

How university students negotiate cognitive-social interactions and leverage cognitive tools for mobile peer tutoring

Seng Chee Tan, Yin Ling Cheung, Chee Kit Looi

National Institute of Education, Nanyang Technological University, Singapore

This paper reports a case study of 20 university peer tutor-tutee dyads which engaged in online synchronous peer tutoring using MENTOR, a mobile application developed to support peer tutoring. Despite years of research, peer tutoring still attracts significant attention and an emerging area of research is online peer tutoring. This study aimed to contribute to research on mobile peer tutoring, which is still in its infancy stage. Underpinned by Vygotskian social-cultural learning and Wertsch's notion of mediated actions by tools, a qualitative analysis of the recorded tutees' mobile phone screen during the peer tutoring sessions was conducted. Our findings show three different types of peer tutor-tutee social cognitive interactions, with varying degrees of tutees showing agency in seeking clarifications. While most tutees demonstrated some level of agency in seeking clarifications, fewer tutees showed agency in co-annotating on the canvas space. The findings also illuminate how the participants leveraged the canvas tools provided by MENTOR to create a shared understanding and cognitive convergence.

Implications for practice or policy:

- University teachers could engage students in peer tutoring using mobile applications
- Peer tutors could engage tutees by asking questions or pause for clarifications
- Tutees could play an active role in seeking clarifications or offer their ideas
- Mobile peer tutoring participants could leverage features of the technology to create a shared understanding

Keywords: peer tutoring, mobile learning, technological tools, mediation, case study

Introduction

This study examined how university students, engaged in peer tutoring supported by a mobile application, negotiated cognitive-social interactions and co-construction of artefacts to achieve the goal of peer tutoring. Research on peer tutoring has been conducted for more than four decades and has accumulated evidence of benefits, such as enhancing academic performance and attitudinal outcomes (Bakare & Orji, 2019; Boz Yazman, 2019). Various modes of peer tutoring have also been reported and corresponding definitions offered. For example, Evans et al. (2001, p. 161) described peer tutoring as a structured process “involving students in each other’s academic and social development” that “allows students to interact and to develop personal skills of exposition while increasing their knowledge of specific topics.” Topping et al. (2013) experimented with reciprocal peer tutoring that involved switching of tutor or tutee roles among peers from the same program. They stated, “peer tutoring consists of people of similar social status helping others to learn and learning themselves by teaching” (p. 226).

Despite years of research, peer tutoring still attracts significant attention (e.g., Alegre et al., 2019). An emerging area of research is online peer tutoring, such as the use of online discussion for tutoring first-year students by seniors (De Smet et al., 2008) or reciprocal e-tutoring through structured role switching for students taking turns to be e-tutors (Sansone et al., 2018). Ghadirian and Ayub (2017) also reported different e-moderating behaviours of undergraduates and related their behaviours to their perception of online learning.

The use of mobile technology for peer tutoring, however, is still in the infancy stage. A literature search for mobile technology for peer tutoring was conducted using Ebscohost with databases such as Academic Search Complete, British Education Index, Education Source, ERIC, APA PsychArticles, and APA PsycINFO. The search terms were “peer tutor* AND (mobile) AND (college or university or higher education or postsecondary education or undergraduate)”, from 2000 to 2021, limited to journal articles. Of the 82 items identified, 14 were related to peer tutoring and among those, only 3 used mobile technologies to support peer tutoring. For example, the use of instant messaging for learning a foreign

language (Baek et al., 2017), for peer support among university students (Timmis, 2012), and the use of mobile phones by Syrian refugees to learn English (Tanrikulu, 2021). Compared with other digital solutions, mobile technologies offer flexible and convenient applications of peer tutoring at different locations and time, that could enhance help-seeking behaviours. A needs analysis conducted by the authors (Tan et al., 2020) revealed some useful features of such an application. However, none of the articles reported dedicated mobile applications developed to support peer tutoring. This study focused on the following research questions:

1. What do online peer tutoring sessions supported by the mobile application look like?
2. How do peer tutor-tutee dyads negotiate cognitive-social interactions?
3. How do peer tutor-tutee dyads leverage social cognitive tools for mobile peer tutoring?

These questions are crafted to help direct the research to explore several pertinent issues. First, given the embryonic state of research, the first research question aimed to illuminate the process of mobile-supported peer tutoring. Second, a critical factor for successful peer tutoring is the meaningful interaction between tutors and tutees (e.g., see Cantinotti et al., 2017). The second question aimed to uncover how the peer tutor-tutee dyads negotiate their social cognitive interactions. Underpinned by Vygotskian theory of social-cultural learning (Vygotsky, 1978), peer tutoring involves cognition through social interactions, and tools or instruments have a transformative power that enables such process. For example, do tutees always play the role of passive recipients of information? Also, the social interactions between a peer tutor and tutee are usually mediated by language (talks), but in the case of mobile learning, other tools could mediate this process. In this study, a shared synchronous canvas was made available to the peer tutor-tutee dyads. The third research question aimed to examine how the dyads use the features of this canvas and their own communication strategies to achieve some level of shared understanding.

Literature review

Peer tutoring

Peer tutoring has historically been conducted in several ways, varying in the dimensions of peer tutor-tutee competence level (e.g., a qualified senior sanctioned by the teacher as a peer tutor or someone volunteers as a peer tutor), amount of structure (e.g., formal sessions arranged by the teachers versus fluid exchanges among peers), and the roles of tutors and tutees (e.g., fixed roles as peer tutors or tutees, or rotating of roles in reciprocal peer tutoring). Peers form the critical social elements in learning. Learning takes place in the zone of proximal development (ZPD), "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Peers, having overlapping ZPDs, are likely to empathise with one another over the challenges in learning, and play the rotating roles of a tutee and tutor. Post-Vygotskian theorists such as Lave and Wenger (1991) highlighted the distributed nature of cognition, which views knowledge (and intelligence) as not residing in a single person's head but distributed across people, and artefacts in the context of the interactions. In a community, there is naturally distributed expertise and interest among peers. In various contexts and for different topics, learners can assume a role of being more knowledgeable others (Vygotsky, 1978). Thus, it is feasible for reciprocal peer tutoring to occur where students could play the roles of a tutor or a tutee depending on their knowledge or expertise of a topic (Bakare & Orji, 2019).

Peer tutoring has been regarded as a form of collaborative learning by several researchers (e.g., De Smet et al., 2008) and a few concepts of collaborative learning are pertinent to peer tutoring. For instance, peer tutor and tutee have to reach a common ground (Clark & Brennan, 1991) to enable a shared understanding of what is being discussed. Research studies have also shown that peer tutoring is facilitated by a good working relationship between a tutor and tutee (Boz Yaman, 2019) and a good social network among peer tutors and tutees (Dong et al., 2019). Meaningful interactions between a peer tutor and tutee remain critical. Also, peer tutors usually assume agency by initiating discussion and communicating effectively (Boz Yaman, 2019) and they may play several roles, including motivating tutees and constructing knowledge with tutees (De Smet et al., 2008).

The term agency refers to individuals operating with mediational means (Wertsch et al., 1993), as well as engaging in intentional goal-directed actions (Damşa et al., 2010). Tutees can also show agency by playing

an active role in the tutoring process. In short, both parties need to be actively involved in the process (Westera et al., 2009). The social-cognitive interactions between a peer tutor and a tutee are mediated by tools and artefacts, which are elaborated in the next section.

Tools for mediated actions and cognition

Mediated action (Wertsch, 1994) is the concept of how humans leverage cultural tools to enhance our competence in accomplishing specific actions, such as using a mobile phone to interact with others anytime, anywhere. From the perspective of social-cultural learning theory (Vygotsky, 1978), learning is necessarily social as it occurs first through the inter-mental plane (with more knowledgeable others such as tutors) and then to the intra-mental plane (a person internalising what is learnt). Learning is also cultural as "learning is a necessary and universal aspect of the process of developing culturally organised, specifically human psychological function" (1978, p. 90). According to Vygotsky, tools or instruments have a transformative power that enables us to achieve higher mental functions. In sum, cultural tools are a critical part of learning as we learn to use the cultural tools and these tools act as a mediator for learning.

From a cultural-historical perspective, these tools are products resulting from relevant knowledge (e.g., advancement in mobile technology and ubiquitous learning) and as they are used by the community, they are subject to constant innovation and change. Vygotsky focused on a person mastering the existing culturally produced mediational means (e.g., a heuristic). Wertsch (1994), however, argued that humans are not just using these tools, but are transforming the use of the tools, and associated meaning systems in the process. Gillespie and Zittoun (2010) held that tools "designed for one purpose, or conceptualized as being for one purpose, may, in the next moment, become appropriated and used for a second purpose" (p. 44).

In the context of using a computer application as a tool, the difference in intended design versus usage can also be explained from the theory of affordance. Gibson (1979) proposed affordance as an ecological concept, the *action possibility* available in an environment to an individual, such as an ecological niche that supports specific animals in nature. Norman (1988) applied the concept to human design and highlighted how the design of an object is perceived by people as cues to its functions and uses. Kennewell (2001) extended the concept to both attributes and constraints, stating "the attributes that provide potential for action" which is coupled with constraints as "the conditions and relationships between attributes that provide structure and guidance for the course of actions" (p. 106). The designer of a tool might have intended affordances in mind, and have certain attributes and constraints built into the design of a tool. The actual usage, however, is dependent on how the users perceived the affordances. Thus, the canvas of a mobile application might have certain design features (e.g., annotation), but the users might contribute to the creative use of these features in different ways.

Computer-based cognitive tools that support cognitive-social interactions

To Vygotsky, cognitive tools are cultural tools that help us in thinking. Mathematics operations, for example, are cognitive tools. Following this conceptualisation, a computer-based tool (e.g. calculator) supports mathematical calculations but with enhanced efficiency (computes faster with no errors). Pea (1985), however, suggested using computers as a cognitive tool goes beyond enhancing the efficiency of thinking (amplifying a tool) but reorganises the tool and affords new ways of thinking (e.g., a spreadsheet that supports calculation and calculations for different scenarios). Salomon et al. (1991) differentiated between "tools that work for us" and "tools with which we work" (p. 3). They suggested that cognitive tools have effects with the tools in terms of enhancing performance, as well as effects of the tools that result in changes in students' competence. Jonassen (2000) called cognitive tools *mindtools* that work as intellectual partners with students to help develop their critical thinking. A mobile peer tutoring application can be considered a social mindtool (Tan, 2019) because it mediates the social cognitive interactions among learners. In short, researchers suggest using computers in transformative ways that support cognition beyond the material and cultural thinking tools.

Artefacts for mediated actions

To Vygotsky (1978), tools and signs (e.g., language) play different mediating roles because tools are for physical work and directed outward at material objects, whereas signs are for psychological and social

interactions, and directed inward at changing one's mind and behaviours. In the context of learning through social media, Rambe (2012) reported how Facebook mediates student learning with technological tools (e.g., interaction space) and conceptual tools (e.g., questions, queries). Markauskaite and Goodyear (2017) argued that epistemic tools (p. 242), or tools for knowledge-related work, encompass both material and symbolic tools that mediate our knowing of nature, directed at both sign and material world, and for changing the knowledge of the world. Popper (1979) distinguished the World 1 (physical), World 2 (mind), and World 3 (knowledge inscribed in World 1) objects. For example, when we put our thoughts (World 2) into writing on a piece of paper (World 1), the inscribed physical paper then contains embedded symbols representing our thoughts (World 3). Epistemic artefacts become the bridge for assessing one's cognitive ideas and mediate the dialogic interactions among people.

Paavola and Hakkarainen (2005) coined the term *triological* approach to learning, as dialogic interactions among people plus the mediation by knowledge artefacts. Examination of knowledge artefacts provides a means for us to study the conceptual interactions among people. For example, when students engage in a discussion using an online forum, the notes they create (knowledge artefacts) allow us to examine their exchanges of ideas (Fitzgerald & Palincsar, 2017). Artefacts thus possess the thing, or property, that can be worked on. The inscription represents one's idea. The functional aspect allows one to act on ideas, and the affordance to explain something. In this study, the canvas on a mobile application can be seen as an epistemic tool that mediates interactions among learners as a peer tutor is teaching a tutee.

Methods

Research design

This study adopted a case study approach (Stake, 1995) that focused on the empirical investigation of the phenomenon of mobile peer tutoring within a real-life context. In this study, a case is defined as a peer tutor-tutee dyad. It is an instrumental case study (Stake, 1995) in that the focus is not on the cases (the peer tutor-tutee dyads) themselves, but these cases were used to understanding the mobile peer tutoring process between the participants. An interpretive approach was adopted as the study focused on understanding the processes of mobile peer tutoring that is a relatively unexplored area, rather than comparing one method of learning with another.

Participants and procedures

Approval for this study was given by the Institutional Review Board (IRB-2020-02-038-01) at the Nanyang Technological University in Singapore. Various methods of recruitment were used, including physical posters and emails. Follow-up communication to explain the research and their rights as research participants and to obtain their consent was conducted with the students who responded. This study was part of a larger study and this paper focused on the relevant data source and analysis. There were 21 students who gave their consent to participate in this study. Following the intention of the mobile application, reciprocal peer tutoring (Bakare & Orji, 2019) was encouraged, instead of the traditional tutoring performed by peer tutors sanctioned by the university instructor. The students were asked to provide a topic for which they needed tutoring, and a matching peer tutor, among the participants, was identified by the researchers. The sessions proceeded once a peer tutor-tutee dyad agreed to the matching. One peer tutor-tutee did not make use of canvas and was excluded from this analysis. Consequently, the analysis focused on data from 20 peer tutor-tutee dyads.

The participants were asked to download the mobile application using their mobile phones and were provided with log-in information. An agreed time for both parties was negotiated and the peer tutor and tutee were asked to go to any location they deemed conducive to the sessions. Information about the locations of the participants was not collected to respect their privacy. The data collection occurred in the third quarter of 2020 when in-person interactions were restricted due to the COVID-19 pandemic. The peer tutoring occurred through MENTOR with voice communication and shared annotations on the canvas. To reduce potential confounding effects due to the presence of the researchers, the tutee was asked to project their screen to a concurrent Zoom set-up so that the tutee's mobile screen, together with the voice recording of the peer tutor and tutee, could be recorded. No constraint was placed on the duration of the peer tutoring sessions.

Mobile application

A needs analysis conducted by the research team (Chung & Tan, 2019; Tan et al., 2020) showed students’ preferences for features in a mobile application such as peer tutor-tutee matching and shared canvas space integrated with voice communication and text messaging. Such a mobile application was not available when the team started the development in 2017. The mobile application MENTOR was thus developed (Chung & Tan, 2019; Tan et al., 2020) by analysing the learning psychology and behaviours related to peer tutoring and the corresponding affordances. For instance, using a mobile application allows users to seek help anytime, anywhere. To encourage self-regulation, tutees were asked to identify the level of cognitive processing the tutees expected of a topic (Anderson & Krathwohl, 2001). This was presented to the tutee as a statement: “I would like to learn how to...” and the following options were available: “remember, understand, apply, analyse, evaluate, synthesise”. When the peer tutor and tutee were paired and logged on at the same time, they could communicate via voice over internet protocol (VoIP) and a canvas would appear (Figure 1). If they had preloaded a document, it would appear on the canvas. If not, an empty canvas would be available.

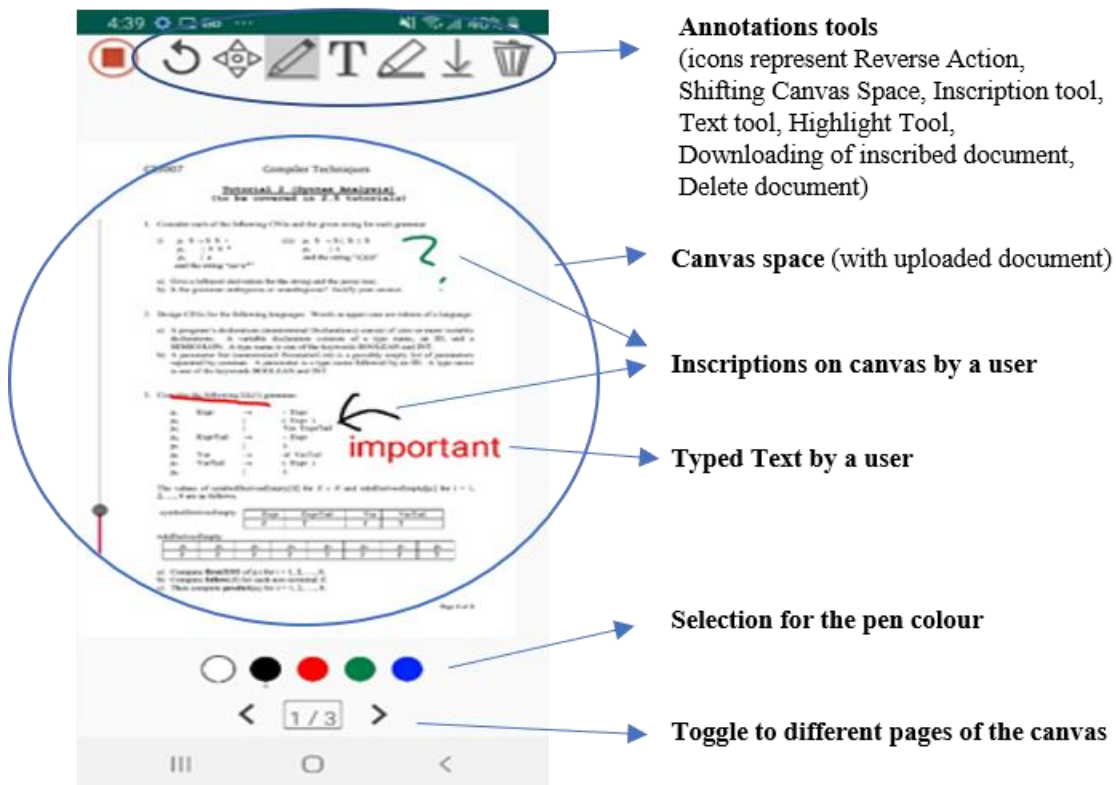


Figure 1. The annotatable shared canvas space

Methods: Analysis of the process

The main source of data was the video recordings of the tutee’s mobile screen, with the associated talks between the peer tutor and tutee, and the corresponding inscriptions on the screen. The researchers viewed the video recordings (screen capture of tutee’s mobile phone) and the audio recordings several times to understand the process of peer tutoring.

To answer the research questions and based on the literature review on the mediated actions and cognitive tools, the following framework (Figure 2) guided the analysis. The analysis focused on the talks (mediation by language) between the peer tutor and tutee dyads, and the following sub-questions were asked: “Who led the talks?”, “Did the peer tutor invite the tutee to talk?”, “Did the tutee actively seek clarifications?”, and “Did the tutee offer his or her own ideas?”. Simultaneous to the peer tutor-tutee talks was the canvas space, where documents could be uploaded and annotated by both the peer tutor and the tutee. The following sub-questions were asked: “Who led the use of the canvas space?”, “Did the peer tutor invite the tutee to

annotate?”, and “Did the tutee actively contribute to the annotation?” Another set of questions related to how the participants made use of the tools provided in the canvas space (reverse action, move canvas, inscription, typed text, highlight, download, delete), when using the free-hand inscription tool, and enquired what other communication strategies each brought into the canvas space.

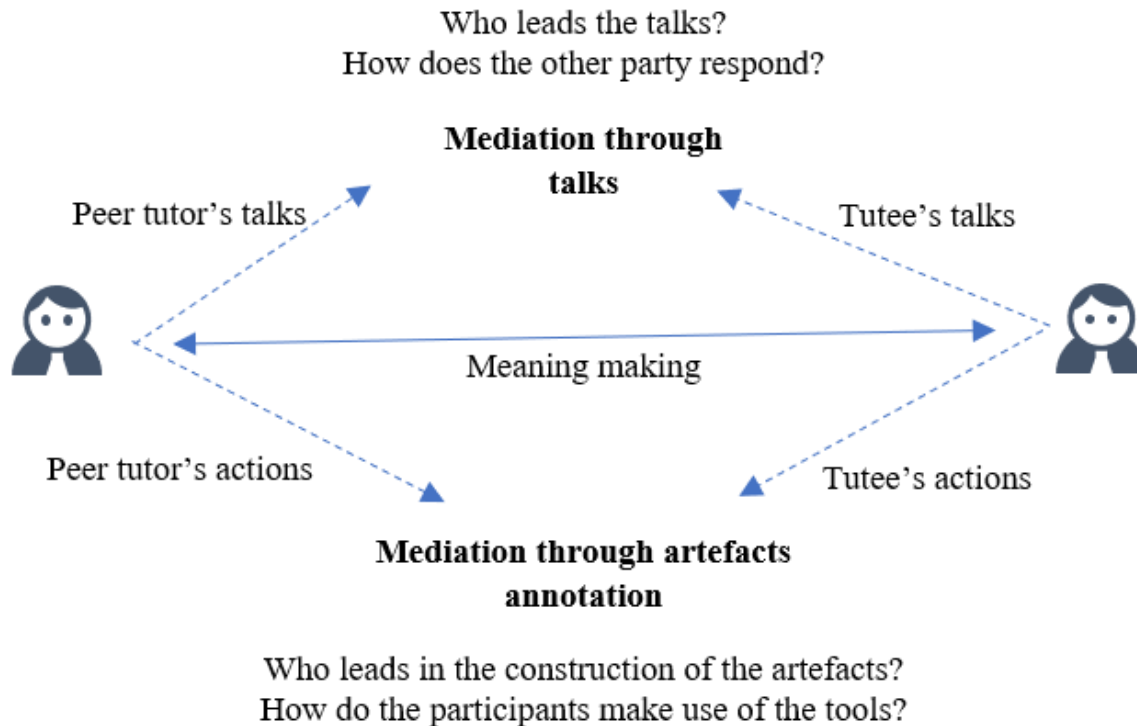


Figure 2. Framework for analysis

Findings

To answer the first research question, we first provide short descriptions of the peer tutoring process demonstrated by three pairs of peer tutor-tutee dyads that epitomise the three typical interactions.

Didactic approach

In Case 18, the tutee wanted to understand more about natural language processing (NLP) in the field of artificial intelligence. The peer tutor started by introducing himself and the topic of NLP. He provided the explanation using simple-to-complex sequencing, starting with the meaning of NLP and examples of NLP applications. This was followed by how NLP works, and then the more technical terms of morphology, syntax, semantic, pragmatic, and phonology were introduced. As he explained, he scribbled the keywords on the canvas. For example, he explained two categories of parsing (nominal phrase [NP] and verbal phrase [VP]) and scribbled the keywords and the relationship on the canvas (Figure 3). The explanation was peppered with short questions like “Any question so far, no right?”, which would be responded to by the tutee with short answers like “Okay”. The session lasted for 27 minutes and 25 seconds. Out of the 20 peer tutor-tutee pairs, only Cases 18 and 20 showed the strong didactic approach where tutees were reticent for almost the entire duration of tutoring.

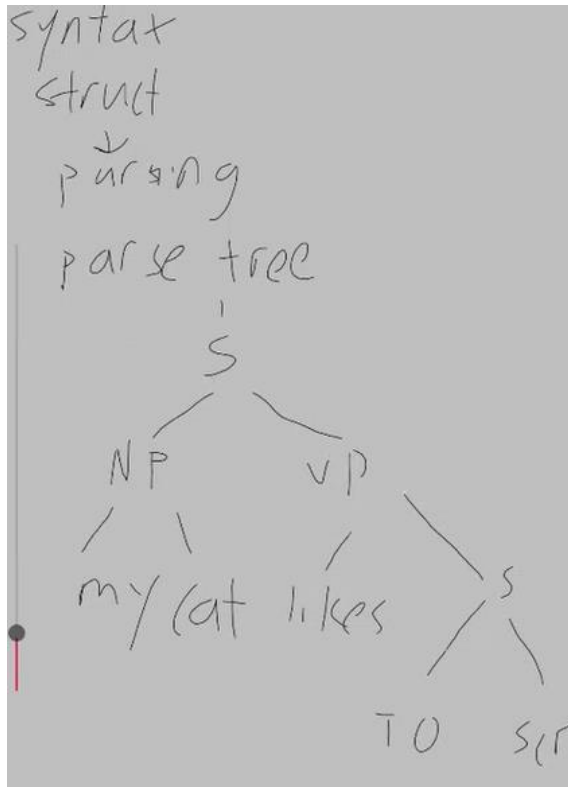


Figure 3. Canvas was used by the peer tutor to record the keywords in Case 18

Tutee actively seeking clarification

In Case 3, the tutee wanted to find out how knowledge building can be used for adult learning. The peer tutor started the session by scribbling the topic of tutoring (Figure 4, point 1). As the tutee was talking, the peer tutor scribbled the key ideas conveyed by the tutee (Figure 4, point 2). The peer tutor then began explaining the approach to eliciting ideas from the participants and scribbled these ideas below (Figure 4, point 3). He explained, “If you don’t set the parameters and it’s too wide, they may learn things all over the place..” To this, the tutee clarified, “When you said parameters ... in terms of topic? In terms of content?” As the peer tutor was elaborating on setting parameters, the tutee scribbled his understanding of “setting parameter” (Figure 4, point 4). The tutee then asked the peer tutor if asking these questions (e.g., How do aeroplanes fly?) are examples of setting parameters? The peer tutor then clarified this concept further and went on to explain the subsequent actions the tutee can do with his trainees. There were 7 cases where tutees actively sought clarification (Cases 3, 5, 7, 8, 10, 17, 19).

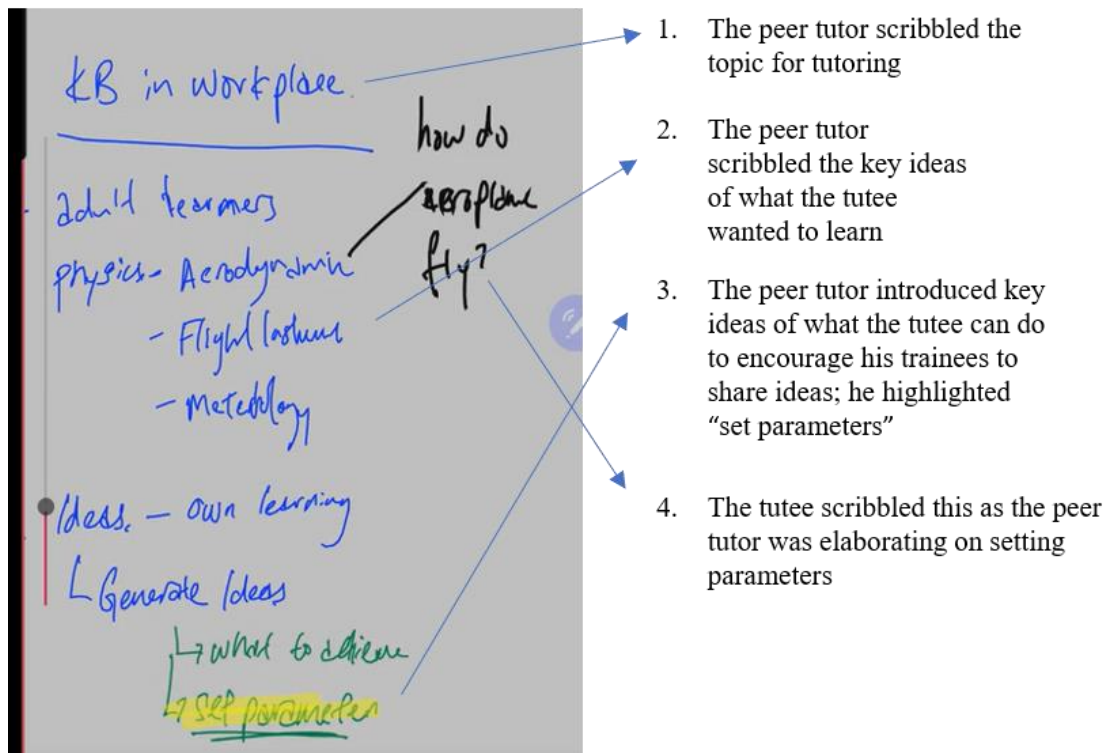


Figure 4. Inscription by the tutor and tutee during the peer tutoring

Peer tutor-tutee co-construction

In Case 14, the tutee wanted to analyse the differences between writing an abstract and writing an introduction for an academic paper. Due to the different resolutions of the mobile phones of the users, the canvas may appear out of the screen and require a user to move to different parts of the canvas. Figure 5 and 6 show what appeared on the same piece of canvas, but due to the limitation of the screen size, the screen captures are separated into two figures. Also, the users can type or scribble the text anywhere on the canvas, not necessarily top down; the number shows the sequence of appearance of the texts on the screen. The peer tutor first invited the tutee to type, on the canvas, the key points he would include for an abstract (Figure 5), while she typed the list of key points needed for an introduction at the lower part of the canvas (Figure 6). The tutee typed a long list horizontally (Figure 5, point 1). At the same time, the peer tutor typed several key points (top-down list) (Figure 6, point 1). The peer tutor then read the tutee's answer and commented on his answer. She circled "information" and suggested providing more details (Figure 5, point 2). She then commented that "method" should include "participants", "protocol", and "data" (Figure 5, point 3). After commenting on the answer of the tutee, the peer tutor went on to explain what to include in an introduction (Figure 6). She explained that the introduction requires more in-depth descriptions (Figure 6, point 2), whereas one to two succinct sentences from the introduction could be added to the abstract (Figure 6, point 3) to form the background of the study. The tutee thanked the peer tutor for the elaboration and he opined that what the tutor described was for a scientific paper, and sought further clarification on whether the same approach can be used for academic writing in other disciplines.

What we observed, in this case, was that the tutee assumed a high level of agency in questioning and defining the space of what he wanted to learn, and even offered comments on the tutor's answer. There were 11 cases that showed the varying extent of tutees offering his or her ideas during the tutoring (Cases 1, 2, 4, 6, 9, 11 to 16).

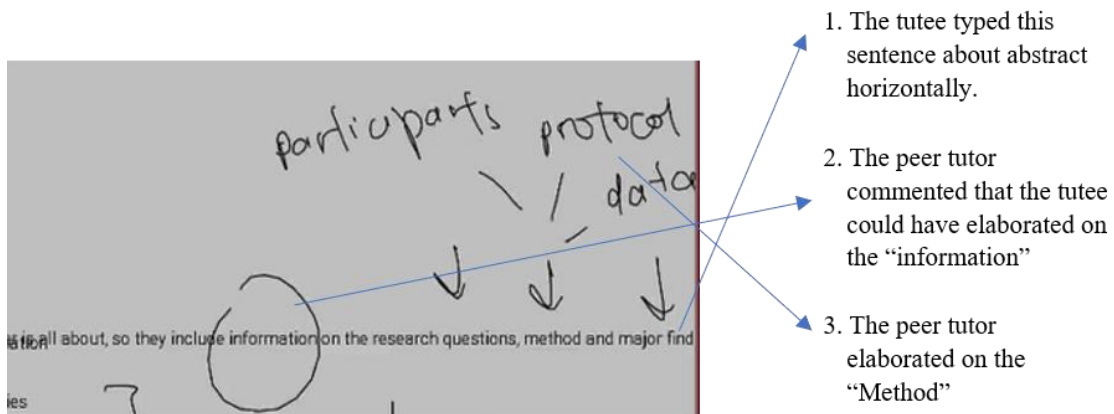


Figure 5. Co-annotation of the canvas by the tutor and tutee, top part of the canvas

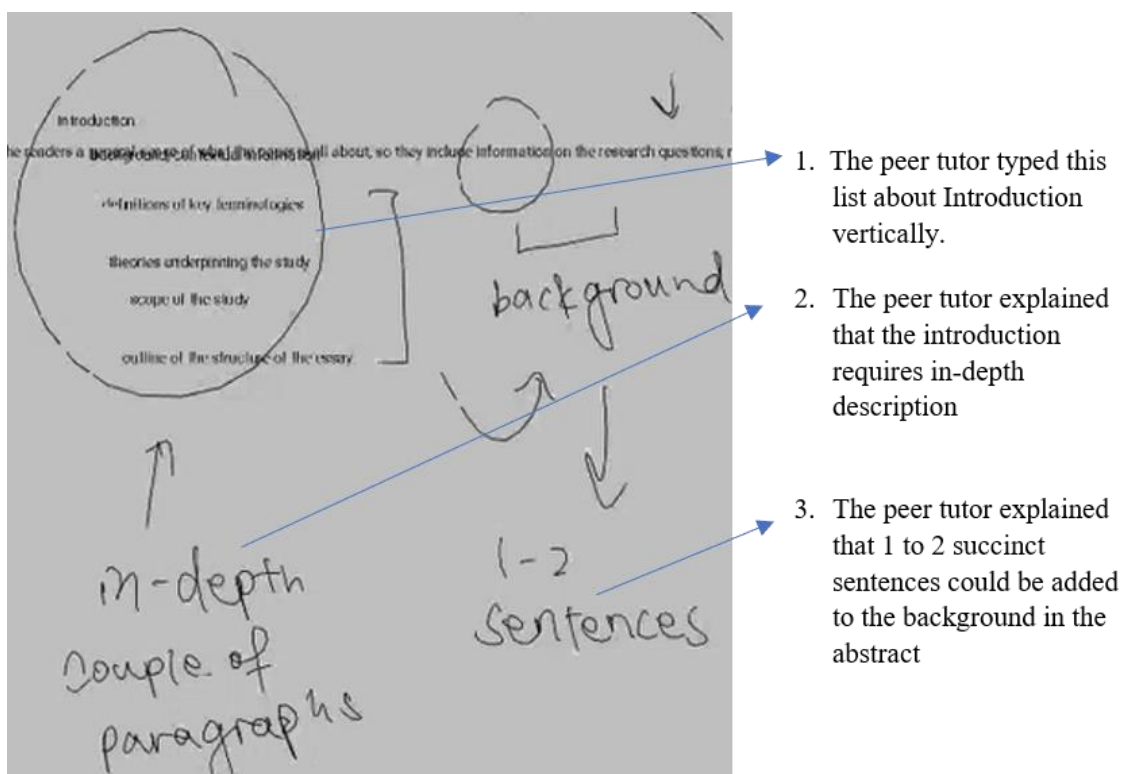


Figure 6. Co-annotation of the canvas by the tutor and tutee, lower part of the canvas

To answer the second research question, we examine the distribution of roles between peer tutors and tutees, their level of agency in directing the process, and how they made use of the canvas tools as they talked.

Negotiating social interactions: Tutors’ responsibility and tutees’ agency

In a peer-tutoring context, the peer tutor is assumed to be the more knowledgeable. Thus, the agency in directing the discussion is expected to rest with the peer tutor. This was manifested as most peer tutors took the lead in the peer tutoring session, usually starting by introducing themselves and the topics. They played their roles as tutors by providing explanations to the tutee and trying to engage the tutees by asking questions. The tutees, in response, asked questions or provide cues (e.g., uttered “OK”) to let the peer tutor know that their messages were received. This is similar to the typical situation of a tutorial conducted by a university faculty.

In the online context and without the presence of video cues, turn-taking between the dyads was often directed by the peer tutors, such as asking a question, for example, “Do you understand this part?”, “Are

you okay with this?”, “Can I move on?”, or simply pausing. Thus, a tutee who wanted to be more active in this process needed to discern such cues to jump in with a question. A few tutees shared that they missed the opportunity to ask questions when there was no appropriate space in the form of a question or a pause created by the peer tutors.

The differences in the level of interactions were influenced by the tutees' agency in the process. For example, in Case 18, the tutee played a passive receiver role. She asked a simple short question only once when prompted by the peer tutor and provided short responses such as “Okay” most of the time. More than 95% of the interaction talking was done by the peer tutor. In other cases, the tutees demonstrated a higher level of agency by asking questions. In Case 3, however, the tutee elaborated on what he wanted to find out about implementing knowledge building in the context of professional training for adults. The tutee also jotted his ideas on the canvas and clarified with the peer tutor whether he applied the tutor's suggestion correctly (Figure 4).

At the other end of the agency dimension, some tutees played an active role in the process, sometimes offering their ideas. This was illustrated in Case 14, where the tutee wanted to analyse the difference between writing an abstract and an introduction for an academic paper. He took up the peer tutor's suggestion by typing his ideas of writing an abstract on the canvas. He even countered the tutor's suggestion by pointing out the limitations of the tutor's approach. In Case 11, the tutee wanted to practice solving equations and he took the initiative to write an equation on the canvas for the tutor to coach him.

Cognitive tools: Functional roles of mediating artefacts

To answer the third research question, we examine how the participants created mediating artefacts to help them establish the shared understanding. The canvas afforded the space and a suite of tools for the participants to create artefacts to mediate their meaning-making process. The goal was to achieve cognitive convergence such that the tutee and peer tutor achieved some level of common understanding of the topic being discussed. In demonstration of this convergence, our analysis showed the participants creating artefacts for several related functional roles: (a) inscription of text to record key ideas for grounding, (b) elaboration on inscribed ideas (shows sequence, shows hierarchies, emphasises inscribed ideas), and (c) explaining using model or diagrams.

One approach used by the peer tutor-tutee dyads was to simply record (type or scribble) the key ideas being discussed on the canvas. The inscription of key ideas can be seen in all the above three case descriptions. This approach was characterised by the synchronicity between speech (phonological representation) and text inscription (morphological representation).

Once the ideas were inscribed on the canvas, further meaning-making strategies were demonstrated. For example, in Figure 4, the text inscription captures other information such as *hierarchy* (e.g., Figure 4, use of arrow to show concepts under aerodynamics) and *emphasis* (e.g., Figure 4, using highlight for emphasis). In Figure 5, the peer tutor circled the “word information” typed by the tutee, and scribbled more words (protocol, data) and drew a line to link to the word “method”. Later, she circled what she typed (Figure 6), scribbled an explanation that these are in-depth descriptions for writing an introduction, drew a square bracket, scribbled “background” and linked it to the introduction typed by the tutee. Beyond inscription, the peer tutor attempted to achieve *grounding* (circling) and *relating* (linking lines).

Beyond the three illustrative cases, we witnessed other functional roles of mediating artefacts. These include a model to explain the use of games in education (Figure 7) and the use of a diagram to explain the differences between single-thread and multithread (Figure 8). These are pre-identified models or diagrams that the peer tutor brought into the canvas to enhance the explanation.

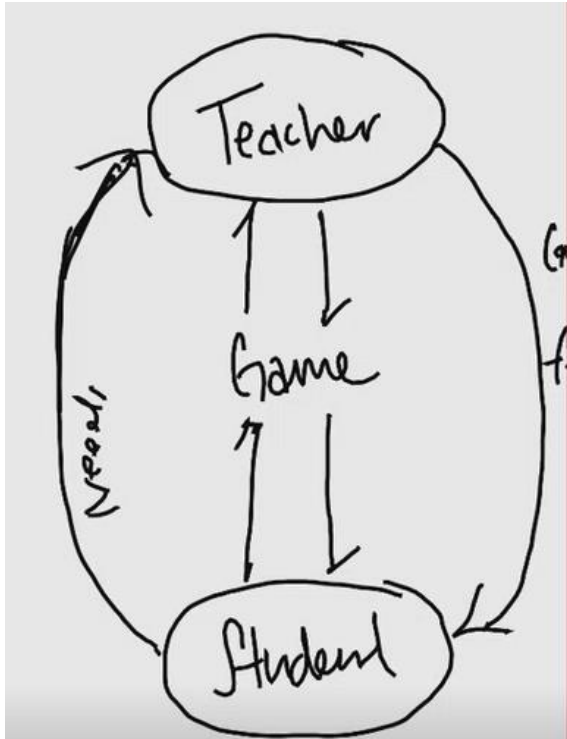


Figure 7. Hand-drawn model explaining the use of educational games

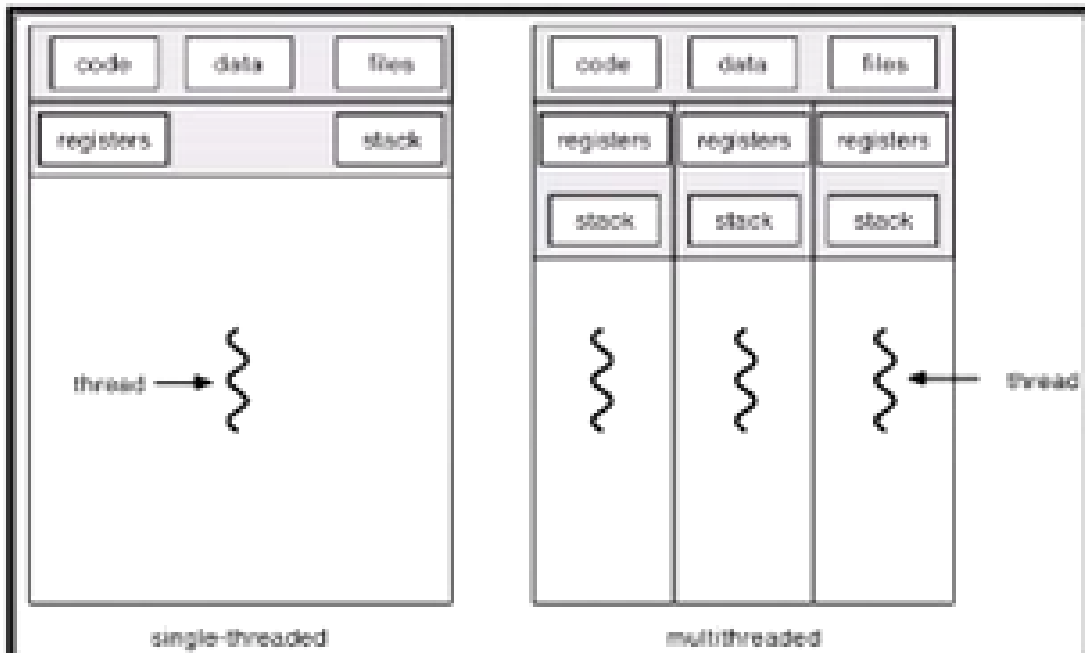


Figure 8. Pre-loaded diagram explaining differences between single-thread and multithread programming

Discussion

Negotiating cognitive-social interactions

This study examined how peer tutor-tutee dyads made use of a mobile application developed to support peer tutoring. If we take the affordances of the tools as the intended affordances and constraints specified by the developers of the mobile application, this study revealed how the participants jointly manoeuvred this space and the various configurations of peer tutor-tutee partnerships that emerged towards achieving

the goal of peer tutoring The process of peer tutoring was mediated by talks (language) via the VoIP protocol of the mobile application, as well as (co)construction of artefacts using the canvas in the mobile application (Table 1). As a dyad embarks on the process, negotiation of social interactions is reflected in the unspoken rules manifested between the pair, starting with the basic turn-taking and the more fluid interactivity. The peer tutors were assumed to have the control, with varying degrees of responsiveness from the tutees. The peer tutors played the teaching or scaffolding roles as expected, and tutees demonstrated various degrees of agency besides the expected receiver of information.

The social negotiation between a peer tutor and the tutee occurs along a continuum with one end defined by the highest level of tutor agency and the other end the highest tutee agency (Table 1). The peer tutor's agency in leading the tutoring session was expected, and was reflected in all tutoring sessions where the peer tutors initiated the interactions with the tutees by introducing themselves, stating the topics of tutoring, or clarifying the questions asked by the tutees. Peer tutors extended this agency by inviting the tutees, either to ask questions or to draw on the canvas. While some tutees played the role of passive recipients, waiting to respond to the peer tutor's actions, others demonstrated more agency by actively seeking clarifications, and a few showed strong agency by offering their ideas as counter-arguments or even initiated the use of the canvas space. Intriguingly, while many tutees were active in seeking clarifications or offering their ideas, tutee's agency was not frequently manifested in the use of the canvas. Only 6 out of 20 tutees showed co-annotations on the canvas.

Table 1
The variation of peer tutor-tutee agency configurations

		Tutor agency		Tutee agency	
Talks (mediation through language)	Peer tutor leads the talks	Peer tutor invites the tutee to ask questions	Tutee actively seeks clarification	Tutee offers his or her own ideas	
Canvas (mediation through artefacts)	Peer tutor leads the annotations on the canvas	Peer tutor invites the tutee to annotate on the canvas	Tutee co-constructs the annotations on the canvas	Tutee leads the annotations on the canvas	

What the peer tutors and tutees demonstrated reflected their epistemological stance towards learning. Taking an acquisition approach to learning (Sfard, 1998), knowledge can be treated as objects that can be passed from the peer tutor to the tutee, as exhibited in the didactic approach of Case 18. A responsible peer tutor would transmit knowledge as effectively as possible and the tutee would receive it correspondingly as actively as possible. What the peer tutor-tutee co-construction of Case 14 demonstrated, however, was that learning could be participatory (Sfard, 1998) where meaning-making and co-construction of understanding are prized, rather than one-direction transmission. The tutee in Case 14's counterargument showed clearly this orientation. This finding is consistent with the research results reported by Lin and Yang (2013) and Westera et al. (2009). The similarity could be due to the fact that successful peer tutoring depends on the meaningful interaction between tutors and tutees. Both peer tutors and tutees needed to be actively involved in the learning process for peer tutoring to be successful.

Use of artefacts

The use of the canvas space demonstrated how the artefacts mediated the peer tutoring process. The use of canvas space by the participants demonstrated the use of epistemic tools (Markauskaite & Goodyear, 2017) for knowledge-related work. The inscriptions on the canvas corresponding to the talks provided the grounding necessary for collaborative situations. Various strategies like highlighting, indentation, hierarchy, and linking were used to enhance explanations. The use of models implied invocation of principle or theory level explanation. In the cases discussed, the use of canvas was directed at knowing and is thus an epistemic tool. It is not merely a tool that works for the peer tutor and tutee, but a tool that the peer tutor-tutee dyads work with, as a human-computer intellectual partnership, to bring about meaning-making of a topic. Specifically, the findings echo Fitzgerald and Palincsar's (2017) recommendation that "it is difficult to imagine that students would have engaged in sense-making discussions of the same quality

without the support of the scripts” (p. 325). It should be noted that Fitzgerald and Palincsar’s (2017) participants were in a sixth-grade science class in a middle school in the United States. By contrast, our study investigated university students studying a variety of subjects. Therefore our results complement those of Fitzgerald and Palincsar (2017) by using a significantly different population of university students.

Besides using the built-in features of the tools (e.g., move, typed texts, colour, highlight), the participants made full use of the free-hand inscription tool and brought in new elements such as hierarchy, indentation, circling, linking. This showed the participants’ ability to discern the intended affordances of the mobile app, and their creative partnership in extending those affordances. The participants displayed agency (Wertsch et al., 1993) in the actions mediated by the tools, not simply using the tools as provided, but transforming the power of tools in achieving cognitive convergence.

Mobile peer tutoring

In this study, MENTOR, a dedicated application was developed for the learners. In addition to reflecting on how the learners use the application, the affordances provided by the mobile devices are also highlighted. In this regard, researchers have explored the use of mobile devices for learning in higher education (e.g., Nami, 2020). Mobile learning makes use of portable devices that provide convenient access to learning in different contexts beyond a classroom, thus affording spontaneous access and interaction across various contexts, or what is commonly described as anytime, anywhere learning. Narayan et al. (2019) proposed the design principles for heutagogical learning (or student-determined learning) with mobile and social media tools. Applying Narayan et al.’s (2019) principles pertinent to this study, for example the portability and accessibility of the mobile devices, coupled with MENTOR application, encouraged learner participation (engaging in mobile peer tutoring anytime, anywhere), personalisation (identifying the topics that need tutoring), and productivity (providing the tool for social negotiation and mediating the interactions with artefacts). These are also known as the 3Ps’ (personalisation, participation, and productivity) pedagogy proposed by McLoughlin and Lee (2008) for networked society. The mobile solution also allows the learners to determine their learning contexts, at a place or location of their choice. In short, although this study focused on the social negotiation process with cognitive tools, mobile devices, as the carrier of the tool, play a critical role in this process.

Conclusion

This study set out to examine how peer tutor-tutee dyads in a university use a mobile application to conduct peer tutoring. By showing the images of peer tutor-tutee interactions and how participants leverage the cognitive tools provided in the mobile application, this study provided a glimpse into the potential and possibilities of mobile peer tutoring. Our findings showed how the peer tutor-tutee dyads negotiated the social cognitive interactions of didactic instruction by tutors, tutors explaining and tutees actively seeking clarifications, and tutees showing strong agency by offering their own ideas. Our findings revealed that most of the tutees (11 out of 20) showed some degree of agency in offering their ideas whereas tutees acting as passive receivers were the minority (2 out of 20). How the dyads interacted potentially revealed their epistemology, that is whether they viewed learning as acquiring knowledge, learning as participating in the discourse, or learning as co-construction of knowledge.

Mediating the peer tutor-tutee interactions were the talks via VoIP. In the online synchronous context, unlike in-person tutoring, peer tutors need to consciously create a space for the tutees’ clarifications by asking tutees questions, or simply a pause. The shared canvas space of the mobile application provided another critical mediating tool. The peer tutor-tutee dyads used various tools provided in the canvas (inscription, colour, highlight, zoom) to create common grounding for shared understanding, and didactic strategies of showing sequence, hierarchy, or emphasis. In the canvas space, however, there were few instances (6 out of 20) where the tutees show agency in co-annotation and co-construction of artefacts.

The findings of this study provided ideas for further exploration. For example, to relate the epistemological beliefs of the participants with their behaviours and to explore why few tutees participated in co-annotation of the canvas. The epistemic agency (Scardamalia & Bereiter, 2010) of learners is a relatively less explored area. It is about students taking over the direction of learning and managerial roles that are normally left to the teachers. Tan and Ku (2014) showed, in their study, how participants in a course showed epistemic agency by initiating knowledge-related dialogues and creating shared understanding. In this knowledge

age, how to encourage university students to assume epistemic agency is even more urgent. This study was conducted with a small sample size from convenience sampling. This was partly due to various measures imposed during the COVID-19 pandemic, which limits the generalizability of the findings. Future studies could then also have a more representative sampling of students from different disciplines, and any disciplinary differences could be analysed. Having a control group that undergoes predominant in-person peer tutoring set up by the university staff for comparison could also reveal more clearly the advantages or constraints of mobile peer tutoring.

In sum, this study provided a glimpse into how university students make use of a mobile application for peer tutoring through the three types of peer tutor-tutee social cognitive interactions, with varying degrees of tutees' agency. It also showed how the participants made use of VoIP and canvas tools afforded by the mobile application to create a shared understanding and cognitive convergence.

Acknowledgement

This study was supported by Temasek Foundation.

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Corresponding author: Seng Chee Tan, sengchee.tan@nie.edu.sg

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Please cite as: Tan, S. C., Cheung, Y. L., & Looi, C. K. (2022). How university students negotiate cognitive-social interactions and leverage cognitive tools for mobile peer tutoring. *Australasian Journal of Educational Technology*, 38(2), 113-128. <https://doi.org/10.14742/ajet.7334>