Automated CSCL Group Assessment: Activity Theory based Computational Method

Wanli Xing
University of Missouri
wxdg5@mail.missouri.edu

Sean Goggins
University of Missouri
Gogginss@missouri.edu

ABSTRACT
This workshop paper describes automated assessment of CSCL groups based on activity theory. In contrast to our prior work, the algorithms and analysis presented here focus entirely at the small group unit of analysis. The work presented is exploratory and preliminary in nature. It is our hope to refine it through participation in this workshop.

1. INTRODUCTION
It is known that assessment can strongly affect learning [1]. Interestingly, though several studies [2, 3, 4] have extensively studied the theoretical and methodological positions in CSCL, assessment of collaborative learning is still an implicit issue [5]. Group learning is a foundational concept in CSCL, but a good deal of assessment continues to focus on the individual. Even group assessment remains largely summative in nature [3, 6]. For example, after a review of 186 articles [6], it was determined that the most common practice for group assessment was to evaluate collaboration products including many types of assignments and feedback mixed with self-report questionnaires and interviews. These assessments are usually administered after the collaboration, which fundamentally undermines the theoretical constructs of CSCL. After all, 'ongoing' and 'real-time' are key characteristics of the core concepts of CSCL [7,8]. Assessment methods using collaboration products or ex post facto questionnaires/interviews were unable to study change on longer time scales [15] and also disconnected from the instructional setting [3].

Essentially, without an established way to assess group performance and learning during collaboration, research communities are diverging in their identification of indicators of group performance. According to Gress, et al [6], there are roughly four possible directions for group assessment and more than 70 measurements used as to assess successful collaboration, tools usage, social interaction and communication, and group knowledge and meaning construction. The diversity of views on measuring group learning indicates that experimentation and validation of different approaches is required. Such research must be systematic, as the problem space is not clearly bounded, and the approaches are varied. From this, a fundamental question is raised: how could we systematically assess group performance in CSCL?

In response to this basic question, we approach group assessment in CSCL through the lens of activity theory, from which we holistically frame group process, interaction dynamics in the activity system. In addition, a quantification model of activity theory is built based on the electronic trace data generated by the students for the group level assessment. As a result, the whole process could be easily automated to release the teachers' assessment burdens. This paper is organized as follows: We first describe the theoretical framework that guided this study. Then the VMT background and dataset is described. Last, we propose the research methodology and results.

2. THEORETICAL FRAMEWORK
The Activity System model developed by Engestrom [9] offers a way to comprehensively frame collaborative knowledge development process while linking together social behavior and its interdependencies [10, 11]. To illustrate, an activity system provides three characteristics for analyzing learning in group work [12]: activity theory focuses on contextuality and is oriented towards comprehending systematically group dynamics, objects, mediating artifacts and social organization; it also relies on dialogical theory of knowledge and thinking (language and communication) with a concentration in human cognition; further it is a developmental theory that aims to explain changes in human practices over time.

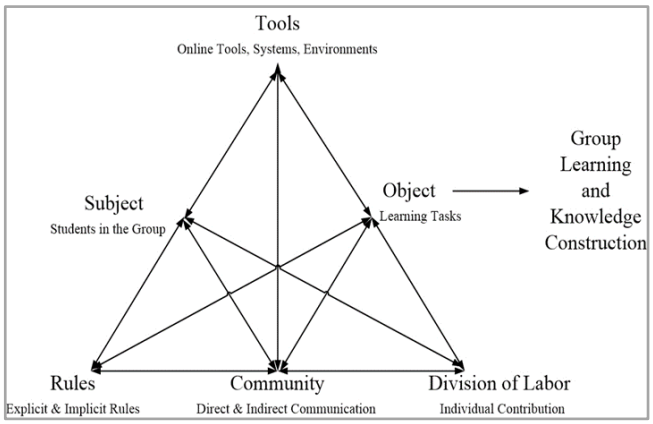

Figure 1 - Activity Theory analysis in Group

A model of the structure of an activity system was formulated by [9], and includes the interacting components namely: subjects, tools, rules, community and division of labor (see Fig. 1). The activity of group learning is "the joint activity of a student, physical/symbolic tool(s), and another person(s) performing together as a working social system to achieve some outcome under constraints such as rules." In our CSCL group assessment context, the outcome and process of this transformation may both be seen as learning and knowledge. It is the sum of the system components and the tensions among them that make up the learning and knowledge construction and influence the learning outcomes. Current assessment practices of group performance from various learning theories often address part of the activity of the learning system, focusing only on process, context, cognition or artifacts or mix of two or three. Activity theory helps us to address the complex interactions and see into group performance in the socio-technical CSCL environment (see Table 1).

Table 1 - Detailed description of Activity Theory Operationalization

Measure-metric	Definition
Object	Complete learning tasks together such as solving a problem or producing an artifact (e.g. essays)
Subject	Students involve and participate in the learning activity. When assessing group performance, effort, motivation, relationships, group composition etc. should be taken into account
Tools	Computers, online tools, systems, and environments that mediate the learning and collaboration activity
Community	Direct and indirect communication enables the group of students to maintain a sense of community and belongings.
Rules	Implicit and explicit rules and guidelines that constrain the activity. For example, teachers can set specific rules for a learning task (explicit) and an students can only use the functions residing in the supporting tools or bounded by social established norms (implicit)
Division of Labor	Coordination between group members in the overall object.

3. METHODOLOGY

3.1 Research Context

In this study, we operationalize activity theory as a lens for making sense of electronic trace data from a synchronous math discussion board, focusing on several modules of a course designed to be taught with Virtual Math Teams with Geogebra (VMTwG) software (Figure 2). The class is called "Dynamic Geometry." Each includes a team of three to four. This course also contained different modules or sub-set problems for a group of students to solve collaboratively. The full curriculum currently includes a total of 18 topics, and is available at the project website (http://vmt.mathforum.org).

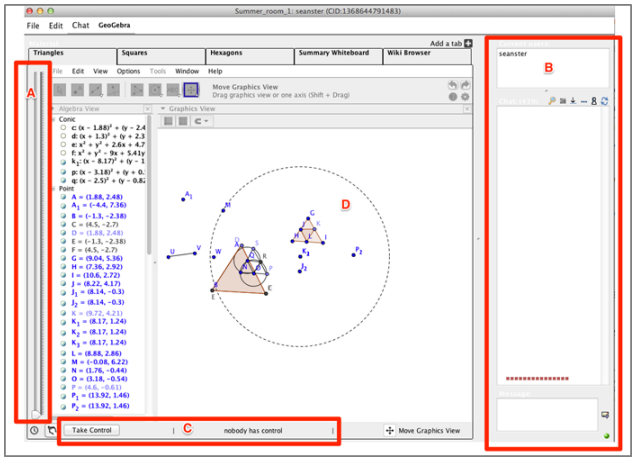

Figure 2 - VMTwG of an analytical tool for collaborative math discourse

Figure 2 provides us with a guide for understanding the cognitive learning discourse in VMT. There are four sections in Figure 2. Section A reveals the time dimension. It is the VMT replayer bar. Each action within VMTwG is logged with a timestamp. Section B is the chat window. Here, text is entered in chat. Future analytics in this project will focus on the analysis of the actual text in those windows, in concert with GeoGebra gestures. Sections C and D are related to Geogebra actions. C is the "Take Control" button mentioned previously. Section D is the GeoGebra window itself. Students are working to create an equilateral triangle within an equilateral triangle, and many approaches are being tried. This is an ordinary part of how VMTwG facilitates interactive problem solving discourse among teams.

3.2 Dataset Description

We collected all the log data for this study in .txt format, which centers on specific event types from the CSCL environment (VMT): Awareness, Geogebra, System, Chat, and WhiteBoard (Wb). The Chat event type logs all the messages that students communicate with each other. Awareness records the actions of erasing the chat messages when the student realizes they are full on the chat bar. Geogebra logs information on how students visually construct a geometry artifact (e.g. add a point, or update a segment etc.). The System event type records information on how the VMT environment is accessed. For example, a student joins a virtual room, leaves a virtual room or views different tabs created by the students or teachers. Wb logs more specific actions on how tools are being used in the white board areas such as resizing of objects, creating a textbox, etc. For every event type, we have logs of what action (adding a point, sending a chat, erasing a message, or creating a text box, etc.) the student makes under what subjects/tasks (modules and tasks) as well as the starter (source) and receiver (Target) of those messages. In addition, the environment logs the information about when this action takes place (time) and in which virtual room (group) the event occurs.

Figure 3 shows a sample of original log data.

Subject	Topic	Room	Source	Target	Time	Finish Time	Event Type	Event
Dynamic Geometry	Topic 02	Holland_Group_1	elijah_b	elijah_b	0:00:00	34:49.7	Geogebra	2013-03-01 13:34:49.746 - elijah_b -> tool changed to Move
Dynamic Geometry	Topic 02	Holland_Group_1	elijah_b	elijah_b	0:00:02	34:52.4	Geogebra	2013-03-01 13:34:52.400 - elijah_b -> tool changed to Move Graphics View
Dynamic Geometry	Topic 02	Holland_Group_1	chris_j	elijah_b	0:00:05	34:58.1	system	2013-03-01 13:34:58.111 - chris_j -> Now viewing tab Where's Waldo?
Dynamic Geometry	Topic 02	Holland_Group_1	elijah_b	chris_j	0:00:10	35:08.3	awareness	2013-03-01 13:35:08.340 - elijah_b -> [fully erased the chat message]
Dynamic Geometry	Topic 02	Holland_Group_1	elijah_b	chris_j	0:00:10	35:30.1	chat	2013-03-01 13:35:30.111 - elijah_b -> Im new controller
Dynamic Geometry	Topic 02	Holland_Group_1	chris_j	elijah_b	0:00:08	35:43.8	chat	2013-03-01 13:35:43.779 - chris_j -> ok i am timekeeper
Dynamic Geometry	Topic 02	Holland_Group_1	minkailu_	elijah_b	0:00:08	35:46.0	system	2013-03-01 13:35:46.049 - minkailu_s -> Now viewing tab Relationships
Dynamic Geometry	Topic 02	Holland_Group_1	minkailu_	minkailu_	0:00:01	35:47.6	system	2013-03-01 13:35:47.618 - minkailu_s -> Now viewing tab Equilateral
Dynamic Geometry	Topic 02	Holland_Group_1	chris_j	minkailu_	0:00:07	35:59.6	awareness	2013-03-01 13:35:59.612 - chris_j -> [fully erased the chat message]
Dynamic Geometry	Topic 02	Holland_Group_1	elijah_b	minkailu_	0:00:01	35:55.9	Geogebra	2013-03-01 13:35:55.872 - elijah_b -> tool changed to Segment between Two Po
Dynamic Geometry	Topic 02	Holland_Group_1	chris_j	elijah_b	0:00:06	36:08.8	chat	2013-03-01 13:36:08.844 - chris_j -> MINK... COME BACK
Dynamic Geometry	Topic 02	Holland_Group_1	minkailu_	chris_j	0:00:04	36:13.6	system	2013-03-01 13:36:13.615 - minkailu_s -> joins the room
Dynamic Geometry	Topic 02	Holland_Group_1	chris_j	minkailu_	0:00:03	36:28.2	chat	2013-03-01 13:36:28.223 - chris_j -> SHE IS BACK
Dynamic Geometry	Topic 02	Holland_Group_1	chris_j	chris_j	0:00:00	36:39.6	chat	2013-03-01 13:36:39.625 - chris_j -> \"
Dynamic Geometry	Topic 02	Holland_Group_1	elijah_b	chris_j	0:00:37	37:17.3	Geogebra	2013-03-01 13:37:17.339 - elijah_b -> tool changed to Select Object
Dynamic Geometry	Topic 02	Holland_Group_1	elijah_b	elijah_b	0:00:02	37:20.0	Geogebra	2013-03-01 13:37:19.969 - elijah_b -> tool changed to Move
Dynamic Geometry	Topic 02	Holland_Group_1	chris_j	elijah_b	0:00:07	37:57.6	chat	2013-03-01 13:37:57.647 - chris_j -> hey eli are you done

Figure 3 - Sample of logs from VMT

4. MEASURE CONSTRUCTION

4.1 Subject

Even though the individual learns as result of the group learning and that group in CSCL, according to [7], group could only learn by assuring the individuals learn. Subject in Activity Theory represents the individual student efforts to the problem solving. When mapped to our log data, it represents all endeavors that all the individuals in that group make during the whole training under the all modules.

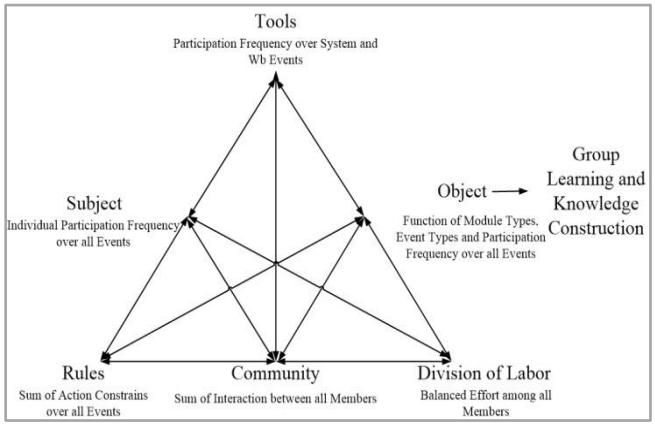

Figure 5 - Activity Theory analysis in VMT Group

4.2 Rules

According to Figure 5, Rules includes implicit and explicit rules. Under the social-technological construct, the rules are the implicit rules that constrain students' actions. In this VMT context, students have to perform actions that the VMT environment offers. Therefore, the rules are reflected by the actions the student uses across all the modules.

4.3 Tools

Group knowledge and meaning is speeded across people and artefacts [7]. Tools dimension in activity theory help focus on the process where tool facilitate the group knowledge development. VMT tools that facilitate the learning activity. Under the VMT context, the tools are the System and Wb where the groups action for tool usage is registered.

4.4 Community

All the communications that help maintain the community structure. In terms of the VMT context, students use chat to directly communicate with other group members, and use the awareness function to erase the chat messages which can be categorized as an indirect contribution to the community. Therefore, accumulation of these two dimensions of group members was used to indicate the community dimension.

4.5 Division of Labor

It is a measure of how balanced the workload is shared among team members. This dimension would have the highest value if all the members in a group shares equally for the workload and would have the lowest value if just one of the member takes care of the whole problem. Therefore, our method to indicate the balance of the work among team members, also division of labor is based on the standard deviation of the group effort with the perfect division.

4.6 Object

The CSCL activity is to achieve the object of a group student active involvement in the whole class. Hence, the first factor to consider is the number of modules the group of students participate in. In order to quantify whether the group is active in those learning modules, we incorporate the totally frequency of participation and the number of event types. By doing this, we can avoid too high of ratings for the group who participates in all the modules but makes very few actions or contributions.

In sum, based on activity theory, we have built a quantified model for a group performance in CSCL activities specific to the VMT environment: [Subject, Rules, Tools, Community, Division of Labor, Object] in Figure 5.

5. RESULTS

Group performance is represented as 6 dimension sets (after standardization) (see the table below). By investigation into those numbers alone, the teacher can provide specific advice to a particular group. For example, if the value of a group in the Community dimension is very low, the teacher could suggest for the group to communicate more between team members. Future work requires test this methodology in other settings.

Table 2 Sample Group Modeling based on Activity System after Standardization

Dimension / Group	Subject	Tools	Community	Rules	Division of Labor	Object
Group 1	4.988	1.181	0.780	1.103	0.732	0.432
Group 2	1.162	1.088	1.041	1.130	1.239	0.367
⋮	⋮	⋮	⋮	⋮	⋮	⋮

6. REFERENCES

[1] Frederiksen, Norman. "The real test bias: Influences of testing on teaching and learning." American Psychologist 39, no. 3, (1984): 193.

[2] Dennen, Vanessa Paz. Looking for evidence of learning: Assessment and analysis methods for online discourse. Computers in Human Behavior 24, no. 2 (2008): 205-219.

[3] Strijbos, J-W. "Assessment of (computer-supported) collaborative learning." Learning Technologies, IEEE Transactions on 4, no. 1 (2011): 59-73.

[4] Stahl, Gerry, Timothy Koschmann, and Dan Suthers. Computer-supported collaborative learning: An historical perspective. Cambridge handbook of the learning sciences 2006 (2006).

[5] Strijbos, J-W. "Assessment of (computer-supported) collaborative learning." Learning Technologies, IEEE Transactions on 4, no. 1 (2011): 59-73.

[6] Gress, Carmen LZ, Meghann Fior, Allyson F. Hadwin, and Philip H. Winne. "Measurement and assessment in computer-supported collaborative learning." Computers in Human Behavior 26, no. 5 (2010): 806-814.

[7] Sfard, Anna. "On two metaphors for learning and the dangers of choosing just one." Educational researcher 27, no. 2 (1998): 4-13.

[8] Reimann, Peter. "Time is precious: Variable-and event-centred approaches to process analysis in CSCL research." International Journal of Computer-Supported Collaborative Learning 4, no. 3 (2009): 239-257.

[9] Leont'ev, Aleksei N. The problem of activity in psychology. Journal of Russian and East European Psychology 13, no. 2 (1974): 4-33.

[10] Nardi, Bonnie A., ed. Context and consciousness: Activity theory and human computer interaction. The MIT Press, 1996.

[11] M.F. de Laat, "Networked Learning", PhD dissertation, Utrecht Univ., the Netherlands, 2006.

[12] Duda, Richard O., Peter E. Hart, and David G. Stork. Pattern classification. John Wiley & Sons, 2012.