



QUASHIGAH, EDEM

COLLABORATIVE PROBLEM SOLVING ACTIVITIES IN NATURAL LEARNING  
SITUATIONS: A PROCESS ORIENTED CASE STUDY OF TEACHER EDUCATION  
STUDENTS.

Master's Thesis in Education.

FACULTY OF EDUCATION

Master's Degree Programme in Learning Education and Technology

2017

University of Oulu  
Faculty of Education  
Edem Quashigah: Collaborative Problem Solving Activities In Natural Learning  
Situations: A Process Oriented Case Study of Teacher Education Students  
Master's Thesis in Education, 34 pages, 4 appendices  
September 2017

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This research focused on a 21st century learning skill known as 'Collaborative Problem Solving' (CPS) by carrying out a process oriented study of identifying CPS activities, namely; Audience Awareness (Perspective Taking), Coordination, Adaptive Responsiveness (Perspective Taking), Problem Re-Analysis, Task Exploration and Problem Analysis as they spring up in their natural collaborative learning setting.

The main aim of this thesis is to explore the prevalence of the selected examples of Collaborative Problem Solving skills throughout the process of collaborative sessions by unearthing (a) How often the CPS activities occur/emerge during natural group working situations and (b) The differences between occurrences of the general group CPS activities and the individual group member participation to the CPS occurrences.

The researcher made use of video data that was primarily collected by the researchers from the Prep21 Project (Preparing Teacher Education Students for the 21<sup>st</sup> Century Learning Practices); A research project conducted by the collaboration of researchers from multiple university institutions namely, University of Eastern Finland, University of Jyväskylä and the University of Oulu. The participants of the research constituted a total of 8 first year international teacher education students. They were formed into a total of 2 groups with 3 – 4 members and were asked to work on several mathematical didactic tasks over the course of 3 different sessions.

The data was analysed using the QSR International Nvivo data analysis software to simultaneously examine the occurrences of the targeted group CPS activities as well as individual contributions to those CPS activities.

It was found from results of the research that, when pitted against each other, the occurrences of CPS activities vary, in that, they don't all occur on the same level or at the same frequency. The most often occurring CPS activity is 'Audience Awareness (Perspective Taking)', whereas the least often occurring is Problem Analysis.

The pedagogical implications of this research in teaching practice is that educators can be mindful of the fact that when students engage in CPS activities, there are differences in the individual and group occurrences. Not all students actually partake in each activity as it unfolds. This should thus motivate educators to strategize new ways of improving upon the involvement or participation of the students through carefully tailored scripts.

Keywords: Collaborative Learning, Collaborative Problem Solving, Prep21, Video Data Analysis, Teacher Education Students, Process-Oriented Approach.

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## 1 INTRODUCTION

Collaboration is one of the 21st Century Key skills, which is a prerequisite for working and acting in the learning society (Binkley, Erstad, Herman, Raizen, Ripley, Miller-Ricci, & Rumble, 2012). The 21<sup>st</sup> century skills revolve around the 4 C's, namely: Critical Thinking, Creativity, Communication and Collaboration. Furthermore, collaborative problem solving (CPS), which is the main focus of this thesis, has been named by the previous research as one of the core 21<sup>st</sup> century skill (Care, Scoular, & Griffin, 2016).

Collaborative problem solving (CPS) happens to be a competency of critical importance in the educational and career fields (Rosen & Foltz, 2014). Thus, there is a high demand for modern day educational systems and agents to adopt or adjust to create affordances for acquiring such skills. The Organisation for Economic Co-Operation and Development (OECD) have in recent years laid emphasis on the collaborative problem solving skills. This has been reflected in the Programme for International Student Assessment (PISA).

Hesse, Care, Buder, Sassenberg, & Griffin, (2015) point out the relatively unknown degree to which individuals can be prepared for solving problems collaboratively by being tutored on how to engage in the necessary collaborative problem sub-skills in a suitable manner. Hesse et al, (2015) went further to propose further research that distinguishes between cognitive and process approaches. In the effort to effectively promote the recognition and consideration of CPS skills and activities into the educational systems, unconventional approaches towards the assessment of such skills must be introduced and incorporated. This is to support the pre-existing traditional assessment methods which may not be appropriate for the evaluation of those skills (Care et al, 2016).

Furthermore, although there has been the creation of numerous innovative methods of creating good collaborative learning environments however, Davier & Halpin (2013, p.10) reveal that relatively lesser research conducted lays emphasis on the contributions of individuals to “(a) the contributions of individuals to the outcomes of a collaborative project or to (b) the processes of interaction that lead to those outcomes”. They further posit that; most existing research usually focus on the outcomes of the entire group (e.g. Cohen et al., 1999; O’Neil, 1997; Woolley et al., 2010) without analysing the dynamic interactions of the collaboration. Consequently, such an approach does not lead to reveal the knowledge and contributions that individual participants bring to the teamwork during the task (Davier & Halpin, 2013). This indicates a gap in research where there is the need for insight into the

individual-level outcomes of CPS activities to discover how each participant contributed to the collaborative activity. In an attempt to bridge this gap, this research also looks into the individual-level outcomes of the CPS activities thereby taking a further step towards securing the reliability when it comes to the assessment and overall scoring of CPS activities. This research dives into a 21st century learning skill known as ‘Collaborative Problem Solving’ by carrying out a process oriented study of identifying CPS activities as they spring up in their natural collaborative learning setting. The videos of the participating groups will be analysed qualitatively. To better facilitate the generalizability of the observed qualitative data, the observed CPS activities will be quantified thus making use of mixed methodology method of research to shed light on the qualitative findings. This thesis will begin with a review of the theoretical framework that constitutes an attempt at making known the researcher’s perspective and understanding of the topics surrounding the coding categories (CPS and its selected activities). Next, a walk through of how the video data was purposefully selected, analysed qualitatively and finally, a discussion of results and implications for further research.

## 2 THEORETICAL FRAMEWORK

### 2.1 Collaborative Learning

The situation in which two or more people learn or attempt to learn something together can be defined as collaborative learning (Dillenbourg, 1999). Also, Roschelle & Teasley (1995, p.70) define collaboration as "... a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem".

Collaborative learning is fast becoming revered as an effective and efficient educational strategy and researchers recommend that short phases of collaboration should be incorporated into learning activities for optimization (Care et al., 2016). However, Rummel & Spada (2005) argue that collaboration does not occur as easily as one may expect. The norm of conducting collaboration in the classroom setting; by having students seated in groups where they are tasked to discuss topics or perform shared tasks; does not guarantee automatic collaboration among the students. This is as a result of the failure of the educator to ensure that the students possess effective communicative, cooperative and problem solving skills (Gu, Chen, Zhu & Lin, 2015).

From the definition of Collaborative learning by Roschelle & Teasley (1995), it can be inferred that for collaboration to happen, there must be a shared understanding of the problem that is being solved.

In the field of collaboration, it is not unusual to have an assumption that through collective action, the potential of the team becomes relatively greater than that of individuals (Senge, 1994). Barnes and Todd (1977) in their study of groups engaged in assigned talk stated that groups attain higher cognitive levels than those attained by individual members. This implies that problem solving has a higher potential of success if done collectively through collaboration.

This also supports Nelson's (1999) suggestion that the use of collaborative problem solving methods provides a pedagogical value to the maximization of the collaborative process in that; if done correctly, learners would be able to engage in problem solving activities. This is because instead of being placed in learning environments where unnatural structures exist that may lead to the hindering of the flow of interaction and learning thus curtailing effective and efficient problem solving, they would instead be provided with learning environments that lead to the creation and support of naturally occurring collaborative processes.

## 2.2 Collaborative Problem Solving

CPS as defined by O'Neil, Chuang & Chung, (2003, p. 369) refers to 'problem solving activities that involve collaboration among a group of individuals'. From this definition, CPS can be viewed as consisting of two parts, 'collaboration' and 'problem solving'. O'Neil, (1999) concludes that there is no universal definition of Problem Solving but recommends that of Mayer and Wittrock (1996, p. 47) which postulates problem solving as a 'cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver.'

Taking these two aspects into account, CPS has been described in the 2015 PISA Framework as "... the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution" (OECD, 2013).

The Collaborative Problem Solving activity has further been defined as "...a joint activity where dyads or small groups execute a number of steps in order to transform a current state into a desired goal state" (Hesse, Care, Buder, Sassenberg, & Griffin, 2015, pg.39).

CPS skills have been differentiated as social and cognitive aspects (Hesse et al., 2015). The social aspect calls attention to the collaborative skills necessary for the management of contributions from peers and the cognitive aspect calls attention to the necessary problem-solving competencies required for managing tasks in their problem spaces and apply their reasoning skills (Care et al., 2016). Within the major CPS domains (Social and Cognitive), Hesse et al, (2015, p.43 & 47) identified a total of 5 categories which further split up to form a total of 18 subcategories. However, due to the secondary nature of the case study data, only a handful of the categories could be observed. Thus, for the purpose of this thesis, the following CPS activities were selected.

- (1) Perspective Taking (*Adaptive Responsiveness & Audience Awareness*)
- (2) Coordination (*Resource Management*)
- (3) Task Exploration (*Information Collection*)
- (4) Problem (re)Analysis.



### 2.3 Perspective Taking

The perspective taking skill can be explained as the capability of an individual to view a problem through the eyes of a fellow collaborator (Higgins, 1981). Perspective Taking can further be defined as one's "ability to understand the perspective of others and focuses on the quality of the interaction between students during CPS such as how students respond and adapt to one another" (Care et al., 2016, p. 252).

Zuckerman, Kernis, Guarnera, Murphy, & Rappoport, (1983) argue that, in the absence of this perspective taking ability, the students are sure to commit egocentric bias as a result of the presumption that they as well as everyone on their team are on the same page. On the other hand, when a student takes the perspectives of fellow collaborators into consideration, there is more likely to be a "smoother coordination between collaborators, appropriate responses to others' contributions, and recognition of others' understanding to allow for tailoring of communication" (Care et al., 2016, p. 253).

Here, the points of view of the members are taken into consideration and the individual student adjusts his attitude towards the learning situation to be in line with what is needed (Hesse et al, 2015). This is in contrast to the miscommunication resulting from the students presuming/assuming situations and acting how they personally see fit. Perspective taking on an emotional level can be associated with the idea of empathy that one has with his fellow collaborator (Batson & Morgan, 1999) where that individual is able to emotionally understand and identify with the others in his team. On a communicative or linguistic level, perspective taking occurs when an individual is able to modify his contributions to the understanding of the intended recipient based on the interpretations of feedback gotten from that recipient (Hesse et al, 2015).

Hesse et al, (2015) in designing a framework for teachable CPS skills placed perspective taking into two aspects, namely: adaptive responsiveness (responding skills) and audience Awareness. Adaptive responsiveness can be defined as "responding skills that become apparent when problem solvers manage to integrate contributions of collaborators into their own thoughts and actions" (Hesse et al., 2015). Here, the participants can begin expressing this skill by taking into account the prompts and contributions of their peers, incorporating them or taking it further by adapting those contributions and using them to suggest alternative solutions.

Dehler, Bodemer, Buder, and Hesse (2011) argued that audience awareness skills are equivalent to the ability to modify one's contributions to suite others' knowledge and

understanding. This comes about as a result of the individual being conscious of the needs of the fellow collaborators and consequently modifying his behaviour to one that best suits the needs or requirements of the collaborator as well as the task being carried out (Hesse et al, 2015). Previous research has shown that during collaboration, novice students often find it difficult to tailor their contributions to their partner's needs (Hesse et al, 2015). Whereas, proficient students will be able to better tailor their contributions for their partner's current level of understanding (Care et al., 2016).

## 2.4 Coordination

Coordination as defined by O'Neil, Chuang & Brown, (1997, p. 413) is "a process by which group resources, activities, and responses are organised to ensure that tasks are integrated, synchronized, and completed with established temporal constraints".

'*Coordination*' as explained here is referred to as '*Resource management*' in the CPS framework created in a previous research carried out by Hesse et al. (2015) and it falls under the cognitive domain of CPS activities. According to that research, the coordination (resource management) activity comes about as a result of collaborators bringing their resources, knowledge and varying expertise together during the problem-solving process and managing them to achieve the common goal.

Indeed, as clearly stated by Hesse et al. (2015), "Collaborative problem solving is not a uniform process but a complex, coordinated activity between two or more individuals". Coordination therefore plays a rudimentary role in the initiation and maintenance of common ground or mutual knowledge throughout the collaborative process (Barron, 2000).

From this, it could be deduced that, in the attempt to have a mutual knowledge and understanding of the task at hand, there needs to be a level of coordination where the participants organize the available resources.

Also, Brown, (1987) argues that, the management of resources during a collaborative activity serves as an important aspect of planning. Therefore, in planning for a collaborative problem solving task, it is very important to take into consideration the management of available resources. Doing this would further facilitate a smoother flow of the activity as a whole (Brown, 1987).

Coordination therefore revolves around the way collaborators identify potential resources and put them to efficient use to complete a task (Hesse et al, 2015). This could be done by identifying the existence of the resources, allocation of these resources to specific tasks and

further suggesting to the team of collaborators that the resources be put to use in the task (Hesse et al, 2015).

## 2.5 Task Exploration

According to Van Gundy (1987), a problem solver's classification of the problem is one of relatively subjective nature. This is because, the classification depends heavily on how familiar the problem solver is with the 3 major components of problem solving namely; the problem's initial state, the desired goal state, and the transformations needed to make the initial state more like the goal state (Reitman, 1965).

Consequently, when one is working with a well-structured problem, the 3 components are made clearly available. However, ill-structured problems don't have clearly stated components thereby making it more difficult to grasp and solve. In an attempt to successfully solve these ill-structured problems, the problem solver must attempt to increase familiarity thereby giving some form of structure to the previously ill-structured problem (Van Gundy, 1987).

In light of these circumstances 'Task Exploration' activity can be described as, one's attempt to identify the necessary information that is required for accomplishing a given task while taking into consideration how and when it can be acquired (Hesse et al, 2015).

In their CPS framework, Hesse et al. (2015) revealed the varying levels of the 'Task Exploration' CPS activity (*Information collection skill*) in 3 main sub indicators. They ranged from the basics of assessing an immediate activity and identifying that some form of information is needed; through to indicating the nature of the needed information; and ultimately taking the current, alternative and future activities into account when identifying the information needed (Hesse et al., 2015).

These levels are in relation to Newell & Simon's (1972) 'means-end-analysis' approach. This approach revolves around the strategy of tackling problems by identifying possible actions that reduce the gap between a current state and a goal state through 'forward search' and 'backward search' approaches. 'Forward-search' involves simply taking the existing state of a problem and finding the most appropriate strategy for solving, in effect working towards the desired goal state whereas 'backward-search' involves taking a most likely successful desired goal state and working backwards to validate the chosen solution.

Throughout the problem solving process, problem solvers have access to varying forms of information as well as different means of gaining the needed information. It is therefore essential

that these problem solvers acquire the necessary skills to be able to determine when specific information is needed and also identify from which sources to get them (Larson and Christensen, 1993).

## 2.6 Problem Analysis and Problem Re-Analysis

According to Gunzelmann & Anderson (2003), planning falls among one of the core activities of the problem-solving process. The planning of problem-solving activities as characterized by Hesse et al., (2015) begins with the '*problem analysis*'. This is the stage where a joint or individual illustration of a problem is sub-divided into subtasks with corresponding sub-goals (Hesse et al., 2015, p. 48).

The segmentation of the problem into sub-tasks and sub-goals results in making the problem-solving process more organized and pursuable. This means that, the sub-tasks or goals in effect, serve as critical benchmarks that facilitate the monitoring and evaluation of one's progress throughout the problem-solving activity.

The characteristics of a good problem solver is his/her ability to formulate specific, achievable and clear goals as against the formulation of vague goals or no goals at all and prior research into teamwork has stressed that the specificity of goals in group situations have a positive impact on the overall group's performance (Weldon and Weingart, 1993).

Hesse et al., (2015) refer to the Problem Analysis activity/skill in their framework of CPS skills as '*Organizes*' and this is expressed when the problem solver '*Analyses and describes a problem in familiar language*' and this falls under the cognitive domain of CPS activities alongside Coordination and Task Exploration. Here, the problem solvers attempt to state the problem in ways that help them to better understand it, divide it into subtasks and finally, reorganize those subtasks into a sequence that would guarantee the possible attainment of the goal.

Another CPS activity that succeeds Problem Analysis is '*Problem Re-Analysis*'. However, despite the uncanny similarity in name (*coding category*) used for the purpose of this research, it is arguable that the fundamental difference between the two general areas resides in how each one is used in the problem-solving process. '*Problem Analysis*' predominantly used in the effort for task regulation purposes where the problem to be solved is scrutinized and the necessary information consequently is gathered. This is relatively in contrast with '*Problem re- Analysis*' which comes after the problem-analysis stage. Here, the difference

lies in the manner with which the use of the gathered information is directed towards knowledge building and learning (Hesse et al., 2015).

A fundamental characteristic of Knowledge Building is the ability to derive ideas from one's fellow collaborators and use them to refine how problems are represented, how plans are made and how activities are monitored. At its peak, it manifests in problem solvers being able to critically synthesize and incorporate contributions of others into the decision making process (Scardamalia, 2002).

The decision-making process as according to O'Neil et al., (1997, p. 415) can be defined as a group's 'ability to integrate information, use logical and sound judgement, identify possible alternatives, select the best solution and evaluate the consequences'.

Problem solvers generally rely on varying elements of information when carrying out tasks. This information is most often unevenly and asynchronously distributed and thus need to be shared among themselves (Hesse et al., 2015). This results in the necessity to constantly be willing to change their minds to fit the newly acquired information.

Prior to when decisions are made within teams that are regarded as highly effective; all available information and resources are carefully thought about and factored. This decision-making process leads to an increase in the overall performance of the team (Chung, O'Neil, & Herl, 1999).

Hesse et al., (2015) refer to the Problem Re-Analysis activity/skill in their framework of CPS skills as '*Hypothesis (What if)*' and this is expressed when the group '*adapts reasoning or course of action as information or circumstances change*'.

In the ideal Problem Re-Analysis stage, some hypotheses are formulated throughout the problem-solving process regarding how the goals can be achieved. When the problem solvers are faced with an obstacle, they may stubbornly decide to keep to their original approach despite this. More competent students on the other hand express the ability to draw from specific cases of a range of situations by setting and testing their hypotheses. Here, the students endeavour to try out new options as they acquire new information relating to the task or when they encounter a dead end in their tasks. Ultimately, they reconstruct their understanding of the problem and in a sense, recalibrate their points of view towards the problem in search of new solutions (Hesse et al., 2015).

### **3 AIMS and RESEARCH QUESTIONS**

The main aim of this research is to explore the prevalence of the Collaborative Problem Solving activities throughout the process of collaborative sessions. The resulting frequencies will throw more light on the instances where CPS activities emerge during natural group working situations both within the groups as a whole and among the group members as well.

The research questions are as follows:

**RQ 1.** How often do the CPS activities occur during natural group working situations?

**RQ 2.** What are the differences between occurrences of the groups' CPS activities and the individuals' CPS occurrences?

## 4 METHODOLOGY

This research examines the occurrences of the targeted group CPS activities as well as individual contributions to those CPS activities. In the initial stage of the research, Qualitative Research Methods were used in unearthing the occurrences of the selected CPS activities from the video data. However, Quantitative Methods were later incorporated into the thesis analysis.

Consequently, the researcher's use of qualitative research methods and the incorporation of quantitative methods in the research analysis takes this research into the realm of what is described as *Mixed Methodology* (Puntambekar, 2013). In the mixed methods approach, researchers combine qualitative research techniques and methods with that of quantitative research in the same study (Johnson & Onwuegbuzie, 2004).

This research deals with collaborative problem solving which springs out of collaborative learning activities. Collaborative learning, being a complex and continuous interchange between individual work, group work, as well as the context in which the learning is taking place, presents a challenge with research methodology. This is because, of the dilemma researchers face in examining how the group constructs knowledge collectively as well as how they simultaneously examine the individual learning and contribution (Puntambekar, 2013).

To solve this recurrent dilemma, there has been increasing use of mixed method approaches to integrate the studies of interactional processes with learning outcomes in collaborative learning and education (Creswell & Plano Clark, 2007; Maxwell & Loomis, 2003; Tashakkori & Teddlie, 2003).

This research inadvertently falls under such a methodological challenge or dilemma because its focus is on the process of collaboration '*where the targeted CPS activities occurred in the data*' and in order to overcome this, the researcher made ample use of the mixed methods approach during the data analysis stage of the research. The data analysis protocol, including coding categories and coding principles, will be explained in detail in the 4.3 chapter.

### 4.1 Context and Participants (Prep21)

This research made use of video data that was primarily collected by the researchers from the Prep21 Project (Preparing Teacher Education Students for the 21<sup>st</sup> Century Learning Practices). Prep21 is a research project that was conducted by the collaboration of

researchers from multiple university institutions namely, University of Eastern Finland, University of Jyväskylä and the University of Oulu. In the Prep21 research, first year international teacher education students (N = 96) were formed into a total of 6 groups with 3 – 4 members. They were required to work collaboratively on several mathematical didactic tasks and environmental science courses. In total the Prep21 project collected 115 hours of video data from 133 group working situations. This research was conducted in Finland, so only part of the collected data was in English. This influenced the researcher who lacks adequate understanding of the Finnish language to select only the videos presented in English for analysis.

## 4.2 Data Collection

Derry et al, (2010) put forward that in their observation that, due to the rapid development of top notch video technology, there has been an increased affordance for the archiving, studying and sharing of quality video components used for research. This goes to support the statement made by Erickson, Green, Camilli, & Elmore, (2006) that video records are arguably not just data, but instead should be regarded as ‘resources’ for developing data.

Although the video data used in this research was not collected first-hand and with the manifest intention of exposing these CPS Activities, it had a possibility of being utilized in this research.

The Prep21 video data still had the potential to serve as a resource for unearthing CPS activities that could be analysed as and when they occurred in their natural learning situations. The analysis and further development of data in line with this thesis’ aims and research questions was however done by the researcher.

During the data collection stages of the Prep21 research and due to reasons unknown to the researcher, some participants failed to show up during some of the task sessions. To counter the shortcomings of the data collection resulting from the absences as well as language barriers, the researcher selected specific video data (i.e. *Sessions 1, 3 & 6 of Groups 3 and 4 of the prep 21 research*) on the grounds of ‘*purposive sampling*’. Purposive sampling is a sampling method that creates the affordance for the researcher to select data that has



particularly interesting characteristics which the researcher deems convenient with regards to the aims of the research (Derry, Pea, Barron, Engle, Erickson, Goldman & Sherin, 2010). After examination of the 17 videos provided from the Prep 21 cohort, further steps were taken to narrow down the sample size and this resulted in 6 videos strategically being selected for the research. They comprised of:

- i. ITE Group 3, Sessions 1, 3 & 6
- ii. ITE Group 4, Sessions 1, 3 & 6

The selected videos altogether amounted to a total of 5 hours, 41 minutes and 29 seconds.

Table 1.

*Display of video data available from the corpus of Prep21 research.*

<u>GROUPS</u>	<u>Problem Solving Sessions</u>						<u>Group Total</u>
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	
3	1**	x	3**	x	5	6**	4
4	1**	2	3**	4	5	6**	6
5	x	2	x	4	5	x	3
6	1	2	3	x	x	6	4

**Note:** \*\* marks the videos that were selected for this research and 'x' marks the videos that were missing from the corpus.

As can be observed from table 1, group 6 also had videos of the sessions 1, 3 and 6 available but has been excluded from the case study sample size. This is because, there were instead 4 members in the 1<sup>st</sup> session and rather 3 members in the 2<sup>nd</sup> and 3<sup>rd</sup> sessions contrary to the similar characteristics of the Groups 3 and 4. Also, there was at least one participant missing from the sessions 1 and 6 from both groups 3 and 4. However, all participants were present for session 3 in both groups. Therefore, the sample size was a total of 8 participants ( $n = 8$ ).

### 4.3 Data Analysis

Research practices in the learning sciences is being transformed by the swift and steady development of video technology. This video technology being made affordable and easily useable presents the average researcher with potent and dynamic ways to boost the collection, distribution, analysis, presentation and archiving of data and numerous projects in the learning sciences integrate and assimilate a sizeable video component (Derry et al., 2010).

One such example of a fairly new, affordable, usable and high-quality video technology is the QSR International Nvivo data analysis software; a software that supports qualitative and mixed methods research (Bazeley & Jackson, 2013). Data analysis of this research was primarily done using of the QSR International NVivo data analysis software.

For the purpose of this research, the researcher transcribed the aspects that were qualitatively deemed to have the necessary CPS activities in question. The use of the transcription here in getting an intermediate representation of the data aided the researcher in fleshing out from the videos what exactly occurred and which aspects to throw more emphasis on during further analysis (Jordan & Henderson, 1995). Also, as Engle (2007) and Mischler (1991) with colleagues point out, the transcripts are iteratively revised in the later stages of research until they gradually provide a reliable record of what the researchers view as the most relevant aspect of the video for providing relevant research evidence.

Intermediate representations of the video data during the process of analysis were obtained in the form of narrative transcriptions. This allowed for the easier and more transparent identification and segmentation of the identified CPS activities (Baron, Pea & Engle, 2013). These narratives coupled with the transcriptions of what was said and done helped to give a quick and in-depth understanding of the various reasons for marking the video segments as relevant to the research from the point of view of the researcher.

Following suite of some qualitative researchers such as Engle, Langer-Osuna and McKinney de Royston (2008), the researcher made use of 'explanatory narratives' during the analysis. Here, particular phenomena of CPS activities were identified from the video and further elaborated by aligning the narratives with the theoretical concepts that this research is made up of (Barron et al, 2013). The researcher did this by giving explanations of why those segments of the video data were being marked down and focused on. This was aimed at making transparent a quick and in-depth understanding of the various reasons for marking

the video segments as relevant to the research from the point of view of the researcher as this study has some qualitative characteristics.

The researcher in an attempt to adopt this strategy iteratively analysed the data in two main rounds. The first round of analysis was to identify and flesh out the general occurrences of the selected CPS activities. The second round of analysis was to code the individual participants' active engagement in the collective group CPS activities. The researcher first watched the videos multiple times prior to the recording/coding of the data. During the coding, the videos were watched initially at a normal pace to get the overview of the CPS activity occurrences. Then, to further understand their relevance to the research, the researcher focused attention on the particular aspects of interest of the data. At this stage, the video was watched repeatedly and at a much slower pace to allow for a more focused analysis where more emphasis was placed on the selected segments of the video data (Erickson, 1982). During the first stage of analysis where the researcher just focused on the general occurrences of CPS activities at the group level, the researcher had an epiphany and that led to the second main stage of analysis. It was at this stage that each individual participants' active engagement in the CPS activities were analysed and coded.

The reason for this stems from the researcher's realization during the first stage of analysis that; since the activities being analysed were collaborative in nature, there was a continuous interchange happening between the individual work and group work (Puntambekar, 2013) and this had a possibility of being reflected (if not affecting) in the individual contributions to the CPS activities. Consequently, this resulted in the birth of the second research question. **(RQ 2: *What are the differences between occurrences of the general group CPS activities and the individual CPS occurrences.*)**

Throughout the data analysis process of this research, the researcher continuously invited colleague researchers from similar educational backgrounds to partake in crosschecking the coded data. This was an effort by the researcher to make sure that there was little to no instance of personal bias. The researchers were presented with random aspects of the video data and presented with the coding categories and were asked to code as they saw fit. Their

views were aligned with that of the researcher in all the instances as was confirmed in corresponding discussions that took place after the scrutiny.

The Coding categories for the selected CPS Activities used in this research were adapted from research being carried out by Pöysä-Tarhonen, Näykki et al, (Unpublished Manuscript) which was also modified from Hesse et al., 2015. (*Refer to Appendix A.*)

The selected coding categories for this research were 6 in total; namely:

- i. Coordination
- ii. Adaptive Responsiveness (Perspective Taking)
- iii. Audience Awareness (Perspective Taking)
- iv. Problem Analysis
- v. Problem Re-Analysis
- vi. Task Exploration.

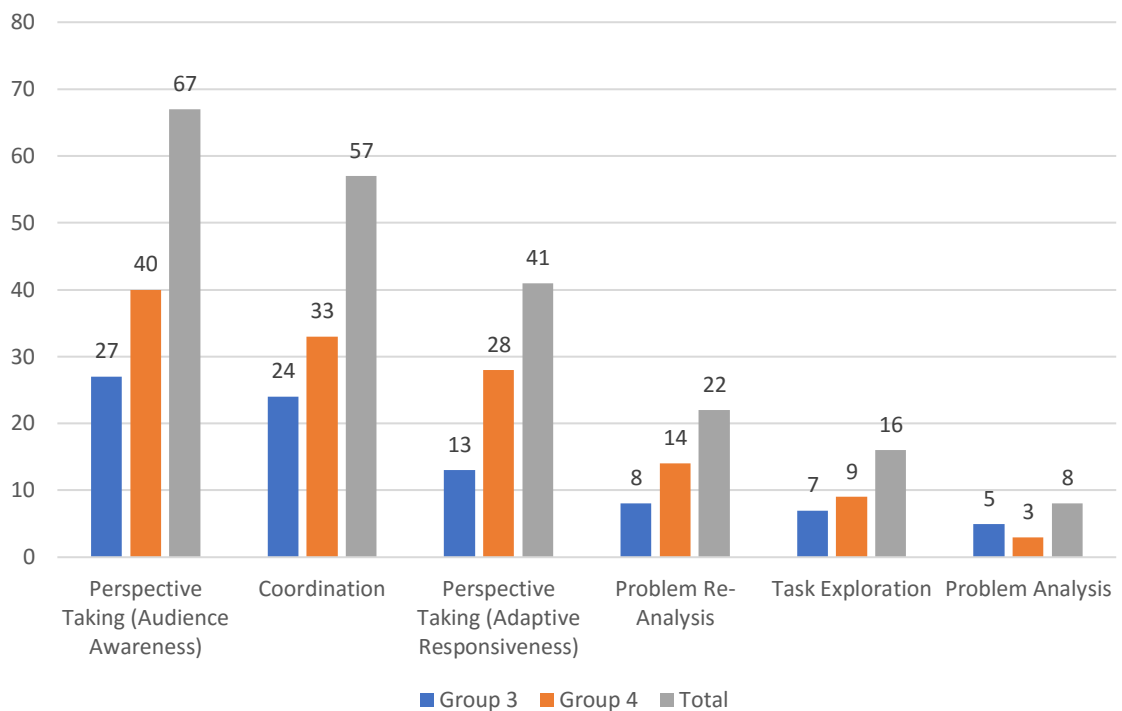
Compared to the adapted coding categories made available in *Appendix A*, this research is missing out on one coding category named ‘Participation’ which had the description of ‘a participant interacting with, prompting and responding to the contributions of others’. It’s coding was discontinued in the early stages of data analysis because it conflicted with the researcher’s initial intention to analyse the CPS activities as a collective group activity. From the point of view of the researcher, there would be an individual involved in the ‘participation activity’ at all points in time during the collaborative session. Thus ‘participation’ would run throughout the whole problem solving process thereby making the analysis meaningless to the intentions of the researcher.

## 5 RESULTS

The aim of this research was to find out how often CPS activities occurred from the natural group working situations and also to look into the differences between the individual participants' contribution to those CPS activities and the group CPS activities.

### 5.1 How often do the CPS activities occur during natural group working situations?

The results of the data analysis indicate the frequency of occurrences of CPS activities from the group sessions. *Figure 1* illustrates the frequencies of each observed CPS activity. The total frequency for each CPS activity is preceded first by that of group 3 and second by that of group 4.



*Figure 1.* Frequency of CPS Activities in descending order from the highest frequency to the lowest.

According to the results of the analysis, the researcher uncovered 6 CPS activities namely; Audience Awareness (Perspective Taking), Coordination, Adaptive Responsiveness (Perspective Taking), Problem Re-Analysis, Task Exploration and Problem Analysis. They collectively amounted to a total of 211 occurrences. The mean number of CPS activities in all the analysed group situations was 35.17, however the analysis revealed that all the CPS

activities did not occur equally. There were vast differences between each CPS activities' occurrence.

Out of the total of 211 occurrences, Perspective Taking (*Audience Awareness*) ( $f=67$ ), Coordination ( $f=57$ ) and Perspective Taking (Adaptive Responsiveness) ( $f=41$ ) were recorded as the highest occurring activities making up 31.8%, 27.0% and 19.4% respectively. Problem Re-Analysis ( $f=22$ ), Task Exploration ( $f=16$ ) and Problem Analysis ( $f=8$ ) were lacking behind with below average occurrences of 10.4%, 7.6% and 3.8% respectively.

Looking further into how the occurrences differed between the groups, the results show that there was a 20.4% difference between the group 3 and group 4 occurrences across all CPS activities. Group 3 experienced 39.8% out of the total occurrences whereas group 4 experienced 60.2%. Additionally, in each case of CPS activity, the participants in group 4 ( $f=127$ ) were collectively engaged in CPS activities more often than the participants in group 3 ( $f=84$ ) with the exception of Problem Analysis which had group 3 having the higher frequency of 5 as against that of group 4 which had a frequency of 3 occurrences.

Also, the trend of the hierarchical order in which they appear could be seen in each group as well. Perspective taking (Audience awareness) remained the most occurring CPS activity in both group 3 ( $f=27$ ) and group 4 ( $f=40$ ) and Problem analysis was still the least occurring CPS activity in both groups 3 ( $f=5$ ) and group 4 ( $f=3$ ).

An in-depth representation of how each group fared in their 3 sessions with regards to the occurrences of CPS activities can be found in the *Appendix B*. Furthermore, in an attempt to support the observations of the researcher during the video-data analysis, qualitative

examples based on the transcribed interactions during each CPS activity have been displayed as follows:

#### Audience Awareness (Perspective Taking)

##### Example 1

00:15:21.9 - 00:16:03.8 \_ (Group 3 Session 1)

There was an expression of Audience Awareness activity during the task when both Carl and Pearl picked up on signs of Harriet having a hard time understanding some elements of the task. The flow of their contributions from then onwards was tailored towards Harriet's understanding.

After noticing that Harriet had been silent for a while, Carl repositions the blocks on the table by **Harriet** and says to her *"That's ten"*.

**Pearl** jumps in to explain further *"Like one of these..."* interrupted by **Harriet** asking *"Why?"* and then continues *"One of these is a unit."*

**Carl** then adds *"This is 1, so if we have 10 of these, it becomes 10"* and Pearl supports him by adding *"so technically, this would be now here"*.

#### Coordination

##### Example 2

00:04:13.3 - 00:04:33.8 \_ (Group 4 Session 6)

There was a Coordination activity when Doreen prompted the group to turn to the internet as a resource for accomplishing the task. Alexi also joined in by acknowledging another potential resource relevant to their task.

**Doreen**: Should we use the internet... Does one of us have the internet handy?

**Alexi** : Yeah we have a second iPad. You can do that (She gives Doreen the iPad) and I would look through... we have slides here (She begins going through the slides).

#### Adaptive Responsiveness (Perspective Taking A)

##### Example 3

00:57:31.1 - 00:57:44.7 \_ (Group 4 Session 1)

In this Adaptive Responsiveness activity, Patricia accepted Esther's prompt to go about solving the problem a certain way that was suitable for her.

**Patricia** (Concludes a previous explanation): .... *So, like that.*

**Alexi** (Mumbles in agreement): *Mmmhmm...*

**Esther:** But I think it was supposed to... We were supposed to use these (points to blocks) so these were 20 on the side.

**Patricia:** Okay, go for it... So that you're not confused... But Yeah... Good.

(They then proceed to move on with the task)

## Problem Analysis

### Example 4

00:25:07.3 - 00:26:01.1 \_ (Group 3 Session 3)

There was an instance of Problem Analysis activity where Paula pointed out a different way or sequence to go about accomplishing the task. Paula and Harriet joined in as well in trying to settle on which sequence was best.

**Paula:** Is it easier for you to...

**Pearl** (Interrupts): I look at it from this side.

**Paula:** No like... draw from this to this... or from these to these? (Pointing to places on the paper)

**Harriet:** *It's a lot easier doing it from...* (Points to a paper far from her but closer to Paula)

**Paula** (Completes her sentence for her): From these to that... I would say, the other way around.

**Pearl** (Agrees with Paula): This one is easier doing it the other way around. If you start from here not from here.

**Paula:** Yeah, Yeah, Yeah...

(They continue discussing)

## Task Exploration

### Example 5

00:30:16.0 - 00:30:22.0 \_ (Group 4 Session 6)

There was an occurrence of the Task Exploration activity when Esther identified that they would need information from the task coordinator while they were having a moment of doubt.

**Patricia:** Well, we didn't have that one there and he was saying we were wrong.

**Doreen:** Are you sure... oh really?

**Esther:** I think it's there... We should ask, but I think...

**Patricia:** I don't see it, but...

**Esther:** I do see it... I don't see how it's not there, so...



**Doreen:** There's nothing there.

(They continue to discuss)

### Problem Re-Analysis

#### Example 6

00:15:43.5 - 00:16:22.5 \_ (Group 4 Session 3)

There was an instance of Problem Re-Analysis activity when the participants realized there was something wrong with their work. They then tried to look at the task from a different perspective.

**Esther** says; "I think the up might not be the same as front."

**Patricia** is confused and asks; "*sorry what do you mean?*"

**Esther** explains further by saying; "cos this is our front now, we took up, should've been like here. But this is the front side for us now (changes angle of blocks)

**Patricia** agrees; "Yeah, yeah true". **Doreen** as well; "Ohhhh I see".

**Patricia** tries to reaffirm her reasoning; "*And then this is the side?* (points to another angle of the blocks)"

**Esther;** "Yeah this is the side"

**Doreen** then adds; Okay so we just built it wrong... **Patricia** interrupts; "NO.!"

**Doreen** continues; "Not wrong but..."

**Alexia** then tries to complete Doreen's sentence; "*With a different...*"

They then all acknowledged the change in reasoning by saying in unison "*YEAH*".

## 5.2 What are the differences between occurrences of the general group CPS activities and individual CPS occurrences?

The study also set out to determine whether there were any overall differences in terms of the general number of CPS occurrences and each individual student's active engagement in the CPS. Diving deeper into the on-goings of how each individual participant actively contributed in the CPS Activities, the answers to the second research questions were obtained.

Isolating the results of group 3, Sessions 1,3 & 6 into account, table 2 shows how each individual participant actively engaged in the CPS activity that led to the group total.

From table 2, it can be observed that Carl ( $f=57$ ) and Pearl ( $f=54$ ) were the most actively engaged members of their group sessions in total. Harriet ( $f=42$ ) and Paula ( $f=30$ ) were the

least actively engaged of the group. There was however not much disparity between all 4 members' general engagement in the CPS activities as they were all actively involved in the problem-solving process. This is in spite of the overall results shown in table 2.

It would be important to note that both Harriet and Paula were each at some point in the data collection and analysis absent from 1 of the 3 sessions (*Paula from Group 3 Session 1 and Harriet from Group 3 Session 6*). This affects the representation of their overall frequency of total participation in the selected CPS Activities. They were however equally active during the sessions where they were present.

This is visible in the breakdown of how each individual participant of Group 3 actively engaged in the CPS activities per session. This has been represented in table format in the *Appendix C* of this research paper with the hopes of making clear how each participant fared and how each group total of CPS activity came about.

Table 2.

*Total Frequency of Individual Participants' involvement in CPS activities Group 3 Session 1,3 & 6.*

CPS Activities	Frequency ( <i>f</i> ) of Individual Participants				
	<b>Harriet</b>	<b>Carl</b>	<b>Pearl</b>	<b>Paula</b>	<b>Group Total</b>
Perspective Taking (Audience Awareness)	13	20	21	8	27
Coordination	9	11	8	8	24
Perspective Taking (Adaptive Responsiveness)	4	9	7	9	13
Problem Re-Analysis	8	8	8	1	8
Task Exploration	5	5	6	1	7
Problem Analysis	3	4	4	3	5
<b>Total</b>	<b>42</b>	<b>57</b>	<b>54</b>	<b>30</b>	<b>84</b>

Table 3 displays how each individual participant in group 4, sessions 1, 3 & 6 actively engaged in the cps activity that led to the group's total occurrences.

From table 3, it can be observed that Esther ( $f=81$ ) was the most actively engaged member of the group. However, this was not much of a difference from Patricia ( $f=79$ ). Alexi ( $f=61$ )

and Doreen ( $f=57$ ) were quite less actively engaged in those cps activities as compared to Esther and Patricia.

Again at this stage, there were no disparities between the participants' in terms of how they each actively engaged in the CPS activities.

It would be important to note here that both Doreen and Patricia were at some point in the data collection and analysis absent from 1 of the 3 sessions (*Doreen from Group 4 Session 1 and Patricia from Group 4 Session 6*). This could affect the representation of their overall frequency of total participation in the selected CPS Activities. An in-depth representation of how each individual participant of Group 4 actively engaged in the CPS activities per session has been provided in the *Appendix D* of this research paper.

Table 3

*Total Frequency of Individual Participants' involvement in CPS activities Group 4 Session 1, 3 & 6.*

CPS Activities	Frequency ( $f$ ) of Individual Participants				
	<u>Alexi</u>	<u>Doreen</u>	<u>Esther</u>	<u>Patricia</u>	<u>Group Total</u>
Coordination	13	14	15	17	33
Perspective Taking (Adaptive Responsiveness)	17	15	21	16	28
Perspective Taking (Audience Awareness)	16	17	27	25	40
Problem Analysis	1	2	2	2	3
Problem Re-Analysis	11	6	13	12	14
Task Exploration	3	3	3	7	9
Total	61	57	81	79	127

An in-depth representation of how each individual participant of Group 4 actively engaged in the CPS activities per session has been provided in the *Appendix D* of this research paper. Furthermore, another result of this study worthy of mentioning is that, as can be observed from both tables 2 & 3 and their corresponding breakdowns in *Appendix C & D*, the overall 'Group Total' frequency of each CPS activity does not represent the sum the frequencies representing each participants' active engagement in that CPS activity. This is as a result of the researcher's secondary stage of coding. As explained earlier in the data analysis aspect

of this research paper, the researcher initially just focused on coding the general occurrences of CPS activities at the group level. Then after studying the data some more; coded each participant's active engagement in each CPS activity. Therefore, it can be understood that for each occurrence of a group CPS activity, either 1 or all of the participants may have represented. Thus, the irregular nature of the relationship between the group total and the individual participant's frequency.

## 6 DISCUSSION

This research explored the prevalence of Collaborative Problem Solving activities as they occurred throughout the natural group working situations. The main findings of this research revealed that, from the case study of 6 videos from 2 Groups with 3 sessions each, there was a total of 211 occurrences of the selected CPS Activities.

With 6 different CPS activities making a total of 211 occurrences, it can be concluded that there was an average of 35.17 occurrences per CPS activity. 3 out of the 6 CPS activities selected for the purpose of this research namely *Perspective Taking (Audience Awareness)* ( $f=67$ ), *Coordination* ( $f=57$ ), *Perspective Taking (Adaptive Responsiveness)* ( $f=41$ ) occurred above average whereas the remaining 3 CPS activities namely *Problem Re-Analysis* ( $f=22$ ), *Task Exploration* ( $f = 16$ ) and *Problem Analysis* ( $f = 8$ ) had relatively below average occurrences.

Consequently, based on the findings of this case study, it can be concluded that with regards to the ratio of various CPS activities, the findings of this research sheds light on the fact that when pitted against each other, the occurrences of CPS activities vary, in that, they don't all occur on the same level or at the same frequency (Davier & Halpin, 2013).

Rosen & Foltz (2014) state that one challenge of CPS assessment in collaborative learning sessions is how aspects of information from individual participants and groups as well as their communications and actions are synthesized. In order to expose information pertaining to the individual contributions of the participants to the CPS activities in this research, the individual-level outcomes of the CPS activities were observed (Davier & Halpin, 2013).

Similar to the works of Rummel & Spada, (2005) which attempted to look at CPS from an individual perspective as well as a group perspective, this study did not unearth any meaningful findings worthy of generalization pertaining to the differences between the group CPS activities and individual participants' involvements in the CPS activities.

Additionally, prior research has been conducted by Wu, Yann-shya (2000) that investigated how individual and collaborative mathematical problem solving took place in instructional contexts when anchored in authentic problem situations. Their findings revealed that "results for collaborative problem solving were not significantly better than those for individual problem-solving.". However from that same research, it was mentioned that quantitative results in CPS research was limited and thus revealed very little about how the learning process took place where the participants constructed their understanding.

From the analysis, with regards to the frequency of CPS activities, it was observed that the participants of group 4 ( $f = 127$ ) were collectively engaged in CPS activities more often than those of group 3 ( $f = 84$ ). From the observation of the researcher, it all depended on the qualities and characteristics of each participant in the group. Group 4 seemed to have more members who kept creating affordances for the activities to come up. An example from this research could be taken from the Audience Awareness (Perspective Taking) CPS activity. If a participant was most often having problems understanding the task, it gave the other members a higher probability of participating in this activity by tailoring their contributions towards that participant in distress. On the other hand, if one finds himself in a group where everyone moderately understood the tasks, he would score a relatively lower frequency of Audience Awareness (Perspective Taking).

Rummel & Spada, (2005) mentioned the importance and difficulty of common ground being established among group participants. Studies by Clark & Brennan (1991) imply that 'grounding' is the same as 'Shared Understanding' which so happens to be of importance to Collaboration. Grounding here can be defined as "...the process by which participants progressively build and maintain and shared conception" (Dillenbourg & Traum, 2006, p.123). Clark & Schaefer (1989), further state that the process of grounding is one of collaborative characteristics. This is because, effort is required from both parties in the anticipating, preventing, detecting and repairing misunderstanding the contributions of others (Dillenbourg & Traum, 2006).

Findings of this research showed that the highest frequency of individual involvement in CPS activities were not always equal to the group CPS activities. This reveals that not all the individuals actively participated equally in the CPS activities. The researcher has reason to believe that a reason for this could be that they achieved 'Common Ground' or 'mutual knowledge' (Barron, 2000). A rough speculation of the researcher is that instead of the participants repeating the same actions of their peers, they just go along with them because they accept the contributions there is no need to disrupt the collaborative flow having accepted the others' contributions. On the other hand, the presence of common ground could be observed as a potential flaw for looking at collaboration from the individual perspective.

## **6.1 Reliability and Ethical Issues**

Reliability of the research was ensured by implementing certain measures for consistency of the coding (Silverman, 2013) . The video data was double coded by the researcher. Further

steps were also taken to ensure the reliability where 3 other colleague researchers (all from similar educational background) were invited by the researcher to take part in coding and scrutinizing random aspects of the video data. A further latent backing for the reliability of the data came into play when the researcher undertook a second level coding of ‘*individual participant*’ occurrences against the already coded ‘*group*’ occurrences of CPS Activities as described in the data analysis chapter (pg. 14).

This research made extensive use of video data from the Prep21 Research. Thus, due to the non-anonymous nature of the videos, certain measures were taken to secure the confidentiality of the participants (Derry et al., 2010). Upon reception of the video data, and throughout the length of the research process, the identities of the participants were not revealed. Instead, ‘*Pen names*’ were developed by the researcher thereby securing confidentiality of the participants.

Furthermore, access to the video corpus was restricted and kept exclusively for the researcher. Personal information of the participants was not disclosed even in the stages of ‘*co-coding*’ when other researchers were invited to take part in affirming the reliability of the research.

## **6.2 Limitations**

One factor that caused a limitation in this research was the absenteeism of some participants during the sessions. This may affect the data if the frequencies of CPS activity accumulated throughout each session are compared with other sessions in the same group. E.g. Sessions 1 being compared to session 3 in ITE Group 3 (Where different individuals were absent from each sessions).

Furthermore, due to the context/ situation specific characteristic of qualitative research in general (Silverman, 2013), this research had a strength which was reflected in the ‘*naturalistic quality*’ of the data with regards to CPS activities which consequently led to the authentic results/findings of the ‘*case study*’. However, the limitation and weakness experienced here lie within the fact that the results cannot be generalized to the other groups that were not analysed in the study and in effect other groups that carry out CPS Activities.

Regardless, the findings of this research give an insight into how often CPS Activities occur and may serve as a basis for what to expect next time.

This research possesses aspects of both qualitative and quantitative research methods.

The researcher qualitatively exposed the CPS activities as they happened during the CPS process. It would be rational for the researcher to acknowledge that this presents some limitations because the exposed CPS activities are at the discretion of the researcher's perception as at the time of conducting the research. However, to counter this and thereby strengthen the reliability of this study, the researcher has provided detailed explanation of the data analysis as well as qualitative examples so as to enable the reader to have an accurate understanding of the procedures and findings.

Qualitative research is time consuming in nature therefore the scope of this research had an effect on the researcher's selection and analysis of only 2 groups with 4 participants each. Due to the limitation caused by the relatively small sample size and limited resources of this research, this research could not be taken a step further to unearth the reasons for this therefore, further research in this area is encouraged.

### **6.3 Future Research**

As encouraged by Hesse et al, (2015), this study takes a relatively small step towards the process orientated approach to CPS activities. The use of aspects of this framework of CPS activities for this study contributes to existing research done by Hesse et al, (2015), in that, it validates the framework in terms of sifting out the selected examples of CPS activities that come about in learning situations. Therefore, based on this study it can be concluded that, in using a competent framework such as that of Hesse et al, (2015), one can be able to perceive such CPS Activities in group learning situations and tap into them.

A suggestion from this case study for future research is that, research should be done with the aim of discovering the various potential reasons for the differences in total group occurrences of CPS activities as against individual engagements.

Hopefully, this research will serve as a source of motivation to future researchers with similar interests to look into the achievement of common ground during collaboration thereby avoiding chaos and its consequences on the 'observable' active participation of each collaborator.

Furthermore, from the analysis, the researcher discovered that some activities involved the simultaneous participation of all group members (E.g. *Problem Re-Analysis and*



*Coordination*) while others only had room for one individual member's participation (E.g. Task Exploration). This should be taken as a cue for the need for further research on unearthing the specific activities that come about from the simultaneous involvement of all the group members as against CPS activities that require only one individual's participation at a time as well as their reasons for such characteristics. This would go a long way to inform educators on how such activities could be identified and assessed in terms of groups or individuals.

## 7 CONCLUSION

Pioneers in the field of Collaborative Problem Solving (e.g. *Care et al 2016; Griffin et al., 2012; O'Neil, 2003; Davier & Halpin, 2013; Hesse et al., 2015; Rummel & Spada, 2005; Gu et al., 2015; etc.*) are taking concrete steps towards the development of technology that equips educators with the means of collecting assessment data on their students to have accurate and deep understanding of their degrees of skills and expertise in 21<sup>st</sup> Century skills. This research contributes to such an effort by affirming the validity of such Collaborative Problem Solving skills and their subsequent subcategories in that, they can actually be observable from both the individual work and collaborative working perspectives.

The aim of this study was to explore the pervasiveness of selected examples of CPS activities as they occurred in natural group working situations. The study looked at these CPS activities from 2 dimensions (*Group and Individual*).

With regards to the ratio of various CPS activities, the findings of this research sheds light on the fact that when analysed together, the occurrences of CPS activities vary, such that, they don't all occur on the same level or at the same frequency. The further breakdown of the group CPS activities into individual involvements did not show significant discrepancies that can be generalized.

However, this research validated the works of Hesse et. al, (2015) by validating selected aspects of its framework for teachable CPS skills in that, they could be used in unearthing the CPS activities as and when they occur in natural learning situations. This research presents some practical implications to the field of teaching and instruction in such a way that, now teachers can be mindful of the fact that when students engage in CPS activities, there are differences in the individual and group occurrences. Not all students actually partake in each activity as it unfolds. This should thus motivate educators to strategize new

ways of improving upon the involvement or participation of the students through carefully tailored scripts.

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## Appendix A

<b>Social aspects of CPS skills</b> ('Collaborative' Part of CPS)		
Code	Description	Indicator/Criteria
<b>Perspective taking:</b>	(a) Does a participant accept and adapt contributions by other group members?	(a) (high quality): <b>contributions or prompts of others are used to suggest possible problem solving paths</b> , (middle): contributions or prompts of others are adapted and incorporated, (low): contributions or prompts of others are taken into account
	(b) Is a participant (aware of) adapting her/his behaviour in relation to other group members needs/intellectual capabilities?	(b) (high quality): <b>contributions are tailored to recipients based on interpretation of recipients' understanding</b> , (middle): contributions are modified for recipient understanding in the light of deliberate feedback, (low) contributions are not tailored
<b>Cognitive aspects of CPS skills</b> ('problem solving part' part of CPS)		
<b>Coordination</b>	Is a participant (a group) able to manage resources or people to complete a task?	(high quality): <b>suggest that people or resources be used</b> , (middle): allocates people or resources to a task, (low): uses/identifies resources (or directs people) without consultation
<b>Task exploration</b>	Does a participant (a group) explore and understand elements of the task?	(high quality): <b>identifies need for information related to current, alternative, and future activity</b> , (middle): identifies need for information

		related to immediate activity, (low): identifies the need for information related to immediate activity
<b>Problem (re)analysis</b>	(a) Does a participant (a group) analyse and describe a problem (orientation phase);	(a) (high quality): <b>identifies necessary sequence of subtasks</b> , (middle): problem is divided into subtasks, (low): problem is stated as presented
	(b) Does a participant (a group) adapt reasoning/course of action as information or circumstance change? (task/check-up phase)	(b) (high quality): <b>reconstructs and reorganises understanding of the problem in search for new solutions</b> , (middle): tries additional options in light of new information or lack of progress, (low): maintains a single line of approach



## Appendix B

i.

*Frequency of CPS Activities within ITE Group 3, Sessions 1, 3 & 6.*

CPS Activities	Frequency			
	<u>Session 1</u>	<u>Session 3</u>	<u>Session 6</u>	<u>Group Total</u>
Perspective Taking (Audience Awareness)	9	15	3	27
Coordination	5	7	12	24
Perspective Taking (Adaptive Responsiveness)	3	3	7	13
Problem Re-Analysis	7	1	0	8
Task Exploration	5	1	1	7
Problem Analysis	1	2	2	5
<b>Session Total</b>	<b>30</b>	<b>29</b>	<b>25</b>	<b>84</b>

ii.

*Frequency of CPS Activities within ITE Group 4, Session 1, 3 & 6.*

CPS Activity	Frequency			
	<u>Session 1</u>	<u>Session 3</u>	<u>Session 6</u>	<u>Group Total</u>
Perspective Taking (Audience Awareness)	11	18	11	40
Coordination	9	9	15	33
Perspective Taking (Adaptive Responsiveness)	6	12	10	28
Problem Re-Analysis	7	5	2	14
Task Exploration	6	2	1	9
Problem Analysis	0	3	0	3
<b>Session Total</b>	<b>39</b>	<b>49</b>	<b>39</b>	<b>127</b>

## Appendix C

i.

*Frequency of CPS Activities in Group 3 Session 1 CPS activities.*

CPS Activities	Frequency				
	<u>Harriet</u>	<u>Carl</u>	<u>Pearl</u>	** <u>Paula</u>	<u>Group Total</u>
Coordination	4	5	4	0	5
Perspective Taking (Adaptive Responsiveness)	2	3	2	0	3
Perspective Taking (Audience Awareness)	8	9	8	0	9
Problem Analysis	1	1	1	0	1
Problem Re-Analysis	7	7	7	0	7
Task Exploration	5	4	5	0	5
<b>Total</b>	<b>27</b>	<b>29</b>	<b>27</b>	<b>0</b>	<b>30</b>

Note: \*\* was missing from the session.

ii.

*Frequency of CPS Activities in Group 3 Session 3 CPS activities.*

CPS Activities	Frequency				
	<u>Harriet</u>	<u>Carl</u>	<u>Pearl</u>	<u>Paula</u>	<u>Group Total</u>
Coordination	5	3	1	1	7
Perspective Taking (Adaptive Responsiveness)	2	3	3	2	3
Perspective Taking (Audience Awareness)	5	10	11	7	15
Problem Analysis	2	2	1	1	2
Problem Re-Analysis	1	1	1	1	1
Task Exploration	0	0	1	1	1
<b>Total</b>	<b>15</b>	<b>19</b>	<b>18</b>	<b>13</b>	<b>29</b>

iii.

*Frequency of CPS Activities in Group 3 Session 6 CPS activities.*

CPS Activities	Frequency				
	** <u>Harriet</u>	<u>Carl</u>	<u>Pearl</u>	<u>Paula</u>	<u>Group Total</u>
Coordination	0	3	3	7	12
Perspective Taking (Adaptive Responsiveness)	0	3	2	7	7
Perspective Taking (Audience Awareness)	0	1	2	1	3
Problem Analysis	0	1	2	2	2
Problem Re-Analysis	0	0	0	0	0
Task Exploration	0	1	0	0	1
<b>Total</b>	<b>0</b>	<b>9</b>	<b>9</b>	<b>17</b>	<b>25</b>

Note: \*\* was missing from the session.

## Appendix D

i.

*Frequency of CPS activities in Group 4 Session 1.*

CPS Activities	Frequency				
	<u>Alexi</u>	** <u>Doreen</u>	<u>Esther</u>	<u>Patricia</u>	<u>Group Total</u>
Coordination	2	0	3	9	9
Perspective Taking (Adaptive Responsiveness)	3	0	5	5	6
Perspective Taking (Audience Awareness)	4	0	6	11	11
Problem Analysis	0	0	0	0	0
Problem Re-Analysis	5	0	6	7	7
Task Exploration	2	0	1	5	6
<b>Total</b>	<b>16</b>	<b>0</b>	<b>21</b>	<b>37</b>	<b>39</b>

ii.

*Frequency of CPS activities in Group 4 Session 3.*

CPS Activities	Frequency				
	<u>Alexi</u>	<u>Doreen</u>	<u>Esther</u>	<u>Patricia</u>	<u>Group Total</u>
Coordination	5	5	6	8	9
Perspective Taking (Adaptive Responsiveness)	8	9	10	11	12
Perspective Taking (Audience Awareness)	7	9	14	14	18
Problem Analysis	1	2	2	2	3
Problem Re-Analysis	5	4	5	5	5
Task Exploration	1	2	2	2	2
<b>Total</b>	<b>27</b>	<b>31</b>	<b>39</b>	<b>42</b>	<b>49</b>

iii.

*Frequency of CPS activities in Group 4 Session 6.*

<b>CPS Activity</b>	<b>Frequency</b>				<b>Group Total</b>
	<b><u>Alexi</u></b>	<b><u>Doreen</u></b>	<b><u>Esther</u></b>	<b>** <u>Patricia</u></b>	
Coordination	6	9	6	0	15
Perspective Taking (Adaptive Responsiveness)	6	6	6	0	10
Perspective Taking (Audience Awareness)	5	8	7	0	11
Problem Analysis	0	0	0	0	0
Problem Re-Analysis	1	2	2	0	2
Task Exploration	0	1	0	0	1
<b>Total</b>	<b>18</b>	<b>26</b>	<b>21</b>	<b>0</b>	<b>39</b>