Assessing Interaction Patterns: Basis for Classroom Collaborative Policies

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Abstract

Purpose and Research Question - Learners' interaction pattern has become an important factor in the teaching-learning process. Studying learner interactions in problem-solving activities can help educators make decisions on the appropriateness of the activities. This study developed problem-solving activities to assess the interaction patterns of the learners as a basis for collaborative classroom policies.

Methodology – In this study, descriptive research design utilizing qualitative data to determine the learners' interaction patterns in a Mathematics classroom. Seven activities were developed using the cyclical evaluation-revision process based on the K to 12 curriculum standards.

Findings – The data revealed that among the three (3) cases of groupings, only Case 1 showed a very high collaboration since all group members collaborated actively in the activities. Group interaction patterns of the learners depend on the group composition and members' abilities. Furthermore, the abilities of each member appeared to contribute to the interaction patterns that facilitated and maintained group cohesion. This study prompt to suggest policies in the collaborative Mathematics Classroom: (i) Identify the abilities of the learners; (ii) Group the learners according to their abilities; (iii) Assign roles and responsibilities; (iv) Guide learners to make decisions in solving the problem; (v) Teacher must always monitor the progress of the learners doing CPS activities, and (vi) a quick self/peer evaluation is encouraged to assure that each member is doing their part in the activity.

Significance and Contribution in Line with Philosophy of LSM Journal -

This article contributes by illustrating the learners' interaction pattern in teaching Mathematics through a problem-solving approach. The three cases of collaboration presented in this paper suggest considering the abilities of the learners in grouping the students in collaborative problem-solving activities in the mathematics classroom.

Keywords: Interaction patterns; Collaborative Problem Solving; Open approach

Introduction

Background and Overview

Collaborative Problem Solving (CPS) is one of the most critical and necessary skills in education and the workplace (Medina et al., 2019). It is a setup that stirs dynamic and positive engagements of learners to perform most of the classroom activities. A part of it is to allow learners to collaboratively work with their peers. In the same sense, collaborative problem-solving (CPS) learning opportunities generated during the interaction are virtually known and have already been widely studied in the literature (Luckin et al., 2017). From an interactionist perspective (Long, 1996; Pica, 2013), interaction among peers has been shown to provide possibilities for comprehensible input, feedback, and output, thus facilitating learning. Additionally, from a sociocultural perspective (McLeod, 2019), there has been a growing interest in peer interaction while completing collaborative tasks. Researchers as cited by Mayo and Agirre (2018) have recently claimed that collaborative work allows learners to co-construct meaning and pay attention to communication without teacher intervention (Payant & Kim, 2017; Storch, 2016; Swain, 2000).

For a series of collaborative problem-solving (CPS) activities, interaction is emphasized, thus allowing the engaged groups to form patterns. As Williams (2000) described, this interaction pattern refers to how the members of a group work together to build an understanding of the mathematics, in particular, the extent to which learners evaluate, build upon, and combine the ideas contributed by each member. Interaction patterns can be realized when learners are exposed to multiple activities that promote collaborative problem-solving and critical thinking skills. These can be achieved by following 'Teaching Mathematics through Problem-solving (TMPS), which is one of the approaches encouraged in the Philippine educational system to attain these K-12 learning skills in the Mathematics classroom.

Teaching Mathematics through Problem-solving (TMPS) is an instructional approach that utilizes collaborative problem-solving (Fi & Degner, 2012; Cai & Lester, 2010). Teachers use problem-solving as a primary means to teach mathematical concepts and help the learners to synthesize their mathematical knowledge (Donaldson, 2011). Problems then become the springboard in facilitating the learning of mathematics. As an approach, the TMPS provides an innovative way of teaching mathematics utilizing open-ended problems. This can also be solved in various ways and will expectedly elicit different responses.

Rationale and Research Objectives

Problem-centered approaches, including TMPS, are found to be effective in improving learner achievement (i.e.,.Perveen, 2010; Matheson, 2005; Donaldson, 2011; Selmer & Kale, 2013; Natinga, 2016; Latif, 2016). Existing literature on TMPS and similar approaches have focused only on these aspects: 1) the problem used, 2) the processing of the lesson, 3) the affective dimension of problem-solving, and 4) learners' problem-solving technique. However, there are also studies (i.e., Yetton & Bottger, 1982; Moore & Anderson, 2014) that have been undertaken on the use of TMPS as it occurs within small groups utilizing collaborative problem-solving (CPS). Also, studying interactions have found to be helpful in understanding the dynamics of collaborative problem-solving in specific contexts (Hoek et al., 2005; Kumpulainen et al., 2003). Thus, this study investigates what goes on in the collaborative problem-solving (CPS).

The study of interaction patterns is a way to bridge the gap between the teacher's good intentions for the class and the behaviour which occurs in the classroom. The verbal interaction pattern created by the learners has become an important factor in the teaching-learning process, and therefore, it should be identified and utilized for optimal learning (Ifamuyiwa & Lawani, 2008).

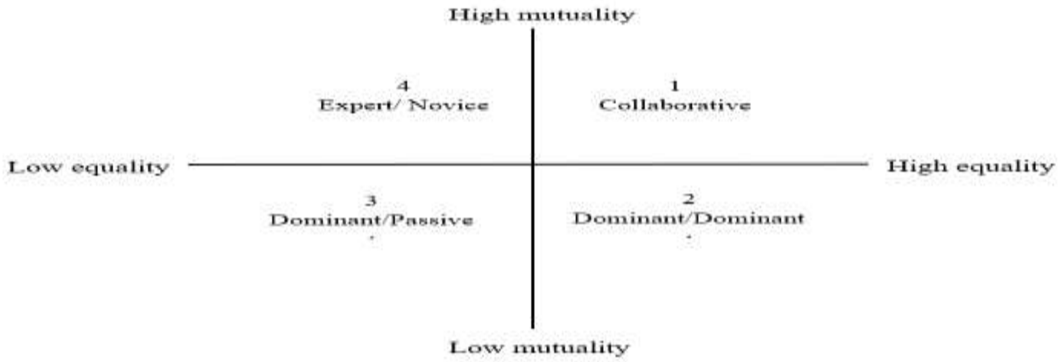
Considering that studying learner-learner interactions in CPS activities can contribute to a deeper understanding of collaborative problem-solving in mathematics by using the developed relevant rubric of assessment in conjunction with deeper discourse analysis. Furthermore, in the context of the TMPS approach and CPS activities, this study intends to develop and validate CPS activities, implement, and utilize the developed activities, analyze learner-learner interactions during implementation, and examine the interaction patterns in a Collaborative Problem-solving Mathematics Classroom.

Framework and Literature Review

The theoretical considerations for the analysis of the interaction patterns of the learners is anchored upon the Discourse Analysis Frameworks by Hoek et al. (2005). Also, this study is anchored on teaching mathematics through problem-solving (TMPS). This framework and approach employ principles such as constructivist and sociocultural perspectives of learning (Cai & Lester, 2010). The TMPS approach consists of four (4) major components: (1) presentation of the problem, (2) learners explore and solve the problem collaboratively, (3) processing of the lesson, and (4) summarization of important concepts. In all parts of the TMPS, it is aimed that the learners construct their knowledge as they engage in an unfamiliar mathematical problem. Such knowledge construction will be facilitated both by the teacher and peers. The teacher becomes a 'knowledgeable other' in the sociocultural perspective of learning.

A group engagement does not necessarily result in successful CPS (Nokes-Malach et al., 2015). Regarding the teacher's role in the TMPS, Vygotsky's sociocultural theory of development points to the importance of social processes in developing cognitive functions. A framework of Hoek and Seegers (2005) and Storch's Model of Dyadic Interaction by Storch (2002) (Figure 1) were used as frameworks for analyzing learner-learner interactions.

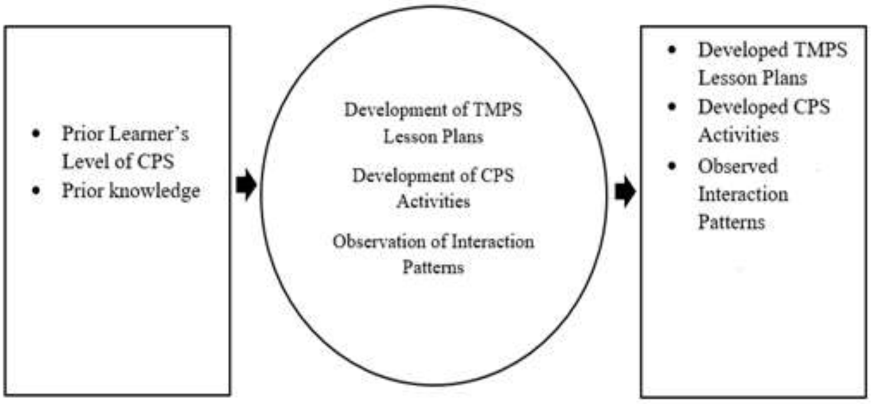
Figure 1 Storch's Model of Dyadic Interaction



As a result, a framework for analyzing verbal interactions was developed, identifying the following interaction patterns (see Appendix A). The framework was adjusted by the researchers and turned into a checklist for observing the learners' interactions during CPS activities.

The conceptual framework of this study is depicted in Figure 2 by a schematic diagram. The developed lessons and collaborative activities were used as inputs throughout the research study. The level of CPS and prior knowledge of the learners are crucial elements that could influence the study's outcome. Before being implemented, the designed TMPS lessons and CPS activities were validated and tried out. The developed TMPS lesson plans, developed CPS activities, and observed interaction patterns of the learners during the CPS activities are all expected outputs.

Figure 2 The Conceptual Framework of the Study



Methodology

The study is a descriptive research design that utilized qualitative data to determine the learners interaction patterns in a Mathematics classroom in teaching mathematics through problem solving (TMPS) context. The respondents of the study were the Grade 9 learners of one of the public schools in Region 10, school year 2018-2019. Two (2) out of twelve (12) sections were randomly selected, a total of 68 respondents. The participating learners were mainly used for individual work. Prior to teaching experiment, they had almost no experience with working in small groups in a mathematics class. In each class, some groups of four (4) learners were purposefully selected for observation. They were given the same task of solving problems in a specified time.

Data Analysis

In this collaborative group work, learners composed of different abilities and personalities of the learners were exposed to CPS activities. Each group was given a task with 15 minutes duration for each activity. The data were collected through audio and video records and analyzed the interaction patterns using the discourse analysis frameworks. For the L-L interactions, the framework of social interactions adapted from the work of Hoek and Seegers (2005) and Storch's Model of Dyadic Interaction (see Figure 1) were used in the study.

Table 1 Data sources used to investigate learner responses to CPS activities

Type of Data	Description of Data

Audio Records	Audio records of learners undertaking CPS activities
CPS Activities	Test of understanding administered during group activities
Checklist	A checklist during CPS activities that also includes observations of learners throughout the whole implementation in which the study was undertaken

The analysis focused on the learners' interaction as they worked to solve the problems. In three (3) collaborative groups with similar ability distributions (Case 1); the leader dominated the group discussion (Case 2), and members of the group had less collaboration in the activities (Case 3) were chosen for analysis.

One main reason for selecting these three (3) cases was the differences in collaboration among members of each group. Case 1, whose members collaborated well; Case 2, whose leader showed a comparable ability to solve CPS activities; and Case 3, whose members were dependent on each other. The researchers analyzed whether these differences in learning outcomes could be attributed to differences in response to their interaction patterns in the three (3) cases. Also, this analysis included the identification of the amount of time when learners did the activities and discovered the concepts themselves.

RESULTS AND DISCUSSION

Interaction Patterns in a Collaborative Problem-Solving Classroom
Analysis: Case 1

Case 1 was a group of all members who collaborated actively in the activities as summarized in Table 2. Two members were categorized as 'Proficient' and two were 'Approaching Proficiency' based on their achievement level.

Table 2 Case 1: Observed Learners' Activity during CPS

Amount of Time	Observed Learners Activity during CPS
3 mins	Read and understand the problem.
1 min	Identify the given and know what is asked.
1 min	Make a plan and decide what method to be used based on the given
1 min	Return to the problem to clarify the next requirements.
4 mins	Solve for what is asked.
2 mins	The leader explains the answer to the group.
1 min	Make a conclusion.
2 mins	Copy the answers in the manila paper for reporting.

The leader began by instructing the group to read and comprehend the problem during the first three (3) minutes. They usually took part in a group discussion by analyzing the problem and determining what the unknown was, as well as the data and the triangle drawing figure. They devised a strategy and chose a method based on the information provided during the fourth, fifth, and sixth minutes. They discovered a connection between the given angle and the unknown side, which aided them in determining which trigonometric ratio to employ to determine the pole's height. See sample excerpt found in Figure 3.

Figure 3 Case 1: Sample Excerpt of Participation in Understanding the Problem

M2	Ang gipangita kay other side of the tent. *(The unknown is the other side of the tent.)*
M3	Pero dapat nato makuha daan ang pole sa height. *(But we have first to find the height of the pole.)*
M1	So 90° ang isa ka angle ani. *(So, one of angles is 90°.)*
M3	Kung 90° na siya, ang opposite niya mao ang unknown na other side of the tent. Since opposite man siya, so ang gipangita nga side is the hypotenuse. *(If that is 90°, the opposite side of that angle will be the unknown which is the other side of the tent. Since it is an opposite, so the unknown side is the hypotenuse.)*
M2	Unsa man dayun atong pwede maggamit ani? *(What we are going to use then?)*
M3	Kato manang SOH CAH TOA. *(That's SOH CAH TOA.)*
M4	Opposite mani oh, tapos hypotenuse, so SOH. *(If this an opposite, and hypotenuse, then SOH.)*
M3	$\sin 30° = \frac{O}{H} \Rightarrow \sin 30° = \frac{h}{20} \Rightarrow h = 20 \times \sin 30° \Rightarrow h = 10m$
M4	Oh, sakto na na. So ang height sa pole kay 10m. *(Yes, that's right! Thus, the height of the pole is 10m.)*

Before answering what was asked, they first returned to the problem to clarify the next requirements. They solved the problem as a group during the seventh to tenth minute time. Besides the "leader," other members critically followed by asking questions and formulating doubts. They were asking questions like why they had to divide or add 10 to their answer and formulating doubts when they sensed that there was something wrong with their answer, like the 1.41 meters. See sample excerpts in Figure 4.

Figure 4 Case 1: Sample Excerpt of Asking Question during Discussion

M2	Pangitaon napod dayun nato ang hypotenuse sa isa ka triangle. *(Let's find next the hypotenuse of the other triangle.)*
M1	45 man ang degree tas nakuha na nato ang height which is opposite tas pangitaon nato ang hypotenuse *(Since the angle is 45°, and we already found the height which is the opposite side, so we are going to find the hypotenuse.)*
M3	So, SOH napod. *(Then, let's use SOH again.)*
M2	Pangitaon sa nato ang adjacent. *(But let's find first the adjacent.)*
M3	Ha? Pwede mangud ta modiretso gamit ang sine. Sine man ang gamiton. *(But, we can directly use the sine. Let's use the the sine function.)*
M2	So, $\sin 45° = \frac{10}{x}$
M3	Then, $x(\sin 45) = 10$ $x(7.07) = 10$
M3	Then, $x = \sin 45° \times 10 = 5\sqrt{2} \approx 7.07$
M4	So, mao na na atong x? *(So, that's already our x?)*
M1	Oo. *(Yes.)*
M2	Then, divided by 10.
M3	Idivide ug 10? (Why it has to be divided by ten?)
M2	Ay, di diay. 7.07 diay na. *(I mean, that's 7.07.)*

M1	Ay ana daw, 10 divided by 7.07. *(Try this, 10 divided by 7.07)*
M3	So, $10 \div 7.07 = 1.41$
M2	Plus 10
M3	Plus 10? Ngano man? *(Plus 10? Why?)*
M1	Nganong i-plus 10? *(Why it has to be added by 10?)*
M3	Isa ka side? 1.41? Gamaya gud. 10 meters sa isa tapos ang isa kay 1.41 ra. *(The other side is 1.41? I think, that is too small compared to 10 meters.)*

If one member showed a disagreement with the group's answer, they would find out where they went wrong and try to solve the problem on their own. According to record evidence, Member 2 was familiar with the special right angle theorem employing the 30°, 45°, and 60° angles, as stated in Figure 5. The body language of the group members continued to increase as Member 2 justified his disagreement with the group's answer by communicating and presenting the solution to the group. Everyone listened and spoke in agreement with Member 2's response.

Figure 5 Case 1: Sample Excerpt of Respecting Groupmates Ideas and Communicating of solutions to the Group

M2	Wait sa daw. *(Wait.) *She tries to answer on her own**
M1	Sure uy? Mubo raman kayo ang 1.41 meters. *(Are you sure? I think 1.41 is too small.)*
(Everyone tries to solve the answer individually)	
M2	Wait lang. Diba 90° ang kilid. Tas ang isa kay 60° ug 30°. Ang isa pod ka triangle kay 90° dayun $45° - 45°$. *(I have an idea. If this is 90°, the other one is 60° and 30° respectively, and the other triangle is has 90° then $45° - 45°$)*
(M1, M3 and M4 listened until M2 continued to solve what she has started but M3 repeat their solution using sine 45° and they found out that the answer is just the same which is 7.07m)	
M2	$10\sqrt{2}$ akong answer dire. *(My answer here is $10\sqrt{2}$. *pointing to the second hypotenuse*)*
M1	Giunsa man nimo? *(How did you do it?)*
M2	Diba, lantawa gani. Diba ang ratio sa $45° - 45° - 90°$ kay $1{:}1{:}\sqrt{2}$. So kung 10 ang isa ka side, ang isa pod kay 10. Dayun hypotenuse man atong gpangita so, gitimes ra sya nko ug $\sqrt{2}$, maong na $10\sqrt{2}$. *(Here it is. We all know that the ratio of $45° - 45° - 90°$ is $1{:}1{:}\sqrt{2}$. So, if one side measures 10 m, the other side is 10m, then the unknown is the hypotenuse. So, I multiplied it by $\sqrt{2}$, that's why it becomes $10\sqrt{2}$.)*
M3	Daw bi? *(So? *Trying to understand M2's solution*)*
M1	So ang hypotenuse diay kay leg times $\sqrt{2}$. Unsa lugar atong answer? *(So it means that the hypotenuse is leg times $\sqrt{2}$. What is now our answer?)*
M2	$10\sqrt{2}$
M3	Kay? *(how?)*
M2	Kay 10 man iyang leg. *(Because the measure of the leg is 10m.)*

M3	Ah okay. So $10\sqrt{2}$ ang answer ani. *(Ah, I see. So the answer is* $10\sqrt{2}$*.)*
M1	Oo, ana. *(Yes, that's it!)*
M2	So ato diayng gigamit ana kay special right angle kay 45° man siya. *(So the method that we were using by the way is special right angle theorem since it is 45°).*
(M3 has still doubts so M2 continues to explain using the special right triangle theorem which is $45° - 45° - 90°$*.)*	

During the thirteenth minute, everyone decided what to conclude in the problem based on their answer. Lastly, during the last two (2) minutes, there was already a decrease in the frequency of members changing ideas since it was when they wrote their answers on the manila paper for reporting. The members of this group demonstrated that it was possible to reach a solution using a special right triangle theorem even if they started their solution using the trigonometric function sine.

This group discovered two (2) solutions. Member 2 got the answer using the special right triangle theorem. Member 2 explained to the group and tried to figure out where they had gone wrong in their previous solution using trigonometric ratio sine. They brainstormed together and built a new solution using trigonometric ratio, and they found out that they got the same answer using two (2) different ways, as recorded in Figure 6.

Figure 6 Case 1: Sample Excerpt of Participating in Making Decisions on the Solution

M3	Ako raba ang reporter, unsaon mani pag explain. *(I will be the one to report, how to explain this?)*
M2	Ingna gigamitan natog special right theorem. *(Tell them that we're using special right angle theorem.)*
M3	So atong conclusion kay? *(What is now our conclusion?)*
M1	Therefore, we conclude that the other side of the tent is $10\sqrt{2}\,m$.
M3	Express daw to 2 decimal places, sakto lagi to atong answer nga 1.41m. *(Express it to two decimal places, so my last answer was right which is 1.41m.)*
M2	$10\sqrt{2}$=14.14. So. 14.14 man gud. *(It's 14.14.)*
M3	Dili uy. *(No. it's not.)*
M1	1.41 man to atong first answer dba? *(Our first answer was 1.41, right?)*
M3	Duha lugar atong answer. Balik daw, *(So do we have two answers. Let's check it,)* $\sin 45° = \frac{10}{x}$
M2	$\sin 45°$=0.707
M3	Haynako! 0.707 man gud. Dili man 7.07. *(Ahh I see. It's 0.707 not 7.07)* So, $x \sin 45° = 10$ $x(0.707) = 10$ Divide both sides by 0.707 so 14.14.
M1	Oh diba, pareha ra sya? *(See? The answers are just the same.)*
M3	Therefore, we conclude that the other side of the tent is $10\sqrt{2}\,m$.

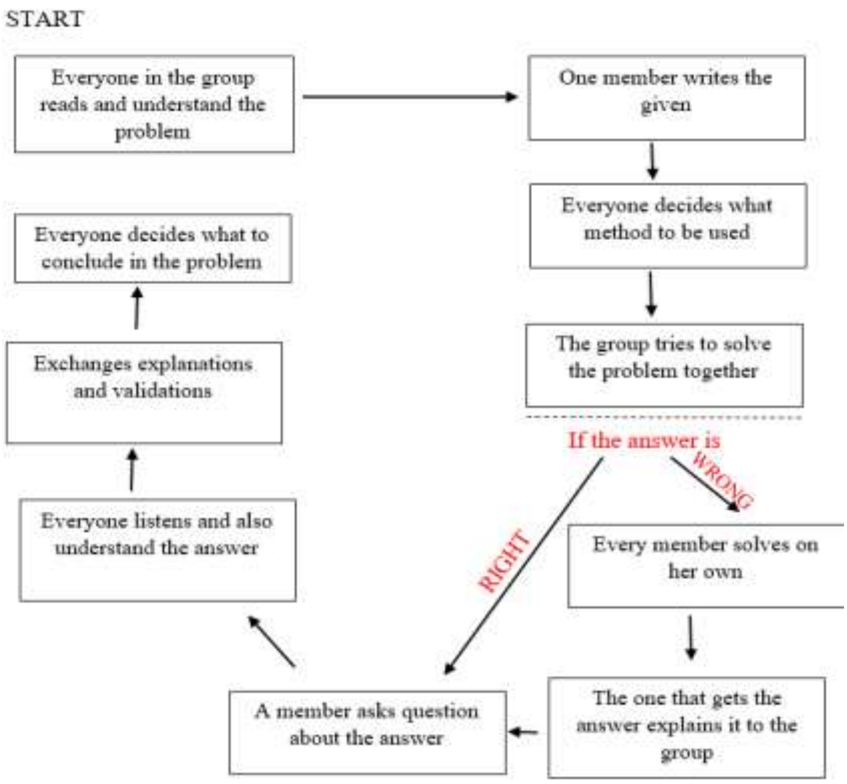
M2	Hala, feet man ang gigamit. Therefore feet na tanan. *(Ohh, the given is feet, so we have to use feet as a unit.)*

Each member of the group was focused on the same goal -- to answer the problem collaboratively. They indeed collaborated actively, and members had an equal distribution of ideas. They also evaluated each other's contributions critically and allowed their groupmates to correct themselves by showing agreement or disagreement with the answer.

The abilities and personalities of each member appeared to contribute to the interaction pattern that facilitated and maintained group cohesion. Attributes of each group member appeared to be integral to the creation of this cohesion. The interaction pattern presented above was based on the transcription of their conversation during the activity, as displayed in the sample excerpts above.

Since all group members are collaborating actively in the activities, the group has a high level of collaboration. In a high level of collaboration, there is an equal distribution of roles and a high impact on problem-solving capacity based on Cobo et al. (2000) and Mercer (1996) in Hoek et al. (2005). This also supports Storch's Model of Dyadic Interaction, where members showed high equality and high mutuality relationship. The high equality is evident in interactions where learners take direction from each other, and high mutuality describes interactions rich in reciprocal feedback and sharing of ideas (Damon & Phelps, 1989).

Figure 7 Usual Interaction Pattern of High Level of Collaboration



Analysis: Case 2

Case 2 was a group composed of one learner who dominated the process and described a general interaction pattern as described in Table 3. The leader was designated as 'Advanced,' while one member was labeled as 'Proficient,' and two others were 'Approaching Proficiency.' Once the leader had finished formulating an answer, he communicated it to the rest of the groups. In comparison to his groupmates, it appeared that the leader grasped the concept quickly.

Table 3 Case 2: Observed Learners Activity during CPS

Amount of Time	**Observed Learners Activity during CPS**
2 mins	Read and understand the problem.
1 min	Identify the given and know what is asked.
2 min	Make a plan and decide what method to be used based on the given
1 min	Return to the problem to clarify the next requirements.
3 mins	Solve for what is asked.
3 mins	The leader explains the answer to the group.
1 min	Make a conclusion
2 mins	Copy the answers in the manila paper for reporting.

During the first two (2) minutes, the leader began by leading the group to read and understand the problem. Generally, the leader would explain what he had understood in the problem to the group. During the third, fourth, fifth, and sixth minutes, they identified the given and knew what was asked, made a plan, and decided on the method to be used based on the given presented. They returned to the problem during the seventh minute to clarify the next requirements.

Everyone solved the problem in the next three (3) minutes, however the leader was occasionally the first to get the answer. While the other members of the group glanced at the sheet and listened, the leader communicated his results. Members might occasionally make comments or ask questions regarding the answer, but they would generally just affirm the leader's answer. Members were just willing to accept contributions without critical reflections. Sample excerpt found in Figure 8.

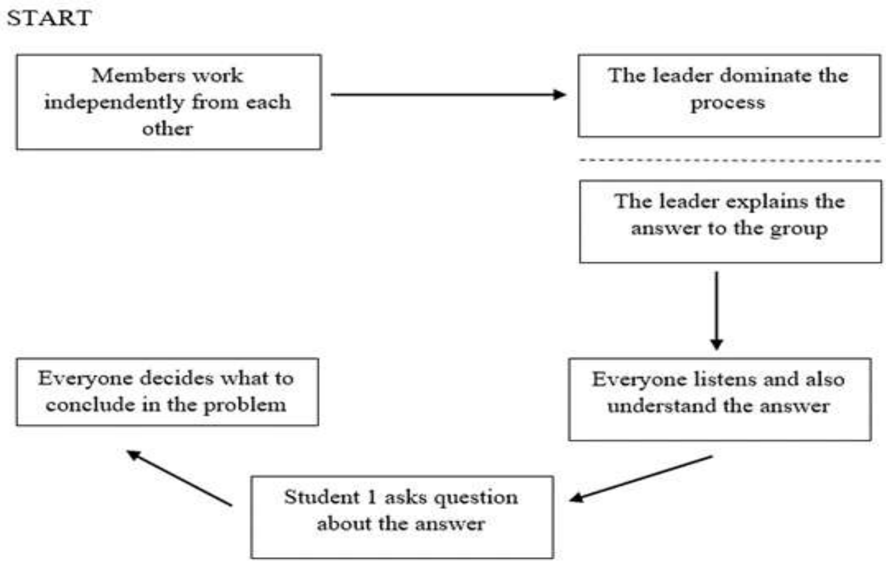
Figure 8 Case 2: Sample Excerpt of a Leader Dominating the Group Activity

Leader	Wait sa, magsolve sa ko. *(Wait! I'll solve it.)*Grabbed the activity sheet and answer it in her own**
Leader	Nganong find first the height of the pool? (*Why we have first to find the height of the pool?)*
M1	Lagi. *(Yes, why is it?)* *After 2 minutes kay nhuman ug answer ang leader then gpasulat ang answer sa member* *After 5 minutes, he explains the answer to the group*
Leader	So $\sin 30 = \frac{O}{H}$ $\sin 30 = \frac{x}{20}$ $x = 20(\sin 30)$ $x = 10$

	Nakuha nman nato ang height, so gamiton na nato ni para mkuha ang isa ka side sa triangle. Ilet nato sya as y. *(Sincee we got the measure of the height, so we're going to use it to find the other side of the triangle. Let the unknown be y.)* So, $sin45 = \frac{10}{y}$ $y(sin45) = 10$ $y = \frac{10}{\sin 45}$ $y = 10\sqrt{2}$

But member 1 remained a greater distance from the leader's answer than the other group members did. Member 1 occasionally looked at his answer during this time and listened to the discussion. This group's body language indicated learners were generally focused on the task, but the level of engagement was not high as illustrated in Figure 9.

Figure 9 Usual Interaction Pattern of Moderate Level of Collaboration



Case 2 spent most of their time answering the problem yet only the leader did most of it. The leader spent much of the time involved in peer tutoring to raise the understanding of the other members. Possibly, if the group had collaborated longer, more opportunities would have arisen for other members in Case 2 as illustrated in Figure 10.

Figure 10 Case 2: Sample Excerpt of a Group with Moderate Collaboration

L	Paghatg daw mog duha ka number nga pag itimes kay kay 1200. *(Give me two numbers that the product would be 1200)*
M1	40 and 30
L	Magboot2 raman ta ani bsata ang goal kay ang area kay 500-700. So akong plano kay ang height maoy 40m ang kaning sa base kay 30. Then kwaon dayn nato ang mga sides kay 600 mana ang area ana. Dayun ang pagkuha sa sides sa mga angle, I 30-60-90 rana.

	(We have to assume the measure and the he goal here is to have an area within the range of 500-700. So my plan is that the height would be 40m and measure of the base is 30m. Then let's find the measures of the other sides sine the ares is 600. To find easily the other sides, we'll use the 30-60-90.)
M2	So atong I right triangle? *(So, we have to assume that it is right triable?)*
L	Oo para madali. *(Yes, so it would just be easy.)*
M2	So dili diay na obliuque atong gigamit kay 30-60 nman. *(Thus, our triangle is not oblique sine we're using 30 and 60 degrees.)*
M1	So kitay mag assume? *(So, we will be the one to assume the given, right?)*
M2	Yes.
(After three minutes)	
L	Ay, naa nakoy answer. *(I have already an answer.)*

Based on the evidence, the understanding of concept was minimal for members of the Case 2 since there was a lack of responsiveness of the group and members to work independently and the leader dominated the process. But the leader in this Case 2 was expected to help, discuss and explain the answer to the group, and fill any gaps in each other's understanding (Slavin, 1995). The group had a low equality and low mutuality relationship of the members, thus the leader was described as dominant member and the rest were passive members according to the Storch's Model of Dyadic Interaction, resulting a moderate level of collaboration.

Analysis: Case 3

Case 3 (Table 4) involved a group of people who were completely reliant on their leader, as well as a leader who felt under pressure at all times. It was observed that the group did not comprehend very well the problem and tend to answer the problem not in a step-by-step way. The leader was labeled as 'Proficient' while the rest of the groupmates were labeled as 'Approaching Proficiency.'

Table 4 Case 3: Observed Learners Activity during CPS

Amount of Time	Observed Learners Activity during CPS
1 min	Read the problem.
1 min	Identify the given and know what is asked.
1 min	Decide what method to be used based on the given
4 mins	Solve for what is asked.
1 min	Return to the problem to clarify the next requirements.
2 mins	Finalize the answer.
1 min	Make a conclusion.
2 mins	The leader explains the answer to the group.
2 mins	Copy the answers in the manila paper for reporting.

During the first minute, the leader read the problem to the group but sometimes they did not understand it very well. The leader restated the problem for the members to understand. During the second and third minutes, they identified the given and decided on the method based on the given. But they forgot to clarify what was really asked in the problem (Figure 11).

Figure 11 Case 3: Sample Excerpt of Accepting Contributions without Critical Reflection

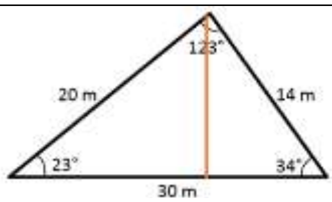
Leader	$\sin 30° = \frac{O}{H} \Rightarrow \sin 30° = \frac{h}{20}$ $h = 20 \times \sin 30°$ $h = 10\ ft$ (Height)
Leader	Unsa gani ng atbang sa angle? (What do you call the side opposite the angle?)
M1	Opposite
Leader	So opposite over
M2	Adjacent?
Leader	Opposite over adjacent, so TOA $\tan 45° = \frac{O}{A}$
L	Pila ang tan 45?
M2	1⇒ $tan\ 45 = \frac{O}{A}$ $1 = \frac{10}{A}$
L	Gamit ang 45° and the height of the pole which is 10, ug ang gipangita kay hypotenuse. So opposite over hypotenuse. Unsa nga trigo ratio para makit.an ang hypotenuse? *(Using the 45° and the height of the pole which is 10, and the unknown is the hypotenuse. So, this is opposite over hypotenuse. What trigonometric ratio to find the hypotenuse?)* **suddenly another group asked**
Other group	What trigo ratio did you use?
M2	Tangent $\theta = \frac{O}{A}$
L	Wala man tay adjacent, wala pod tay hypotenuse sa pikas triangle. Unsaon ni pagkuha? Naa nman tay opposite ug hypotenuse sa first triangle.. . *(We don't have the value of the adjacent and also the hypotenuse of the second triangle. How to find the hypotenuse of the second triangle knowing that we have the opposite and the hypotenuse of the triangle?)* **They focused on the first triangle and they thought they will get first the adjacent side of the first triangle.**
M2	SOH
L	COS. So $\cos 30° = \frac{O}{A}$ **Do not consider Member 2's idea.**
M2	Cos 30 is 0.867 **But considering the leader answer even if it is wrong.**

This group's first encounter with CPS activity (Activity 3) was noted as a difficult problem for them. They had trouble measuring the other side of the tent, which put them behind the other groups. The leader would occasionally fail to respond to the thoughts of the other members. Members in Case 3 had a variety of qualities and lacked confidence in their responses. They were willing to receive contributions without requiring critical analysis.

For the next four minutes, they started solving the problem. In Activity 4, it was observed that it took minutes for them to solve it because the leader decided and solved it without considering the member's idea. They solved again and then finalized their answers for two (2) minutes. They returned to the problem during the eight minutes to clarify the next requirements.

During the eleventh minute, they made a conclusion, and the leader explained the answer to the group. During the last two (2) minutes, the secretary copied the answers in the manila paper for reporting (Figure 12).

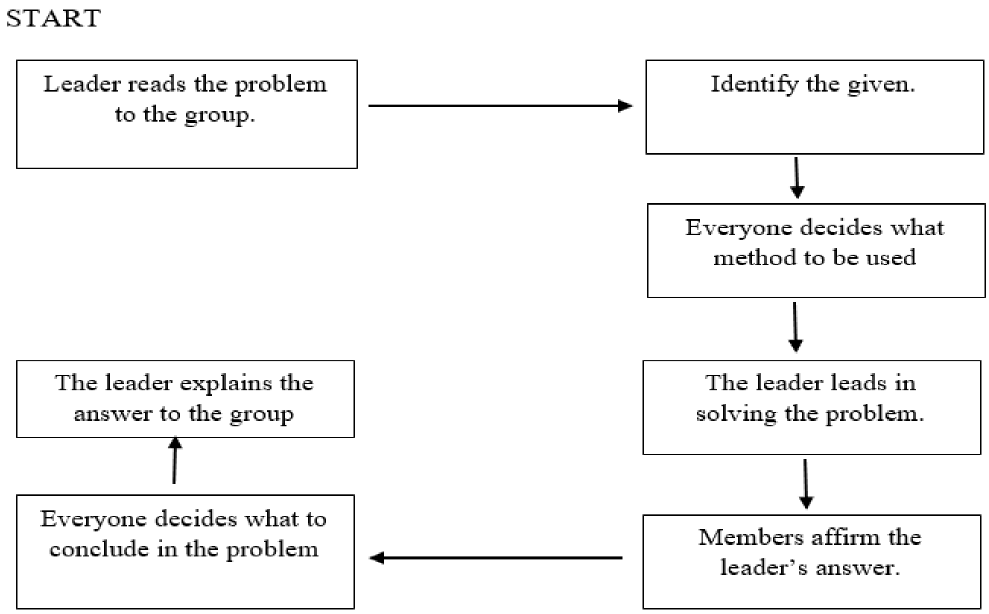
Figure 12 Case 3: Sample Excerpt of Making Decision without Understanding the Process



L	So, $\sin 23° = \frac{x}{20}$. Wala man tay x. *(So we don't have yet the value of x.)*
M1	No, mao mana atong height. *(No, that's already our height.)*
M2	So, x is our height.
Leader	So, $x = (20)\sin 23°$
M1	$\sin 34°$ sa. So, $\sin 34° = 0.56$
M2	$x = (20)\sin 23°$
	x =7.8
L	7.8 divided by 0.56
M2	13.93
M1	Dayun unsa na mana? (*So what's next?)*
L	$A = \frac{1}{2}bh$
	$A = \frac{1}{2}(30)(13.93)$
M2	Therefore, the area of the triangle is $208.95m^2$

Observation of the audio data indicated that the members of this group lacked the focus on what should be done every after activity. Members did not respond well to each other's contributions. They dismissed others' ideas without consideration and explanation. Sometimes, they accepted contributions without critical reflection, just like how they divided 7.8 into 0.56, which made their solution wrong. If there was an idea from one member, they just accepted it even if it was wrong, which made them conclude a wrong answer. There was a low engagement in this group. The usual interaction pattern of case 3 is presented below (Figure 13) where members considered the leader as an expert.

Figure 13 Usual Interaction Pattern of Low Level of Collaboration



Since every group is composed of different learners with different abilities, their interaction patterns really vary from one another. Table 5 shows differences in functioning in Case1, Case2, and Case 3. Case 1 worked together to generate new ideas, and Case 2 operated primarily within a peer tutoring model. It appeared that greater understanding resulted when learners spent their collaborative sessions generating new ideas. This was supported in Yetton and Bottger (1982) study, wherein it is generally accepted that group performance is a positive function of member ability. Also, Bales and Borgatta (1966) findings showed that group interactions could generate expectations based on the behaviors and abilities of group members, which would guide subsequent interactions. Evidence suggested the factors associated with group composition affected the learning opportunities that would arise within a group.

Table 5 Differences in Functioning in Case1, Case2, and Case 3

Characteristic	**Case 1**	**Case 2**	**Case 3**
Engagement in the task	High level of engagement at all times. Even higher when new way of solving was discovered	Moderate level of engagement at all times due to the dominant member	Low level of engagement
Interconnection between student discourse	Reflect each other's ideas Exchange explanations and validations	Members consider "leader" as expert	

Number of ways discovered	2	1	1
Relationship between the content of the CPS activities and the present concept development of the learners.	Generally all members worked together.	The majority of the time of the CPS activities and mathematical discourse of the group was not outside the leader's present understanding. Most of the ideas come from the leader.	Leader worked independently and had a competitive attitude.
Primary mode of group operation	Mainly creation of new ideas collaboratively.	Mainly peer tutoring	Mainly depending each other.
Storch's Model of Dyadic Interaction (Figure 1)	High mutuality and high equality (Collaborative)	Low equality/ low mutuality (Dominant/Passive)	High equality and low mutuality (Dominant/Dominant)

Classroom Policies in the Collaborative Mathematics Classroom

This research would like to address this question "*How would teachers incorporate collaborative problem solving into their instruction?*" After implementing all the activities in determining the learners' achievement level and collaborative problem-solving level and analyzing their interaction patterns, the research prompted to suggest classroom policies. In promoting engagement among learners in problem-solving, it is important to establish a learning environment that would welcome learners' involvement. It should start by setting expectations for the learners, clearly explaining the process, and following these suggested policies in the collaborative Mathematics Classroom:

i. *Identify the abilities of the learners.* Learners differ in their ability to define the problem and generate possible solution pathways (Case 1). According to Landvogt (1998), if teachers can recognize the attributes possessed by learners who display ability in a particular area of learning, educators can modify teaching approaches to foster these characteristics in all learners, including gifted learners. Teachers' awareness of this particular capability is accelerated when they focus their attention on the profile of learner's ability to solve problems developed in this study.

ii. *Group the learners according to their abilities.* Another way of maximizing opportunities for the learners to learn is to group them according to their abilities. This study illustrates the need for a common mathematical background in members of a collaborative group to promote the exploration of new ideas (Case 1). Without this common background, learners may not possess overlapping understanding about the task, which could reduce the amount of exploratory activity undertaken by the group (Case 2).

iii. *Assign roles and responsibilities.* Assigning group roles can be a beneficial strategy for successful group work design since it offers an opportunity for high-quality, focused interactions between group members. Learners are more likely to stay on task and pay closer attention to the activity at hand when their roles in the collaboration are clear and distinct. It also provides all learners with a clear avenue for participation. In the same lines, assigning group roles reduces the likelihood of one member completing the task for the whole group, or "taking over," to the detriment of others' learning. Hence, the teacher must provide learners with a list of roles and brief definitions for each role at the beginning of the CPS activity.

iv. *Guide learners to make decisions in solving the problem.* Evidence from this study challenges the need for an expert other (Vygotsky, 1978) to assist learners in moving through their understanding (Case1) and suggests learning opportunities for the group are not maximized in a predominantly peer tutoring group (Case 2). Step in and give feedback when learners need help, but also let them work some concepts out in their own.

v. *Encourage the teacher to monitor the progress of the learners doing CPS activities.* Keep track of their improvements by checking their activity and informing them of their results every class. In this way, they could be motivated to do more for the next activity and for being informed of their progress as well.

vi. *Remind learners to give contributions together to the problem. A quick self/peer evaluation must ensure that each member is doing their part in the activity*.

Conclusion

The interaction patterns of the learners in the following cases showed that:

- Case 1: Since all members of the group collaborated actively in the activities, the group has a high level of collaboration.
- Case 2: Understanding concept was minimal for members of the second case since there was a lack of responsiveness in the group and members worked independently from each other, and the leader dominated the process. But the leader, in this case, was expected to help, discuss, and explain the answer to the group, and fill any gaps in each other's understanding. The group had low equality and low mutuality among the members; thus, the leader was described as a dominant member, and the rest were passive members resulting in a moderate level of collaboration.
- Case 3: The leader worked independently and had a competitive attitude, and members were dependent on the leader. They had minimal interactions with each other and were described as having high equality and low mutuality. Thus, Case 3 had a dominant member who showed a low level of collaboration in the group.

As a result, each member's abilities and personalities appeared to play a role in the interaction patterns that promoted and maintained group cohesion. Attributes of each group member appeared to be integral to the collaborative problem solving. Group interaction patterns appeared to depend on the group composition, and group composition appeared to affect learners' engagement and collaboration. Furthermore, this study demonstrated the potential for learning where an approach such as CPS was utilized, but the study also highlighted the policies in a collaborative Mathematics classroom that required considerations for the approach to be more effective.

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APPENDIX A

Checklist for Learner-Learner Interaction

Activity	1	2	3	4	5	6	7
□ Members work independently from each other							
□ Members do not respond to each other's contribution							
□ One (or two) learners dominate the process							
□ Dominant learners do not respond to other's ideas							
□ Dominant learners dismiss other's ideas without explaining why							
□ One student takes leading role							
□ Other students beside the "leader" critically follows by							
□ Asking questions							
□ Formulating doubts							
□ Formulating doubts							
□ Demanding argumentations							
□ Exchanges explanations and validations							
□ "Leader" acts as organizer and guide							
□ Members consider "Leader" as expert							
□ Members talk to agree							
□ Members are willing to accept contributions without critical reflection							
□ Repetitions in statements are prevalent							
□ Confirmation of ideas are frequent							
□ Participants collaborate actively							
□ Members have equal contribution of ideas							
□ Members evaluate each one's contribution critically							