

COLLABORATIVE KNOWLEDGE BUILDING PROCESS: AN ACTIVITY THEORY BASED ANALYSIS

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Abstract

Collaborative knowledge building (CKB) is seen as a means for achieving desired learning outcomes in educational contexts as well as facilitating sharing and distribution of knowledge among community members. However existing CKB studies do not appear to identify and account for the tools used by groups (at individual and group level) as part of the CKB process. The paper addresses this issue by describing a method for studying CKB using a community of practice group knowledge building activity as the research context. The method is based on operationalising activity theory constructs for analysing and studying the group's knowledge building activity. Data analysis involved conceptualising the CKB process as an activity system in which the group worked towards a shared object and identifying the ensuing contradictions in the CKB activity system. Results from the analysis illustrate participant's use of reflective thinking processes for resolving contradictions and as a tool for articulating knowledge and developing a shared understanding. Two types of contradictions are identified from the analysis; resolving which helped the group to achieve their objective. The efficacy of using activity systems as a holistic and flexible unit of analysis for studying CKB is illustrated through the discussion of results. The results have educational as well as practical implications in terms of developing research tools for analysing CKB, collecting data from a group context,

developing tools for improving group-work and building knowledge from experience within knowledge communities.

COLLABORATIVE KNOWLEDGE BUILDING PROCESS: AN ACTIVITY THEORY BASED ANALYSIS

Key Words: collaboration, knowledge building, knowledge communities, activity theory, focus groups

1. INTRODUCTION

The emphasis on collaboration as means for knowledge building within the literature on computer supported collaborative learning (CSCL) has led to a renewed interest in collaborative knowledge building (CKB hereafter) as a means for achieving desired learning outcomes in educational settings (Scardamalia & Bereiter, 1994) as well as facilitating sharing and distribution of knowledge among community members in organisational contexts (Lipponen, Hakkarainen, & Paavola, 2004). Collaboration is seen as a critical means for knowledge building within organizational (Owen, 2001; Simonin, 1997) and educational contexts (Stahl, 2006). Collaboration can facilitate knowledge building by bringing diverse perspectives and views to the problem space (Vygotsky, 1930/1978).

Studying CKB and the process by which groups build knowledge is one of the central topics of research in CSCL (Stahl, 2006). Early studies in CKB (For details refer Dillenbourg, 1999; Dillenbourg, Baker, Blaye, & O'Malley, 1996) focused on analysing the effectiveness of learning and knowledge building by analysing the role of different variables in the process (e.g. group size, group composition, task etc.). Recently the focus of the studies has shifted to understanding how the process of CKB results in the co-creation of knowledge artefacts and on understanding the interactive processes that help groups and communities to build knowledge (Stahl 2006). The focus has gradually shifted from analysing learning outcomes and studying effective conditions for CKB, to understanding the processes involved in the emergence of knowledge building at the group level (Dillenbourg et al., 1996; Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen, 1999). The central question of how knowledge is created through collaborative activities has become the main focus of attention in studies on CKB.

Stahl (2006) in his studies of CKB partly answers the above question by presenting a model of CKB process (Stahl, 2000). Stahl's model of CKB was used as a starting point and as a conceptual framework for describing a group-work activity in an academic context (Singh, Hawkins, & Whymark, 2007). Findings from Singh et al's (2007) study extended Stahl's model of CKB to account for the role of reflective thinking activities in the CKB process (Figure 1). The modified and extended model (Figure 1) will be used in this study for describing the process used by a group to collaboratively work on a shared problem and build knowledge. The model includes cycles of personal

understanding (individual level processes) and social knowledge building (group level processes) along-with underlying reflective thinking processes.

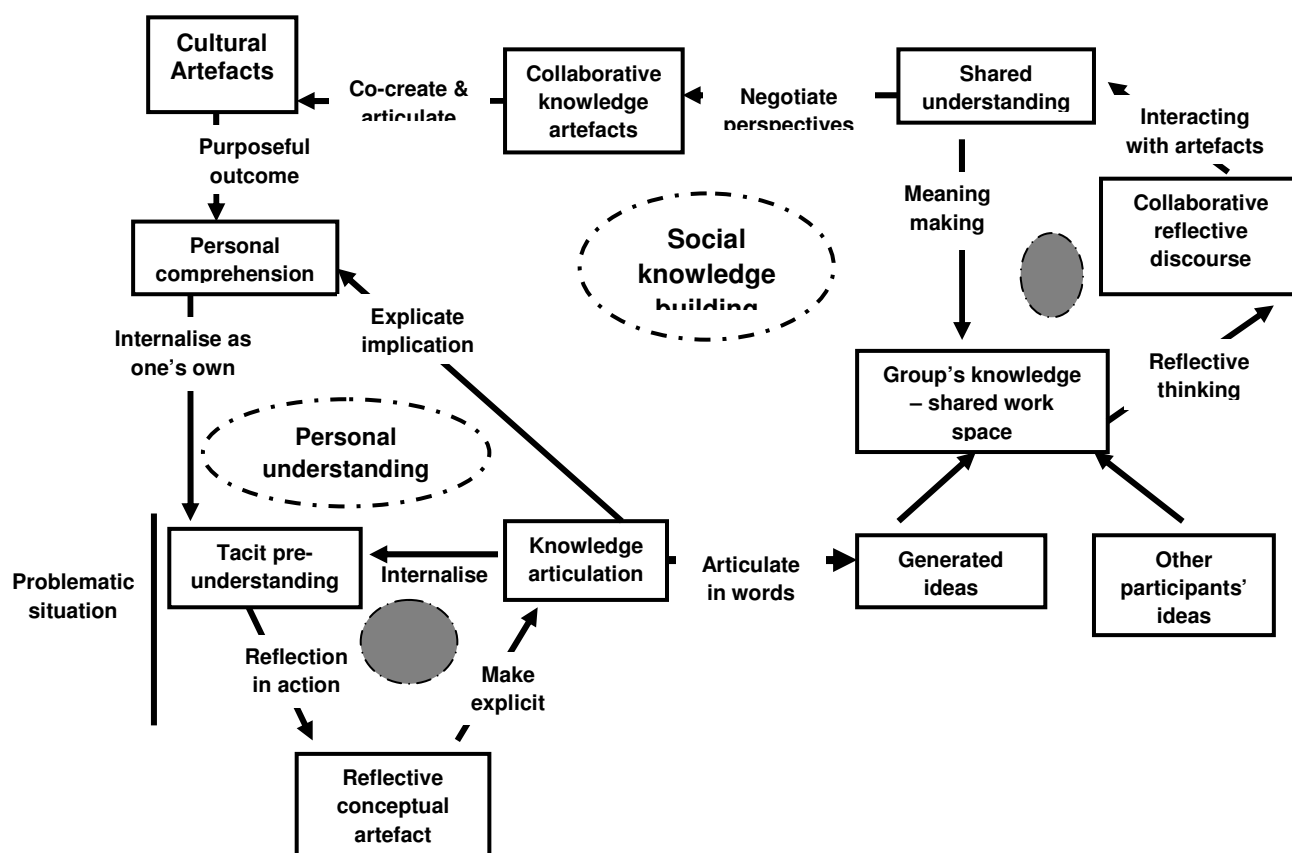


Figure 1: Model of CKB process (Singh et al., 2007)

Some of the recent studies in CKB (For e.g. Stahl, 2006) draw on ethnomethodology to show the emergence of knowledge at the group level. Methods like conversational and discourse analysis are used to analyse brief moments of collaboration during which the group extend their level of knowing (Lipponen et al., 2004). However focusing only on the group as the unit of analysis does not allow the flexibility to fully explain and analyse the relationship between the individual, social and the cultural environment (i.e. interrelated roles of - the individual, the individual and the group, and the individual's and group's relation with the ongoing collaborative activity). Lipponen et al (2004) argue that the existing methods do not appear to capture the dialectics of mediation in the CKB process due to their tendency to reduce the process to immediate interactive episodes between the participants. Furthermore, existing studies do not appear to account for the mediating artefacts and processes which underlie the process of CKB. Identifying and analysing the nature of these artefacts and how they mediate the process of CKB will help in developing a better understanding of the CKB process.

Studying the CKB process requires 1) a holistic unit of analysis which can account for the transformations occurring during the process (i.e. how the CKB process unfolds in practice), and 2) at the same time accounts for the mediating tools and artefacts used by the group participants at the individual and group level. A holistic unit of analysis would be able to identify what tools participants use, and how participants' articulate knowledge (individual level process in the cycle of personal understanding), what mediates the development of shared understanding, and how knowledge artefacts are co-created (group level processes in the social knowledge building cycle). The analysis of the CKB process, specifically the nature of tools being used (at the individual and group level), requires a unit of analysis that is flexible enough and allows the researcher to zoom in to the individual level and at same time zoom out to the processes at the group level. Activity theory is presented here as an analytical tool which provides a flexible unit of analysis and offers a coherent methodology for studying the CKB process.

The purpose of this paper is to describe an activity theory based method (Boer et al., 2002) for studying the CKB process. This is achieved by: using Figure 1 model as the starting point for describing a community of practice group activities, and using activity theory constructs for analysing their knowledge building process and group-work. Activity theory constructs (Hawking and Whymark, 2006) and language allow for the representation of a collaborative activity without stripping it of its complexity and provides a detailed description of the context, including identification of the mediating processes and tools used by the participants as part of the CKB process.

The next section introduces the concept of CKB followed by a discussion on how the knowledge creation metaphor of learning helps in conceptualising the process of CKB as an activity system. This is followed by a section that describes the educational context from where the data was gathered using focus groups. The section on data analysis describes a four step activity theory based analysis of the CKB process. The four step method involves analysing the CKB process in close collaboration with practitioners. Results from the data analysis are examined in the discussion section. The last section presents an integrated model of CKB process based on sequentially documenting the transformations in the CKB activity system.

2. COLLABORATIVE KNOWLEDGE BUILDING

CKB is defined as a social communicative process aimed at the co-creation of knowledge artefacts (Stahl, 2006). CKB refers to collective work for the advancement and elaboration of knowledge artefacts (Paavola, Lipponen, & Hakkarainen, 2002). Knowledge artefacts are defined as products or objects of thinking and reasoning that can be collectively argued about (Bereiter, 2002). Lipponen et al (2004) in their review of the underlying theories of knowledge building introduced knowledge creation metaphor of learning as an alternative to the acquisition and participative views on learning and knowledge building. The knowledge creation metaphor of learning (Lipponen et al., 2004) conceptualises

CKB as a collaborative process for developing shared objects of activity which can only be accomplished by participating in cultural practices and by becoming members of knowledge communities (Paavola, Lipponen, & Hakkarainen, 2004). Therefore, CKB is understood as an active meaning making process directed towards developing shared objects of activity. The constructs of the knowledge creation metaphor of learning pertinent to this study are discussed below (Lipponen et al., 2004; Paavola et al., 2004):

- The knowledge creation metaphor of learning aims at understanding how something new is created (could be in the form of practice, model, idea, artefacts). Engeström (2001) proposes the study of the transformations in the group activity whereby new forms of practices are created.
- The object relatedness of human activity. The object represents the motive for the activity (completing research projects, drafting strategy etc.), and the products of the collaborative activity (knowledge objects, artefacts). The objects of collaborative activity can be knowledge (Lipponen et al., 2004) or a material thing (model or idea) (Engeström, 2001). Therefore, the knowledge creation metaphor of learning emphasises that collaborative activities are driven by or mediated through these shared objects rather than individual actions constituting the process of knowledge building (Paavola et al., 2004).
- The mediating nature of the CKB process. Mediation in this context implies that groups achieve their object by means of, or through mediating objects (Stahl, 2006). The CKB process is organised around shared object of activities for co-creating knowledge with the entire process being mediated by jointly created artefacts (Lipponen et al., 2004). Participants interpret meaning and build knowledge by interacting with these artefacts.

There is also evidence based on the review of existing studies showing that reflective thinking plays an important role in the CKB process (For details refer to Singh et al., 2007). Reflective thinking is an active thinking process for monitoring one's own learning process to bring about an effective conceptual change. Reflective thinking plays a significant role in evaluating one's own learning process, bringing about an effective conceptual change (Kim, 2005), articulating tacit knowledge (Tillema & Van der Westhuizen, 2006), and helping achieve shared understanding (Yukawa, 2006).

A pilot study conducted by the authors showed the possibility of participants using reflective thinking as a tool for articulating knowledge and developing a shared understanding as part of CKB process. The pilot study used Stahl's model of CKB as a starting point for analysing the CKB process and extended it to account for the role of reflective thinking in the CKB process. The extensions to the original model are highlighted by incorporating two cycles of reflective thinking activities in the CKB model (Figure 1). In this paper we aim to further the understanding of the mediating nature of the CKB process by using activity theory as a data analysis tool. The next section provides background information of the context from where the data was gathered followed by the section on data analysis.

3. THE CASE

The case considered in this paper involved a group of academics who were part of a community of practice (COP) project. The COP was established to discuss and share assessment practices as part of a research project with specific research objectives. Therefore the COP group provided an authentic context for analysing their CKB process. The data for the paper was gathered from two focus group activities involving 8 participants after the COP group had completed their group activities (Table 1).

	Purpose	Tasks	Followed by
Group Activity 1	Gather data on specific research questions developed by the COP group using ZingThing™ groupware for capturing knowledge (referred to as Zing hereafter)	Brainstorming and generating ideas to capture prior experiences and knowledge of assessment practices	Focus Group activity – the COP group reflecting on their group activity experience
Group Activity 2	Analyse the data from Group Activity 1 and identify 3 major themes	Developing a shared understanding of the themes for each of their research questions	Focus Group activity – the COP group reflecting on their group activity experience

Table 1: Data gathering

An electronic face-to-face focus group activity followed each of the group activities, with two broad interconnected objectives. Firstly the focus group activity was used as a reflective intervention designed to help the group to analyse their own group processes, i.e. how they worked together. Secondly, the focus group activity was used by the researcher (who was also the facilitator of both the group activities) to gather data for studying the CKB process using the COP group activities as the context. Lipponen et al (2004) argue that an understanding of the CKB process can only be achieved by analysing the process in close collaboration with practitioners in authentic contexts. Therefore gathering data using focus groups, in which the COP group reflected on their group activity tasks, provided the real life authentic context for analysing the CKB process.

An electronic focus group is a group interview technique seeking to explore a specific issue with the help of a facilitator using some form of information communication technology (e.g. chat room, electronic conferencing, groupware's) (Rezabek, 2000). The rationale for using focus groups to gather data is based on the social constructivist epistemology. Paavola et al (2004) argue for understanding CKB within the social constructivist paradigm since both the approaches (i.e. CKB and social constructivism) aim to understand the creative

aspects of human cognition. The paradigm is based on the principle that individuals construct knowledge based on their experience and are constantly refining knowledge of the world by interacting with the environment. The focus group activity was aimed at gathering data on the processes and tools used by the COP group to complete their tasks. Therefore the focus groups helped in creating a context in which, the COP group participants could jointly reflect back on their group activity experience and, capturing participants' perceptions of how they completed their group activity tasks.

The focus group questions were administered synchronously using Zing. Zing allowed the group to work collaboratively on their shared objective and the output was recorded within the groupware allowing for the generation of a report which could be used for analysis. Using electronic focus group to gather data helped in obtaining diverse viewpoints from participants anonymously and capturing participants' experience of the group activity succinctly. The CKB model was used by the researchers as a heuristic tool for developing the focus group questions. The primary source of data was the participant responses to the focus group questions captured using Zing.

4. DATA ANALYSIS

This section describes an activity theory based method for analysing the COP group's activities and how they collaboratively created knowledge. Activity theory is used as a data analysis tool for providing rich descriptions of the CKB processes used by the COP group to achieve their object. Activity theory is a descriptive theory of human thought and behaviour within the context of a specific activity. Activity theory offers a framework for describing the CKB activity, as well as provides a set of perspectives on practice that interlink the individual and group level processes (Engeström, 2001). Engeström in his studies on collective human activity (Engeström, 1999a, 2001) provides a descriptive model for capturing, analysing and presenting activity based data. His activity system model (For details refer Engeström, 2008) is suited to study the CKB process as learning and knowledge building is considered to be an activity system. The activity system involves subjects and mediating artefacts (cognitive, physical) that act to transform particular objects of activity to achieve an outcome. Table 2 provides a brief overview of the constructs of activity theory that helped in analysing the data.

The role of contradictions in analysing the COP group's CKB process is further elaborated here. Within the group activities and interactions, contradictions in understanding are constantly being identified and resolved as participants work together to reach a shared understanding of the topic under discussion. Contradictions are "historically accumulating structural tensions within and between activity systems" (Engeström, 2001, p137). Contradictions need not be seen negatively but as "driving forces", "tensions" and opportunities for transforming the activities (Whymark & Hawkins, 2006). "To develop means to resolve or transform these contradictions (instead of merely shifting them elsewhere)" (Nelson & Kim, 2001, p.4), and these contradictions were identified

within the data to capture the dialectics of mediation between the individual and group level processes. Engeström (2008) indicates four different levels of contradictions that need attention during data analysis:

1. Primary contradictions occur within each constituent element of the activity;
2. Secondary contradictions occur between the constituent elements of the activity;
3. Tertiary contradictions occur between object/motive of central activity and culturally advanced form of central activity;
4. Quaternary contradictions occur between the central activity and its neighbour activities.

Construct	Description	Data analysis process
Object directed activity	Every activity is directed towards a purpose and results in transformation of the object into an outcome.	Analysis involved identifying COP group's object of activity and analysing its transformation into an outcome.
Contradictions	Role of contradictions as a source of change and development within the activity system.	Identifying contradictions within the COP group activity system helped to explain the nature of interactions, what drove the activity, and how different perspectives were resolved to develop shared understanding and create knowledge artefacts.
Transformations	Activity can only be understood through analysis of its developmental transformation.	Analysis focused on studying the transformation of object (e.g. from idea generation - to developing shared understanding - to building knowledge), that is, identifying how the COP group activity unfolded.
Tools	Human activity is mediated by tools and artefacts (physical or conceptual).	Analysis involved identifying the tools used by participants to co-create knowledge artefacts.

Table 2: Constructs of Activity theory (Adapted from Whymark & Hawkins, 2006)

Method

The method used to analyse the CKB process is based on Boer et al's (2002) method for studying knowledge sharing. Column 1 of Table 3 lists the steps involved in data analysis and column 2 shows what was done for each of the steps.

Steps in data analysis	Data analysis process
1) Choose the organisational setting (identify context) & translate it into an activity system.	The 2 COP group activities were conceptualised as an activity system using elements of Subject, Object, Tools, Rules, Community and Division of Labor (Figure ii).
2) Define activity systems at other contextual levels of analysis.	The COP group activity system was expanded to identify the interrelated activity systems at other contextual levels by differentiating between objects of activity (Figure iii).
3) Describe the mediating processes between the components of each activity system by indicating the development of each component and the potential tensions within and between these components.	<p>The tasks involved in the COP group activities (i.e. their tasks of gathering data by generating ideas, and data analysis by developing shared understanding) were related with the corresponding CKB process (from the CKB model) and conceptualised as an activity system to develop the unit of analysis.</p> <p>The data gathered during the focus group activity was analysed to identify recurring themes and related with the corresponding activity system (Table iv).</p>
4) Explore how knowledge building reveals itself within and between the activity systems by relating to the transformations of their objects and tools.	Each of the activity systems were examined to identify the mediating tools and processes used by analysing the transformation in the object of the activity. Analysis of the focus group data involved inductively relating the data with theory (activity theory and reflective thinking) to provide rich descriptions for each of the CKB sub-processes (Table v).

Table 3: Data analysis steps (Adapted from Boer et al., 2002)

Step1

The purpose of this step was to conceptualise the two COP group activities as an activity system (Engeström, 2001). Figure 2 shows the COP activity system as a set of interrelationships between the elements of the activity system.

The subject of an activity represents the participant(s) who are the focus of an investigation (Boer et al., 2002), in this case the COP group participants working towards an object. The object of the activity refers to the “problem space at which

the activity is directed” (Boer et al., 2002, p4) or what is being transformed into an outcome (Kaptelinin, 2005). The object of COP group activities was to gather data on their research questions and analyse it to develop three common themes for each of their research questions.

Tools represent the mediating physical and conceptual artefacts that are used to transform the object. The tools used by the participants included Zing, group discussion and language (such as social interactions within the group) as it allowed participants to communicate with each other, articulate knowledge and develop a shared understanding. The rules for the COP group activities were based on participation and sharing of experiences and knowledge. The community included the facilitator who is also the researcher investigating the CKB process. Division of labor defined the responsibilities within the COP group activity.

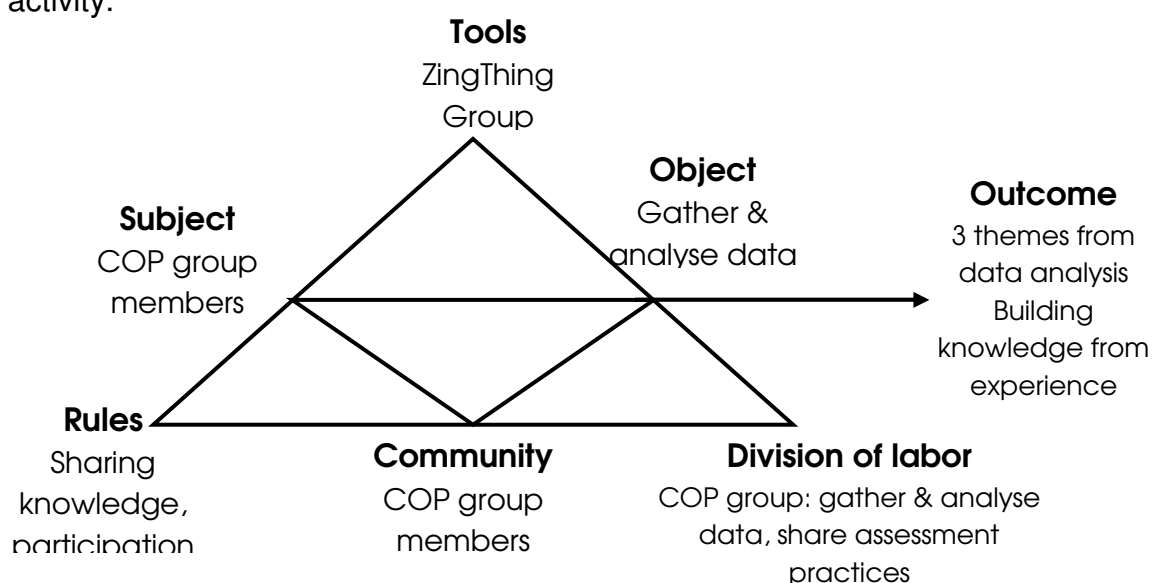


Figure 2: COP group activity system

Step 2

This step was aimed at identifying detailed activity systems at different contextual levels. Contextual levels represent the different level of analysis as part of the CKB process (e.g. individual, group). Identifying activity systems at different contextual levels allowed the researcher to focus on a particular level and then identify the mediating processes at that level.

Figure 3 shows the expanded COP group activity system. The three different levels identified in the figure correspond to the different contextual levels of the COP group activity system. The figure also helps in representing the interrelated nature of the COP group activities and the focus group activities.

Activity systems at different contextual levels were identified by differentiating between the objects of the activity (Yamagata-Lynch, 2003). For example the first level of the figure corresponds to the two COP group activities whose objective was to gather and analyse data as part of their project. On a higher level the objective also included sharing assessment practices amongst the

members of COP. The second level of the figure corresponds to the focus group activities which were conducted immediately after the COP group activities. The focus group activities were used by the researcher to gather data on the processes used by the COP group to achieve their objectives (i.e. to gather data on the CKB process using COP group activity as the context). In other words this activity was used as a reflective intervention in which the COP group members reflected on their group activity experience and analysed how they were able to achieve their objective.

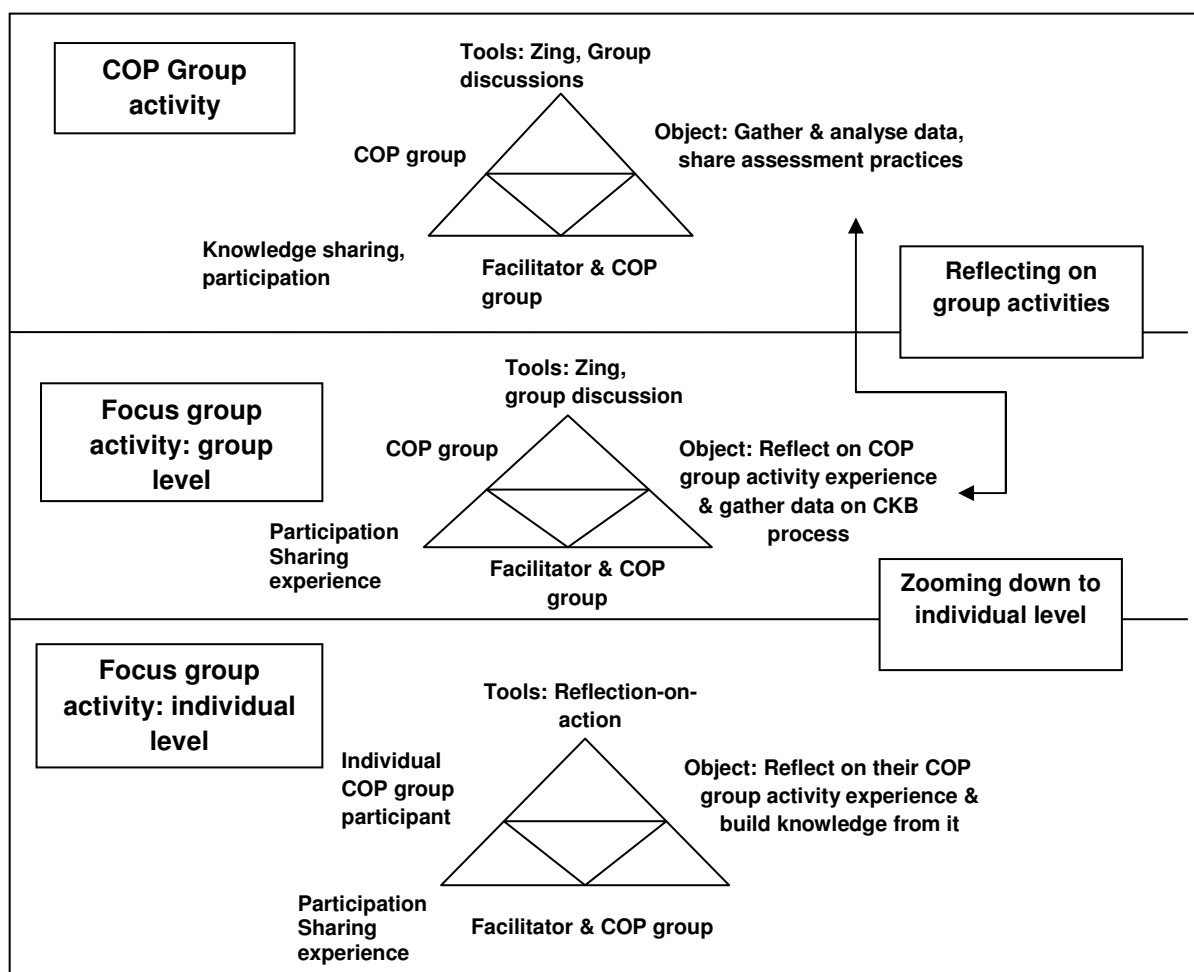


Figure 3: Expanded COP group activity system at different contextual levels

The third level shows the focus group activity system at the individual level. Identifying this level helped the researcher to focus the analysis at the individual level processes. Activity theory uses meaningful object directed human activity as the unit of analysis. In this study the unit of analysis was the expanded activity system shown in

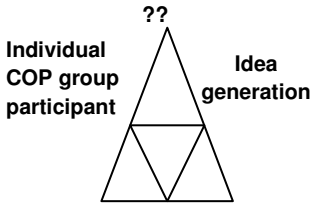
Figure 3. The rationale behind step 2 was to provide the researcher with a lens for analysing and conceptualising the CKB process. It allowed the researcher to map the interconnected nature of the activities and show how the outcome of one activity affected the future activity system. Since the aim of the study was to analyse the process of CKB as it unfolds,

Figure 3 helps in conceptualising the process, derive the meaningful unit of analysis at different planes of analysis and describing the contextual levels from a rich qualitative data set.

Step 3

This purpose of this step was to identify the tasks from the COP group activity and relate them with the corresponding sub-processes from the CKB model. It involved conceptualising the identified CKB sub-process and the related COP group activity task as an activity system for developing the unit of analysis, and analysing the data gathered from the focus group activity related to the relevant CKB sub-process (Table 4).

The first column in Table 4 identifies the sub-process from the CKB model that is the focus of analysis. In column 2 the sub-process is related with the corresponding COP group activity task and conceptualised as an activity system for developing the unit of analysis. The third column shows the focus group question that was posed to the participants for analysing that sub-process. Column 4 shows the themes identified from the analysis of the focus group data. The themes were developed by reading and re-reading the report generated from Zing (which captured the data). This allowed for identifying the recurring themes regrading and analysing the activity system's related to each of the sub-processes in the CKB model, and this iterative process was followed for each of the focus group questions.

Sub - process of CKB being examined	Related COP group task - activity system as the unit of analysis	Focus group question	Themes from focus group data analysis
Knowledge articulation at individual level – what tools do individual participants use to articulate knowledge?		How were ideas generated during the group activity?	Previous experiences, making logical connection between past knowledge and current situation, group interactions, thinking and reflection on past knowledge

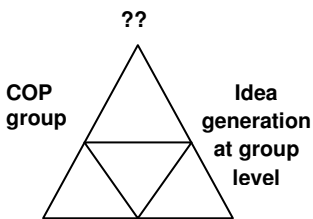
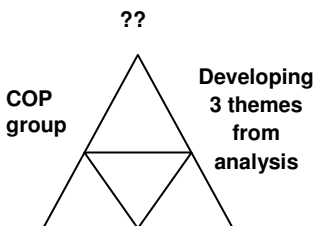
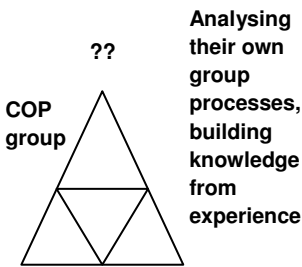
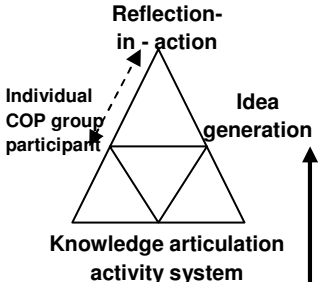
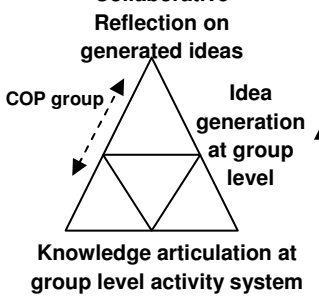
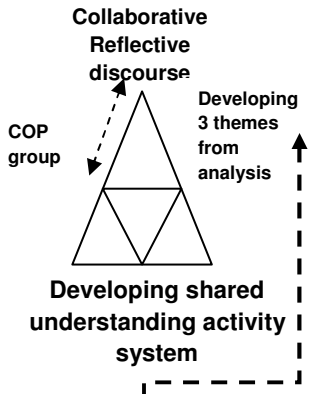
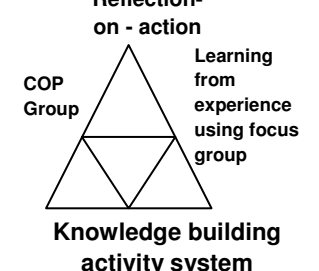
Knowledge articulation at group level – what tools does the group use to articulate knowledge?		How were other participant ideas used to generate more ideas?	Discussion of question from different perspectives, drawing on experience of others, discussion triggers recall of experiences, incorporating others ideas, clarifications led to generation of further ideas
Process of developing a shared understanding – what mediates this process? What is the purpose of developing shared understanding?		<p>How was shared understanding about the themes developed?</p> <p>What is the purpose of developing shared understanding?</p>	<p>Discussing ideas, understanding ideas, clarifications, understanding differing views and reaching consensus</p> <p>Reflection on own ideas, completion of COP project, changing personal viewpoint, re-defining meaning of key themes, theme expansion & new themes from discussion</p>
Process of collaboratively building knowledge artefacts from experience		What can you learn from these activities?	Knowledge about how groups work, knowledge about data analysis in groups, understanding other COP members viewpoint, consensus making process in groups

Table 4: Developing the unit of analysis

Step 4

This step analysed the activity systems identified in Table 4. Analysis involved inductively mapping the themes from the focus group data analysis (column 4, Table 4) onto the corresponding activity system to identify the tools used by the participants (individual and group level). Analysis also involved identifying the inherent contradictions within the activity systems and examining the tools used by the COP to resolve those contradictions.

Activity system of the CKB process & corresponding COP group activity task	Reflective contradictions (Hawkins & Whymark, 2005)	Developmental contradictions - Transformation in Object of activity	Level of analysis
	<p>Secondary contradiction</p> <p>What tools were used by COP participants (individual level) to articulate knowledge? How were the tools used by the participants? (R)¹</p> <p>Process of reflection-in-action</p>	<p>From brainstorming/generating ideas to relating previous contexts to current activity for drawing out knowledge using reflection-in-action (D)²</p>	Individual
	<p>Secondary contradiction in concurrent activities</p> <p>What tools were used by the COP group (group level) to articulate knowledge? (R)</p> <p>Collaborative reflection & clarifications of questions and ideas</p>	<p>From knowledge articulation at individual level to bringing multiple perspectives to the problem space through collaborative reflection (D)</p>	Group
	<p>Secondary contradiction</p> <p>What tools were used by the COP group to develop a shared understanding about the 3 themes in their data analysis? (R)</p> <p>Collaborative reflective discourse</p>	<p>From developing common themes to actually understanding each idea. From achieving objective to understanding each other's view to bring about conceptual change at individual level (D)</p>	Individual – group level
	<p>Quaternary contradiction</p> <p>What and how did the COP participants learn from the focus group activity for a future activity? (R)</p>	<p>From working on group objective to building knowledge from what was done – internalising knowledge</p>	Individual – group – community level

¹ R – reflective contradictions (details in Discussion section)

² D – developmental contradictions (details in Discussion section)

Collaborative knowledge building

Table 5 shows an activity system based analysis of the CKB process. The first column shows the activity system analysis of the corresponding CKB process and the COP group activity task. The double arrow connectors show the interconnected and interdependent nature of the activity systems with the outcome from one activity system affecting the composition and the transformation in the object of the following activity system. The dotted double arrows in the activity systems are the identified contradictions which are further explained in column 2. The contradictions were identified using the framework and questions developed by Hawkins and Whymark (2005). Column 2 also identifies the tools used by the participants (individual and group level) to resolve the contradictions. The tools were identified by inductively relating the themes identified from the focus group data analysis (column 4, Table iv) with existing theory on reflective thinking (Eraut, 1995; Yukawa, 2006) and mapping them onto the corresponding activity system. Column 3 shows the transformation in the object of the activity into an outcome. The last column shows what level of analysis the corresponding activity system is focusing upon.

[illegible]

Figure 4: An integrated model of CKB process (Adapted from Singh et al., 2007)

Describing each and every sub-process from the model in detail is out of the scope for this paper. An important point to note is that it would be wrong to assume that the process of CKB always goes through same sequence as shown. However, the integrated CKB model combined with the concept of CKB activity system is a useful starting point for developing a better understanding of the process of CKB and the possible design of technological scaffolds for the process. The next section discusses the results from previous section, specifically focusing on the processes of knowledge articulation, developing a shared understanding, and building knowledge from experience.

5. DISCUSSION

This section firstly discusses the mediating role of reflective thinking processes and the tools used by the COP group participants at the individual and group level. Results from Table 5 are used as the point of reference for discussing the results. Constructs from reflective thinking theory (Eraut, 1995; Yukawa, 2006) are used to illustrate the role of reflective thinking process as a mediating tool for articulating knowledge and developing a shared understanding. Secondly this section discusses the role of contradictions in the CKB process and how resolving those contradictions led to the transformations in the COP group activity system. In discussing the above points, the following section establishes the efficacy of using activity system as the unit of analysis and a method for analysing the CKB process.

Individual and group level processes

Analysis of the first activity system (knowledge articulation – refer Table 5) shows that participants used reflection-in-action as a mediating tool for articulating their knowledge. This is evident from the participant responses to the focus group question. The themes emerging from the analysis of the focus group data show that the COP group participants used the process of reflection-in-action as a mediating tool for articulating their knowledge and experiences. The process involves “thinking at a meta level about the process one is engaged in a particular context” (Eraut, 1995, p15). Engaging in the process of reflection-in-action helped the participants to actively think over an ongoing activity and relate their previous experiences and knowledge with the current activity. Participants used the reflection-in-action process as a tool for drawing out their previous experiences and articulating knowledge. The concept of tool is borrowed from activity theory constructs. Tools are instruments and an agent for transmitting the meaning and thinking (McDonald, Le, Higgins, & Podmore, 2005). The word tool is used here in the sense of a conceptual and a ‘thinking tool’ that helped participants to draw out the relevant knowledge.

The outcome from the first activity system (i.e. knowledge articulation at individual level) was used as a resource during knowledge articulation at the group level.

Collaborative knowledge building

The participants used the generated ideas (i.e. other participant's ideas) as a resource for articulating knowledge at the group level (i.e. generating more ideas based on the existing ideas captured on Zing), refining ideas and building new ideas based on the generated ideas. The themes emerging from the analysis of the focus group data show's that participants used collaborative reflection as a mediating tool in this process. Collaborative reflection involves making explicit personal viewpoints and perspectives and presenting it to the group using language as a tool (Singh et al., 2007). This helped the group in developing further ideas by drawing on other participant's ideas, getting a different perspective, and building new ideas which could not have been developed by the individual participants on their own. An important point to consider here is, that idea generation at the individual and group level were going on simultaneously. These concurrent activities are being differentiated here for analytical purposes to highlight the use of collaborative reflection as a tool for articulating knowledge at the group level. It also brings forth the usefulness of using activity system as the unit of analysis to describe the dialectical and interrelated relationship between the two activity systems. Highlighting this relationship helped in identifying the mediating tools used by the participants at the individual and group level.

The object shared understanding activity system was to develop 3 themes from the list of generated ideas for each of COP group's research questions. This process required the COP group to work collaboratively on their shared object and achieve consensus for each of the themes. The group was able to achieve their object of developing a shared understanding by - attending to individual perspectives, sharing multiple perspectives and knowledge with the group, evaluating each idea, re-conceptualising the idea in relation to the identified theme, getting feedback from other participants to achieve consensus, and the resulting conceptual change. The three interactional characteristics of collaborative reflection (Yukawa, 2006): (1) sharing experience, knowledge, and feelings; (2) achieving intersubjective understanding through collaborative meaning making; and (3) synergy between collaborative reflection and relationship building were evident in the participant responses to the focus group question. Thus the group was able to develop a shared understanding by interacting with the co-created artefacts and interpreting meaning using reflective thinking as a tool at the individual level and collaborative reflective discourse as a tool at the group level.

Analysis of the knowledge building activity system shows participants using the COP group activity as a reflective experience for building knowledge. In the knowledge building activity system (expanded version in Figure 5), the COP group used reflection-on-action as a mediating tool at the community level to build knowledge from their group activity experience. Reflection-on-action was achieved by asking the COP group participants how they completed their group activity tasks using the focus group activity. Thus the focus group activity allowed the COP group to jointly reflect on the processes they engaged in while completing their group activity tasks.

The group activity experience became an artefact for the entire group to reflect back upon, thus turning it into a shared artefact (Hershkowitz & Schwarz, 1999). The shared artefact was used by the participants as a reflective experience during the focus group activity. Thus the focus group activity can be defined as a process of engaging in reflection-on-action, during which a group experience's an activity, analyses that activity, and evaluates the relevance of that activity to collaboratively build knowledge. In this case the group was able to build knowledge about working in collaborative research projects and regarding data analysis processes in groups.

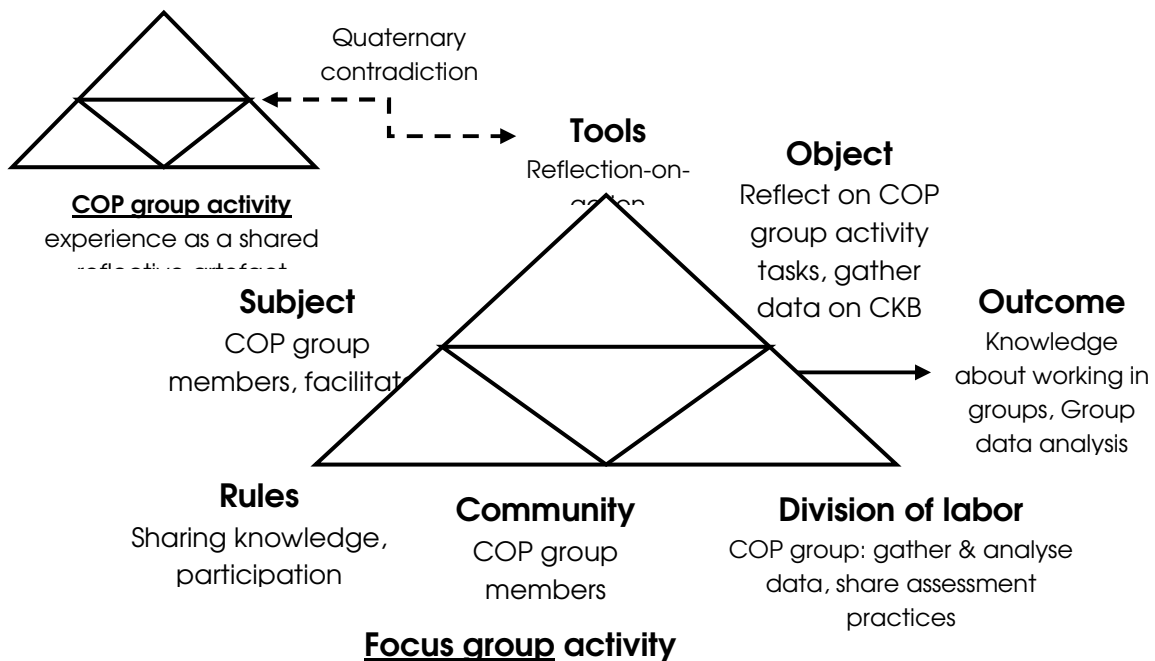


Figure 5: Knowledge building activity system

Contradictions and transformation in the COP group activity

This section discusses the role of contradictions in the CKB process and how resolving those contradictions led to the transformation in the object of the activity (i.e. achievement of object by the COP group). "Contradictions are not points of failure or deficit in the activity system in which they occur. They are not obstacles to be overcome in order to achieve goals. Rather than end points, contradictions are starting places" (Foot, 2001). Expanding on the definition of contradictions as starting places from which transformation of the activity can occur; we present two types of contradictions that can occur at any of the four levels of contradictions as defined by Engeström (2008) – developmental contradictions and reflective contradictions.

Developmental contradictions are those which require a type of development in order for the object of the activity to be achieved, or the removal of something which is blocking the achievement of the object. In other words, developmental contradictions identify where new knowledge is required, that builds on existing

individual or group knowledge. Examples of developments which could occur at the four levels of contradictions are presented in Table 6.

Reflective contradictions allow participants to focus on issues that when considered will increase the level of understanding at the individual and/or group level. Reflective contradictions are especially useful in collaborative reflective activities, as these contradictions are a means by which individuals/groups reach a shared understanding. Addressing reflective contradictions leads to a deeper and a richer understanding for participants. It is worthy to note that reflective contradictions can also be developmental contradictions as described in Table 6, as they may prevent the achievement of the object. However, reflective contradictions are primarily understood as contradictions of understanding, rather than contradiction due to a lack of development.

Contradiction Level	Developmental Contradiction examples	Reflective Contradiction examples
Primary	The object of the COP group activity transformed from idea generation to developing shared understanding to building knowledge from their group activities using the focus group activities.	Issue that individual needs to engage in self-reflection to achieve object. Issue within the tool (e.g. how can participants use the reflection-in-action process) that requires consideration
Secondary	Subject(s) needed to understand the generated ideas i.e. resolving contradictions between object and tool.	Understanding how the tool can be used to achieve the object (e.g. how engaging in collaborative reflection led to shared understanding)
Tertiary	Tool modification occurs through its use (i.e. Current activity and culturally advanced activity can be viewed as a version of before and after)	How can participants use the knowledge from their current activity in a future activity?
Quaternary	Development is required in two concurrent activities (refer Figure iv).	Discussion of researcher's object and COP participant's object to increase the shared understanding of both activities & building knowledge from it.

Table 6: Developmental and reflective contradictions

6. CONCLUSIONS

One of the outcomes of the study is the identification of developmental and reflective contradictions which highlight the issues that when addressed allow for Collaborative knowledge building

successful achievement of the object (or to some degree of success), as well as a richer and a deeper experience for the participants. Identifying and resolving these contradictions can help groups to achieve their objective and internalise the knowledge gained from the experience which can then be used for future activities.

Another important contribution of the paper is the method used to study the CKB process (i.e. gathering data using focus groups and using activity theory for data analysis). This method is a novel way of studying the process in close collaboration with practitioners and is grounded in the theoretical guidelines of knowledge creation metaphor of learning. Aligning with the social constructivist epistemology, this study analysed the COP group's participant's accounts of how they worked together and completed their group activity tasks. Using focus groups to gather data not only helped the researcher to study the CKB process, but at the same time helped the COP group to understand their own group processes. The focus groups created the context in which the COP group was able to build knowledge from their experience.

As demonstrated in the paper, activity theory constructs, specifically using interrelated activity system's as the unit of analysis helped in capturing the dialectics of the CKB process. CKB process involves a set of processes that are aimed at the individual and group level. Using activity system as the unit of analysis helped in highlighting the mediating nature of the process and identifying the tools used by the participants at the individual and group level. Activity theory constructs provided an efficacious and a coherent methodology for providing rich descriptions of the CKB process, and capturing the transformations in the CKB activity system.

The application of four step activity theory based data analysis helps in providing rich descriptions of the underlying CKB processes. The integrated model of CKB process is a useful cultural artefact for representing the individual and group level processes as part of CKB (Stahl, 2006), a tool for pursuing discussion amongst researchers, and a useful step towards better understanding the process of CKB. Drawing attention to the tools used by the group to build knowledge is one of the first steps towards the design of possible technological and/or facilitation scaffolds for the CKB process. The results, from analysing the process of CKB, are not aimed at generalisations, but instead at developing a better and a holistic understanding of CKB. The results have educational and practical implications in terms of developing research tools for analysing CKB, collecting data from a group context, and developing tools for knowledge communities to build knowledge from experience which can be used in future activities. More data from different contexts (e.g. groups from organisational contexts, knowledge intensive group problem solving contexts), and further development in theory (e.g. how shared objects mediate or "drive" the process of CKB) is needed to further our understanding of CKB, and modeling the underlying processes involved as part of CKB.

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