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Designing and evaluating a mobile peer tutoring application: A cultural historical activity theory approach

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Designing and evaluating a mobile peer tutoring application: A cultural-historical activity theory approach

This study focuses on university students' experience of peer tutoring supported by a mobile application called MENTOR (Mobile Education Networked Tutoring On Request) that was developed by the research team. The development of the mobile application was underpinned by theories related to self-directed learning, self-regulated learning, students' help-seeking behaviours, as well as Vygotsky's social-cultural learning theory. Using cultural-historical activity theory (CHAT) as the framework, this study examines the affordances of the mobile application, the student's perception of the application, the uptake of affordances, and the contradictions identified through CHAT. The participants identified tutor's factors (e.g., tutoring skills) and technological factors (e.g., annotatable canvas) that facilitated the process, and appreciated the affordances of convenience, flexibility, physical safety, and psychological safety of the mobile peer tutoring, especially during the COVID 19 situation. A few contradictions were identified through CHAT, which served as the impetus for improvement. Among these are the novelty of mobile peer tutoring and the lack of cues about turn-taking. Some participants did not understand the requirement to indicate the level of cognitive processing. This study contributes to the design and implementation of mobile technology in supporting peer tutoring, an under-researched topic.

Keywords: mobile learning; peer tutoring; cultural historical activity theory; design and evaluation; institutes of higher learning

Introduction

This study examines university students' experience of peer tutoring supported by a mobile application. The mobile application was developed to support anytime, anywhere peer tutoring among students studying in institutes of higher learning (IHLs).

In general, peer tutoring involves learners, who are of similar status and have overlapping or shared curriculum, helping one another to learn specific topics or solve problems by playing the roles of a tutor (Topping et al., 2013). A peer tutor can be a higher achieving or a senior student, who has shown evidence of having a better

knowledge of the topic. Alternatively, peer tutoring could also be done as reciprocal tutoring (Sansone et al., 2018), involving students in the same class or equivalent standing.

While research on peer tutoring has existed for more than two decades, the literature is relatively silent on the use of digital technologies in supporting peer tutoring. Among the few studies, De Smet et al. (2008) reported e-moderation of online asynchronous discussion by fourth-year college students for freshmen. Mobile technology, coupled with a spectrum of mobile application tools, affords new student-technology partnerships and innovative pedagogies for various educational contexts (Lim & Churchill, 2016). It is particularly more relevant and urgent during the COVID-19 pandemic when lockdown prevents physical interactions among students. However, mobile technologies have not been well exploited to support peer tutoring. A literature search conducted with EBSCOhost using the terms "peer tutor*" and "mobile" (in the field Abstract) showed 46 returns, but most articles reported the use of mobile devices or existing applications for tutorial. Commercial applications such as OfficeHour (https://ohapp.io/) have been reported but the theoretical basis for the development or efficacy of usage of the mobile applications was not available.

To address this gap, a mobile application called MENTOR (Mobile Education Networked Tutoring On Request) was developed (Tan et al., 2020). This study was guided by the following research questions:

(1) What affordances of a mobile application and what implementation arrangement would support peer tutoring?
(2) How did the participants perceive their peer tutoring experience with the mobile app?

(3) Using cultural-historical activity theory analysis, which design affordances of the mobile peer tutoring environment were positively perceived and leveraged by the participants? What are some contradictions that can inform us of the areas of improvement?

Affordances refer to Kennewell's (2001) definition of "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). For example, the canvas (shared annotatable white space) in MENTOR allows participants to co-annotate a document but they are constrained by the tools available in the canvas.

Literature review

Vygotsky's (1978) social constructivist theory of learning has been used to explain learning through peer tutoring. Vygotsky emphasized the importance of social interactions in learning: learning happens first on the social plane (interactions with others) and then on the individual plane (within a person). A person internalizes what he or she learns through social interactions with others who are the "more knowledgeable others" (e.g., teachers). Peer tutoring, regarded as a collaborative learning strategy, involves social interactions among peers who act as the more knowledgeable others. Another important Vygotskian principle of learning is that effective learning occurs within a person's Zone of Proximal Development or ZPD (Vygotsky, 1978), which is a space between the person's current development and his or her potential development when assisted by more knowledgeable others. Among peers, the ZPDs are likely to overlap. A peer who has experienced similar challenges and difficulty in learning a specific topic could sometimes address a student's learning difficulty better than an

instructor; the choice of language and level of explanation by a peer is also likely to be within the ZPD of a learner.

The choice of more knowledgeable others is a critical consideration. Young children have more options of more knowledgeable others (e.g., teachers, parents, friends) for help. Students from institutes of higher learning (IHLs), however, have a restricted pool of people who possess specialized disciplinary knowledge and skills. Also, given the large class sizes in most IHLs, it is impractical for tutors to meet individual student's needs promptly (Westera et al., 2009). Peer tutoring provides a viable option to augment the roles of a formal instructor.

Peer tutoring entails the execution of help-seeking strategies from the learners. Help seeking initiated by learners often begins with an awareness of their learning difficulties and challenges, a form of self-regulation (Karabenick, 2011). Help seeking is also related to the affective needs of a learner (Newman, 2000), including the feeling of being cared for (relatedness), feeling of independence in taking charge of own actions (autonomy) and feeling of gaining knowledge or skills (competence). There are also social aspects of help seeking, such as knowing whom to approach and how to seek help in a socially appropriate way. Some learners may avoid seeking help from a tutor for fear of exposing weaknesses to the tutor that may form a negative impression. A peer of a similar social status is more appealing (Gazula et al., 2017), especially when there is an established social relationship (Boud & Lee, 2005).

Empirical evidence of the benefits of peer tutoring has been reported in terms of academic achievement, cognitive, social, and affective dimensions of learning. In terms of academic achievement, there are positive effects of peer instruction on students' learning and understanding of a topic (Bakare & Orji, 2019); students could gain as much knowledge and skills taught by peers or faculty members (Rees et al., 2016), or in

some cases, obtain better grades (Morgan et al., 2017). Cognitively, peer tutoring was effective in rectifying misconceptions (Cakiroglu & Ongoz, 2017). Socially, peer tutoring helped to distribute the responsibility for learning to students and empower the e-tutors (Topping, 2008). Affectively, peer tutoring enhanced student responsibility and both individual and group rewards (Falchikov & Goldfinch, 2000); improved students' self-esteem and confidence (Boz Yaman, 2019); provided emotional support and positive role models (Muir, 2018); and enhanced students' satisfaction with the learning environment (Lin et al., 2017).

Methods

Research design

The project was at the initial phase of deploying the mobile application, thus, an interpretive approach was adopted. Qualitative analysis of the interview, which allows for deeper exploration of the students' experience, forms the main source of data. This preliminary study adopted an instrumental case study design (Stake, 1995): the participants were interviewed to provide insights into the design and efficacy of the mobile application in terms of the processes, participants' experience, perceived benefits, and obstacles faced.

Sampling

This study used a convenience sampling of 21 peer tutor-tutee dyads in a University. For an interpretive case study, a sample size of 21 falls in the range of 15 to 30 interviews suggested by Marshall et al. (2013). Also, for a qualitative study, it is more critical to reach data saturation when no new themes emerged. Guest et al. (2006) suggested that data saturation usually occurs after 12 interviews.

Procedures

The research ethics application was approved by the university's Institutional Review Board (IRB-2020-02-038-01). The students were recruited via physical posters posted within the university campus and email to schools of education and computer science and engineering. Students who responded to the call were contacted and briefed and data collection proceeded only when consent was obtained. Once a tutee-tutor pair was formed, a peer tutoring session was conducted and the mobile screen was recorded, together with the audio. A follow-up interview of the tutee was conducted separately and the audio of the interview was recorded.

Methods - Interview

The interview was conducted using a semi-structured protocol. Key questions (e.g., "How would you describe your experience during the tutoring session?") were asked to elicit responses from the participants about their experience, the facilitating factors, the challenges, and suggestions to improve the mobile apps. Supplementary prompts (e.g., "Can you recall what went smoothly?") were asked when necessary.

This study follows the constant comparison method (Freeman, 2005) to analyze the interview data. The unit of analysis is the idea relevant to the investigation, that is, process, experience, and outcomes related to mobile peer tutoring (e.g., "the canvas in the mobile app is helpful"). In essence, the main ideas mentioned by the participants were compared for similarities and differences and conceptual labels were given (e.g., Tutor factors: clear explanation). Next, relationships among the categories are identified, for example, conditions conducive to online tutoring are related to anytime, anywhere affordance (Technological factor) of the mobile peer tutoring. Finally, the main factors related to mobile peer tutoring experience and process are highlighted and elaborated in this study, so as to align with the research questions.

Analysis Using The Cultural Historical Activity Theory (CHAT)

In this study, CHAT was used to analyze the tutor-tutee interactions for mobile peer tutoring, first for the design of the mobile application and later for the examination of the participants' interactions. Aligned with Vygotsky's theory explained in the earlier section, peer tutoring is regarded as a social-cultural activity driven by the specific goal of help seeking. A social cultural approach to mobile learning has been applied by Preito et al. (2016) that prizes "the cultural and linguistic diversity of its participants while also bridging the school and home lives resulting in authentic learning" (p. 346). The expanded CHAT framework (Engeström, 2001) was used to analyze the enactments of the peer tutoring sessions. In the expanded CHAT framework, the activity system relates the activity to a larger social-cultural context by including other interacting components such as rules, community and division of labour, as shown in Figure 1 in the Findings section.

CHAT was chosen as the framework for analysis because it allows mobile peer tutoring to be examined at the meso level when the peer tutoring activity is taken as a unit of analysis, while linking it to actions (e.g., explaining a concept) and operations (e.g., using features of canvas). Looi et al. (2011) opined that there is a higher tendency to miss out on mechanisms happening at the meso level (systemic whole) when following interactions in small groups (isolated components). Another reason for using CHAT is the analysis of contradictions within activity systems (Foot & Groleau, 2011). Contradictions generate "disturbances" which are "deviations from the normal scripted course of events in the work process, normal being defined by plans, explicit rules and instructions, or tacitly assumed traditions" and could "appear in the form of an obstacle, difficulty, failure, disagreement, or conflict" (Engeström, 2008, p. 24). Engeström and Glaveanu (2012) identified four levels of contradictions inherent in any activity system. A *primary* contradiction occurs at the node (e.g., a tutee who is more receptive to in-

person tutoring); a *secondary* contradiction occurs between nodes (e.g, an affordance of mobile application not leveraged); a *tertiary* contradiction occurs between the object of a current activity system and the object of a more culturally advanced activity (e.g., mobile peer tutoring versus in-person tutoring); a *quaternary* contradiction occurs between the current activity system and its neighboring activity systems (e.g., a feature of the mobile app by the development team is not recognized by the peer tutors). Critically, contradictions are not regarded as negative but are the impetus for "innovative attempts to change the activity" (Engeström, 2001, p. 137) because they trigger the expansive learning cycle towards improving the activity system (Engeström, 2001).

Findings and Discussions

Participants

The study recruited 21 university students in Singapore. Table 1 shows the information about the participants, their topics of peer tutoring, the level of Bloom's taxonomy they pegged their request to, and the duration of the session.

Place Table 1 about here

CHAT analysis for Mobile peer tutoring application

This section answers the first research question: "What affordances of a mobile application and what implementation arrangements would support peer tutoring?".

Place Figure 1 about here

The *object* (mobile peer tutoring) was new to the participants. In some schools, peer tutoring had been arranged by university instructors where senior students who had done well in specific subjects were recruited as peer tutors, and classes at specific times were made available for potential tutees to attend. This practice was suspended at the

time of the study due to the COVID-19 lockdown. Hence, the students did not have prior experience of organized peer tutoring at the time of data collection.

For this study, a mobile peer tutoring application called MENTOR was developed (Tan et al., 2020). In terms of *tool*, the mobile phone was chosen because of its portability, easy connection to wireless networks, and ubiquitous access to the application. MENTOR allows the arrangement of peer tutoring anytime and anywhere to cater to the sense of autonomy and competence. A user needs analysis and user-experience study was conducted (Tan et al., 2020) earlier leading to the version of MENTOR reported in this study. Also, a canvas and asynchronous and synchronous communication tools (voice, text, annotation) and sharing of documents through the canvas provide the socio-cyberspace for social interactions needed for peer tutoring. The canvas space affords the means to establish common grounds (Teasley & Roschelle, 1993) that are essential for collaboration.

To facilitate productive help-seeking for tutoring, several *rules* were created. MENTOR requires learners to identify the level of cognitive processing (Bloom's taxonomy by Anderson & Krathwohl, 2001) for topics or problems that need help to encourage self-regulation and effective help seeking. The prompt "I would like to learn to…" and six ensuing choices "remember, understand, apply, analyze, evaluate, create" were presented to the participants so that knowledge of Bloom's taxonomy was not a pre-requisite for the participants.

Vignette of how a tutor-tutee pair leveraged the affordances of the mobile peer tutoring application

As part of the answer to Research Question 2, we present a vignette of peer tutoring between Henry (tutee, pseudonym) and Branson (tutor, pseudonym), to illustrate how MENTOR was used to support peer tutoring. Henry (a teacher in a private school)

wanted to learn from Branson (a teacher in a public school) about how his school implemented MakerSpace to develop students' 21st-century skills. Henry chose the "Understand" level because he wanted to understand how Branson designed and implemented STEM activities for his students.

Branson uploaded a pdf document of an article that reported his school's program into MENTOR. At the agreed time (via Chat, one of the features of MENTOR), Branson initiated the session and Henry accepted the session. A canvas appeared that showed Branson's article.

When ensued was a dialogue that lasted for 16.5 minutes. Branson started by asking Henry to reiterate his question. He then moved to the specific page of the article (Fig 1 right) and started explaining his school's approach, complemented with his hand-scribbled annotation and highlighting. The excerpt below illustrates this process:

> After brainstorming, the school implemented the STEM in Science (he scribbled Sci), Maths (scribbled "Ma"), and Social studies (scribble "SS")… Let's say Science. After going through the concept of (the) digestive system, the teacher actually asked the students to create a model using scrap materials… and assessed whether the materials used are suitable. For example, some students used (a) sponge to represent stomach…but what we can give students in education is …the joy of learning (circled "Joy").

The conversation was natural and there were frequent interactions. For instance, Henry asked Branson about the challenges in his school and Branson highlighted the need to communicate the values of doing Makerspace to the students. Henry then shared his experience about how his team managed to convince the students, as well as the school leaders about the maker activities to help students learn and enjoy their learning.

Place Figure 2 about here

CHAT analysis – Uptake and Contradictions

To answer Research Question 2 and 3, CHAT analysis was used to analyze the tutees' perception. Thematic coding was carried out using the interview transcripts from the 21 tutees. In Figure 3, positive findings related to the participants' uptake of the intended affordances (as reflected in their interviews) were prefixed with [+]. Contradictions within CHAT carry the prefix [-x], with x representing the types of contradiction (1-primary, 2-secondary, 3-tertiary, 4-quaternary)

Place Figure 3 about here

Uptake of affordances

Participating in mobile peer tutoring was a new experience for most participants; only 5 participants (24%) said they had prior experience with a similar mode of one-to-one online peer tutoring. There were 14 participants (67%) who indicated past peer tutoring experience face-to-face, during their K-12 education. Despite this, among the 21 participants, 19 (90%) explicitly stated that their overall experience with the peer tutoring session was good.

Our findings show that the participants were able to leverage the affordances of the mobile application intended by the development team for peer tutoring. Among them, most tutees (71%) indicated instrumental help-seeking behaviors (Nelson-Le Gall & Jones, 1990), aiming for improving understanding of a topic towards achieving a sense of competence (Newman, 2002). Only 6 tutees used expedient-oriented help seeking (Butler, 1998) to complete an assignment or to prepare for a test. In terms of Bloom's taxonomy, participants chose "apply" (28.6%), "understand" (23.8%) and

"analyse" (23.8). The two ends of the levels ("synthesis", "evaluate" and "remember") attracted much fewer selections.

The reasons cited for the good experience have been attributed to two broad categories: 1) Factors related to the mobile application (Tool, Fig 3) and 2) factors related to tutors (Division of Labor, Fig 3). These factors worked together to facilitate learning.

In terms of tools, only one participant did not use the canvas, 20 out of 21 participants who used the canvas (95%) mentioned the affordances of canvas that supported the tutoring process. The synchronous co-annotation affordance facilitated the discussion. The drawing or texts on the canvas helped the participants visualize the concepts and processes that were being explained. The fact that this canvas can be saved for future references (4 participants; 19%), and the synchronous display between tutor and tutee screen added to the strength of the canvas (6 participants; 29%).

The critical roles of these artifacts could be understood from Popper's (1979) notions of cognitive artifacts. According to Popper, while we can touch and feel physical objects (World 1 objects), our thoughts and ideas are intangible (World 2) unless they are inscribed on a medium (World 3). In other words, these cognitive artifacts mediate the intangible inner thinking with explicit manifested representations. Making the intangible thinking visible, coupled with the synchronized communication, has been instrumental in the peer tutoring process. Also, a few participants explicitly mentioned that the canvas could be saved for revision, thus adding a dimension to the cognitive artifacts—the persistent record that affords the opportunity for revisiting the ideas discussed during the peer tutoring session. Audio sound-bytes are ephemeral without recording and subject to the effectiveness of human memory. Therefore, some

participants also suggested including audio recording as an additional feature of MENTOR.

The ease of use of the mobile application was explicitly mentioned by 7 (33%) participants. As indicated by the participants, the near real-time sharing of canvas helped in the communication. The synchronous mode also means opportunities for interactivity, where tutees could clarify their doubts quickly. At least two participants compared this with asynchronous online discussion, which they felt was less effective because of the lag time in getting a response. The canvas allowed communication through sharing of documents, drawing, and text input. This has been explicitly mentioned by 95% of the participants as one of the most useful features.

For the object (mobile peer tutoring), the participants mentioned the conditions when such mode of interactions can be useful. All 21 participants (100%) appreciated the convenience and flexibility of accessing peer tutoring anywhere and anytime. The data collection coincided with the COVID-19 lockdown, which served as an authentic situation for using technology to minimize disruption to teaching and learning. Eight participants (38%) expressed that the lockdown during the COVID pandemic served as a good reminder of how online peer tutoring preserved the continuity of this mode of interaction. Additionally, not meeting face-to-face reduced the opportunity for the spread of the disease, following the government's legislation on safe distancing measures. Interestingly, another aspect of security that nearly half of the participants (48%) mentioned was the level of psychological safety accorded via mobile peer tutoring. Two participants expressed their preference for the initial meeting between a tutor and tutee to be conducted via a virtual environment to avoid feeling awkward or embarrassed, while eight others felt that the comfort of home assured them with a safe and confidential workspace.

For the division of labor, several participants had positive feedback about the tutor's skills. Among the tutor's factors, one salient theme cited by 16 (76%) participants is that the tutors provided a clear explanation, followed by the tutors' competence (knowledge) in the subject matter (38%) as well as the ability to communicate effectively (33%). More specific tutoring skills were cited by different participants, such as tutors sharing real-life examples or personal experience (24%), checking tutee's understanding (24%), encouraging thinking, and providing memory technique for remembering some facts (29%). This finding is consistent with the research results reported by Boz Yaman (2019). See Figure 4 for more information.

Place Figure 4 about here

Intriguingly, a few tutees (3 participants) specifically mentioned that the canvas afforded not just the tutors, but also the tutees for co-annotation. One tutee used it to record the key points while the tutor was explaining, and one tutee drew a diagram, together with the tutor, as a way to test her knowledge (Division of Labor, Fig 3). In collaborative learning vernacular, the canvas helps provide the common grounding (Teasley & Roschelle, 1993) so that the tutor-tutee dyad could have a shared understanding of what is being discussed.

CHAT Analysis - Contradictions

To answer the question "What are some contradictions that can inform us of the areas of improvement?", our analysis focused on the method of analyzing contradictions (Foot & Groleau, 2011) in CHAT. This analysis of contradictions was an intentional attempt aims at uncovering ways to enhance the mobile peer tutoring environment.

Despite the generally positive experience, when asked to choose between in-person or online peer tutoring, 13 out of 21 participants (62%) still preferred face-to-

face tutoring. Our findings show that most tutees did not have prior experience of mobile peer tutoring (primary contradiction) whereas most had prior experience of in-person tutoring. This could have led to a high percentage of preference for in-person peer tutoring (tertiary contradiction). A tertiary contradiction occurs between the object of a current activity system and the object of a more culturally advanced activity. In this case, due to unfamiliarity, cultural acceptance of the new mode of tutoring through a mobile device is yet to be established. About 8 participants (38%) opined that mobile peer tutoring is more appropriate for simple topics. By "simple", they meant that the explanation does not involve the use of several resources nor the need for complex diagrams such as editing an elaborate mathematical formula or creating engineering blueprints respectively.

One primary contradiction was the formation of the community. The mobile application would work well if there was a large population of tutors who had registered their expertise and available time slots. It would increase the probability of a tutee finding a matching tutor. This was a teething issue for a new application.

In terms of the mobile application as the mediating tool (secondary contradictions), several issues still plagued the usage. The participants suggested ways to further improve MENTOR. While some participants liked the mobile device for its convenience and portability, a few opined that the small screen limited what can be shared and viewed. The annotation feature was well appreciated, but it could work better if a stylus was used because hand scribbles could be illegible. Some participants felt that video, in addition to audio, should be made available because it carries important non-verbal cues. They suggested that it would improve the presence or it facilitates interactions. This lack of video cues led to another secondary contradiction, that is, the turn-taking rule. A few participants shared that with audio-only

communication, it could be difficult to know when the tutor has the intention to pause, and it was difficult to determine the appropriate juncture to ask a clarifying question. Consequently, some of them missed the opportunity to ask questions because the conversation had progressed to another topic. On the other hand, some felt that without showing video of the participants afforded psychological safety. One participant countered that even with video, on a small screen, the eye contact and micro-expression could not be discerned and it was not possible to have the same in-person interaction.

In this study, a quaternary contradiction occurred between the tool-producing activity (by the development team) and the participants using the tool for mobile peer tutoring. This was manifested as the failure of uptake of the intended affordance of the tool. One such example was the need for the tutee to indicate the level of cognitive processing of the problem (using Bloom's taxonomy). It was intended to encourage self-regulation and to create an awareness of the level of learning for the help-seeking. A few participants from the education field appreciated this option and could immediately see the value. Some tutees, however, asked about the purpose of indicating the level of cognitive processing, and some even selected more than one level.

Conclusion

This study set out to investigate the university students' experience of mobile peer tutoring and their perception of the process, values, and challenges, as well as students' uptake of the affordances of a mobile application and contradictions in the activity system. A mobile application called MENTOR was developed for this purpose to support anytime, anywhere peer tutoring. Qualitative analyses of interview data provided insights into the conditions deemed suitable for mobile peer tutoring: immediacy and accessibility to peer tutoring, when physical and psychological safety is a concern, and when the topic of consultation is not too complex.

A CHAT analysis reveals positive findings regarding the uptake of the intended affordances of the mobile peer tutoring environment, such as the canvas. On the other hand, analysis of contradictions in CHAT suggests some areas for improvement. While some of these can be tackled easily with technical effort (e.g., including an eraser and video), others are inherent issues such as the small screen size of mobile devices. These imply the need to take a systemic approach to the implementation of mobile peer tutoring. Beyond the provision of a mobile application, implementation of mobile peer tutoring requires man-machine partnership, where cultural acceptance of tutees and tutoring skills of tutors need to be developed, and the system support to ensure technical stability.

We acknowledge the limitations of the convenience sampling and the small sample size of this study, partly due to challenges in recruitment during the COVID 19 lockdown. Although the initial plan was to compare mobile peer tutoring with the existing in-person tutoring arranged by the university instructors, the in-person tutoring sessions were suspended due to COVID 19. Consequently, the experimental study design was not used.

Given that the project was at the initial phase of development, this study was not designed for causal inference nor generalizability to a population. A future study could expand the sample so that the results could be generalised to specific student populations of IHLs. An experimental study could also be conducted to compare the efficacy of mobile peer tutoring with traditional in-person peer tutoring.

Acknowledgement

This study is funded by the Singapore Millennium Foundation (SMF) Grant sponsored by the Temasek Foundation.

Disclosure statement

No potential competing interest was reported by the authors.

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Table 1. Level of Bloom's taxonomy identified and duration for each peer tutoring session

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Participant code	Background	Topic of peer tutoring session	Bloom's level	Duration of peer tutoring (mins, sec)
LS002	Undergraduate	Investing	Understand	17m, 00s
LS003	Undergraduate	Artificial intelligence	Understand	26m, 31s
LS004	Undergraduate	Scientific writing	Apply	9m, 32s
LS007	Undergraduate	Artificial intelligence	Understand	17m, 55s
LS008	Undergraduate	Teaching	Evaluate	16m, 40s
LS009	Undergraduate	Artificial intelligence	Apply	13m, 06s
LS017	Postgraduate	Scientific writing	Analyse	21m, 27s
LS019	Postgrad diploma	Education	Analyse	15m, 22s
LS024	Undergraduate	Computer science	Analyse	13m, 12s
LS025	Undergraduate	Mathematics	Apply	15m, 02s
LS026	Postgrad diploma	Language	Analyse	10m, 13s
LS027	Postgraduate	Education	Understand	16m, 15s
LS029	Postgrad diploma	Science	Apply	11m, 24s
LS031	Postgrad diploma	Biology	Remember	16m, 09s
LS033	Undergraduate	Software engineering	Analyse	18m, 05s
LS034	Undergraduate	Computer science	Evaluate	14m, 20s
LS036	Postgrad diploma	Biology	Remember	28m, 00s
LS040	Postgraduate	Education	Evaluate	16m, 24s
LS041	Postgraduate	Education	Apply	15m, 05s
LS042	Postgraduate	Education	Understand	16m, 07s
LS043	Postgrad diploma	Teaching	Apply	19m, 59s

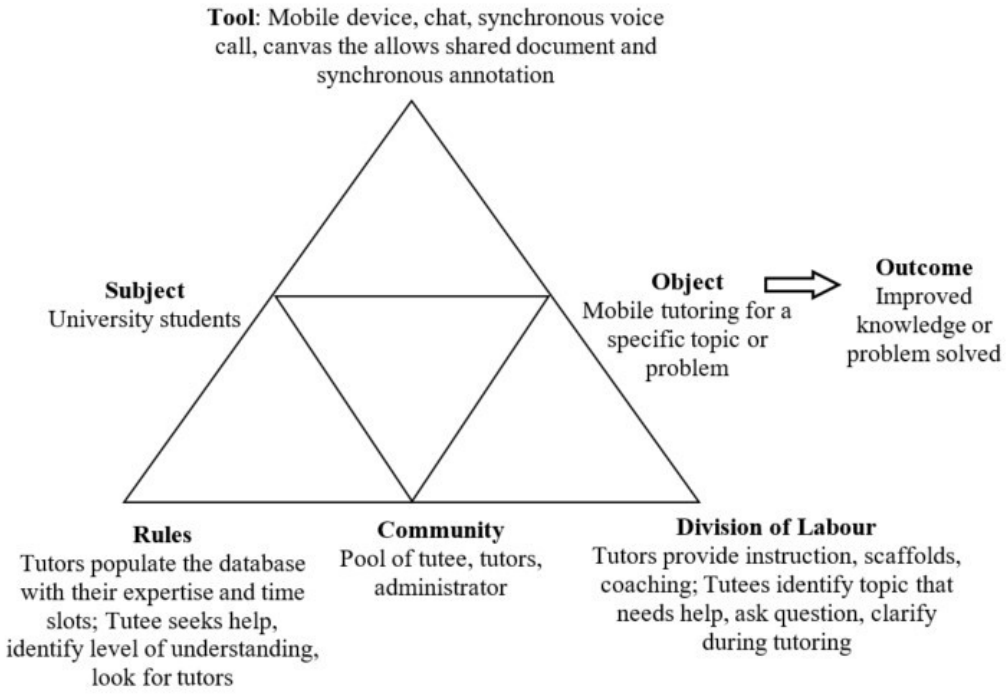

Figure 1. Representation of mobile peer tutoring activity system using Engeström (2001) expanded activity structure

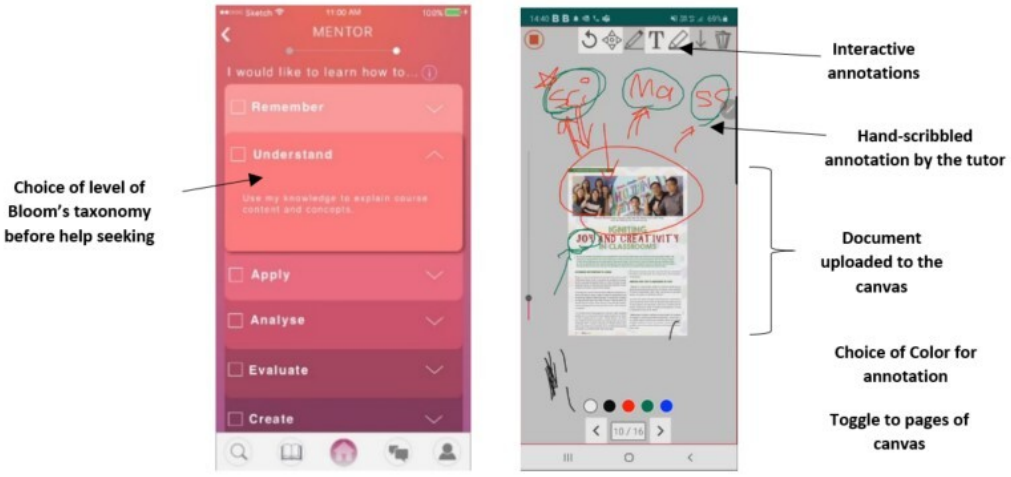

Figure 2. Screen shots of MENTOR. (Left) Tutee identified Bloom's level when seeking help, (Right) the interactive and synchronized canvas.

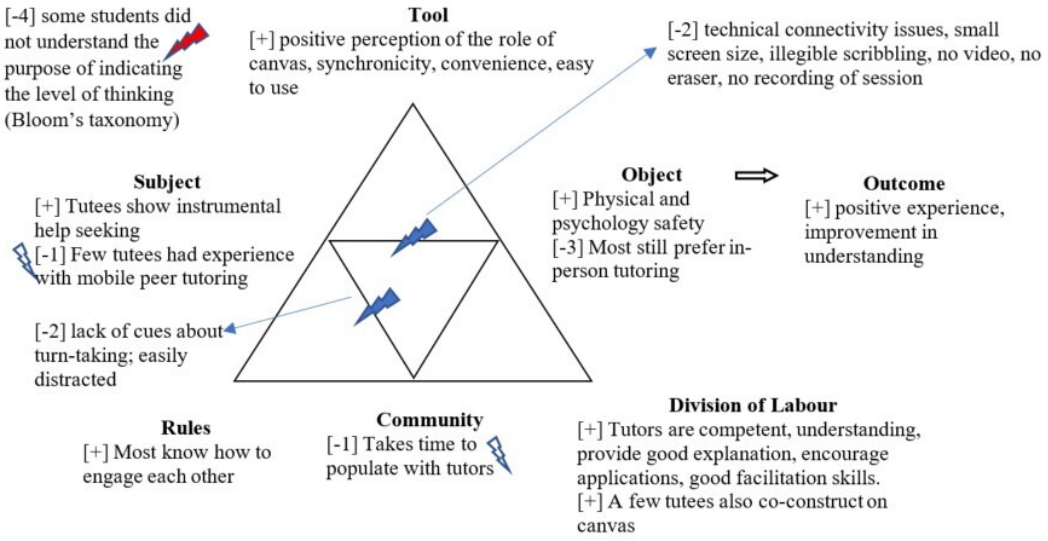

Figure 3. CHAT analysis for both positive uptake of affordances of MENTOR and contradictions

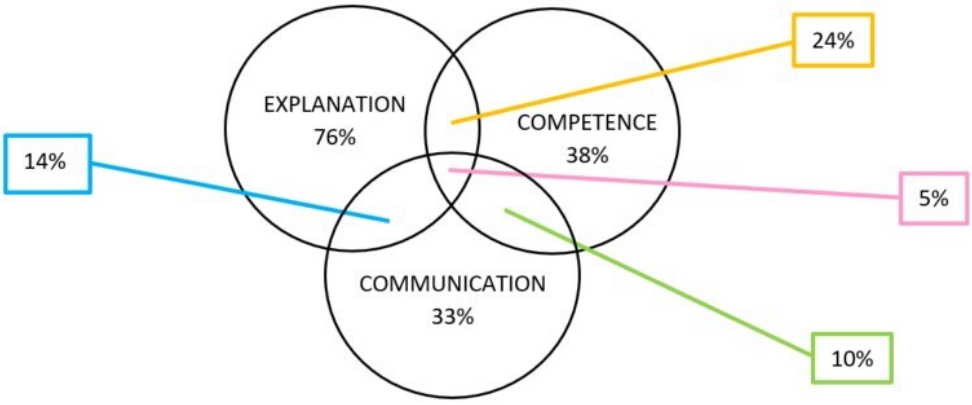

Figure 4. Venn diagram reflecting participants' feedback on the positive tutor characteristics

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