Community-based individual knowledge construction in the classroom: a process-oriented account

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Abstract
This paper explores the process of knowledge convergence and knowledge sharing in the context of classroom collaboration in which students do a group learning activity mediated by a generic representation tool. In analysing the transcript of the interactions of a group, we adapt the group cognition method of Stahl and the uptake analysis methodology of Suthers to understand how the members of the group did meaning making in their interactions, and how individual members did uptakes of their interactions and applied their new shared knowledge or understanding in new situations. The transcript is taken from our school-based research using the Group Scribbles software technology which provides representation spaces for individual, group or class work to support collaborative practices. Our work contributes toward a methodology for explaining a process-oriented account of a small group interaction through face-to-face communication over external shared representations.

Keywords
collaborative learning, knowledge convergence, knowledge sharing, uptake analysis.

Introduction
Collaborative learning connotes the notion of groups of learners sharing and developing mutual understanding through social interactions. They co-construct knowledge by working on joint problems or tasks, including making individual contributions, partaking in discussion and arriving at joint solutions (Roschelle & Teasley 1995). In doing so, they adopt ideas from their peers and share specific conceptions after collaborating. They influence one another, and converge or diverge with respect to knowledge.

Knowledge convergence happens from the reciprocal nature of collaboration which leads to an increased similarity in the cognitive representations and knowing of the group members. It has been conceptualized in various ways. It is interpreted as how members of the group are becoming similar with respect to their knowledge, as knowledge equivalence and as shared knowledge prior to, during, and subsequent to collaborative learning (Weinberger et al. 2007). Knowledge convergence is also defined as an increase in common knowledge where common knowledge refers to the knowledge that all collaborating learners had (Jeong & Chi 2007). Learners who converge in knowledge have been found to benefit more from collaborating than learners who do not (Fischer & Mandl 2005).

Research into the processes of knowledge convergence has explored notions that learners share knowledge through discussion by explicating their knowledge in contributing ideas within a discourse, and other learners integrating these ideas into their own line of reasoning (Weinberger et al. 2007). A collaborative learning community can solve problems which individual members could not, and the group cognition processes cannot be decomposed into the aggregation of
individual cognitions (Stahl 2006). Yet, within such a collaborative learning community or setting, there must be community-based individual knowledge building and knowledge sharing (e.g. more and more individuals in the community can now solve problems of type X). There is also uptake or acceptance of patterns of collaboration that leverage cognitive diversity of the community members (e.g. when employing pattern of collaboration Y, the community can solve problems of type X, but without it, the community cannot solve them).

In this paper, we seek to operationalize this notion of community-based individual knowledge building or construction. In community-based individual knowledge construction, we mean that the group members could have the same or similar knowledge because each of them collaboratively interprets a situation or solves a problem together. Fischer & Mandl (2005) note that more research is needed on the role of knowledge convergence in collaborative knowledge construction. Our work contributes to a process-oriented account of how a small group of students achieve knowledge convergence and knowledge sharing through participation and access to the groups’ interactions and external representations.

We do this in the context of the use of a technological system that provides external representations for public sharing. Our data is obtained from a classroom in which students do a group learning activity using a generic representation tool. The work is part of a three-year school-based research project using the Group Scribbles (GS) software technology which provides representational spaces for individual, group or class work to support collaborative practices.

The data collected comprises verbal talk as well as recorded digital artefacts and screenshots arising from the interactions. We are motivated to look for a data analysis method that can help us do microanalysis of how students build on each other ideas and make meaning in their group collaboration. The closest analysis methods that are available are the group cognition methods of Stahl (2008) and the study of intersubjective meaning making by Suthers (2006); however, they work only on computer logs. Our data includes face-to-face conversation and computer logs, and therefore we adapt their methods to trace the interaction moves in the data we have collected in the classroom. In analysing the transcript of one such group interaction, we adapt the uptake analysis methodology of Suthers to understand how the members of the group make meaning in their interactions, and how individual members made uptakes of their interactions and applied their new shared knowledge or understanding in new situations. Our work contributes towards a methodology for explaining a process-oriented account of a small group interaction through face-to-face communication over the GS environment. This account helps us to understand how collaboration does lead to community-based individual knowledge construction.

This paper is structured as follows: Section 2 reviews frameworks for interaction analysis of collaborative interaction; Section 3 presents the research setting and design; Section 4 describes the collaborative task; and Section 5 proposes the types of response linkages identified in the group interactions. An analysis of the interactions of a group of four students doing the collaborative task is provided in Section 6. Section 7 provides some further discussion and concludes the paper.

Frameworks for interaction analysis of collaboration

In the computer-supported collaborative learning community, there is interest in analysing the interaction processes in online learning environments. We adopt the framework of interaction analysis as the analytical tool of this study. Interaction analysis is an interdisciplinary method for the empirical investigation of human relations with each other and the environment (Jordan & Henderson 1995). In analysing interactions in such environments, researchers have to take into account the construction and manipulation of representations on the shared workspace which may or may not be augmented by face-to-face interactions. Participants collaboratively build knowledge through negotiation and sharing of their perspectives on constructed/co-constructed representations, bringing upon a flow of interrelated ideas that provides the basis for the group’s intersubjective meaning-making (Suthers 2006), common ground (Clark & Brennan 1991) and a shared world (Stahl 2008). The works of Dillenbourg (1999) and Stahl et al. (2006) call for the need to design process-oriented methodologies to analyse interactions. Collaborative learning situations cannot be analysed using traditional psychological methods because of the way independent variables interacted with one another, making it chal-
lenging to establish causation between the conditions and the effects of collaboration (Stahl et al. 2006).

The work of Garcia and Jacobs (1999) adopted the methodology of conversational analysis (Goodwin & Heritage 1990; Sacks et al. 1974) to study interactions during online conversations. They analysed videotaped recordings of individual participant’s computer screens during the sessions that captured the moment-to-moment interaction. They argued that the use of single point logs to analyse chat transcripts did not sufficiently capture external interaction processes such as the behaviours of participants when using the computer to transmit information (Rintel et al. 2001). One limitation of conversational analysis is the difficulty of administering video captures of participant’s screen when students are geographically apart. Garcia and Jacobs’ work was adapted by Stahl (2006) to study maths chat interaction in dual-space interaction environments using the concept of turn taking and adjacency pair. However, the sequential nature of postings may disrupt conversational coherence, challenging researchers to identify turn-taking and adjacency pair appropriately. Suthers et al. (2007) developed the methodology of uptake analysis and the notation of uptake graphs to analyse how knowledge building is accomplished in a computer-mediated collaborative environment involving a chat stream and evidence mapping tool. Uptake is the description of the act of a participant taking reifications of prior or ongoing participation as being relevant for further participation in an ongoing process of meaning making.

Uptake analysis begins by identifying uptake events which participants are taking up contributions that are either theirs or belonging to other participants and doing something further with it (Suthers 2006). Collaborative knowledge construction, which includes intersubjective learning, takes place when participants contribute their own interpretations leading to a joint composition of interpretations resulting from interactions. When participants contribute their own interpretation on contributions, they are taking up contributions from fellow participants and doing something with it, forming the basis of an uptake event. According to Suthers (2006), uptake events are possible in any medium where participants are able to interact. This is useful when applied to situations where the interactions do not involve conversation such as technological mediums where interactions are often in the form of representations. Upon identifying the uptake events, it is necessary to recognize how and what the participants have jointly accomplished through the series of uptakes in order to study collaboration knowledge construction.

In this paper, we will explore the process of how a group achieving knowledge convergence through face-to-face discussions mediated by a shared representational workspace. Our approach is to do an interaction analysis of the intragroup collaboration using concepts from uptake analysis by considering interactional moves from the discourse in verbal and technological interactions.

Research context for collaborative discussions in the classroom

Our data is drawn from a project which introduces rapid collaborative knowledge building practices in classrooms (Looi et al. 2010). Collaborative activities are co-designed by the teachers and researchers. The students work on groups of four in their collaborative discussions. The students in a group are seated next to each other, and they engage in face-to-face talk. They use a technology called Group Scribbles (GS) which enable them to create private scribbled posts in their private space, and then move them to the group space which can then be viewed by others. It enables collaborative generation, collection and aggregation of ideas through a shared space based upon individual effort and social sharing of notes in graphical and textual forms.

GS supports hand-drawn sketches, enabled by the inking affordances of Tablet PCs, and thus can be more expressive of the key concepts one wishes to communicate than a neat, chiselled presentation would have been (Norris & Soloway 2003). An informal sketch may be able to solicit participation of others in active reasoning more effectively than a more formal, fixed diagram would have. Moreover, the act of drawing, gesturing and speaking in close synchrony allows one to focus the attention of others on the meaning of the diagram he was preparing (McCullough 1996). Effectively supporting students’ face-to-face interactions and elaborating students’ interaction as well as coordination in collaborative learning becomes possible with the use of GS.

The GS user interface presents each user with a two-pane window. The lower pane is the user’s personal work area, or ‘private board’, with a virtual pad of fresh ‘scribble sheets’ on which the user can draw or type (see
Fig 1). The essential feature of the GS client is the combination of the private board where students can work individually and group boards or public boards where students can post the work and position it relative to others', view others' work and take items back to the private board for further elaboration. Figure 1 shows a lesson activity in class in which each pupil posts answers to the question ‘When does the heart beat faster/slower?’ in the private board, and then moves their answers to the public board for sharing. The students’ scribble notes showed a multiplicity of ideas they generated which enabled the teacher to initiate discussions on the interesting postings. For example, one student posted ‘just before examination’ in the category of ‘faster heartbeat’, a contribution which surprised the teacher and the class and which prompted the teacher to initiate a discussion on why this might be the case.

A design-research approach is adopted in the school-based work to address complex problems in real classroom contexts in collaboration with practitioners, and to integrate design principles with technological affordances to render plausible solutions (Brown 1992; Collins 1992). In the work with a primary (elementary) school in Singapore, two primary 5 classes (about age 11) were involved. Every week for 10 weeks, two-lesson periods (totalling an hour and 10 min) for the subjects of science, mathematics and the Chinese language-adopted GS lessons which were conducted in a computer lab. Each pupil has an individual Tablet-PC (TPC) with a GS client software installed.

In the collection of data, two or more researchers observed each class and took down detailed field observation notes. One video camera was set behind the classroom to record the classroom session, while two other video cameras were focused on two target groups of students. Screen capturing software Morae 2.0 was installed on the TPCs to record the interaction of the pupils using GS. Taking the perspective of interaction analysis, we attempt to make sense of some of the interactions between students using concepts from uptake analysis and to understand how collaborative experiences are structured as interpersonal interactions sustained over the GS medium and face-to-face talk (Stahl 2006). While the data discussed in this paper is collected from a GS classroom, the analysis of interactions presented in this paper is not specific to GS and can be adopted for synchronous communication (whether face-to-face or text-based) over shared representations (whether digital or otherwise). In the next section, we will discuss the analysis of the interactions within a group of students in the mathematics lesson.

**The collaborative task**

This data is from a Primary 5 mathematics class on the topic of finding ratios. The GS activities were
co-designed by the researchers and the teachers to achieve the objectives of the school curriculum, albeit in non-traditional ways. They were designed not for the convenience of research, but were integrated tightly with the science curriculum topics. By analysing the interactions, we show how knowledge spreads in a weekly routine lesson in which GS is used to support rapid collaborative knowledge building and thus our focus in this paper is not targeted at establishing the efficacy of GS over other existing tools and approaches.

The lesson objectives are for the pupils to understand the concept of ratio as a way to show the relative sizes of two quantities, to understand that a given ratio does not indicate the actual size of the quantities involved and to draw a comparison model to represent two quantities given the ratio. Groups can also comment on other groups’ solutions. In this class lesson, the first activity on GS was to have each group of pupils practise writing a ratio given two sets of items (e.g. three shirts to two pants, four pencils to five erasers, etc.). The coordination of the activity is achieved socially by the teacher, and not by a technology-enabled script.

For GS activities, the class is divided into groups of four students, and a typical activity would be to get members of each group to work on a common problem. We will focus on the interactions of one target group of students who were seated next to each other. In this way, we can observe the students’ talk over their GS representations as well as their verbal talk. The group we observed comprised of four students: Terry, Helen, Victor and Quentin. Figure 2 shows their seating arrangements.

Figure 3 shows a screenshot of the group board that the group worked on. The ratio activity required each group to work out the ratio when dividing two pizzas among three children. Each of the four students in this group was asked to do their individual work, either thinking about the solution or creating their private GS note and then posting onto the group board. Each student created notes in his or her private board (not shown), and then moved them to the group board which could be shared, viewed and manipulated by other team members. The members of the group were expected to discuss their individual solutions within the group and to arrive at some consensus.

Identifying types of responses in the group interactions

Figure 4 shows the flow of actions and interactions of the four students. It is motivated by Suthers’ uptake diagrams (Suthers 2006) and Stahl’s group cognition analysis (Stahl 2008). Stahl (2006) uses a diagram of the responses of the postings in a chat between three participants in a chat environment in which the postings of each participant are placed in chronological order in a column for that individual. Stahl uses solid arrows to indicate his notion of math proposal adjacency pairs and dashed arrows to indicate other kinds of responses. The unit of interaction is a media event, which includes creating, editing or deleting a representation on a GS note, or a verbal utterance made. We identify uptakes by looking for some kind of evidence of media dependencies, representational association and semantic relatedness (Suthers et al. 2007). We try to unpack semantic relatedness further instead of using a generic uptake link.

For our work, after analysing several group interactions, we propose five types of responses (Looi et al. 2010):

1. Agreement on a contribution: One agrees with an idea that was suggested by another person.
2. Agreement with improvement of a contribution: One comes up with a better idea building on the previous contribution.
3. Disagreement on a contribution: One shows disagreement with what someone has proposed.
4. Incomprehension of a contribution: One does not understand or comprehend what someone was trying to express.
5 Other dependent relationship between contributions: None of the above, but there is evidence of semantic relatedness.

Weinberger and Fischer (2006) distinguish five social modes characterized by different degrees of transactivity: externalisation, elicitation, quick consensus building, integration-oriented consensus building and conflict-oriented consensus building. We see a loose mapping of response 1 to quick consensus building, response 2 to integration-oriented consensus building and responses 3 and 4 with conflict-oriented consensus building.

For the purpose of illustrating these types of responses, we extracted one segment of the actions and interactions between participants in Fig 4 and expressed them in a textual transcript form:

(In Y1 and H1, Victor and Helen had posted their individual answers onto the group board)
Terry (T2): Two divided by three children, which means each one should get 0.3 something.
Terry (T3): (Tried to divide two pizzas among three children) Cannot, it is impossible! It will give a number of 0.333 33.
Helen (H2): (Pointed her answer post to Terry) Then each pizza divided into three, then each person will get two!
Victor (Y1): No need what, you can use short cut, like that! (referring to his answer post)
Helen (H3): (Interrupted Victor) Then each pizza divided into three, then each person will get two!

Terry (T4): (Murmured to himself) Oh ya, she is right.
Terry (T5): (Attempted to start sketching) Aiya, I don’t know.
Victor (Y3): Yes, like what I post! Helen, look at what I have posted!
(In H4, Helen looked at Victor’s post and posted a ‘?’ comment on his method)

For the first type of response, agreement on a contribution, one agrees with the idea that was suggested from the other. Terry’s response in T4 to Helen’s suggestion made in H3 showed an example of an agreement on a contribution.

For the second type of response, agreement with improvement of a contribution, one comes out with a better idea based on the original one from the other, besides agreeing on that. As Victor heard of Helen’s suggestion, he made a remark that his method was a short cut in comparison with her idea in Y1. This would infer that Victor proposed an improvement of Helen’s idea in addition to concurring with her.

For the third type of response, disagreement on a contribution, one is disagreeing with the idea proposed by the other instead. In this case, in H3, Helen interrupted Victor’s suggestion and repeated her suggestion to Terry. This would a sign that she saw her answer as more appropriate than his.

For the fourth idea, incomprehension of a contribution, one is not able to understand or comprehend what the other was trying to express. An example of such
Activity: Students are to divide 2 pizzas among 3 children in form of fraction

<table>
<thead>
<tr>
<th>Terry</th>
<th>Helen</th>
<th>Victor</th>
<th>Quentin</th>
<th>Researcher’s interpretation of media events(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td></td>
<td></td>
<td></td>
<td>Was doing his mathematical working</td>
</tr>
<tr>
<td>T2</td>
<td>H1</td>
<td></td>
<td></td>
<td>Vicar drew it after he knew answer was 2/3</td>
</tr>
<tr>
<td>T3</td>
<td>H2</td>
<td></td>
<td></td>
<td>Terry had difficulty in fraction, so he represented his answer in decimals</td>
</tr>
<tr>
<td>T4</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>T5</td>
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</tr>
<tr>
<td>T6</td>
<td></td>
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</tr>
</tbody>
</table>

Fig 4 Intra-group interaction in a math activity.
would be when Helen posted a ‘?’ comment on Victor’s post in H4.

The last type is none of the above, but there is some kind of dependency or semantic relationship. For example, in T2, Terry started his conjecture that each one should get 0.3 something when two was divided by three children, and subsequently in T3, he tried attempting his working out and realised he got an illogical (which he meant by impossible) answer of 0.333 33 and commented that his answer could not be the one. So the action taken and comment made by T3 is a contribution that is dependent on another contribution (in T2) before that.

The representation of these five types of responses can give us a way to study possible different flow of patterns of a student’s learning through intra- and inter-group collaboration, e.g. whether a student has learnt after going through several rounds of incomprehension, or after going through some disagreement with other friends. They might also illuminate even whether a student has actually learned by just agreeing consistently with every suggestion made by others. In the analysis of GS intra-group discussions, we do see a spread of all five types of uptakes.

Analysis of the group interaction

The activity in our targeted group commenced as follows: Terry drew a circle, and then undid the action as he verbalized his reasoning (refer to Fig 4, T1–T3). Concurrently, Helen and Victor posted notes that showed a graphical way of dividing the pizzas. Helen created two notes showing the division of each pizza into three equal parts, and then directed Terry to the notes (Fig 4, H1 and H2). Victor also drew two circles in one note, with divided parts for three imaginary persons: A, B and C. He drew the note after he figured out the answer of 2/3 (Fig 4, Y1). Victor told Helen that his was a ‘short-cut’ solution to the problem (Fig 4, Y2 and Y3). Helen interrupted Victor and emphasized her own explanation (Fig 4, H3). At this point, temporal proximity is evident as Terry made a quick comment ‘Oh ya, she is right’ after he understood Helen’s solution (Fig 4, T4). Temporal proximity helps us to establish an uptake relationship.

In essence, Helen posted two GS notes showing her understanding of how to divide a pizza into three pieces. Terry had an uptake from the contributions from Helen, and developed some understanding on how to divide the pizza. He tried to divide his pizza in a similar way but could not replicate the division, and so he typed his answer out in text. While Terry developed an understanding on how to divide, he was not able to replicate or express it in a pictorial format (Fig 4, T5). The GS notes supported multimodal expressions, as Terry could not express his understanding in a visual way, but was able to type out his understanding in a textual way (Fig 4, T6). From Terry’s textual post, there is evidence of semantic similarity where Terry’s final method of combining the two pizzas and then dividing into the six slices is his interpretation of Helen’s explanation of ‘having each pizza divided into three’ to him. Terry’s attempt to ‘distribute two to each person’ on his post was derived from Helen’s idea of ‘each person get two’ as well. Terry’s finalised answer was the evidence of uptake from Helen’s and it was different as compared with his original attempt in decimals initially. We see this uptake as an instance of uptake across the representational space, that is, there is evidence of media dependency with the uptake built upon the media representations which are shared across participants. Victor developed his own solution representation which was less decipherable than Helen’s solution, and stuck to his own solution. He might have perceived the query posted to him, namely, ‘?’ as irrelevant as he thought his solution was correct (Fig 4, Y4).

Although both Helen and Victor proposed solutions on dividing the pizza, Helen’s proposal was verbalized and taken up by Terry while Victor was not developed further. We see this as an instance of an uptake across people. Helen’s proposal can be considered a pivotal contribution (Wee & Looi 2009) because of its potential affordance of knowledge construction offered to the group. A pivotal contribution is one that seems instrumental in influencing the knowledge building process. Victor’s proposal seemed to lack clarity and he did not actively attempt to engage the others to explain his proposal. Both proposals offered different approaches and were mathematically correct. However, it will be useful to find out how Victor’s failed proposal could have been developed by other members.

Each student relied on their own individual work even though they discussed as a group. Terry wanted to
re-create his own solution after he has seen Helen’s solution. We see Terry’s effort as an imitation routine where he tries to individualize the understanding as his own ability (Sfard 2008). The way the group approached this problem is for each of them to individually craft their solution or solution steps, and then discuss and learn from each other. This has been one pattern of activity design for group work on GS. The current class seating arrangements is still like that of a traditional class (see Fig 2) which was constrained by the network cabling to the students’ Tablet PCs. Terry and Helen were seated next to each other, facilitating their more frequent verbal interactions; Helen and Victor who were seated a row behind also interacted verbally.

The group interaction happened very fast, in about 2 min, manifesting rapid collaborative knowledge building. Helen and Victor started with visual representations and talked over it. Terry learned from another group member Helen on how to divide a pizza for a specified ratio and how to express the ratio. Helen and Victor both posted a graphic note representation, and verbalized over their own notes. Terry built on the contributions from Helen, and developed some understanding on how to divide the pizza.

Subsequent potential evidence that Terry’s interactions in this group activity improved his understanding was found during the subsequent activity in the same class session where he was able to comment and critique on two other group’s solutions for a different ratio problem (Fig 5). Quentin’s GS posting (Fig 4, Q2) showed a mistake in his answer. At that point of time, he did not notice it, as none of his group mates posted a similar numerical answer as his. He realised his careless mistake and amended it eventually when he spotted a similar representation, but of a different answer on another group board (Fig 6). We see these as instances of uptakes across time, in a continual process of meaning making beyond the intense group session that was discussed above. Indeed the teacher told us that she realized that after conducting this activity, she observed that there was not enough clarity in what constitutes the whole in formulating the fraction, and that some students did have problems with expressing the mathematical notation for the part-whole concept. Hence, she re-emphasized the correct concept to her students at the end of that GS lesson and the subsequent mathematics lesson. She made use of this feedback to refine her preparation in conducting the same lessons for the other classes as well, as she anticipated such similar mistakes could also happen to her other classes.

**Discussion and conclusion**

In developing a process-oriented account of how a group of learners achieve knowledge convergence and sharing, we have explored various frameworks in supporting analysis of collaborative knowledge building through the media affordances of GS as well as the face-to-face interactions mediated by the GS artefacts. We adapted Stahl’s group cognition methods (2008), and Suthers, Dwyer, Medina and Vatrapu’s uptake analysis framework (2007) to study group interaction in GS. In
this episode of small group collaboration in the fractions activity where students learn representational notations for fractions and ratios, we shared some instances of how the uptakes are identified across the students in the group. There were evidences of uptakes across the representational space mediated by face-to-face discussions that helped members of the group to further develop his or her understanding. The proximity of the posts to each other served a deictic function as students could talk about and refer to something by posting near it. There were also evidences of uptakes across time that showed members such as Terry and Quentin manifesting their understanding later in the sessions when they commented on other postings. Although Quentin was not involved in the intense interactions in these few minutes, there is evidence later (from his comments on other related work) to show that he has acquired some understanding.

In the episode here, the uptake analysis shows collaboration within the group leading to knowledge convergence, namely, a common understanding of how to divide the pizza appropriately for a given ratio. The pivotal contribution of Helen manifested clarity as compared with that of Victor, and this helped towards this convergence. We postulate that if we perform analysis of all the intragroup interactions as well as the intergroup interactions, we can piece together a fabric of how knowledge sharing happens and how knowledge spreads in the classroom through collaborative discussions mediated by the technology.

Fig 6 Process which Quentin went through in changing his answer.
Our data analysis method examines both technology inscriptions as well as verbal utterances with deictic references (from the video recordings). Like in Suther’s uptake analysis and Stahl’s group cognition analysis, the critical link is identifying uptakes across time, space and people, and providing evidences for such uptakes. We distinguish five types of semantic links which are the researchers’ interpretation of the uptake or reference relationships in order to help us make sense of the group interactions. Different types of responses can be further explored to see if they can provide a handle to study possible different patterns of students’ interactions through intra- and intergroup collaboration, for example, in the boundary conditions such as whether and how a student has learned after persistent rounds of incomprehension, or rounds of agreement, or rounds of disagreement in a group interaction.

We have explored triangulating the identification of uptakes with post-event recalls and reflections from participants in the group collaboration in the context of the Virtual Math Team (VMT) Chat environment (Wee & Looi 2009). Future work includes having multiple people doing the data analysis and defining a form of reliability estimates for identified uptakes.

We hope that the work reported here will contribute towards a data analysis method for analysing how interactions occur in intra-group collaboration as well as inter-group collaboration in a blended situation, and how they lead to knowledge convergence and sharing. Given the tremendous challenges with analysing the rich data in the classroom setting, as the researchers need to record and observe the full communication over and above the technology interactions, this work provides an account of what is feasible in analysing an intra-group interactions as well as between-group interactions.

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