Online Collaborative Learning: Applicability in Comparison with Individual Learning and Face-to-face Collaborative Learning

Romyna Fortuna G. Mapile, Minie Rose C. Lapinid

De La Salle University, Manila, Philippines

romyna_mapile@dlsu.edu.ph, minie.lapinid@dlsu.edu.ph

Abstract: This classroom-based action research aimed to determine the applicability of implementing Collaborative Learning in online setting to help students develop their interaction with one another and improve their academic performance. Participants of the study consisted of Grade 8 intact pilot section of a public school in an urban community which yielded only 20 valid responses. Student participation during online collaborative learning made use of the first three stages of Siemen's Connectivism taxonomy. Quantitative data were taken from Student Attitude Survey, individual and group learning activity sheets, and achievement test, while qualitative data were taken from focus group discussions. Transcripts of the recorded online collaborative learning were analyzed using content analysis following Garrison's Practical Inquiry Model. Results showed that there is a significant increase in students' scores in the activities done collaboratively than those done individually. However, only 12 out of the 20 students successfully passed the achievement test. Additionally, results of the content analysis of the video recording transcripts show that among the four categories of Garrison's Practical Inquiry Model, students made more extensive use of integration and exploration during online collaborative learning. In terms of students' attitudes toward the intervention, the results indicated a positive response with regard to their experience with online collaborative learning. Analysis of the focus group discussions using interpretative phenomenological analysis revealed similarities and differences in collaborative learning between an online and face-to face learning.

INTRODUCTION

When the World Health Organization declared COVID-19 as a pandemic due to the widespread of the Novel Coronavirus disease, lockdowns and social distancing protocols disrupted everyone's normal everyday life which led to the closure of large gathering venues such as movie theaters, museums, churches, and even educational institutions (Sahu, 2020).

In compliance to the directive of the secretary of Department of Education concerning the preventive measures against COVID-19, all schools in the Philippines implemented distance learning as delivery mode (Department of Education, 2020). In line with the different learning

modalities during distance learning, some public schools offer a variety of learning delivery modes to students, whichever was suitable to their situation. Students who cannot afford to have an access online may enroll in printed modular learning. While those who might have access to internet although possibly unstable, may enroll in blended learning – a mix of online and modular learning – as their mode of instruction during the pandemic. Lastly, those who have stable internet connections but cannot to go to school to retrieve and/or submit modules in compliance to the preventive measures against COVID-19 may enroll in online learning.

Throughout the school year 2020-2021, the students were learning in isolation at home either through following a printed learning module or through synchronous and asynchronous online learning. This raised doubts on the quality of learning as there is lack of social interaction and communication. Studies have shown learners in online education need various support not only from instructors, but also from peers since peers are essential in forming learning environment where they may collaborate and be engaged in learning (Wang et al., 2019; Tay et al., 2021). Furthermore, teachers could adopt collaborative learning in their online classes to develop learners' practical skills and knowledge, collaborative problem-solving skills, and teamwork skills, especially in mathematics (Tsai, 2010). For this reason, this study examines the implementation of collaborative learning in online distance learning during the pandemic.

LITERATURE REVIEW

Online collaboration is the online version of the traditional in-class collaborative learning (Ku et al., 2013) with the exception that group meetings in online setting are held synchronously or asynchronously via the internet. In this approach, it is possible for students to interact with one another despite limitations in time and locations (Nurdiyanto et al., 2017). Furthermore, collaborative learning in online environment develops interaction among learners and a sense of social presence, which promotes students' improvement of learning and their capability to adapt to various teaching techniques, as well as their motivation and satisfaction (Magen-Nagar & Shonfeld, 2018).

The implementation of collaborative learning in mathematics online class was anchored on the first three stages of connectivism together with Garrison's Practical Inquiry Model (PIM). Connectivism emphasizes that in an online learning environment, the most common means of finding and producing knowledge is through interaction and dialogue (Siemens, 2005). This framework is helpful to understand collaborative learning in an online setting. Learning in the digital age, according to Siemens, is no longer based on individual knowledge acquisition, storage, and retrieval; instead, it is based on connected learning that takes place through interaction with difference sources of information as well as involvement in communities of common interest, social networks, and group tasks. Moreover, one of Connectivism's most notable aspects is interaction and connections. It refers to the connections between nodes in a network that allow information and knowledge to flow (Banihashem & Aliabadi, 2017). With students viewed as

nodes in a network of learning system, this theory supposes that learning rests on diversity of opinions among students forming connections and collaboration with other nodes (AlDahdouh, 2018).

Garrison's PIM addresses cognitive presence in order to provide a tool for evaluating critical discourse in a discussion (Garrison et al., 2009). It was used in other studies as a coding framework to investigate the students' online discussion (Liu & Yang, 2012). In order to explain and comprehend cognitive presence in an educational setting, the practical inquiry model suggests four phases – triggering event, exploration, integration, and resolution. The stages of the practical inquiry model are an idealized logical structure of the critical inquiry process and should not be regarded as constant but changes over time. The PIM is more involved with thinking processes than with individual learning results. As a result, it may be utilized in online conversations to measure critical discourse and higher-order thinking (Garrison et al., 2009). In addition, the PIM was determined to be the best applicable to analyze cognitive dimension and provides a clear description of the knowledge-building processes that take place in an online discussion (Schrire, 2004).

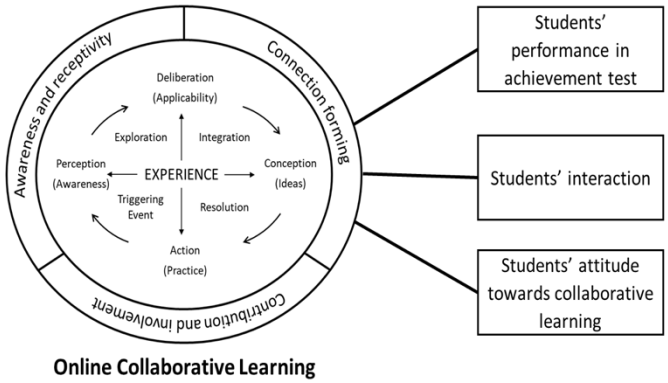

Figure 1: Framework of the Study

As presented in Figure 1, online collaborative learning (OCL) is anchored in connectivism, which has three major components namely (1) awareness and receptivity, where learners acquire basic knowledge for handling information abundance and have access to resources and tools; (2) connection forming, where learners use the tools and understand the acquired knowledge from the first stage to be able to form connections with their network and (3) contribution and involvement, where the learner begins to actively participate in the network, and allows it to recognize the learner's resources, contributions, and ideas, resulting in reciprocal understandings and relationships (Sitti et al., 2013).

Concurrently, online collaborative learning is anchored on the four phases driven from Garrisons' PIM namely which are the four major phases of cognitive presence that can be seen in students' online discussions (Garrison et al., 2009). The first one is triggering event which is the process of

becoming aware of an issue by starting an investigation. The second phase is called exploring, which is where students are looking for relevant information, reflecting, and exchanging explanation to solve a problem. The third phase is integration, a process of making meaning from a variety of sources and suggesting solutions to the given problem. Lastly, resolution is a phase in which implementing or defending potential solutions with a new idea occurs. Students may return to a prior phase, hence these four phases do not necessarily have to be in sequential order (Swan et al., 2009).

PROBLEM STATEMENT

This study intends to determine the applicability and viability of collaborative learning in synchronous online class setting. Specifically, it seeks to answer the following:

1. How are the learning activities developed?
2. What are the students' performances in their individual learning tasks, collaborative learning tasks, and achievement test in mathematics?
3. How interactive are the students during collaborative learning in an online setting based on the four categories of Garrison's Practical Inquiry Model – Triggering Event, Exploration, Integration, and Resolution?
4. What are students' attitudes towards online collaborative learning?
5. How do students perceive online collaborative learning as compared to face-to-face collaborative learning?
6. How do the students interact based on the first three stages of Connectivism – awareness and receptivity, connection-forming, and contribution and involvement?

METHODOLOGY

The study is an action research that utilized mixed methods approach. The qualitative data consists of students' perceptions on online collaborative learning compared to face-to-face collaborative learning, and transcripts of students' interactions during collaborative learning. Quantitative data consist of students' self-report attitudes towards the implemented collaborative learning, students' academic performance using classroom assessment tools such as activity sheets and achievement test.

Since very few students in the public school where the study was conducted can afford online learning, only an intact class of 40 students who have a gadget and an access to internet connection was requested to participate in the study. However, in the observance of research ethics, only 28 students gave their consent. And out of these, the study yielded 20 valid responses. From the 20 valid responses, there were 9 participants who missed at least one online group work, leaving only 11 who were able to attend all the meetings of online collaborative learning. The class was handled by the first researcher and was divided into small groups with 3-5 members each group for the implementation of online collaborative learning (Moreno et al., 2021). Each group was heterogenous (Murphy et al., 2017) made up of low-, average- and high-ability students.

The research instruments used were online learning activity sheets, a validation guide, an achievement test, an attitude survey questionnaire, and a focus group discussion (FGD). The activity sheets were face and content validated by 3 experts with the use of an adapted validation questionnaire (Yildirim & Orsdemir, 2013). All items in the validation questionnaire used a 5-point Likert scale. The achievement test consisted of a 50-item multiple choice summative assessment that involved all the said topics in mathematics. The Garrison's PIM was used to analyze and determine students' cognitive presence during online discussion transcripts. The student attitude survey questionnaire on online collaborative survey questionnaire was adopted from Korkmaz (2012) and the focus group discussions was used to determine student views on online collaborative learning.

Prior to each online collaborative learning session, students answered the learning activity sheets individually. These were not graded. Students underwent online collaborative learning where they answered the same activity this time as a group. Student mean scores on the activities done individually and by group were compared using paired samples t-test. This is to determine if there is a significant change of scores in the activity when independently and collaboratively. After having gone through all the class activities, an achievement test was administered to the students.

During the OCL, each group activity was recorded. Transcripts of the video recordings were analyzed using content analysis with the use of Garrison's Practical Inquiry Model. Subsequent to the online collaborative sessions, the students answered the student attitude survey and a focus group discussion (FGD) took place. The participants' responses were also recorded and transcribed. The interpretative phenomenological analysis was utilized to analyze students' responses in FGD.

RESULTS

The following results are presented following the order of the corresponding research questions it seeks to answer.

Development of Learning Activities

The learning activity sheets are researcher-made formative assessments items of which were selected based on the Department of Education's most essential learning competencies. The tasks contained probing and guide questions eliciting students' prior knowledge or what they know towards discovering what they do not know in accomplishing the tasks. These are also concept building activities prior to class discussion where students construct knowledge and skills predefined in the lesson. Furthermore, concept building using real-life problems on the following topics corresponding to the online collaborative learning were utilized: linear inequalities in two variables; systems of linear inequalities in two variables; and relations and functions, and dependent and independent variables.

The activity sheets underwent two cycles of revisions and feedback between the two researchers. For the first two activities, only minor revisions took place. For example, in the first activity (problems involving linear inequalities in two variables), the graph of an inequality, which is a half plane, was introduced to the students. After being able to describe the graph based on the points (solutions) on the coordinate plane, they will see that some problems are best represented by an inequality rather than an equation. Subsequently, another problem of the same type was given in the activity. At this point, as they were able to determine that the problem was best represented by an inequality, they were asked in the activity how the graph of an inequality could be determined in terms of the boundary line and the shaded half-plane.

For the third activity, validators commented the questions made were very superficial, thus requires major revision. It was brought up during the cycle of revisions that the concepts should be presented based on real-life. Consequently, the major changes consist mainly in the use of real-life situations for relevance in students' experience and for eliciting students' prior knowledge.

Table 1 shows validators' ratings of the activity sheets. All item responses indicate a positive strong agreement with regard to the validity of the activity sheets. There were few comments brought up by the validators most of which were minor changes in the rubric to be used for the activity. This is consistent with their ratings as indicated in item 5, "The activity will be scored using an appropriate rubric" obtained the lowest mean score among all items in the validators' questionnaire.

Indicators	Activity 1	Activity 2	Activity 3	Overall Mean
1. The questions are aligned to the learning competency intended to be achieved.	5	5	5	5
2. The activity which I assign requires the students to use cognitive skills such as critical thinking, problem solving, and comprehending.	4.67	4.67	5	4.78
3. The activity which I assign are suitable to the students' level.	4.67	5	5	4.89
4. The activity which I assign can be applied in real-life situations.	5	5	5	5
5. The activity will be scored using an appropriate rubric.	4.33	5	4.67	4.67
Overall Mean	4.73	4.93	4.93	4.86

Table 1: Validators' Mean Scores of the Learning Activities

Student Performance

The following shows students' performances on the individual and online collaborative learning activities, and their achievement test as indicated by their individual scores in Figures 3 to 9.

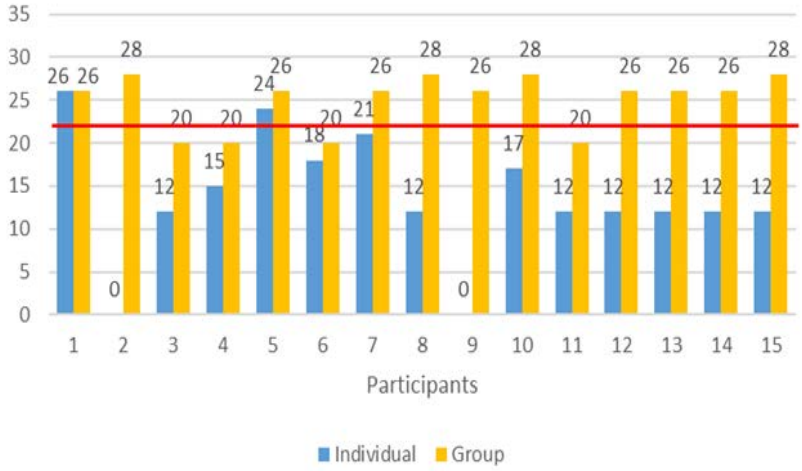

Figure 2: Individual and Group Activity 1 Scores of each Student

As can be gleaned from Figure 2, there were 15 students who participated in the first activity. The lowest among the scores in the individual activity 1 was 0, which were the submitted activities with no answer, while the highest was 26 out of 36. The mean score in this individual activity is 13.67 (*SD* = 7.26). The passing score is 22, and Figure 2 shows that only two students passed the individual activity 1.

With the same activity sheet done collaboratively, Group 2 (Participants 2, 8, 10, and 15) obtained the highest score of 28, both Group 1 (Participants 1, 5, and 13) and Group 3 (Participants 7, 9, 12, and 14) scored 26, and the lowest, Group 4 (Participants 3, 4, 6, 11), scored 20. This reveals that there were 4 students who also obtained the highest score amongst the 15 participants, and 4 students who not only scored the lowest, but also did not meet the passing score, which is 22. The overall mean of scores of each student in this group activity was 24.93 (*SD* = 3.20).

It can also be seen in the figure that only Participant 1 did not have any changes with his/her score. This is because among the members of his/her group, participant 1 has the highest score in the individual activity. Thus, participant 1 was the one who helped his/her groupmates, which resulted to no improvement to his/her score in the group activity. For the rest of the participants, there was an increase of scores between their individual and their group work.

Figure 3 presents that there were 18 students who participated in this activity. Two scored 33 out of 36 were the highest among the participants, while 10 students who obtained the score of 12 were the lowest in the second individual activity. The mean of the scores in this individual activity is 17.33 (*SD* = 7.72). The passing score is 22, and Figure 3 shows that only 6 students passed the individual activity 2.

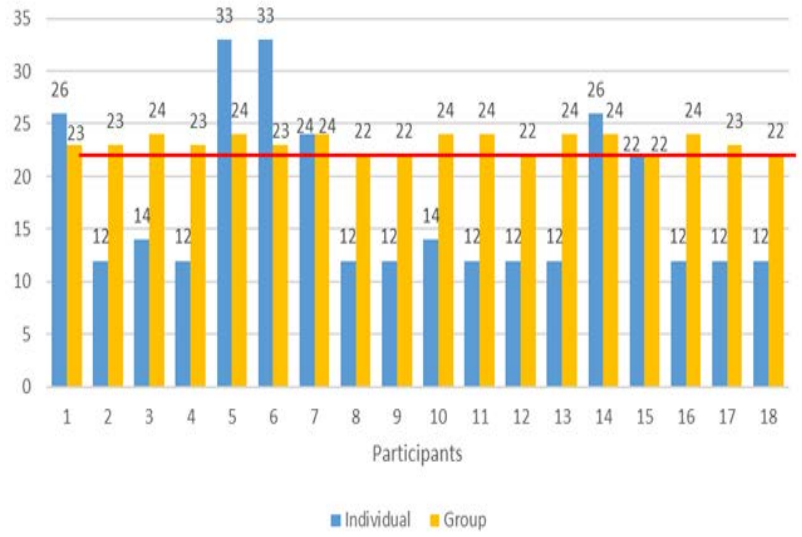

Figure 3: Individual and Group Activity 2 Scores of each Student

In the group work of the same activity sheet, the highest score was 24, which was obtained by both Group 3 (Participants 10, 11, 14, and 16) and Group 4 (Participants 3, 5, 7, 13), Group 2 (Participants 1, 2, 4, 6, and 17) scored 23, while Group 1 (Participants 8, 9, 12, 15, and 18) had the lowest score of 22. This implies that 8 students obtained the highest score of 24 in this group activity. Since the passing score is 22, Figure 3 also shows that all of the groups met the passing score in the given learning task. The overall mean score in this group activity was 23.17 (*SD* = 0.86).

It can be noticed in Figure 3 that Participants 1, 5, 6, and 14 had a decrease in their score during their collaborative work, while Participants 7 and 15 did not have any changes with their scores. These participants were actually the ones who had higher scores in their individual activity amongst their groupmates. Moreover, during online collaborative learning, they were the one who facilitated and helped their groupmates. As a result, instead of having improvements in their scores in the group activity, their scores either were pulled down or had no improvement at all because they were the ones assisting their groupmates and no one was actually helping them. The rest of the participants, however, had an increase in their scores in the second group activity.

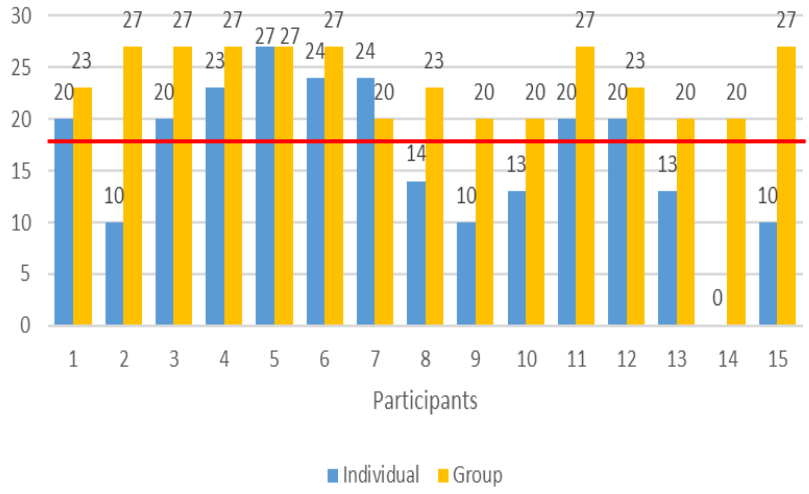

Figure 4: Individual and Group Activity 3 Scores of Each Student

Figure 4 illustrates there were 15 students who participated in this activity. Amongst all the participants in the individual activity 3, the highest score obtained was 27 out of 30, while the lowest was 0. The mean of the scores is 16.53 (*SD* = 7.29). Since the passing score is 18, and Figure 4 shows that there were only 8 students who passed during the individual activity.

During the collaborative work of the same activity sheet, the highest score obtained was 27, which was from both Group 2 (Participants 2, 3, 5, and 11) and Group 4 (Participants 4, 6, and 15). Group 3 (Participants 1, 8, and 12) scored 23, while Group 1 (Participants 7, 9, 10, 13, and 14) obtained a score of 20, which is the lowest. This indicates that a total of 7 participants got the highest score in this activity, and 5 were the lowest. Figure 4 also shows that all of the groups met the passing score in the given learning task, which is 18. The overall mean of scores of each student in this group activity was 23.87 (*SD* = 3.23).

It can be seen in Figure 4 that Participant 5 did not have any changes in his/her score during the intervention, while participant 7 had a decrease in his/her score during online collaborative learning, and the rest of the participants' scores increased on their online collaborative work. Participants 5 and 7 were the highest in the individual activity among the group. Just like in the previous activities, they were the ones assisting their groupmates and facilitating their online group work. Since no one was actually helping them, their scores in the online group work either were pulled down or had no improvement at all.

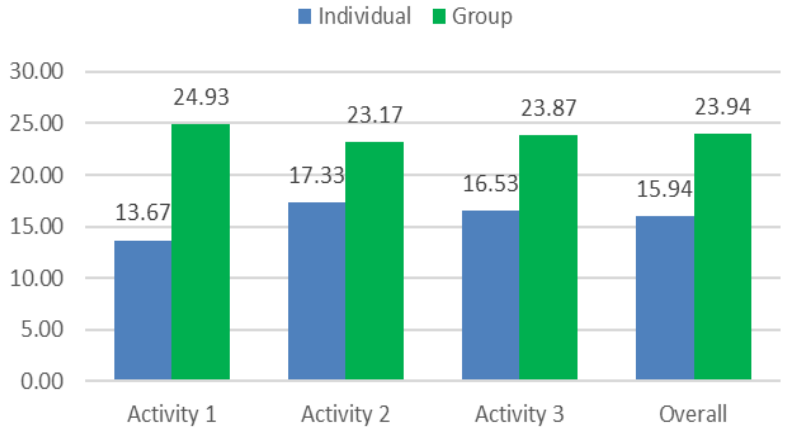

Figure 5: Mean Scores of Students in Both Individual and Group Activities

A paired samples *t*-test was used to determine if there is a significant increase in the scores of the activities when done by group. Results revealed that the mean score in the individual and group activities 1, 2, and 3 have significantly increased at 0.05 level, t = -5.261 with p-value of 0.00006, t = -3.265 with p-value of 0.00227, and t = -4.3122 with p-value of 0.00036 respectively. Consistently, students' overall mean score in the individual activities 15.94 (SD = 2.64) has significantly increased to 23.94 (SD = 2.64), the overall mean score of the group activities at 0.05 level, t = -7.183 with p-value of 2.1544 x 10^{-9}.

The achievement test was administered after the 3-week implementation of online collaborative learning to determine the improvement of students' academic performance after the intervention.

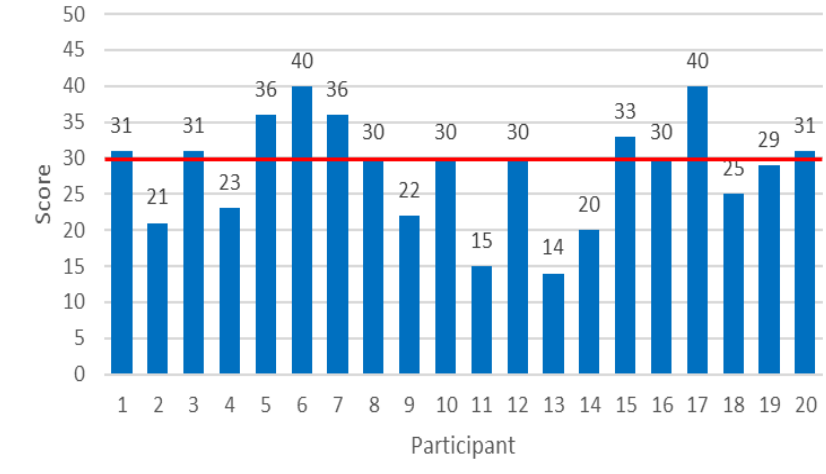

Figure 6: Achievement Test Scores

As seen in Figure 6, two participants who scored 40 out of 50 are the highest among the group, while the participant who obtained the score of 14 is the lowest. The passing score is 60% of the total items, which is 30 points. It can also be seen in Figure 6 that out of 20 participants, there were 12 who passed the achievement test.

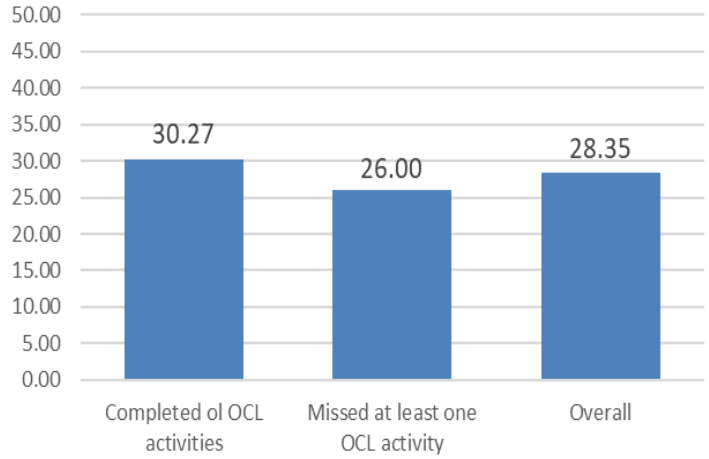

Figure 7: Mean of Students' Scores in Achievement Test

Figure 7 shows the mean scores and standard deviations of the summative test scores of those who were able to complete all the online collaborative learning, those who missed at least once, and the overall. A *t*-test of two samples showed that there is no significant difference between those who have completed online collaborative learning sessions and those who have missed at least once at 0.05 level, $t = 1.761$ with *p*-value of 0.1129. Although there is no significant difference between the mean scores of those who completed the online collaborative activities and those missed at least once, those who completed have a mean score of 30.27, which is numerically higher than those who missed a group activity with mean score of 26.00.

The percentage of each score was computed and grade percentages scale description provided by the Department of Education were used to describe the percentage scores in achievement test (Department of Education, 2015).

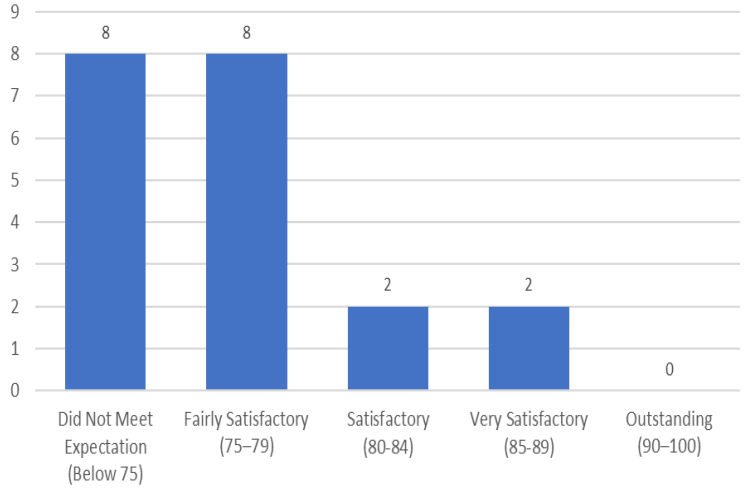

Figure 8: Description of Percentage Scores of the Participants

Figure 8 shows 8 students did not meet the expectation, 8 students were fairly satisfactory, two were satisfactory, and two were very satisfactory. None of the participants was able to obtain a score that is described as outstanding. However, the majority still passed the achievement test.

Student Interaction based on Garrison's Practical Inquiry Model

During online collaborative learning, the students had to meet using the Zoom Software and answer the activities by group. Figure 9 shows a screenshot of a video recording, which illustrates students' group work during online collaborative learning.

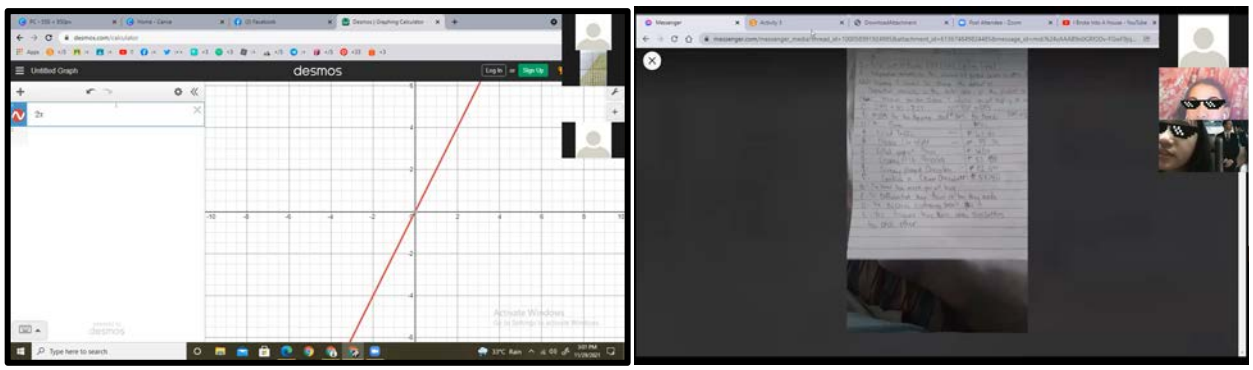

Figure 9: Screenshots of video recordings of online collaborative learning

With the use of content analysis with respect to Garrison's Practical Inquiry Model, the number of messages in each group during online collaborative learning were obtained and were grouped into four categories namely triggering event, exploration, integration, and resolution, following the indicators in Table II (Garrison et al., 2009; Rodriguez, 2014).

Category		Indicators	OCL 1 (%)	OCL 2 (%)	OCL 3 (%)
1. Triggering	a.	Recognizes or identifies problems, concepts, or issue.	1.23	0.84	0.00
	b.	Describes only the assigned problem.	0.61	0.00	0.00
		Sub-total	1.84	0.84	0.00
2. Exploration	a.	Adds to established points but does not systematically defend/justify/ develop.	19.63	28.57	25.93
	b.	Presents relevant background information related to discussion topic.	0.61	1.68	1.85
	c.	Adds suggestions about discussion topic.	1.23	0.00	0.00
	d.	Asks questions seeking specialized information.	9.20	0.84	0.93
	e.	Offers opinions	3.07	0.00	0.93
		Sub-total	33.74	31.09	29.64
3. Integration	a.	Explores potential solutions, applications, or conclusions.	25.15	19.33	36.11
	b.	Draws conclusions or summarizes discussion.	14.11	18.49	12.96
	c.	Reference to previous message followed by substantiated agreement, for example, "I agree because . . ."	1.84	0.84	0.00
	d.	Substantiated building on, adding to others' ideas.	0.00	0.84	0.00
	e.	Synthesis: Connecting ideas. Integrating information from various sources.	6.13	5.04	0.93
	f.	Providing rational, justifications.	0.61	0.00	0.00
		Sub-total	47.84	44.54	50.00
4. Resolution	a.	Applying, testing, defending, or critiquing solutions or conclusions.	11.04	17.65	16.67
	b.	Suggests applications or action to take.	4.91	5.88	2.78
	c.	Commits to solutions or conclusions	0.61	0.00	0.93
		Sub-total	16.56	23.53	20.38
		TOTAL	100	100	100

Table 2: Students' Interaction based on Garrison's Practical Inquiry Model

A total of 390 dialogues and messages, both oral and written, were found in the three online collaborative learning activities. OCL 1 included a total of 163 messages, OCL 2 contained 119 messages, and OCL 3 had 108 messages. For all the three sessions, the average percentage of the messages resulted in 0.89% triggering events, 31.49% exploration, 47.46% integration, and 20.16% resolution. Among the four categories, the lowest percentage was in triggering events (0.89%) and resolution (20.16%). The messages classified as triggering events mainly comprised of explanations of the problems in the activities, and the messages classified as resolution mainly comprised of giving justifications or explanations regarding their answers in the activity (Rodriguez, 2014). Messages accounted for the highest frequencies were integration (47.46%) and exploration (31.49%).3

As mentioned, the lowest category is triggering events which only took place when any of the participants cannot understand a question on the activity, and their groupmates had to explain it. Here are some statement samples that were described as triggering events:

> "*Values listed on the previous item will be plotted on the Cartesian Plane*."

> "*It says in the problem, 'how many washable and disposable masks does Yasmin need to sell to earn at least 100?' in the example given, if she sells 1 washable and 4 disposable masks, she will earn P105, which is greater than P100*."

The category exploration can be seen during online collaborative learning. Below is an excerpt of the dialogue between two students, which illustrates the category exploration from Garrison's Practical Inquiry Model, while they were answering the given question:

> Yasmin is selling a washable face mask (x) for Php 25 each and a disposable face mask (y) for Php 20. How many of both masks does she need to sell to make at least Php 100?
> Question: Do you think an equation represents the solution set of the problem? If not, is an inequality? Explain.
>
> *Student A*: What is an inequality?
>
> *Student B*: I think that's when the symbol is a greater than, less than, greater than or equal to, or less than or equal to. Which in an equation, the symbol used is an equal sign.

The category integration can also be seen from students from the other group while answering the same question. Here is a sample of dialogue of students that illustrates the category integration from Garrison's Practical Inquiry Model wherein the student is trying to verify their ideas from another source of information.

Student C: What is an equation? What is the difference between an equation and an inequality?

(*Student C searches in Google*)

Student C: Equation – a mathematical statement that shows equal value of two expressions. Inequality – a mathematical statement that is less than or more than the other.

Student D: In an equation, the symbol is an equal sign, while in an inequality, the symbol used is greater than, less than, greater than or equal to, or less than or equal to.

(*Student C continues to search in Google for more input*)

Student C: an equation uses factors like x and y, while an inequality uses symbols such as less than or greater than.

Student D: yes, yes. So, the answer in this question is: it is an inequality because it has an inequality symbol.

Lastly, the category resolution from Garrison's Practical Inquiry Model was seen as the students answered a question from activity 3. Below is a sample statement of a student that reveals the category resolution where the student applied what s/he learned from the lesson in another problem.

Question: Patricia is going out for a pizza. The pizza costs P295 plus P30 for each extra topping, which is represented by x. The total cost of the pizza is represented by t. What is the independent variable? What is the dependent variable? Explain your answer.

Student E: I think the independent variable is the number of extra toppings because this varies and is represented by the variable x as indicated in the problem and the total cost of pizza is the dependent variable because it's affected by the cost of the number of extra toppings.

Student Attitude towards OCL

Table 3 presents the means and standard deviations of student attitude ratings on online collaborative learning.

Survey Items	Mean	*SD*
1. I enjoy solving problems regarding the group project using Online Collaborative Learning my group members.	3.95	0.76

2. Being interactive with the other group members using Online Collaborative Learning increases my motivation for learning.	4.00	0.79
3. I enjoy experiencing cooperative learning using Online Collaborative Learning with my group members.	4.15	0.67
4. Online Collaborative Learning improves my social skills.	3.95	0.60
5. I enjoy helping others in Online Collaborative Learning.	4.25	0.55
6. Online Collaborative Learning is very entertaining for me.	4.10	0.79
7. Online Collaborative Learning helps me feel better psychologically.	3.75	0.97
8. More ideas come up as a result of Online Collaborative Learning.	4.50	0.61
9. I think that I have had/will have more successful results since I work with a group in Online Collaborative Learning.	4.25	0.72
Overall	**4.10**	**0.74**

Table 3: Mean Scores and Standard Deviations on Student Attitude Survey (n=20)

As per the mean scores and standard deviations on Student Attitude Survey responses (see Table III), the highest mean among the questions is item 8, "More ideas come up as a result of online collaborative learning." These participants strongly agree to this statement as this item garnered a mean score of 4.50 with standard deviation of 0.61. On the other hand, the item that has the lowest mean score is item number 7, which states, "Online Collaborative Learning helps me feel better psychologically." It may be the item lowest among the others, albeit students still agree to this statement as it garnered a mean score of 3.75 with standard deviation of 0.97.

Student Perception towards OCL Compared to Face-to-Face Collaborative Learning

The students' responses during the focus group discussion were transcribed and these went through the four stages of interpretative phenomenological analysis (IPA) namely (1) multiple reading and making notes, (2) transforming notes into emergent themes, (3) seeking relationships and clustering themes, and (4) writing an IPA study (Pietkiewicz & Smith, 2012).

The first step entails reading the transcript several times carefully. Since the video recordings were available, they were also watched multiple times. Here, notes were added based on observations and views about the interview experience, as well as any other relevant ideas and remarks. They were concentrated on content (what is really being discussed), language used (e.g., metaphors, symbols, repetitions, and pauses), context, or early interpretive remarks. Some personal related comments were also created (Pietkiewicz & Smith, 2012).

Afterwards, the focus shifts from the transcripts to the notes. Nonetheless, a thorough and complete reports prepared in the process indicate accurate reflections of the original material in order to turn

notes into emergent themes. The researcher tried to come up with a concise statement at a little higher degree of abstraction that might correspond to a psychological conceptualization. Nonetheless, this is based on the specific details of the participant's experience (Pietkiewicz & Smith, 2012).

Next, links between emergent themes were established by grouping them together based on conceptual similarities, and providing a descriptive title to each cluster. This entailed collecting a list of themes for the entire transcript before searching for linkages and clusters. Some of the themes were discarded because they did not fit well with the emergent framework or their evidence foundation was insufficient. Numerous superordinate themes and subthemes were included in the final list (Pietkiewicz & Smith, 2012). Table IV shows samples of the researchers' comments, emergent themes and their theme clusters.

Exploratory Comments	Emerging themes	Theme Clusters
The student liked working collaboratively as a group in an online environment since during groupwork, the student can talk to his/her classmates and be friends with them. However, the same thing can also happen if they work collaboratively in face-to-face setting. They would still be able to communicate with one another and be friends.	Student Interaction	Similarities between Online Collaborative Learning and Face-to-Face Collaborative Learning
Working in groups is more enjoyable and a motivation not to get lazy because the student knows that contribution is needed during group work. A student gets encouragement when he/she gets help from his/her groupmates.	Encouragement/ Motivation among learners	
The student would not have learned in class if he/she had to do the activities alone because in collaborative learning, the students would be able to compare their insights with their groupmates, and in case of any error, the groupmates will be able to correct him/her and point out where she went wrong. With this, the student would be able to learn more from the group.	Student Assistance	
Unlike in face-to-face collaborative learning, students need internet connection and gadgets.	Resources	
This student is not really fond of the online collaborative learning as some of his/her groupmates would either have their microphone off the whole time, or they would just leave the Zoom room. In face-to-face, students could just be passive and appear disinterested.	Student Participation	

Students encountered difficulties in online collaborative learning: unstable internet connection and few technical difficulties, which do not happen during face-to-face collaborative learning.	Technical difficulties and Glitches	Differences between Online Collaborative Learning and Face-to-Face Collaborative Learning

TABLE 4: Emergent Themes from Theme Clusters and Formulated Meanings

A narrative summary of the study is then written. Each theme was discussed and illustrated with the researchers' remarks together with the excerpts from focus group discussions. The table of themes is then transformed into a convincing narrative that communicates to the reader the key experience things discovered throughout the analytical process (Pietkiewicz & Smith, 2012).

In this step, similarities and differences between online collaborative learning and face-to-face collaborative learning were identified. During the focus group discussion, students find collaborative learning in both settings promote student interaction, generate more ideas compared to individual learning, provide peer assistance and encouragement among learners, develop soft skills such as time management and communication skills, and produce better outputs compared to the individual output. Likewise, students mentioned differing experiences between face-to-face collaborative learning and online collaborative learning such as more resources are required when conducting online than when it is in face-to-face, technical difficulties and glitches can happen during online, and differences in students' participation.

Student Interaction in OCL

During the process of online collaborative learning, the first three stages of the taxonomy of Siemen's Connectivism, namely awareness and receptivity, connection-forming, and contribution and involvement, were observed.

Awareness and Receptivity

This is the first stage of Siemen's Connectivism taxonomy (Sitti et al., 2013). In here, learners acquire basic knowledge for handling abundant information through access to resources and tools. In this study, before the participants do the activities collaboratively, they had to accomplish the same activities alone. Here, they were given the opportunity to look for sources of information that helped them not only answer their individual activities, but also share the information they obtained to their group. In this study, students made use of video recordings of lessons, Desmos, self-learning modules, and other accessible resources online as their sources of information and shared it with their groupmates.

Connection Forming

In this stage, learners use the tools and understand the obtained knowledge from the first stage to be able to form connections with their networks (Sitti et al., 2013). Here, they are engaged as they share new resources and technologies in their learning environments. During this study, as the students were doing their activities through online collaborative learning, they shared the information they acquired from various resources such as online learning materials, online math tutorials, and online graphing tools, that they accessed in the first stage. They started imparting their knowledge obtained to their group, as they answered the activities that were given to them. This was done by showing their written notes through their cameras, sharing their screens during online collaborative learning, or writing on the screen with the use of the Zoom Applications' annotation tool.

Contribution and Involvement

In the third stage, the learner begins to actively participate more in the group's activities (Sitti et al., 2013). This active participation allows other members of the group to recognize the learner's resources, contributions, and ideas, resulting in reciprocal understandings and relationships. During online collaborative learning, the students acknowledged their groupmate's shared information, and the group discussed about it further. The learners assessed and verified each knowledge shared among the group for students' enlightenment and better understanding of the lesson. This led to clarification, more ideas, and the development of relationships among the learners during the activity.

DISCUSSION

Developing learning activities for online collaborative learning requires conscientious, purposeful and thoughtful efforts making sure that the activities are relevant to students and could elicit their prior knowledge and experience. Allowing colleagues teaching the same discipline especially the experts and seasoned teachers to provide constructive comments could greatly improve the learning activities. The use of a validation guide also proved useful to elicit suggestions.

The mean scores in the activity sheets revealed that students performed better when doing tasks by group rather than doing it individually. This served as a good indicator that the intervention was effective for the students' learning. However, the results of the achievement test do not support the results of the activity sheets for it has revealed very low raw percentage scores despite the intervention. There may be factors underlying this incident, such as some learners may be free-riders during the online group activity. Free-riding can be very unhelpful to the learning outcomes intended during group work (Hall & Buzwell, 2012). Likewise, the study's results show strong reliance from the more capable students to the point that the latter did not get anything from the former. This can be seen in the group score of the more capable students which were not improved

from their individual scores. Another factor that may explain this incident is that some students were shy to participate in the online collaborative learning. The lack of teamwork and interpersonal skills may not only hinder group interaction but may also restrain individual and collaborative learning. Student's lack of confidence might affect his/her learning during online collaborative learning since he/she might not be able to fully contribute to the assigned task (Le et al., 2016).

Students' interaction during collaborative learning in an online setting were analyzed based on the four categories of Garrison's Practical Inquiry Model – Triggering Event, Exploration, Integration, and Resolution using content analysis with respect to Garrison's Practical Inquiry. Results show that messages accounted for the highest frequencies were integration and exploration. Similar to other studies that employed the Garrison's Practical Inquiry Model and content analysis to evaluate learning in discussions, high frequency in integration and exploration was also found (Garrison et al., 2009; Schrire, 2004; Rodriguez, 2014). In this study, integration garnered the highest percentage as they integrated other sources, such as Desmos, a graphing software, when answering the activities. Triggering events obtained the lowest score because as the groups were doing their group activities, they did not try to analyze, explain and solve the problems anymore. The participants would just ask each other their answers to the given items, and if their answers were the same, they would not have any discussion anymore and just moved on to the next problem. This scenario would mean that somehow, the purpose of having the activity done individually first so they could be able to contribute to the group and be accountable with each another's learning is defeated. In this study, the high-performing students failed to dig deeper and assess if their low-performing groupmates really understood the lesson. This may be improved by encouraging the students to always further explain their answers to the group whenever they present their thoughts and ideas. Likewise, the more abled and knowledgeable student may also be encouraged to facilitate and stir up their group's discussion not only by being more directive but motivate their groupmates to share their thoughts on the ideas brought up by their peers. Nonetheless, students may be empowered to look for answers if teachers do not transmit all information and just provide prompt and probing questions as this information are readily available in the internet within students' reach during online collaborative activities.

Nonetheless, the overall mean of the students' responses in the Student Attitude Survey generally indicates a positive agreement with regards to their attitudes with online collaborative learning. Students' top answer being on the aspect of coming up with more ideas means that when working in groups, students strongly agree that they are not only limited to their own thoughts and ideas. They are given an opportunity to realize and explore more ideas that are actually beyond what they can think of. Students find "online collaborative learning help them feel better psychologically" the least in agreement. It may be the item lowest among the others, albeit students still agree to this statement as it garnered a mean score of 3.75 with standard deviation of 0.97. This is because students feel more confident in their ability to understand skills learned when students can practice, investigate, and explore abilities with a groupmate rather than in isolation. Collaboration is enjoyable for students, as we discovered, because they enjoy the social, cognitive, and emotional

benefits of working together (Backer et al., 2018). Moreover, students' attitude towards online collaborative problem solving positively affects the relationship and impact during with fellow learners online, which results to positive knowledge contribution during collaborative work (Panigrahi et al., 2018).

It may be inferred from the results that some of the collaborative learning opportunities and experiences in face-to-face may also be found online: student interaction with each other, more ideas are created, student assistance, encouragement among learners, development of skills, time-efficiency in finishing a task, and better output produced. Nonetheless, there are also differences identified by the students between collaborative learning done face-to-face and online. These are in terms of the resource requirements, modalities of student participation, and the various advantages and disadvantages one have over the other – e.g., interrupted interaction due to technical glitches and difficulties in OCL is viewed as a disadvantage and the need to be physically present is a disadvantage in the face-to-face collaborative learning. Moreover, students expressed online collaborative learning served as an avenue for them to exhibit cooperation and participation even in an online learning set up. This confirms the notion that in the process of online collaborative learning, the first three stages of the taxonomy of Siemen's Connectivism, namely awareness and receptivity, connection-forming, and contribution and involvement are evident. The analysis was further made possible by the interpretative phenomenological analysis.

CONCLUSION AND RECOMMENDATIONS

On the basis of the results, the researchers deemed collaborative learning in online setting is applicable. This affirms that collaborative learning in online environment develops interaction among learners and a sense of social presence, which promotes students' improvement of learning and their capability to adapt to various teaching techniques, as well as their motivation and satisfaction (Magen-Nagar & Shonfeld, 2018). However, its implementation is not without fault nor challenges.

We conclude that one prominent challenge in this study is the needed infrastructures for synchronous online collaborative learning, which resulted in a low number of respondents. It is suggested that for future research studies, a similar study may be implemented in a much larger group of participants for a larger extent of generalization.

Aside from the obvious challenge of the required resources for synchronous online collaborative learning, there were emerging challenges in the need for clear guidelines and mechanisms such as the use of self-and-peer assessment in OCL (Caspari-Sadeghi et al., 2022) to avoid free-riding, to maximize learning for retention beyond the group activity for individual learning reflected in achievement test, and to benefit the more knowledgeable and capable students in mathematics as well as the other peers.

Thirdly, doing the activity individually allowed students to reflect on their own and see how much they could contribute to the online collaborative learning which consequently saves some interaction time but this offsets some opportunities to brainstorm in OCL. In this study, it was envisioned that students could bring with them ideas in OCL for discussion from their individual task into the group by taking more time to try to understand, justify, and defend one another's solutions and come to a resolution for a more meaningful exchange of ideas and productive dynamics of collaboration, instead of sheer comparison of answers (Retamoso, 2022). Furthermore, aside from the use of Garrison's PIM, a closer look at the student exchange of ideas using Sfard's (2007, as cited in Gavilán-Izquierdo et al., 2022) sociocultural theory of commognition may reveal more of students' mathematical thinking through discourse during OCL.

The study conducted a synchronous collaborative learning but future studies may also look into the applicability of online asynchronous collaborative learning. As a result, teachers must always be reminded that when implementing collaborative learning in an online setting, different approaches may be applied as compared to face-to-face collaborative learning.

References

[1] AlDahdouh, A.A. (2018). Jumping from one resource to another: how do students navigate learning networks? *International Journal of Educational Technology in Higher Education*, *15*, 45. https://www.doi.org/10.1186/s41239-018-0126-x.

[2] Backer, J.M., Miller, J.L., & Timmer, S.M. (2018). The effects of collaborative grouping on student engagement in middle school students [M.A. Thesis, St. Catherine University] St. Catherine University repository. https://sophia.stkate.edu/maed/280

[3] Banihashem, S.K., & Aliabadi, K. (2017). Connectivism: implications for distance education. *Interdisciplinary Journal of Virtual Learning in Medical Sciences*, *8*(3). https://ijvlms.sums.ac.ir/article_44815_1d805b7f3567f9430cdd0df28237658d.pdf

[4] Caspari-Sadeghi, S., Mille, E., Epperlein, H., Forster-Heinlein, B. (2022). Stimulating reflection through self-assessment: Certainty-based Marking (CBM) in online mathematics learning. *Mathematics Teaching Research Journal, 14*(2), 145-156.

[5] Department of Education. (2015). Policy guidelines on Classroom Assessment for the K to 12 basic education program. https://www.deped.gov.ph/wp-content/uploads/2015/04/DO_s2015_08.pdf

[6] Department of Education. (2020). *Learning Opportunities Shall Be Available: The Basic Education Learning Continuity Plan in the Time of COVID-19*. https://www.deped.gov.ph/wp-content/uploads/2020/07/DepEd_LCP_July3.pdf

[7] Garrison, D.R., Anderson, T., & Archer, W. (2009). Critical thinking, cognitive presence, and computer conferencing in distance education, *American Journal of Distance Education*, *15*(1), 7-23. https://www.doi.org/10.1080/08923640109527071.

[8] Gavilán-Izquierdo, J.M., Gallego-Sánchez, I., González, A., & Puertas, M.L. (2022). A new tool for the teaching of graph theory: Identification of commognitive conflicts. *Mathematics Teaching Research Journal, 14*(2), 186-212.

[9] Hall, D., & Buzwell, S. (2012). The problem of free-riding in group projects: Looking beyond social loafing as reason for non-contribution. *Active Learning in Higher Education*, *14*(1). 37-49. https://doi.org/10.1177/1469787412467123.

[10] Korkmaz, Ö. (2012). A validity and reliability study of the Online Cooperative Learning Attitude Scale (OCLAS). *Computers & Education*, 59(4), 1162-1169. http://dx.doi.org/10.1016/j.compedu.2012.05.021.

[11] Ku, H., Tseng, H. & Akarasriworn, C. (2013). Collaboration factors, teamwork satisfaction, and student attitudes toward online collaborative learning. *Computers in Human Behavior*, *29*(3), 922-929. https://doi.org/10.1016/j.chb.2012.12.019.

[12] Le, H., Janssen, J., & Wubbles, T. (2016). Collaborative learning practices: Teacher and student perceived obstacles to effective student collaboration. *Cambridge Journal of Education*, *48*(1), 103-122. https://doi.org/10.1080/0305764X.2016.1259389.

[13] Liu, C., & Yang, S.C. (2012). Applying the Practical Inquiry Model to investigate the quality of students' online discourse in an information ethics course based on Bloom's teaching goal and Bird's 3C model. *Computers and Education*, 59(2), 466-480. https://doi.org/10.1016/j.compedu.2012.01.018.

[14] Magen-Nagar, N., & Shonfeld, M. (2018). The impact of an online collaborative learning program on students' attitude towards technology. *Interactive Learning Environments*, *26*(5). 621-637. http://doi.org/10.1080/10494820.2017.1376336.

[15] Moreno, J., Sanchez, J.D., & Pineda, A. F. (2021). A hybrid approach for composing groups in collaborative learning contexts. *Heliyon*. *7*(6). https://doi.org/10.1016/j.heliyon.2021.e07249.

[16] Murphy, K.P., Greene, J.A., Firetto, C.M., Li, M., Lobczowski, N.G., Duke, R.F., Wei, L., & Croninger, R.M.V. (2017). Exploring the influence of homogeneous versus heterogeneous grouping on students' text-based discussions and comprehension. *Contemporary Educational Psychology*, *51*, 336-355. http://doi.org/10.1016/j.cedpsych.2017.09.003.

[17] Nurdiyanto, H., Surjono, H.D., Priyanto, P., & Fitrihana, N. (2017). Collaborative learning model with computer supported learning approach. *Proceedings of the 2017 International Conference on Education and Technology*, 225-228. https://doi.org/10.2991/icedutech-17.2018.45.

[18] Panigrahi, R., Srivastava, P.R., & Sharma, D. (2018). Online learning: Adoption, continuance, and learning outcome—A review of literature. *International Journal Information Management*, *43*, 1-14. https://doi.org/10.1016/j.ijinfomgt.2018.05.005.

[19] Pietkiewicz, I., & Smith, J.A. (2014). A practical guide to using interpretative phenomenological analysis in qualitative research psychology. *Psychology*, *18*(2). 361-369. https://doi.org/10.14691/CPPJ.20.1.7.

[20] Retamoso, I. (2022). The problem corner. *Mathematics Teaching Research Journal, 14*(2), 130-137.

[21] Rodriguez, M.A. (2014). Content analysis as a method to assess online discussions for learning. *SAGE Open*, *4*(4), 1–13. https://doi.org/10.1177/2158244014559019.

[22] Sahu, P. (2020). Closure of universities due to coronavirus disease 2019 (COVID-19): Impact on education and mental health of students and academic staff. *Cureus*, *12*(4). https://doi.org/10.7759/cureus.7541.

[23] Schrire, S. (2004). Interaction and cognition in asynchronous computer conferencing. *Instructional Science*, *32*(6), 475-502. https://www.jstor.org/stable/41953662.

[24] Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning*, *2*(1). http://www.itdl.org/Journal/Jan_05/article01.htm.

[25] Sitti, S., Sopeerak, S., & Sompong, N. (2013). Development of instructional model based on connectivism learning theory to enhance problem-solving skill in ICT for daily life of higher education students. *Procedia - Social and Behavioral Sciences*, 103, 315 – 322. https://doi.org/10.1016/j.sbspro.2013.10.339.

[26] Swan, K., Garrison, D.R., & Richardson, J. C. (2009). A constructivist approach to online learning: the community of inquiry framework. In Payne, C.R. (Ed.), *Information technology and constructivism in higher education*: *Progressive learning frameworks*, 43-57. https://doi.org/10.4018/978-1-60566-654-9.ch004.

[27] Tay, L.Y., Lee, S., & Ramachandran, K. (2021). Implementation of online home-based learning and students' engagement during the covid-19 pandemic: A case study of Singapore mathematics teachers. *The Asia-Pacific Education Researcher*, *30*. 299–310. https://doi.org/10.1007/s40299-021-00572-y.

[28] Tsai, C. (2010). Do students need teacher's initiation in online collaborative learning? *Computers & Education*, *54*(4), 1137-1144. https://doi.org/10.1016/j.compedu.2009.10.021.

[29] Wang, C., Hsu, H.K., Bonem, E.M., Moss, J.D., Yu, S., Nelson, D.B., & Levesque-Bristol, C. (2019). Need satisfaction and need dissatisfaction: A comparative study of online and face-to-face learning contexts. *Computers in Human Behavior*, *95*, 114-125. https://doi.org/10.1016/j.chb.2019.01.034.

[30] Yildirim, R. and Orsdemir, E. (2013). Performance tasks as alternative assessment for young EFL learners: Does practice match the curriculum proposal? *International Online Journal of Educational Sciences*, *5*(3). 562-574. https://www.researchgate.net/publication/291125885_Performance_Tasks_as_Alternative_Assessment_for_Young_EFL_Learners_Does_Practice_Match_the_Curriculum_Proposal.