203*, 104868. https://doi.org/10.1016/j.compedu.2023.104868

Jeon, J., & Lee, S. (2023). Large language models in education: A focus on the complementary relationship between human teachers and ChatGPT. *Education and Information Technologies*. https://doi.org/10.1007/s10639-023-11834-1

Kasneci, E., Sessler, K., Kuchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Gunnemann, S., Hullermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Jurgen, P., Poquet, O., Sailer, M., Schmidt, A., Seidel, T. …, & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences, 103*, 102274. https://doi.org/10.1016/j.lindif.2023.102274

Lai, C. L. (2021). Exploring university students' preferences for AI-assisted learning environment: A drawing analysis with activity theory framework. *Educational Technology & Society, 24*(4), 1–15. https://www.jstor.org/stable/48629241

Lai, C. L., & Hwang, G. J. (2014). Effects of mobile learning time on students' conception of collaboration, communication, complex problem–solving, meta–cognitive awareness and creativity. *International Journal of Mobile Learning and Organisation, 8*(3-4), 276-291. https://doi.org/10.1504/IJMLO.2014.067029

Lavrakas, P. J. (2008). *Encyclopedia of survey research methods*. SAGE.

Lim, W. M., Gunasekara, A., Pallant, J. L., Pallant, J. I., & Pechenkina, E. (2023). Generative AI and the future of education: Ragnarök or reformation? A paradoxical perspective from management educators. *The International Journal of Management Education, 21*(2), 100790. https://doi.org/10.1016/j.ijme.2023.100790

Liou, C. L. (2017). A comparative study of undergraduates' attitudes toward aging in Taiwan and the United States through student drawings. *The International Journal of Aging and Human Development, 85*(3), 265-288. https://doi.org/10.1177/0091415017702906

Liu, C., Lai, C., Hwang, G. J., & Tu, Y. F. (2022). Effects of ASQE-based learning on the information literacy, problem-solving and critical thinking of students with different growth mindsets. *The Electronic Library, 40*(3), 269-290. https://doi.org/10.1108/EL-11-2021-0205

Liu, G., & Ma, C. (2023). Measuring EFL learners' use of ChatGPT in informal digital learning of English based on the technology acceptance model. *Innovation in Language Learning and Teaching*. https://doi.org/10.1080/17501229.2023.2240316

Lo, L. S. (2023). The CLEAR path: A framework for enhancing information literacy through prompt engineering. *The Journal of Academic Librarianship, 49*(4), 102720. https://doi.org/10.1016/j.acalib.2023.102720

Lund, B., & Agbaji, D. (2023). Information literacy, data literacy, privacy literacy, and ChatGPT: Technology literacies align with perspectives on emerging technology adoption within communities. *Data Literacy, Privacy Literacy, and ChatGPT: Technology Literacies Align with Perspectives on Emerging Technology Adoption within Communities*. http://dx.doi.org/10.2139/ssrn.4324580

Miller, H. B., & Srougi, M. C. (2021). Growth mindset interventions improve academic performance but not mindset in biochemistry. *Biochemistry and Molecular Biology Education, 49*(5), 748-757. https://doi.org/10.1002/bmb.21556

Mohamed, A. M. (2023). Exploring the potential of an AI-based Chatbot (ChatGPT) in enhancing English as a Foreign Language (EFL) teaching: Perceptions of EFL faculty members. *Education and Information Technologies.* https://doi.org/10.1007/s10639-023-11917-z

Rospigliosi, P. A. (2023). Artificial intelligence in teaching and learning: What questions should we ask of ChatGPT? *Interactive Learning Environments, 31*(1), 1-3. https://doi.org/10.1080/10494820.2023.2180191

Selwyn, N., Boraschi, D., & Özkula, S. M. (2009). Drawing digital pictures: An investigation of primary pupils' representations of ICT and schools. *British Educational Research Journal, 35*(6), 909-928. https://doi.org/10.1080/01411920902834282

Šorgo, A., Bartol, T., Dolničar, D., & Boh Podgornik, B. (2017). Attributes of digital natives as predictors of information literacy in higher education. *British Journal of Educational Technology, 48*(3), 749-767. https://doi.org/10.1111/bjet.12451

Strzelecki, A. (2023). To use or not to use ChatGPT in higher education? A study of students' acceptance and use of technology. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2023.2209881

Tewell, E. (2020). The problem with grit: Dismantling deficit thinking in library instruction. *portal: Libraries and the Academy, 20*(1), 137-159. https://doi.org/10.1353/pla.2020.0007

Tseng, H., Kuo, Y. C., & Walsh, E. J. (2020). Exploring first-time online undergraduate and graduate students' growth mindsets and flexible thinking and their relations to online learning engagement. *Educational Technology Research and Development, 68*(5), 2285-2303. https://doi.org/10.1007/s11423-020-09774-5

Tu, Y. F., Hwang, G. J., Chen, S. Y., Lai, C., & Chen, C. M. (2021). Differences between LIS and non-LIS undergraduates' conceptions of smart libraries: A drawing analysis approach. *The Electronic Library, 39*(6), 801–823. https://doi.org/10.1108/EL-07-2021-0129

Vermunt, J. D., & Vermetten, Y. J. (2004). Patterns in student learning: Relationships between learning strategies, conceptions of learning, and learning orientations. *Educational Psychology Review, 16*, 359-384.

Wu, T. T., Lee, H. Y., Li, P. H., Huang, C. N., & Huang, Y. M. (2023). Promoting self-regulation progress and knowledge construction in blended learning via ChatGPT-based learning aid. *Journal of Educational Computing Research*, 07356331231191125. https://doi.org/10.1177/07356331231191125

Yan, D. (2023). Impact of ChatGPT on learners in a L2 writing practicum: An exploratory investigation. *Education and Information Technologies*. https://doi.org/10.1007/s10639-023-11742-4

Yeh, H. Y., Tsai, Y. H., Tsai, C. C., & Chang, H. Y. (2019). Investigating students' conceptions of technology-assisted science learning: A drawing analysis. *Journal of Science Education and Technology, 28*(4), 329-340. https://doi.org/10.1007/s10956-019-9769-1

Yeh, Y. C., Ting, Y. S., & Chiang, J. L. (2023). Influences of growth mindset, fixed mindset, grit, and self-determination on self-efficacy in game-based creativity learning. *Educational Technology & Society, 26*(1), 62-78. https://www.jstor.org/stable/48707967

Yu, J., Kreijkes, P., & Salmela-Aro, K. (2022). Students' growth mindset: Relation to teacher beliefs, teaching practices, and school climate. *Learning and Instruction, 80*, 101616. https://doi.org/10.1016/j.learninstruc.2022.101616

Zhang, X., Chen, Y., Bao, Y., & Hu, L. (2023). Robot illustrated: Exploring elementary students' perceptions of robots via the draw-a-robot test. *Journal of Research on Technology in Education*. https://doi.org/10.1080/15391523.2023.2232058