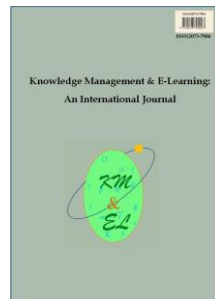# Online knowledge construction mediated by mobile instant messaging

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Online knowledge construction mediated by mobile instant messaging

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Abstract: Widespread use of mobile instant messaging (MIM) both formally by educators and voluntarily by students to support coursework has resulted in increased interest in the academic utility of the technology. However, due to the relative newness of the technology there is a call for more studies on how MIM impacts teaching and learning. To address this need, this case study investigates how MIM mediates online knowledge construction within the context of an economics course project. Online interactions over the course of a 16-week semester were coded and analysed using the Interaction Analysis Model. Analysis of 4,685 online messages revealed evidence of all five phases of knowledge construction: the sharing of information, identification of dissonance, negotiation of meaning, testing, and collective understanding. Both the structure of the course project and the affordances of connectivity, context-free access, and quasi-synchronous communication were found to be key factors in facilitating the knowledge construction process. Findings indicate that MIM may be effective supporting online collaborative learning. Furthermore, specific examples of student interactions offer insights into the complexity of online discussion possible via MIM and the interrelationships between the various phases of online knowledge construction.

Keywords: Mobile instant messaging; Knowledge construction; Affordances; Case study

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1. Introduction

First appearing in 2009, mobile instant messaging (MIM) applications have quickly become a major medium of communication, especially amongst the younger generation (Burke, 2016; Clement, 2019a). With over 2.5 billion users worldwide (Clement, 2019b), MIM applications such as WhatsApp and Facebook Messenger were used to send 62 trillion messages in 2018, accounting for 75% of all mobile messaging traffic (Statista, 2019). Following this trend, MIM is being increasingly used formally by faculty (e.g., Kim, Lee, & Kim, 2014; Rambe & Bere, 2013; So, 2016), and informally by students to communicate about academic topics (Robinson et al., 2015; Tang, Hew, & Chen, 2017). Of the various academic uses of MIM found in the literature, a common theme is the use

of the technology to support groupwork. In these contexts, MIM has been found to facilitate out-of-class interaction regarding course content (Kim et al., 2014) and the sharing of information and resources (Rambe & Bere, 2013; Robinson et al., 2015; Tang & Hew, 2017). These benefits make MIM an effective medium for collaborative learning and social construction of knowledge (Pimmer, Lee, & Mwaikambo, 2018; Rambe & Bere, 2013; Tang, Hew, & Chen, 2017). Thus, several researchers have called for more studies on how this new technology can impact education (Lim, Shelley, & Heo, 2019; Pimmer, 2016; So, 2016; Tang & Hew, 2017).

As an emerging technology with communicative capabilities that could facilitate student interaction, the educational uses of MIM warrant investigation. However, few studies provide examples of how knowledge is constructed online and the types of knowledge that can be generated. Therefore, this study explores the role of MIM in mediating the knowledge construction process in the context of a university course project. Online interaction in a MIM group was analyzed using the Interaction Analysis Model (Gunawardena, Lowe, & Anderson, 1997) to identify a progression of knowledge co-construction over the course of a semester. Drawing on analysis of student interactions, this study offers evidence how MIM helps students to sustain discussions of complex academic content resulting in collective understanding.

2.   Literature review

2.1. Mobile instant messaging

As the name suggests, MIM is smartphone application that allows users to send and receive audio and text messages, images, and digital documents in real time via an internet signal. As messages are sent via the internet, users do not incur any additional charges, making MIM a cost-effective alternative to the standard Short Message Service (SMS) texts sent via a cellular carrier. Unlike social networking sites such as Facebook and Instagram which are platforms to create online networks, MIM is primarily a communication tool. As such, MIM is effective in facilitating both one-to-one and one-to-many communication. Users can send private messages to individuals or create groups based on a common interest or connection (Church & de Oliveria, 2013).

Discussion of the academic uses of MIM has centered on its unique affordances and how they can be leveraged to support coursework. One key affordance is that of connectivity, or the ability to interact with individuals, groups, or an entire online network (McLoughlin & Lee, 2007). MIM takes this affordance one step further by allowing users to adjust the degree of connectivity through the formation of groups (Church & de Oliveria, 2013). Another important affordance of MIM is that of context-free access, or the anywhere anytime communication enabled by the mobile platform (Susilo, 2014). In academic contexts, the anytime anywhere connectivity has been found to facilitate out-of-class student interaction of course content (Kim et al., 2014; Lim et al., 2019; Robinson et al., 2015; So, 2016) and the sharing of academic information and resources (Bouhnik & Deshen, 2014; Cetinkaya, 2017; Tang & Hew, 2017). A third affordance considered instrumental in supporting learning is the capability for both instantaneous and asynchronous communication. MIM is considered a quasi-synchronous medium, with alerts to incoming messages enabling near immediate responses (So, 2016; Tang & Hew, 2017). This ability for quick access to peers and resources has been found to be an important factor is facilitating student interaction in various university contexts (Cetinkaya, 2017; Ishii, Rife, & Kagawa, 2017; Pimmer & Rambe, 2018). However,

MIM is technically an asynchronous medium in that users can receive messages when offline and later review the text communication. Archived messages on MIM have the benefit of serving as a group repository of information (Rambe & Bere, 2013) and, together with time afforded for reflection, can contribute to the co-construction knowledge (Lim et al., 2019; Schellens & Valcke, 2006). In sum, research indicates that MIM with its bundle of communicative affordances can be a powerful tool to facilitate student-to-student interaction and collaborative knowledge generation.

2.2. Use of MIM for groupwork

The widespread use of MIM by students and its affordances has contributed to the increasing use of the technology to support collaborative learning in formal academic contexts. A comprehensive review of the educational uses of MIM revealed that it is most often utilized in university settings to support groupwork (Pimmer & Rambe, 2018). In one key study of the voluntary use of MIM by undergraduate radiology students, the technology was found to help students express their opinions when collaborating on a course project (Robinson et al., 2015). The researchers concluded that the use of MIM extended communication beyond the classroom, provided immediate responses to calls for assistance, and created an efficient means to share resources.

Another study examined the impact of MIM to supplement traditional classroom instruction (Rambe & Bere, 2013). 95 students at a South African university were divided into online discussion groups. The researchers discovered that MIM enabled interaction with peers outside of class, just-in-time access to resources, and the creation of a repository of academic resources. Most importantly, the researchers concluded that the MIM-enhanced interaction fostered a change from individual learning to peer-based knowledge generation.

There have also been studies that have compared MIM to Learning Management Systems (LMS) in supporting group projects. In a study of Korean university students, Kim et al. (2014), discovered mobile instant messaging was superior to the LMS, Moodle, in facilitating online interaction regarding the project and teamwork. Sun, Lin, Wu, Zhou, and Lu (2018) also compared the use of MIM to Moodle and found the messaging application to facilitate deep learning and team building. However, both studies concluded that the MIM was less effective than the LMS in regard to supporting cognitive interactions and knowledge construction (Kim et al., 2014; Sun et al., 2018). The literature is still inconclusive regarding the extent to which MIM can facilitate the generation of knowledge. Although studies have shown that the affordances of MIM have the potential to support collaborative learning, further investigation to provide evidence of the process of knowledge co-construction is warranted.

2.3. Online knowledge construction

To examine how knowledge can be collaboratively generated, many researchers have adopted the Interaction Analysis Model because of its validated and transparent stages of knowledge construction (Gunawardena et al., 1997). The model posits five stages, moving from lower to higher order mental functions. The first phase includes the sharing and comparing of information. Stage two is the identification of dissonance, which is characterized by disagreement regarding ideas. Stage three is the negotiation of meaning. It is in this stage that the co-construction of knowledge occurs through explanations and justifications, which in turn leads to compromise or understanding. The fourth stage involves testing and modification. Testing is done by comparing newly formed ideas with

sources of data, evidence, or personal experience. In stage five, new understanding is characterized by the application of new knowledge. This final stage can take the form of a summary of findings or the application of a newly understood concepts. An overview of the IAM used for the analysis of online data in this study is provide in Table 1.

Table 1
Five phases of the interaction analysis model (IAM) (Gunawardena et al., 1997)

Phase	Description
1	Sharing and comparing of information. Presentation of new information to team members and statements of observation or opinion.
2	The discovery and exploration of dissonance or inconsistency among ideas, concepts or statements. Identifying areas of disagreement, and the asking and answering questions to clarify disagreement.
3	Negotiation of meaning or co-construction of knowledge. Negotiating meanings of terms and negotiation of the relative weight to be used for various agreements. Negotiation of new statements embodying co-construction.
4	Testing and modification of proposed synthesis or co-construction. Testing the proposed new knowledge against existing cognitive schema, personal experience or other sources.
5	Agreement statement / applications of newly constructed meaning: Summarizing agreements and meta-cognitive statements that show new knowledge construction.

Studies that utilize the IAM for the analysis of interactions mediated by new emergent technologies are particularly relevant to this study. However, a comprehensive review of these studies found mixed results in that many studies did not find pervasive evidence of knowledge construction at the highest levels. There were few instances of negotiation of meaning, and virtually no evidence of the testing, modification, and application of new knowledge (Lucas, Gunawardena, & Moreira, 2014). Similarly, in an examination of synchronous online discussions in a PC-based instant messaging platform, much of the interaction was found to be off-topic, and no evidence of the higher phases of knowledge construction was found (Hou & Wu, 2011). An investigation of online discussions supported by an LMS at a Taiwanese university also produced mixed results, with the majority of interactions limited to the sharing and comparing of information (Hew & Cheung, 2011). Although studies reviewed paint a somewhat disappointing picture of knowledge construction mediated by newer technology, two studies of mobile applications offer promise. A comparison of mobile and PC-based learning systems revealed that the group supported by mobile messaging had a higher volume of online communication and significantly more interactions coded at the higher phases of knowledge construction (Lan, Tsai, Yang, & Hung, 2012). Finally, in a study of the voluntary use of MIM to support groupwork, analysis revealed that the technology was effective in facilitating the negotiation of meaning due to the anytime anywhere connectivity it afforded (Tang et al., 2017). Overall, studies that have focused on MIM demonstrate the promise of this new technology to facilitate knowledge generation. However, more research is needed to discover how higher order thinking and knowledge co-construction can be promoted via MIM.

The review of the relevant literature reveals three gaps concerning the potential of MIM to facilitate knowledge construction. First, research has mainly focused on the quantification of student interactions according to the phases of the IAM. Much of the studies utilizing the IAM were conducted in this fashion, reporting the percentage of interactions representative of the different phases of knowledge construction (e.g., Hew & Cheung, 2011; Hou & Wu, 2011; Lucas et al., 2014). Studies that analyze how knowledge is constructed in online interactions and provide examples of what knowledge can be generated are needed. Second, there is also a need for an investigation of knowledge construction mediated by MIM. A recent review of the literature on MIM uncovered just 17 studies focusing on group work in formal educational settings (Pimmer & Rambe, 2018). Furthermore, few researchers have investigated learning mediated by MIM using established frameworks, such as the Interaction Analysis Model (Gunawardena et al., 1997). Finally, a review of the literature uncovered no studies that investigated the role of online knowledge construction within an English-medium economics curriculum. With universities increasing their offerings of English-medium content courses (Macaro, Curle, Pun, An, & Dearden, 2018), this is an area that deserves further study. To address these gaps, this study aimed to examine online knowledge construction through the lens of the IAM and identify the affordances of MIM that facilitated this process.

3. Research questions

The following questions were posed to guide this study:

1. How do students construct knowledge together when they engage in online discussion and interaction for a course project?
2. In what ways does MIM afford student interaction and knowledge co-construction?
3. In what ways does the design of the course project affect student interaction and knowledge co-construction?

4. Method

4.1. Research context and participants

The data for this study come from a larger study on voluntary use of MIM to support university coursework in an English-medium instruction context in Japan. The original study analyzed the interactions of two groups created using MIM to identify academic affordances and online practices that aligned with course objectives. One MIM group consisted of all the members of an intact class and the other group was a sub-group created by four students for the course research project. The course was purposefully selected based on intensity sampling (Patton, 1990) to be representative of a new trend among Japanese students to create MIM groups for academic purposes. A survey of academic English courses at the university was conducted to identify classes which (a) required students to collaborate on a course project, (b) utilized MIM, and (c) demonstrated a high level of intensity in online interactions. After a review of the survey results, an English-medium economics course was selected.

Of the three project groups in the class, one was then selected as an embedded case based on maximum variation sampling (Patton, 1990), or the selection of a group of participants that offer the greatest range of perspectives on a phenomenon. A questionnaire was used to determine the varying degrees to which the students interacted on MIM for both personal and academic use. The group with a mix of students that exhibited low, average, and high levels of MIM interaction was selected as it offered the greatest range of perspectives. Moreover, because each sub-group contained over 4,000 posts, it was impractical to analyze the interactions of all three sub-groups. The online interactions of the selected research project sub-group served as the primary data source for this study. The study was approved by the university's Institutional Review Board and participation was voluntary. Pseudonyms are used in the excerpts to protect the identities of the participants.

The participants for this study (1 male and 3 females aged 19 to 20) were second year students in an English-medium economics program at a private university in Tokyo, Japan. The students were enrolled in two connected courses, a microeconomics lecture and an English for Academic Purposes laboratory. Microeconomic principles were taught in the lecture and the adjunct EAP course provided support in academic writing conventions, outlining of the course textbook, presentation skills, and completion of the course research project.

The MIM application used by the participants was Line, the most popular of such applications in Japan with over 82 million users as of 2019 (Clement, 2019b). It shares much of the same features as other popular MIM applications such as WhatsApp and Facebook Messenger. All participants used the MIM application for daily communication with family and peers prior to this study.

4.2. Research project

A major component of both courses and the focus of the group's online interaction was a case study of a Japanese corporation, Ryohin Keikaku, known to the public as Muji. The project required students to select a company which had recovered from financial difficultly and identify the causes for the problem, the strategies implemented, and outcomes. The students also needed to apply economic concepts introduced in the lecture in an analysis of the company's recovery. The project, which consisted of a research paper and presentation, was announced in the third week of classes. The presentation took place in the final week of the course and students submitted the joint research paper at the end of the term.

4.3. Data collection and analysis

The primary source for data for this study was the online messages posted to the MIM group created by the four participants. There was a total of 4,685 messages posted to this group over the 16-week semester. A complete transcript of student messages was downloaded from Line and translated by the researcher. The translations were checked by another bi-lingual speaker of Japanese and English and member checks were conducted for key excerpts to ensure accuracy. The translated messages were coded and recursively analyzed according to the procedures outlined by Hatch (2002) for qualitative research in educational settings. The coding scheme developed by Gunawardena et al. (1997) was adopted to investigate the social knowledge construction process (See Table 1). A second set of codes was derived from the established Web 2.0 affordances identified in the literature (Lim et al., 2019; McLoughlin & Lee, 2007; Rambe & Bere, 2013; So, 2016;

Susilo, 2014; Tang & Hew, 2017). After an initial round coding, a second researcher with expertise in linguistics and educational technology independently coded randomly selected portions of the transcript which amounted to approximately 10% of the total data. Inter-rater reliability was .87, and disagreements on codes were discussed. The insights gained from this process were used by the original researcher in reviewing the entire coded transcript again for inconsistencies. An additional round code checking was conducted for the key excerpts identified through initial analysis of the data. Any discrepancies in codes contained in these excerpts were discussed with the second researcher until consensus was reached. In addition to MIM, the students also utilized Google Drive as a resource repository. The digital documents were examined and then cross referenced with the MIM communication to investigate how the two technologies were used in tandem to facilitate knowledge construction. A recursive process of seeking confirming and disconfirming evidence was undertaken through repeated analysis of all sources of data until the final conclusions were warranted.

5. Findings

Analysis of the data revealed examples of all phases of the IAM covering a range of topics such as research strategies, peer editing procedures, economic concepts, and the course project. Of the many lines of discussion, one thread concerning the causes for the domestic issues faced by the Muji corporation and the strategies implemented for recovery most clearly demonstrated a progression from incomplete understanding to the accurate application of economic concepts. This line of discussion was selected as the focus of analysis because it exemplified the five phases of the IAM and provided evidence of co-constructed knowledge of course content. What follows is analysis of student interactions that illustrate how MIM mediated collaborative knowledge generation within the context of a university course.

At the start of the project, MIM along with Google Drive were used in tandem to support information sharing and compiling (Phase 1). The students' efforts to identify the causes of the company's problem started with a search for financial data and company information. Below, Romi is seen coordinating the efforts of the other three group members (Excerpt 1):

19:07	**Romi:**	Let's confirm the homework for this weekend.
19:08	**Romi:**	Sai's task: Research the changes in the product ranges for each division of the company from 1997–2004.
19:10	**Romi:**	Chi's task: Research the market characteristics of each section (Household goods, Apparel, Food)
19:12	**Romi:**	Yuki's task: Research the trend of profits / sales for each division from 1997 to 2004.
19:12	**Romi:**	My task: Research the market characteristics of the overall retail industry. Upload everything to [Google] Drive.
....		
19:31	**Yuki:**	By when?
19:31	**Romi:**	By next Tuesday.
19:36	**Sai:**	Thanks

20:18   Chi: Thank you!

(06/04/2015, 1052 – 1069)

Romi's instructions at the start of the excerpt indicate a wide range of information that was to be complied. Details regarding the various product ranges, market characteristics for each product category, financial data, and market characteristics for the retail industry represent a significant amount of information that could not be easily transmitted via a text message. Therefore, Romi instructed the other group members that the information should be uploaded to Google Drive. The replies by the three other group members provide an example how MIM can be utilized to coordinate the sharing of large amounts of information. In fact, the use of MIM to coordinate, search, share, and save became a common practice with seven other instances of such instructions sent during the first weeks of the course. Analysis of the group's Google Drive at the end of the semester revealed the efficacy of MIM in coordinating this compiling of information. There were 25 financial reports, eight journal articles regarding the company's strategies, and 11 files containing data on the company's product range. The exchange is an example of how the combined use of MIM and Google Drive can expand the types and amount of information that can be shared in the knowledge generation process.

The compiling of company data contributed to several rounds of further research and negotiation of meaning (Phase 3) to organize the information. These exchanges resulted in an increase in the complexity of the information exchanged, exemplifying a variation of Phase 1 interaction. Some follow-up research by the group leader led to the following exchange (Excerpt 2:

21:18   Romi: Outline

A. Problem = generated a deficit of 3.8 billion yen in 2001

1. Sales increased slightly, but profit decreased much in 2001

2. Costs were stable around 2001

B. Cause = unnecessary wasteful costs due to over-production

....

21:23   Romi: C. Strategy = Cost reduction through restructuring

21:24   Yuki: Now, specific data is necessary for support.

(06/12/2015, 1422 – 1437)

Above, Romi shared a general outline for the project, which included profit and loss data as evidence of a problem, a possible cause for the company's problem, and the strategy implemented. The message exhibits how MIM was used to share not only sourced information, but also information synthesized from those sources through negotiation of meaning (Phase 3 interactions). The outline was important in that it helped identify necessary supporting data and served as a starting point to reconstruct what occurred within the company. Other studies have found that information sharing can lead to still more Phase 1 interactions (Hew & Cheung, 2011; Hou & Wu, 2011; Lan et al., 2012). However, the example above demonstrates that the analysis and synthesis of information are also factors that can promote further Phase 1 interactions.

The role of MIM affordances in the Phase 1 activities in Excerpts 1 and 2 is also noteworthy. The connectivity afforded by MIM enabled Romi to send out the instructions

and outline simultaneously to other members. Furthermore, content-free and quasi-synchronous nature of the communication ensured that information could be received regardless of where the members were and whether they were immediately available to respond. The record of the instructions and outline also meant that everyone could review the messages, helping to guide them in their collaborative efforts.

Although infrequent, MIM communication allowed the students to resolve cognitive dissonance (Phase 2), leading to other higher order phases of knowledge construction. With the initial stages of information gathering complete, the students began formulating an understanding of the company's financial problems. This process was characterized by constructive disagreement (Excerpt 3):

21:40	**Sai:**	I think the domestic strategy is wrong. Changing the production method means to stop producing an unnecessary amount of goods, which leads to a decrease in inventory and a decrease in costs.
21:44	**Yuki:**	What?
21:48	**Romi:**	I just finished my section [of the research paper draft]. What's going on?
21:49	**Sai:**	By changing the production method, inventory cost decreases. And improvement of product design will lead to increased demand.
21:52	**Chi:**	Does changing the production method mean changing the sales method?
21:56	**Sai:**	The reason for the built-up inventory was their system of simply manufacturing a lot of products at the beginning of each season and selling off their stock, but demand was insufficient.
21:59	**Chi:**	So a decrease in stock will result in an increase in sales?
22:00	**Sai:**	Uh… Wait.
22:02	**Sai:**	If the amount of stock decreases, then cost decreases + no previous problem with sales = profit increases.
22:03	**Chi:**	Ahh, there was no problem with sales. Because of increased costs, profit decreased.
22:04	**Chi:**	So, that was the problem?
22:05	**Sai:**	Yes. That sounds correct.

(06/29/2015, 2338 – 2358)

The interaction above is an example of how the quasi-synchronous capabilities of MIM can support the identification and resolution of dissonance. In a previous interaction, the group had mistakenly concluded that the company had changed their production method, leading to an increase in sales. However, Sai disagreed, posting that the overproduction of goods was a cost-related problem, and resolving this issue would not impact revenue. The message by Sai sent at 21:40 reveals two advantages of quasi-synchronous communication. The alerts to incoming messages along with the ability to review past messages allowed different members to smoothly enter into the discussion at different times. The delay of several minutes for the other members to respond indicates they were not immediately available, with Romi specifically stating she was busy working on a draft of the research paper. The delayed message from Chi was critical

because her requests for clarification initiated a negotiation of meaning (Phase 3): an economic explanation by Sai on how reduction of costs lead to increased profit. Furthermore, Phase 5 interactions are evident when Chi summarized the explanation given by Sai, indicating new understanding. Even within the short interaction, the development of understanding can be observed as students moved from the exchange of information (Phase 1) to disagreement (Phase 2), to the negotiation of meaning (Phase 3), and finally to an agreed upon conclusion (Phase 5). This progression is similar to other studies which have noted relationships between the different phases of knowledge construction (Hou & Wu, 2011, Lan et al., 2012; Tang et al., 2017). However, the exchange above offers an example of how the process of shared understanding unfolds, demonstrating how MIM is able to support meaningful discussions of economic content. The excerpt offers further evidence in support of the assertion that MIM can support peer-based learning (Rambe & Bere, 2013; Tang et al., 2017).

Analysis also revealed how online discussions were sustained, allowing for further identification of dissonance (Phase 2) and negotiation of meaning (Phase 3). With an overall grasp of the company's problems established, the group moved toward discovering the reasons for the cost-related issues (Excerpt 4):

21:20	**Romi:**	This is just my opinion, so I need to check with the teacher. I was thinking that the company did not make a mistake forecasting demand but made the mistake of just producing too many products.
....		
21:22	**Sai:**	Isn't that a mistake forecasting demand?
21:27	**Romi:**	Uh, no.
21:27	**Romi:**	Even if sales matched their forecasts, the real problem was the company constantly overproducing goods and having leftover stock...
21:40	**Sai:**	Umm...
21:58	**Romi:**	Are you convinced?
22:01	**Sai:**	Kind of…
22:08	**Romi:**	Their original strategy was to over-produce and over-stock more than needed, and have inventory gradually decrease through sales to eliminate the situation of having a product out-of-stock.
22:08	**Romi:**	So, the problem is…
22:10	**Romi:**	Not that their forecasts were wrong, but [their initial strategy] was to simply manufacture a lot of products without accurate forecasting.
22:10	**Sai:**	Ahh… That sounds right.
22:10	**Romi:**	Of course, if their general forecasts were off, then there would be even more unsold stock and inventory costs would further increase.
22:11	**Sai:**	I understand!

(06/30/2015, 2537 – 2554)

At 21:22, dissonance is evident as Sai stated that she did not see the difference between the company mis-forecasting future demand and the overproduction of goods.

As in the previous excerpt, disagreement triggers the negotiation of meaning with Romi offering a general explanation of the company's initial policy to produce excess stock to avoid shortages. What is most significant is what followed from 22:01 when Sai was still unconvinced. The time stamps indicate that over 30 minutes had passed since Romi offered her initial explanation, allowing ample time for Sai to process the information. Sai's uncertainty is evident through her response of "Umm..." and "Kind of", which led to Romi then quickly providing a series of deeper explanations of the specific business operations that resulted in excess inventory and high costs. The exchange demonstrates how MIM allows for both quick responses and time for reflection to facilitate nuanced conversations about complex topics.

The relative dearth of Phase 2 interactions found in the MIM group is consistent with other studies of online knowledge construction (Hou & Wu, 2011; Hew & Cheung, 2011; Lucas et al., 2014). However, more important than the number of instances of disagreement is developing an understanding of the role of dissonance in knowledge construction. To this end, Excerpts 3 and 4 offer specific examples of how MIM can be an effective medium to resolve disagreement. Researchers have noted the conversational style of MIM communication fosters a friendly and open online environment (Kim et al., 2014; Sun et al., 2018), which may have contributed to the smooth transition from dissonance to mutual understanding. Moreover, the quasi-synchronous communication afforded by MIM was also important. The ability to quickly ask for clarification and take time to reflect on responses both contributed at varying points to the sustained negotiation of meaning.

Excerpt 4 shows the development of understanding over time when viewed together with all previous interactions. The group members moved from a coordinated compiling of information (Phase 1) to a general outline of events (Phases 1 and 3), to a more in-depth identification of causes through disagreement and negotiation of meaning (Phases 2 and 3), and finally to group understanding (Phase 5). This exchange is example of how MIM can sustain lines of discussion over several weeks moving through different phases of knowledge construction in a text-based medium.

MIM communication was also able to support the testing and modification of ideas (Phase 4). With the group forming a consensus regarding the causes for the company's problems, they moved onto confirming their hypothesis (Excerpt 5):

19:29	**Sai:**	Did the financial problems occur in 2001?
19:30	**Sai:**	[or] 2002?
19:31	**Yuki:**	Uh, I don't think so. [I think it was] 2000-2001.
19:31	**Sai:**	The highest inventory cost was in 2002 though...
19:32	**Yuki:**	Really?!
19:34	**Yuki:**	But overall profit first decreased in 2001...
19:34	**Sai**:	You're right...
....		
19:36	**Romi:**	[How much was] inventory costs?
19:38	**Sai:**	It was 30% [of total costs in the apparel division], so I don't know if it had a major impact.
19:38	**Romi:**	Really? [The teacher] said 30% is huge, didn't he?

19:38   **Sai:**   Ah, I think you're right.

(07/03/2015, 3123 – 3158)

In the first part of the exchange, Yuki and Sai test the notion that high inventory cost was a main cause through an analysis of financial records. By comparing dates and financial data, the pair was able to determine that the company's problem started in 2001 and peaked in 2002. Then, Romi's question at 19:36 initiated two more instances of testing. First, their understanding of the company's problem was compared against inventory cost data and then with insights gained from a meeting with the instructor. The exchange illustrates how the structure of the project and the nature of MIM communication contribute to Phase 4 interactions. The known outcome of the company's recovery, together with publicly available financial records provided a straightforward means of testing ideas. In addition, the connectivity and context-free access afforded by MIM enabled students to quickly and remotely incorporate different sources in the testing process.

Interactions near the end of the semester showed students reaching the highest phase of the IAM, collective understanding. Several MIM messages involved Phase 5 processes as the students correctly applied economic concepts to their project (Excerpt 6):

01:14   **Romi:**   I think the teacher wanted us to connect the strategies to economic concepts, but it seems difficult because of the lack of information.

01:15   **Romi:**   I think it's ok to say process innovation.

01:16   **Romi:**   Do you mean the section on streamlining the production method?

01:17   **Romi:**   We can say that it is process innovation, can't we?

01:18   **Yuki:**   Yes! Easily.

01:18   **Romi:**   But I think it's doesn't connect to over-production...

01:20   **Yuki:**   They changed the production process quite a bit! However, the changes are mostly improvements in material procurement, and I am not sure they connect to cost reduction.

01:23   **Romi:**   Technological innovation!

01:23   **Romi:**   [Photo of a page out of a reference book]

01:24   **Romi:**   Their MD system is a computer system to control production and accurately forecast demand.

01:24   **Yuki:**   Exactly!

01:24   **Romi:**   We can use it!!

01:24   **Yuki:**   For example, the widely acknowledged problem of increasing stock was this: A buyer/manager who has previously experienced sales growth is afraid of product shortages and procures too much product.

01:25   **Chi:**   We can use it for the strategy!!

01:36   **Yuki:**   I'm starting to understand the domestic strategy! Thank you!

(07/08/2015, 3775 – 3800)

The exchange above illustrates the culmination of the knowledge construction process with a negotiation of economic concepts followed by the group reaching a collective understanding. The co-construction of knowledge begins with Romi suggesting process and technological innovation as possible concepts for inclusion. These suggestions prompted explanations from Yuki on how the concepts could be directly applied to business operations. The excerpt ends with Chi and Yuki both making statements of agreement (Phase 5). The reason that the fourth member of the group, Sai, did not take part was mostly likely due to the late hour of the of the exchange. She did eventually post a message expressing her understanding later the next day. The timing of the interactions is noteworthy because it again demonstrates how the MIM affordances of connectivity and context-free access can support the collaborative process. Even at 1:00 a.m., different members were able to contribute ideas and all members were privy to the final conclusions.

The co-construction of knowledge was an ongoing process throughout the semester. The exchange above shows a progression of understanding from the initial coordinated search for information on June 4 (Excerpt 1). Then, from the simple identification of a problem (Excerpt 2), the students were able to sustain a discussion of the company's recovery strategy and its connection to the root causes of the problem (Excerpts 3, 4, 5, and 6) over the course of several weeks. The examples show how each phase contributed to a deeper understanding of the business case study, culminating in an example of new knowledge: the application of process and technological innovation by the company to recover from outdated production practices. Ultimately, all four members of the group reached a collective understanding, demonstrating the potential of MIM affordances to support knowledge co-construction.

6. Discussion

The analysis of interactions in this study revealed all phases of the IAM collectively contributing to new understanding of economic concepts. Gunawardena et al. (1997) stressed that although a progression from lower to higher phases is required, all phases need not occur. The fact that all five phases were identified in an interrelated process is significant in that it offers evidence that MIM is capable of supporting every aspect of knowledge construction. Similar to other studies using the IAM, Phase 1 interactions of sharing information were most prevalent (e.g., Hew & Cheung, 2011; Hou & Wu, 2011; Lan et al., 2012; Lucas et al., 2014). However, a contribution of this study is the example of how multiple technologies can be used in tandem to expand the scope and scale of information shared. The students' use of Google Drive as a digital repository while coordinating their research efforts via MIM enabled large files of information, such as financial records and journal articles, to be shared amongst members. The information dense files saved to Google Drive differ from the Phase 1 activities found in other studies (Hew & Cheung, 2011; Hou & Wu, 2011; Lan et al., 2012). The researchers in previous studies coded for explicit pieces of information shared within the text, limiting the information shared to what could be included in a message. A review of the literature revealed only one other example of the use of MIM and a file hosting service for the purpose of knowledge construction (Tang et al., 2017). Therefore, this study contributes by demonstrating how two technologies can be used in tandem to expand the scope of Phase 1 activities, and provides specific examples of information that can be shared in the co-construction of knowledge. For information intensive projects, educators could utilize this finding to facilitate the sharing of resources amongst students.

The instances of disagreement (Phase 2) were also significant in that they were infrequent yet effectively resolved online. As in other studies using the IAM, there were few interactions representative of dissonance (Hou & Wu, 2011; Lucas et al., 2014). Though researchers have suggested that a cultural component may inhibit online disagreement in Asian contexts (Hew & Cheung, 2011; Lucas et al., 2014), task structure was likely more of a factor in this study. The case study project can be categorized as a complex yet well-structured problem. The project had clearly defined parameters as well as a known start and end state, the core characteristics of a well-defined problem (Jonassen, 1997). Similar to how the debate format in Gunawardena et al's (1997) original study encouraged the identification of dissonance while hindering compromise, the well-defined structure of the case study project influenced knowledge construction. With a known outcome for the case study, there was not much cause for conflicting views. Though infrequent, the instances of disagreement in Excerpts 3 and 4 are significant in that they were effectively resolved online resulting in both negotiation of meaning (Phase 3) and collective agreement (Phase 5). The excerpts illustrate how MIM can be used to mediate conflict and how a well-structured task can promote negotiation without much dissonance. Furthermore, the examples provided in this study may assist educators in facilitating resolution when conflicts occur within student online groups and help move discussions toward mutual understanding.

The examples Phase 3 interactions in this study also differ from those in the literature because they demonstrated a gradual construction of knowledge over time. Many studies have focused on the coding and quantification of the various phases of the IAM (e.g., Hew & Cheung, 2011; Hou & Wu, 2011; Lucas et al., 2014), resulting the lack of actual examples of the extended knowledge construction process. A study by Tang et al. (2017) tracked instances of knowledge generation mediated by MIM, and researchers found that lines of discussion were maintained for up to 3 days. In contrast, the participants in this study were able to sustain discussion of economic concepts for several weeks. The affordances of MIM likely contributed to this ongoing negotiation of meaning. Many online exchanges involved just two or three students. However, mobile connectivity and quasi-synchronous text messages enabled group members who did not participate in a discussion to review archived communication, stay informed, and contribute at a later time. Examples of group members making asynchronous contributions include Chi asking for clarification (Excerpt 3), Sai expressing disagreement (Excerpts 3 & 4), Romi posting instructions and explanations (Excerpts 2 & 4), and Yuki applying economic concepts to their project (Excerpt 6). These excerpts represent how the benefits of time provided for reflection (Kim et al., 2014; Lim et al., 2019), temporally distributed involvement (Rambe & Bere 2013), archived records for review (So, 2016), and anytime anywhere communication (Lim et al., 2019; Rambe & Bere, 2013; Susilo, 2014) can contribute to ongoing knowledge construction. The identification of affordances and the ways that they supported learning my serve to move discussion of educational technology use away from specific applications. The appropriacy of a specific technology could then be determined by whether its affordances align with the requirements and learning objectives of the task.

Unlike studies in which there was a lack of the higher phases of knowledge construction (Hew & Cheung, 2011; Hou & Wu, 2011), analysis revealed evidence of both testing and application of new understanding. The structure of the course project was also critical in facilitating Phase 4 and 5 interactions. First, the known end state of the business' recovery along with accessible financial records allowed for testing and modification, a process more difficult with an ill-structured problem. This conclusion is supported by researchers who have asserted that clear task structure (Koh, Herring, & Hew, 2010; Schellens & Valcke, 2006) and defined objectives (Lucas et al., 2014)

contribute to focused negotiation of meaning. With task structure a key factor in Phases 2, 3, and 4 of the IAM, this study contributes by offering a specific example of a case study project that can facilitate knowledge construction. The finding suggests that educators should carefully consider task structure together with learning objectives when incorporating technology into their courses.

The multiple instances of agreement (Phase 5) are significant in that they indicate a progression of group understanding over several weeks. The examples of students summarizing negotiated ideas (Excerpts 3), expressing understanding of others' explanations (Excerpt 4), and agreeing on the application of course concepts (Excerpt 6) offer concrete evidence of knowledge construction. Moreover, the excerpts provide specific examples of the types of knowledge that can be constructed online: the ability to conduct cost analysis to uncover inventory and disposal issues, deconstruct corporate strategies to apply economic concepts such as process and technological innovation, and accurately utilize financial data to confirm the outcomes of corporate action. Evidence of the complex concepts negotiated online can inform educators on the depth of discussions and meaning-making possible via MIM. In sum, the higher phases of the IAM found in this study are consistent with Tang et al's (2017) study of groupwork mediated by MIM, suggesting the efficacy of MIM in appropriate teaching contexts to promote knowledge construction.

Finally, the individual lines of discussion revealed many instances of non-sequential progression which is consistent with the findings of Hou and Wu (2011) and support Lim et al's (2019) assertion of a non-linear process of knowledge generation. An example can be seen in Excerpt 2 where an outline created by initial round of research is shared with the group (Phase 1 -> Phase 3 -> Phase 1). Moreover, the instances of disagreement (Excerpts 3 and 4) were always preceded by negotiation (Phase 3 -> Phase 2). However, it is important to note that the knowledge construction process was sequential when looking at the arc of the entire semester. The first several weeks were characterized by interactions involving the sharing of information (Phase 1). In the middle of the semester, more negotiation on meaning (Phase 3) were evident. Only toward the end of the semester did the testing of a hypothesis (Phase 4) and mutual understanding (Phase 5) occur. Gunawardena et al. (1997) argued that interactions should be viewed in totality with knowledge resulting from an inter-connected series of exchanges. Thus, the sequence of knowledge construction phases in individual lines of discussion are less important than whether the gestalt formed of all interactions results in new knowledge. In this sense, a key finding of this study is the ways in which MIM and task structure were able to facilitate the progression through the various phases of the IAM to ultimately result in knowledge co-construction over the course of a semester.

7.   Conclusion

The major contribution of this study is the identification and analysis of the progression of online knowledge co-construction mediated by MIM. Although the findings are not generalizable to all contexts, the study adds to the growing body of knowledge of the use of mobile technology to promote collaborative learning. The excerpts demonstrate the interconnected process of online knowledge construction through all five phases of the IAM. The detailed explanations, disagreement leading to negotiation of meaning, testing of ideas, and nuanced economic discussions offer examples of the types of interactions possible via MIM. The progression to a deeper understanding was facilitated by the

unique affordances of MIM (group connectivity, context-free access and quasi-synchronous communication), together with the well-structured course project.

The findings may benefit educators in several ways. First, instructors should consider utilizing a file hosting technology like Google Drive to enhance information sharing. Though communication technology like MIM allows for anytime anywhere interaction, they are limited in the types and amount of information that can be shared. For projects that require the sharing and storing of larger files of information, instructing students on the combined use of different applications may be beneficial. Another practical implication is the impact of task structure on the types of collaborative learning that can occur. This study demonstrated that a well-structured project with a clearly defined start and end state may promote the progression from negotiation of meaning to application and understanding. A final recommendation is to consider the affordances of a technology when selecting an application for use in class. Often instructors choose an application that is popular or convenient. However, the alignment between the types of interactions needed for the completion of a project and those afforded by the technology should be considered carefully.

There are several limitations to this study. First, the scope of the investigation limited the analysis of interactions to those representing a progression of knowledge construction through the various phases of the IAM. The 4,685 messages posted to the MIM group contained other types of interactions such as the planning and distribution of individual tasks, coordination of peer editing activities, and arranging of face-to-face meetings. These interactions did not figure into the analysis for this study. A second limitation is the lack of student perspectives. The findings could have been further justified through interviews with the participants to obtain their view of the collaborative learning process. Furthermore, the data was derived from group interactions from an English-medium economics course at a private Japanese university, impacting the potential transferability of the findings. The economics content of the course, the English-medium instruction, the structure of the course project, and demographics of the students must all be taken into account. Finally, the data was collected as part of a one semester course. Potential avenues for future research could be studies of longer duration and in different learning contexts.

The findings of this study seek to add to the still developing understanding of online learning in formal contexts. The sustained negotiation of meaning demonstrated by the participants may contribute to a better understanding of how task structure and choice of technology lend themselves to different timescales for the construction of knowledge. Continued research on MIM mediated groupwork may lead to ways in which out-of-class student interaction can be leveraged for learning of more complex concepts that require more time and reflection than is available in class.

Author Statement

The author declares that he has no conflict of interest.

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