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My teammate is AI: understanding students’ perceptions of student-AI collaboration in drawing tasks

Jinhee Kim\textsuperscript{a} and Young Hoan Cho\textsuperscript{b}

\textsuperscript{a}Department of STEM and Professional Studies, Old Dominion University, Norfolk, U.S.A.; \textsuperscript{b}Learning Sciences Research Institute, College of Education, Seoul National University, Seoul, South Korea

**ABSTRACT**

Educators expect artificial intelligence (AI) to augment student capabilities and rapidly transform teaching and learning practices. However, little is known about students’ perceptions of AI and what they expect from AI in student-AI teaming. There is a lack of holistic understanding of the nature, effects, and areas of improvement in teamwork by students and AI on learning. This study aims to explore students’ perceptions and experiences about student-AI collaboration (SAC) to provide effective measures for the successful integration and implementation of SAC. In-depth interviews were carried out with 20 undergraduate students in South Korea after a drawing task with AutoDraw. This study found that students expected AI to serve various roles, including a learning mate, a tutor, and an effective tool to complete the task during SAC. Students perceived that SAC could benefit both the students’ affective domain and task performance. In contrast, students addressed multiple barriers to SAC both from the AI-related and student-related aspects. These findings can provide insights into the dynamic interaction between students and AI for problem-solving performance and meaningful learning. This study also provides implications on AI literacy education and the design of educational AI that can be made pedagogically rich to enhance student-AI teams.

**Introduction**

Imagine the following scenario: You are assigned a creative drawing task in an art class. The task requires you to make something out of nothing and hence always gives you a throbbing headache. As “two heads are better than one”, you collaborate with a friend. She actively brainstorms about the creation, offering her creative interpretations, and leading you to serendipitous discoveries. Then, you initiate sketching, and she sketches the next part. You both colour the drawing together to save time. However, she is NOT human; she is Artificial Intelligence (AI).

This scenario leads to a complex situation where a student and an AI teammate need to promptly analyse a learning task, communicate, coordinate a task process and drawing efforts, and generate sound solutions for problems emerging during task operation. In other words, the collaboration between a student and an AI teammate plays a vital role in creating meaningful experiences for a student and enhancing the quality of the drawing task. Although this scenario is hypothetical, the rapid progress and acceleration of AI usage in the human-exclusive domains, such as decision-making, prediction, and logical reasoning, are making a profound impact in education.
Moreover, extensive research discusses the use of AI for learning with a set of tools known as Intelligent Tutoring Systems (ITSs). The system provides step-by-step tutorials, individualized for each student, for topics in structured subjects such as mathematics or physics. Although intuitively appealing, the assumptions embodied in ITSs and the student-system interactions are characterized as tutoring whereby the systems’ typical instructional approach is knowledge-transmission for teaching. In turn, the system overlooks the possibilities of other approaches valued by the learning sciences, such as collaborative learning, guided discovery learning, and productive failure (Holmes et al., 2019). Therefore, the new frontier of research is offering a role of collaborative peer and designing AI’s interaction with students as intelligent support that is more open-ended or exploratory (Kim et al., 2022; Ouyang & Jiao, 2021). For example, AI serves as a novice learner and students assume the role of a better performing peer/or a teacher to correct AI’s errors, which in turn helps students improve domain knowledge and self-efficacy through learning-by-teaching (Matsuda, 2022). In contrast, AI is employed as a group member in a collaborative discussion to promote fair learning participation and encourage students’ self-reflection (Kim et al., 2022; Tan et al., 2022). This reality indicates the new era of education where non-human agents are teaming with students to accomplish high-level learning goals with their student partners.

However, there is a dearth of knowledge about students’ perception of AI teammates in the student-AI collaboration (SAC) scenario. When treating AI as a collaborative peer, students may hold higher expectations from an AI agent, expecting it to play specific roles and perform in some ways and establish relationships between a student and AI (Kim & Lee, 2020). As the teams of students and AI in learning is new territory, exploring how students relate to AI and what characteristics would make for a successful student-AI relationship becomes crucial for understanding and designing AI and instructional strategies (Kim et al., 2022). This study, therefore, attempts to explore and examine students’ perceptions and experiences about SAC to offer effective measures for the successful organization and implementation of SAC. The questions guiding the study are as follows:

1. What are students’ perceptions of the expected roles of AI during SAC?
2. What are students’ perceptions of the advantages of SAC?
3. What are students’ perceptions of barriers to SAC?

**Literature review**

The roles of AI in the realm of AIED have mainly been discussed from two different perspectives: (1) the Tool-centric perspective and (2) the augmentation perspective (Holstein et al., 2019; Mavrikis et al., 2021). From the tool-centric conception of technology, the role of AI has been positioned as a powerful tool to deliver knowledge selected and organized by teachers for students to effectively achieve the learning goals set, or support students to organize and construct knowledge, thereby main focus on the AIED mainly is directed to develop students’ ability to utilize technology tools to achieve students’ learning goals effectively (Baker et al., 2019; Holmes et al., 2019). Although this perspective advanced our understanding of the development of AI-related curricula and pedagogies and educational AI development, it is claimed that a tool-centric conception of AI cannot sufficiently exploit and debate the potential use of AI functionality and the mutual interaction between students and AI in the cognitive process; students utilize AI for their purpose but the role of technology in shaping human action (and identities), however, is non-existent (Ji et al., 2022; Kim et al., 2022). In this respect, post-humanist theory such as Actor-Network Theory (ANT) provides new opportunities for the study to understand and explain the interplay of humans and technology. ANT proposes a symmetrical view of human and non-human agencies, where neither is reduced to the other nor dismissed with any other; both students and AI are agents in their own right and transact all learning activities with each other, thereby SAC should be mutually engaging, but also supportive (Latour, 2005). In line with this, an
emerging line of study has proposed what is known as the augmentation perspective on AIED with careful consideration of AI’s unique characteristics of being autonomous, personalized, and interactive with students. This perspective highlights the role of AI to facilitate learning processes by enhancing students’ cognition with its unique strengths such as quick data collection, analysis, and translation into meaningful insights and actions (Holmes et al., 2019; Holstein et al., 2019). The AI system in this respect is considered equal team members with the student, co-orchestrates complex learning activities, and achieves the effect that neither students nor AI can complete independently (Holstein et al., 2019; Molenaar, 2022). For instance, Lin et al. (2020) explored the AI’s role as an improviser and an ideation partner to propel students’ creative process. The collaboration between a design student and an intelligent robot on a drawing task can be a good example. First, a student sketches on paper. Then, the intelligent robot captures the image, generates ideas according to the input sketch, and sketches them back on paper. The student then continues ideating based on the intelligent robot. Here, the intelligent robot serves as the mechanism of the conceptual shift to inspire students’ creativity, as it aids the creative process of analogical reasoning. Some literature explored the AI’s role to support students in productively interpreting learning data offered by AI (e.g., Echeverria et al., 2018) and building more productive forms of reflection scaffolded by AI (e.g., Serrano et al., 2018). On the other hand, AI can facilitate collaborative learning by augmenting what students can sense and notice about a learning situation. For instance, an AI-based dashboard can visualize both individual and group-level learning processes and contributions to facilitate active participation among all group members, regulate students’ learning process, and improve their performance and quality of collaboration (e.g., Han et al., 2021; Kim et al., 2016).

Nonetheless, some aspects require thoughtful attention to foster SAC and utilize AI more effectively in educational contexts. Existing literature shows five main factors that influence SAC or human–AI collaboration (HAC). First, the predictability and reliability of AI are critical elements for HAC and have a strong impact on human trust in AI (Ryan, 2020). However, improving the AI systems’ accuracy without profound consideration of compatibility with previous versions of the system and user experience may negatively affect the trust level built between humans and AI (Bansal et al., 2019). Second, communication is a core component of teamwork. Verbal and nonverbal communication between humans and AI facilitates team coordination through task division and decision-making (Liang et al., 2019; McNeese et al., 2018). Third, the balance of agency between humans and AI influences their interaction with each other. When human agency is low and machine agency is high, humans tend to over-trust machines and underestimate human judgement to perform a task. This results in outsourcing and reduced vigilance, which is coined automation bias (van Leeuwen et al., 2018). However, when human agency is too high, humans may experience algorithm aversion, the tendency to depend on human judgements over algorithmic suggestions yet the former is suboptimal (Holstein et al., 2017). Fourth, empathy and engagement are crucial factors in SAC contexts. AI must be equipped with the ability to make use of empathic language/messages and other social cues to build rapport with students (Lee & Kim, 2020). Lastly, humans’ level of domain-specific knowledge may lead to differences in interaction and experiences with technology (Rzepka & Berger, 2018). Since AI aims to address domain-specific problems and obtain quality outcomes and experience, the problem-solving process between humans and AI cannot be separated from the domain on which the knowledge of humans and AI is based.

The review of the current literature allows us to develop insight into the collaboration between a student and an AI teammate on a learning task. Despite advanced machine learning algorithms, different implementations of AI and students’ characteristics may most likely result in different effects on team performance. Therefore, this study takes an initial step to explore and understand how undergraduate students would perceive the advantages of collaborating with an AI teammate to perform their learning tasks as well as the barriers to SAC which should be mitigated to maximize team performance. This study is a part of the SAC research conducted by the first author, so it is
closely related to the study that examined whether students’ attitude and domain-specific skills influenced the improvement of task performance through SAC (Kim & Lee, 2023).

**Research methods**

**Participant**

To derive and categorize students’ diverse perceptions of SAC, purposeful sampling was adopted to include students from different majors, levels of drawing skills, and attitudes towards AI. A pre-interview was conducted to examine students’ attitudes towards AI. Students were then grouped into two maximum variations: positive (AI is good, beneficial, helpful, intelligent, and with goodwill) versus negative (bad, not beneficial, not helpful, silly, and with ill will) attitudes (Wu et al., 2020). Table 1 shows the information of the 20 Korean undergraduate students who participated in the study. This study received ethical approval from the university’s Institutional Review Board, and informed consent was obtained from all participants.

**Data collection**

The present study conducted a face-to-face semi-structured elicitation interview of 60–80 minutes for each participant. To facilitate interviews, each student was invited to draw a public advertisement to overcome COVID-19 and to cope with climate change using an AI drawing system, prior to the interview. Among numerous AI drawing systems, AutoDraw was selected as an AI teammate for students in the study due to its interactive features that convert the user’s inaccurate and rough input sketches into stylized drawings based on AI principles. Particularly, it generates a list of suggested images for the students to choose and replace their original sketch, as illustrated in Figure 1.

Before the drawing activity, we explained its purpose and procedures to the participants. Moreover, each participant was given a task instruction with the theme background, guidelines for drawing a public advertisement, and evaluation criteria for the outcomes of tasks (creativity in content, expressivity in expression, and public utility in effectiveness). Furthermore, as it was important to prevent the participants from heavily weighing their first impressions of the system interface, we devised ways to adapt them to the system. For instance, we prepared a short video clip describing the system’s major functions, modes, and conditions and let them try the system a few times.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Age</th>
<th>Major</th>
<th>Duration of art education</th>
<th>Attitude towards AI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Male</td>
<td>24</td>
<td>Technology and innovation management</td>
<td>16 years</td>
<td>Positive</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>24</td>
<td>Art education</td>
<td>16 years</td>
<td>Positive</td>
</tr>
<tr>
<td>3</td>
<td>Female</td>
<td>22</td>
<td>Nursing</td>
<td>12 years</td>
<td>Positive</td>
</tr>
<tr>
<td>4</td>
<td>Female</td>
<td>23</td>
<td>Ceramic arts and design</td>
<td>14 years</td>
<td>Positive</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>24</td>
<td>Industrial design</td>
<td>15 years</td>
<td>Positive</td>
</tr>
<tr>
<td>6</td>
<td>Female</td>
<td>22</td>
<td>Computer engineering</td>
<td>1 year</td>
<td>Positive</td>
</tr>
<tr>
<td>7</td>
<td>Male</td>
<td>24</td>
<td>Material engineering</td>
<td>2 months</td>
<td>Positive</td>
</tr>
<tr>
<td>8</td>
<td>Male</td>
<td>25</td>
<td>Mass media and journalism</td>
<td>3 months</td>
<td>Positive</td>
</tr>
<tr>
<td>9</td>
<td>Female</td>
<td>23</td>
<td>Business management</td>
<td>6 months</td>
<td>Positive</td>
</tr>
<tr>
<td>10</td>
<td>Female</td>
<td>22</td>
<td>Clinical pathology</td>
<td>4 months</td>
<td>Positive</td>
</tr>
<tr>
<td>11</td>
<td>Female</td>
<td>22</td>
<td>Western painting</td>
<td>15 years</td>
<td>Negative</td>
</tr>
<tr>
<td>12</td>
<td>Male</td>
<td>24</td>
<td>Visual design</td>
<td>15 years</td>
<td>Negative</td>
</tr>
<tr>
<td>13</td>
<td>Female</td>
<td>25</td>
<td>Oriental painting</td>
<td>16 years</td>
<td>Negative</td>
</tr>
<tr>
<td>14</td>
<td>Male</td>
<td>24</td>
<td>Film animation</td>
<td>12 years</td>
<td>Negative</td>
</tr>
<tr>
<td>15</td>
<td>Female</td>
<td>23</td>
<td>Graphic design</td>
<td>13 years</td>
<td>Negative</td>
</tr>
<tr>
<td>16</td>
<td>Female</td>
<td>22</td>
<td>Environmental engineering</td>
<td>1 year</td>
<td>Negative</td>
</tr>
<tr>
<td>17</td>
<td>Female</td>
<td>23</td>
<td>International studies</td>
<td>1 month</td>
<td>Negative</td>
</tr>
<tr>
<td>18</td>
<td>Female</td>
<td>24</td>
<td>Mass media and journalism</td>
<td>1 month</td>
<td>Negative</td>
</tr>
<tr>
<td>19</td>
<td>Male</td>
<td>22</td>
<td>Russian language and literature</td>
<td>2 months</td>
<td>Negative</td>
</tr>
<tr>
<td>20</td>
<td>Male</td>
<td>23</td>
<td>Textile engineering</td>
<td>1 year</td>
<td>Negative</td>
</tr>
</tbody>
</table>
A drawing activity between a student and an AI was conducted on the AutoDraw website via a tablet PC (Galaxy Tab 6 and its smart-pen) in a lab-like environment for about one to two hours, depending on the participants’ level of drawing competence and the speed of task completion. Upon the task completion, participants’ final drawing outcomes downloaded in a digital format from AutoDraw (see Figure 2) were collected and used to facilitate interviews. Participants were asked questions regarding their collaborative experience with AutoDraw in completing the given task, such as “What were your initial expectations toward AutoDraw as a teammate?” and “What were the benefits of and challenges during the SAC on a drawing task?” These questions assisted in drawing out qualitative information on the roles expected of AI during SAC, the advantages of SAC, and the barriers to SAC.
Data analysis

This study undertook a thematic analysis, a highly flexible qualitative data analysis method for examining the perspectives of different research participants, highlighting similarities and differences, and generating unanticipated insights, particularly for those relatively nascent stages of the research context, for analysing the data drawn from interviews (Braun & Clarke, 2006). The thematic analysis, which was not bound to a pre-existing theoretical framework, was conducted to capture important and recurring ideas pertaining to research questions across a set of interviews with diverse undergraduate students. Two researchers first conducted a deductive thematic analysis to generate initial themes of the expected roles of AI during SAC, advantages of SAC, and barriers to SAC. Consequently, 42 initial codes were generated and collated into 24 main themes. Further, transcripts were analysed with an inductive approach to identify new emerging codes and themes that were not determined previously. Finally, three themes for the expected roles of AI during SAC, two themes with eight sub-themes under advantages of SAC, and two themes with 10 sub-themes under barriers to SAC were defined (see Appendix A). The interview extracts regarding the themes were then translated from Korean to English.

To ensure the reliability of the qualitative data analysis, the study employed two strategies: (1) respondent validation and employing moderators (Golafshani, 2003). We confirmed the interview transcripts and the analysis results with every participant and allowed them to revise when necessary. In addition, two experts (1 from instructional design and technology and 1 from science and technology policy analysis) reviewed all transcribed interviews and the initially generated themes to ensure that the data is not influenced by the subjective judgement of the author and further examine codes and themes that have not been well identified. These processes were repeated until every expert and author agreed.

Findings and discussion

Students’ perception of expected roles of AI during SAC

AI as a learning mate

Students considered AI as an independent learning mate in SAC and desired AI to present subjective identity as their learning mate. First, students expected AI to become a creative partner guiding them on ideation and thinking out of the box during the task operation process. As P2’s quotation illustrated in Appendix A, although students highlighted that AI cannot perform exactly like humans, they expected such difference would create an opportunity for them to think from other perspectives.

Students also anticipated AI would become their interactive friend whom they can socialize with during the task process and make their learning more engaging and fun. They compared SAC with human-human teamwork and described that each teammate possesses unique personality traits and styles. Such individuals’ unique characteristics make teaming up with other teammates enjoyable and socially satisfying. In this regard, they perceived AI as a digital peer that possesses unique nature and strength, which differs from humans.

AI as a tutor

AI as a tutor was identified as another expected role of AI towards SAC. Students, particularly, expected AI to become a detail-oriented and patient tutor to support and lead them during the task process like a human tutor. They anticipated AI to suggest hints about the best approach and drawing strategy, which could help them learn and improve. Through interacting and practicing with AI, students seemed eager to receive one-point lesson on the task.
**AI as an effective tool to execute the task**

A few students perceived that AI would be used as an *effective tool* to provide support in completing the drawing task more efficiently. This view was particularly presented by students with a negative attitude towards AI. These students specifically expected AI to perform time-consuming, tedious, and tiresome tasks (e.g., drawing the same figures and colouring) effectively and have mechanically flawless performance.

**Students’ perceived advantages of SAC**

**Enhancing the affective domain**

First, students expressed that drawing experience with the AI aroused the sensation that someone was with them to support their drawing task and such perceived feelings enhanced their psychological safety. Students’ perceived co-presence (Mason, 1994) of AI provided emotional comfort/support in the virtual environment. For example, P3 said "I didn't feel like I was left alone to complete the task. I felt much more relieved just because AutoDraw was with me". The co-presence of AI encouraged students to explain their thoughts to AutoDraw, which helped to clarify and organize their drawing ideas.

Second, SAC provoked students to begin a question-and-answer approach to construct their understanding, forge connections between the tasks and their personal experience, and reflect on what they say through the articulation of their emotions and concerns in completing the task (Luft & Patterson, 2002). In turn, this positively affected students’ attitude towards the further drawing task from being passive to active and positive.

Third, students portrayed that the drawing experience with AI was enjoyable. Particularly, students were excited and delighted when AI recognized their drawings and presented a series of recommendations accordingly. Participants became delighted and amused when the AI offered suggestions that were different from their expectations. For instance, P20 said:

> I drew a polar bear. But AutoDraw suggested me a hedgehog and a lion! Perhaps he wanted to draw friends for a lonely polar bear on a sinking iceberg. So I drew them all and it was quite hilarious.

This denotes that AI can induce students’ inclination to engage in and enjoy learning through a fun and interesting experience despite AI's low accuracy (Harton & Pyla, 2012).

Fourth, students’ perceived availability of AI support in need seemed to favourably promote self-efficacy towards the task achievement. For instance, P8 expressed "I'm all thumbs when it comes to drawing. But with Auto’s help, drawing became easy. I realized my potential to be a graphic designer today". This shows that SAC improved students’ motivational dispositions to complete the task while the perceived task difficulty was reduced. However, some participants felt downhearted when AI’s replacement over their original pictures was much better than their performance. They often compared their sketches with those of AI, which lowered their confidence.

**Enhancing the task performance**

Another important value of SAC perceived by students was the enhancement of task performance. To begin with, students positively assessed that their power of expression has improved through the interaction with AI. Students were particularly satisfied with AI’s ability to perceive their rough input sketches and generate a list of clip-art-style pieces for them to choose and replace their original sketch. Although some of the participants disliked its drawing style because it was more computer-like than a human, students mostly appreciated these functions which enabled them to visualize their thoughts implicitly.

Second, the AI allowed them to expedite the completion of the task through role distribution or synergetic interaction, although some students expressed they took more time to complete the task when collaborating with AI as it took time to explore and examine AI’s suggestions. One interesting observation noticed in the role distribution was that the students who expected AI to be an effective
tool to assist their task clearly distinguished AI’s role from theirs (I was a director, being responsible for concept design and overall directing while AI was a follower, said P14). In contrast, some students reported that they experienced SAC in helping each other throughout the task process instead of separating different roles in parallel.

Third, the AI facilitated students’ creative thinking process through actively soliciting possible suggestions for ideation, evoking questions and wonders through unexpected suggestions, and developing linkages between different ideas of a student and AI. Particularly, serendipitous features in the student-AI interaction could act as an instrument for enhancing students’ creative experience. The unpredictability of AI provides students an opportunity to unleash their creative aspirations and develop alternative figures through different mixtures of a student and AI.

Lastly, students expressed that SAC can cost-effectively deliver drawing materials and tools, which can promote wider access to art education. For example, P10 said.

I can freely enjoy drawing activity without great expense since AutoDraw provided all materials needed for drawing.

Students were presented an opportunity to foster improved access to art education, at least in drawing practice, as the materials available by AI are accessible from anywhere, anytime, and at no cost to learn; best within the context of individual students’ abilities through SAC (UNESCO, 2019).

**Students’ perceived barriers to SAC**

*AI-related barriers*

First, the most prominent challenge of SAC seemed to be the AI’s lack of appropriate pedagogical knowledge and support, which might spark changes in students’ drawing, improve their understanding regarding the drawing context, and improve their drawing skills. Students expressed different types and levels of difficulties at different stages during the task completion period and expected AI to properly facilitate the interaction between its resources, pedagogy, and technology. For instance, students with a low level of drawing skills were eager to learn how to draw step-by-step; thus, they sought pedagogical support such as offering just-in-time feedback (P18), providing necessary scaffolding (P19), and breaking down the activity into smaller steps (P7). Meanwhile, students with advanced drawing skills wanted to develop creative thinking to perform an original painting. In this regard, they sought help during the ideation development stage through evoking thought-awakening questions (P5), conducting more open-ended activities and discussion to stimulate their thinking (P1), and brainstorming diverse concepts (P11).

Second, the absence of AI’s socio-emotional skills was another significant challenge to effective SAC. They described that AI teammates not being capable of observing basic communication protocols such as greetings, sense of humour, and turn-taking was frustrating. Similarly, students perceived a real teammate to show empathy and provide motivational and emotional support in a collaborative setting in addition to the demonstration of social interaction skills. These findings enable us to think of how AI should react to students’ behaviours in various contexts during SAC, rather than merely detecting a face and classifying their emotion.

Third, another important challenge was AI’s inability to explain the cause and effect behind its suggestions. Specifically, students did not blame the relatively shallow nature of the recommendation provided by AutoDraw, but they highlighted the necessities of access to detailed and underlying representation or inferences of AI’s recommendation that are understandable for students. Students expected AI to present an interpretation of its recommendation to help them to better understand AI’s suggestions, review their task process, and propose a change to improve the task performance.

Fourth, the lack of communication channels was identified as a critical obstacle to SAC. As existing literature highlights, communication is an essential element in teamwork, which involves team members coordinating together (Salas et al., 2008). However, AI in the present study context was only able to communicate with students via sketching (visual communication). Students with a low
level of drawing skills expressed the difficulty of communicating with AI via drawing only. For instance, P10 said “I draw what I can draw and Auto suggests things based on my poor drawing. How can we create high-quality drawing since we cannot communicate with each other?”. Toward this issue, students anticipated that they could share and interchange thoughts with AI in diverse communication channels, including voice communication, text, or even non-verbal communication.

Fifth, lack of customized content provision was perceived as another challenge. A generation of explosive information created unique challenges for students to manage and harness for insights and actions. Whitworth (2009) described this phenomenon as the premise of info obesity that the AI is information-rich but knowledge-poor. This view contrasts the knowledge transmission model favoured by ITS, which merely provides a series of installed recommendations. Students rather suggest AI support them to actively construct their own knowledge and become empowered problem solvers through customized content provision, which is often associated with exploratory learning by minimizing the cognitive overload and providing automated guidance and feedback based on knowledge tracing and machine learning. More importantly, this customized content and support need to be delivered in a way that is easy to digest, share, and apply with students (Kumar et al., 2019).

Sixth, students pointed out that lack of interoperability as a significant challenge to SAC. Incompatible systems impede the data to be exchanged, processed, and interpreted by students. As P4 presented in Appendix A, an interoperable AI system can further help students to reach relevant and up-to-the-minute learning information to optimize task performance and lessen the documentation burden by reducing the repeated entry of data and cumbersome information retrieval processes. In this study context, the information that drives students’ decisions about the drawing tasks depends on what AutoDraw suggests to them, making them inactive bystanders in the task process. If students are offered better access to and utilize various task-related data, they can take more control of their learning tasks. This allows students to be active managers of data on their tasks from being helpless recipients of data (Lehne et al., 2019).

Lastly, students pointed out the absence of varying levels of automation in AutoDraw was another significant challenges. Students with a high level of drawing skills showed resistance against full automation, which students indicated as territorial issues. For example, P11 said “How dared Auto to fully control my drawing? It’s not a partial change but a complete change! AutoDraw had been trying to overcome my drawing territory”. Conversely, students with a low level of drawing skills expressed that the drawing outcome completed mostly by AI’s automated image lowered the chance of trial and error in drawing practice and their ownership in the outcome as follows: “I didn’t put much effort, I felt like this poster is Auto’s, NOT mine (P6)”. These quotes give us important insights that AI should value students’ agency and harness students’ preference and sense of ownership in learning (Wang et al., 2019). It is necessary to vary the level of automation, which can promote calibrating the level of control and agency between a student and AI during SAC depending on students’ competencies, the difficulty of a task, and learning contexts.

**Student-related barriers**

First of all, students in the study highlighted that their conceptualization of the role of AI, AI as a tool versus AI as a subject of collaboration, affected the mode of collaboration.

I was captured by thoughts that AI is not so much different from other technological tool that I can manipulate its functions. This mind-set somehow led me to think that AI should just follow my instruction and simply fulfill what I want it to perform. And when it failed to do so, I kept on laying the blame on it. (P11)

Her quote indicates that students’ conceptualization of AI as a tool, not as a co-subject, influenced how they interacted with AI and limited AI utilization methods. In addition, students revealed that the conceptualization of AI as a tool could lead to unfairness in treating AI; AI was identified as
scapegoats in SAC (Merritt et al., 2011). To use AI to its full capacity, students should reconceptualize AI as a teammate, and this may render a more sound and enjoyable collaborative learning context.

Second, students’ lack of drawing skills was also an obstacle to SAC. Students with a low level of drawing skills were unable to employ potentially useful sources offered by AI as a result of their insufficient mastery of basic drawing skills. Students’ domain-specific knowledge and skills are necessary for SAC because they should continuously make a decision based on the suggestions by AI. Students with a high level of drawing skills were more likely to use AutoDraw effectively, modifying the figures suggested.

Lastly, students acknowledged that they did not know how to collaborate effectively with AI. Students’ lack of collaborative skills such as accepting opposing viewpoints (“I simply reject every AI’s suggestion when they didn’t meet with my intention. I didn’t really think over the alternative ideas”, P15), negotiating (“Between two different ways of drawing, I simply select one option: my drawing or AI’s suggested figure. I didn’t think of combining two”, P12), coordinating team performance (“I started working without planning task process and time to finish the task. I didn’t consider AI’s abilities and resources it has at the beginning”, P20). This finding is corroborated by the earlier research in student-student collaborative learning environment (Cho et al., 2017), which found low-quality coordination behaviours such as paying no attention to other’s opinion, interrupting them, and rejection of alternative suggestions without justification inhibited team performance.

Conclusion
This study demonstrates the role expected of AI during SAC, the advantages of SAC, and the barriers to SAC drawing from students’ perspectives. It should be noted that this understanding of AI as a teammate in students’ learning context in the study is not target-bound but initiates a point of discussion and provides considerations to better formulate a student-AI team for students’ meaningful learning.

Implications for AI in education
The findings of this study provide implications on what educators and developers should consider for successful AIED. First, students expressed various roles expected of AI during SAC as well as recognized the benefits of SAC on a learning task. Moreover, students did not simply consider AI as a passive resource supplier and tool to be utilized, but as an active contributor to their learning. In this regard, one question that often arises, notably from non-academic audiences, is “Could AI replace our human teachers?” The findings of this study do not stand to replace human tutors. This study poses the possibility of using AI to provide additional opportunities to strengthen current human teachers’ instruction provision. The role of AI will vary depending on the situation: in some settings, AI might play the role of another student who is learning the curriculum alongside students (Baker et al., 2019). In other settings, AI might be a coach that could afford personalized support even beyond formal curriculum and the school environment (i.e., supplementary language support for non-native children) (Ji et al., 2022). These opportunities become even more effective in the context of online personalized learning. For instance, Kim and Lee (2020) well demonstrated how AI serves as a group member, not merely as a tool, by playing diverse roles such as managing the discussion time, encouraging members to participate evenly, and organizing members’ opinions. Although earlier work sought to fully automate the teaching process (Choi et al., 2020) or treated AI as a learning tool for improving goal-oriented tasks (Lee et al., 2020), this study suggests rethinking the role of AI in students’ learning and exploring how humans (both students and teachers) and AI be complementary to achieve more meaningful learning.

Second, students in this study anthropomorphized AI and reacted socially to AI (Nass et al., 1995). For instance, students attempted to communicate with AI as being aware that AutoDraw was unable to speak, expected AI to offer them emotional support and motivate them while completing the task...
and assigned personalities such as creative, interactive, detail-oriented, and patient. These findings are consistent with the Computers are Social Actors (CASA) paradigm highlighting that even though individuals are explicitly aware and acknowledge that the computer is neither human nor deserves to be treated as human, they react socially to computers (Kim & Sundar, 2012). In this regard, prior research highlights the importance of anthropomorphism in AI that promotes interaction pleasure with AI (Kim et al., 2019), increase trust in AI (Waytz et al., 2014), perceived amiability and the sociability of AI, and preference for AI (Broadbent et al., 2013; Yam et al., 2020). However, it should also take note of the Uncanny Valley phenomenon, whereby people’s positive feelings significantly decline or even become negative towards a humanoid that resembles an actual human (Mori, 1970). In addition, Syrdal et al. (2008) argued that people expect anthropomorphic AI to comply with human norms and put higher expectations in their capabilities compared to AI with a machine-like feature. Future studies, therefore, need to identify more specific degrees of anthropomorphism in educational AI and test whether different degrees of anthropomorphism influence students’ interaction behaviour and task performance. Meanwhile, students’ anthropocentric perception towards AI do not fit into the long-held anthropocentric definition of interaction as a process taking place between humans (i.e., students, teachers, parents) (Gunkel, 2012). In this respect, this study suggests future research to explore the theoretical basis (i.e., post-humanist theory such as ANT) or even establish theoretical parameters to understand the nature of SAC and to open up new perspectives on AIED and design educationally relevant interactions with AI (Leander & Burriss, 2020).

Third, this study suggests that the AI developed as a collaborative peer for educational purposes should have a stronger pedagogical grounding. Students expressed that it is not enough for AI to simply provide a list of figures and replace their clumsy hand-drawn figures automatically. Students expected AI to support their learning and address different needs and aspirations of learning. The richest applications of AIED link to the use of explicit AI-based pedagogies. The pedagogically-rich AI has a substantial effect and significance in fostering meaningful learning for students (Holmes et al., 2019). Without having a thoughtful consideration of a range of different teaching and learning approaches underpinning AI, AIED is short of a plausible theory of change to lead a transformative change in education outcomes. Positioning AI in students’ learning would thus require a shift towards education-first from AI-first. In this regard, policymakers, educators, and educational AI developers must collaboratively design a pedagogically meaningful optimization (content curation), communication methods, and socio-emotional interaction between students and AI.

Lastly, the roles of AI in supporting students’ learning tasks may vary depending on how students conceptualize AI, the levels of domain-specific skills, as well as collaborative skills with AI. In this respect, it is crucial to assist students not only to teach how to use AI effectively but also to offer a collaborative experience whereby students can develop a better understanding of AI teammates. In human-human teams, shared understandings of teammates are invoked and developed naturally through time and experience. In contrast, student-AI teaming requires teachers to put more effort into building collaborative relationships. For instance, teachers should create learning activities to promote an understanding of student-AI teams so that students learn AI’s strengths, weaknesses, way of thinking, responses to a specific situation, and vice versa. In doing so, students can recognize the value that AI can offer to the learning experience (Edwards et al., 2018). In addition, the systematic design of instruction should embed SAC within an authentic learning context in which students use their domain-specific knowledge to solve a problem through interaction with AI. Instructors should provide students with adaptive support at different stages of problem-solving performance during SAC.

**Limitations and recommendations for future research**

This study provided an in-depth understanding of students’ perception and expectations of AI teammates as well as barriers to developing SAC. However, this study has several limitations because the perceptions of SAC can vary depending on the characteristics of students, types of AI, and
learning tasks. First, future studies need to validate the findings in many students in different educational levels (i.e., primary and secondary school students) along with various learning tasks (i.e., writing, music composing, research tasks, etc.). Second, the study provided the participants drawing experience with AI to facilitate the interview. However, the selected AI drawing system offers minor support in collaboration settings, and intervention is conducted in a limited time. Future research can provide an authentic co-creative experience between students and the AI system equipped with more advanced functions for collaboration for a prolonged time to form strong opinions about SAC. In addition, future research can analyse and interpret interview data using qualitative data analysis (QDA) software, but not limited to, NVivo, Atlas.ti, MAXQDA, etc. for the different possibilities for interview data analysis and interpretation. For instance, future work can attempt to conduct text mining (i.e., word frequency, keyword-in-context lists, and dictionary-based automatic coding using word-based features) and visualize such relationships, patterns, and dependencies using diagrams, concept maps, charts, etc. Furthermore, future research on teachers’ perception of SAC will offer additional insights into human-AI teaming in education. Teachers should play an important role to facilitate SAC particularly for students with low competencies to collaborate with AI (Kim et al., 2022).

**Disclosure statement**

No potential conflict of interest was reported by the author(s).

**Notes on contributors**

**Jinhee Kim** is an Assistant Professor at the Department of STEM and Professional Studies, Old Dominion University, U.S. A. Her research interests include AI in Education, Human-AI Interaction in Education, and Learning and Teaching Analytics.

**Young Hoan Cho** is a professor at the Department of Education, Seoul National University, South Korea. His research focuses on student-centered learning, online learning, learning analytics, and AI in education. He is a founding director of the Learning Sciences Research Institute, Seoul National University.

**ORCID**

Jinhee Kim [http://orcid.org/0000-0002-3365-7354](http://orcid.org/0000-0002-3365-7354)

Young Hoan Cho [http://orcid.org/0000-0002-1775-7953](http://orcid.org/0000-0002-1775-7953)

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