COLLABORATIVE INQUIRY APPROACHES AND LEVEL OF THINKING AND REASONING SKILLS: BASIS FOR SUSTAINABLE SCIENCE EDUCATION

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ABSTRACT

The study was conducted to investigate the effectiveness of collaborative inquiry approaches such as problem-based learning and project-based learning on improving the thinking and reasoning skills of students. Furthermore, it aimed to determine the difference in pretest and posttest scores, and correlate the students' perceived effectiveness on the approaches' process, implementation and outcomes to the mean posttest scores. Descriptive-comparative research design was used. Sixty Grade 10 students clustered into two groups were selected as respondents in San Pablo City Science Integrated High School during the academic year 2018-2019. Survey questionnaires and pretest-posttest questions were utilized to obtain the data. Results revealed that there was a significant relationship between the students' perceived effectiveness of collaborative inquiry approaches and their mean posttest scores in thinking and reasoning skills. However, the results of the pretest and posttest of the students were significantly different. On the other hand, there was no significant difference between the students' mean posttest scores exposed to problem-based learning and project-based learning. Both learning approaches can co-exist inside the classroom as effective modes of teaching real-world learning and building future-ready skills.

Keywords: collaborative inquiry, thinking skills, reasoning skills, science education

INTRODUCTION

Scientific literacy is the foundation of scientific knowledge to perform scientific processes and skills, and demonstrate scientific attitude and values. This is embedded in the scheme of science education which aims to develop learners to take active and dynamic roles in grasping scientific thinking through exploratory and discovery processes. As stipulated in the Republic Act No. 10533 s. 2013 or the Enhanced Basic Education Act of 2013, learners are geared towards lifelong learning as they are equipped with essential competencies, values, and skills. Hence, the curriculum is designed based on pedagogically sound instruction to provide learners the opportunity to attain quality education in which they construct their own knowledge, reflect on relevant questions through inquiry and curiosity, form hypothesis, and seek evidences to arrive at careful judgments. These processes help them to acquire 21st century skills such as critical thinking, collaboration, creativity, and communication which are recognizably relevant skills to meet the challenges of Industrial Revolution 4.0. Critical thinking is named as the key tool for acquiring intellectual and practical

skills in learning science. This holds the major understanding towards the environment and society as it requires maximum stretch in scientific cognition, process skills and personal reflection (Rowles et. al., 2013). However, this skill is not given much attention and focus inside a science classroom since there were issues on how it should be taught and learned. This accounts for the pedagogy on how it shall be delivered in the developmental sequence of the lesson and how it should be developed among learners.

Teachers are enforced to teach the competencies dictated in the intended curriculum and standard evaluation, compromising the attainment of critical thinking. Thus, learners take exit from program lacking critical thinking which are deemed essential in higher education and workplace (Smith & Szymanski, 2013). Accordingly, a well-established critical thinking denotes thinking and reasoning. (Level 2 Thinking and Reasoning Skills, 2011). These include the higher-order skills of analyzing, evaluating, and creating, and the extensive skills of conceptual thinking, problem-solving, and creative thinking.

Teachers, as curriculum implementers, are encouraged to employ pedagogical approaches which are relevant, responsive and research based. As educators who are responsible in the teaching and learning process, they shall have the pedagogical content knowledge (PCK) which provides scaffold on how content will be taught. It is a construct which is developed through comprehensive observation and meaningful experiences. The K to 12 curriculum asserts that mindful use of pedagogies strengthens the critical thinking of learners.

One of the emerging pedagogies in science instruction is combining collaborative learning with inquiry learning. This supports students' inquisitiveness through social interaction, thus, improving learning performance (Kuhn & Pease, 2008). Inquiry learning provides scientific approach to learning through exploration, discovery, and constructivism. On the other hand, collaborative learning contributes to the quality of learning process through social interaction, participation, and dynamics. Collaborative inquiry learning brings a novel instructional delivery into the educative landscape where learners are engaged in self-directed activities supported by the teacher as the facilitator and peer collaboration (Bell et al., 2010).

Relative to the practice of collaborative inquiry learning is the use of strategies called problem-based learning and project-based learning which enables learners to use their knowledge and skills in realistic, authentic situations. Hence, this study was conducted to determine the effectiveness of collaborative inquiry approaches in improving the thinking and reasoning skills of students in science.

OBJECTIVES OF THE STUDY

This study aimed to investigate the effectiveness of collaborative inquiry classroom approach in improving the thinking and reasoning skills of Grade 10 students of San Pablo City Science High School in Science. Specifically, it attempted to (1) describe the perception of the respondents on the effectiveness of collaborative inquiry approaches; (2) determine the significant relationship between the respondents' perception and their mean posttest scores; (3) determine the significant difference between the pretest and posttest scores of each group; and (4) determine the significant difference between the mean posttest scores of the groups.

METHODOLOGY

The study used descriptive-comparative research design to gather genuine data regarding the students' perception and to compare the utilized approaches. Likewise, correlational method was employed to determine the relationship of students' perception on the effectiveness of collaborative inquiry approaches and their mean posttest scores. Also, this study used pretest-posttest design to determine if there is a significant difference between the pretest and posttest scores of the respondents. Sixty Grade 10 students divided into two groups were selected as respondents in San Pablo City

Science High School during the academic year 2018-2019.

One group was exposed to problem-based learning while the other one was exposed to project-based learning. A validated researcher-made questionnaire was used to obtain the students' perceived effectiveness of the collaborative inquiry classroom approaches as to learning process, learning implementation and learning outcomes. Furthermore, parallel pretest and posttest questions were crafted and administered among respondents to determine their scores. Descriptive statistics such as mean (M) and standard deviation (SD), were computed to describe the respondents' perception on the effectiveness of collaborative inquiry approaches. Frequencies (f) and percent counts (%) were used to determine the performance of the respondents on their thinking and reasoning skills.

Meanwhile, inferential statistics such as paired sample t-test was used to determine if there is a significant difference between the pretest and posttest scores of the groups. Also, independent sample t-test was used to determine if there is a significant difference in the mean posttest scores between groups. Moreover, Pearson Product-Moment Correlation Coefficient was used to determine the relationship between the students' perception on the effectiveness of collaborative inquiry approaches and their mean posttest scores.

RESULTS AND DISCUSSION

1. Perception of the respondents on the effectiveness of collaborative inquiry approaches

Table 1
Respondents' Perceived Effectiveness of Collaborative Inquiry Approaches

Learning Indicators	Problem-based			Project-based		
	M	SD	VI	M	SD	VI
Process	3.47	0.19	HE	3.57	0.12	HE
Implementation	3.47	0.13	HE	3.54	0.14	HE
Outcomes	3.47	0.15	HE	3.65	0.13	HE

The respondents indicated positive perception on the learning process to both problem-based learning (M=3.47, SD=0.19) and project-based learning (M=3.57, SD=0.12), interpreted as *highly effective*. As to problem-based, the process included the students' consistent participation to group tasks with an open mind.

And as a process of inquiry and constructivism, learning is enhanced and supported through active collaborative facilitation (Schmidt, Rotgans & Yew, 2011). As to project-based, the students conduct activities by performing group dynamics. The approach allows students to do active exploration embedded in dynamic classroom approach (Miller, 2017).

Meanwhile, the respondents posted *highly effective* on learning implementation to both problem-based learning (M=3.47, SD=0.13) and project-based learning (M=3.54, SD=014). As to problem-based, doing self-reflection was deemed pertinent. David (2008) stated that collaborative inquiry allows students to work together, analyze concepts and evaluate the approach which helped in enriching student learning. As to project-based, the students adhered to evaluation of outputs through agreed rubrics. This also came as a form of reflection in which performance-based assessments became more reliable when reflecting students' capabilities. Using reliable scoring system in a form of rubric becomes a predominant tool in learning (Kan, 2007).

For learning outcomes, highly effective perception was established by the respondents for both problem-based learning (M=0.47, SD=0.15) and project-based learning (M=3.65, SD=013). As to problem-based, the learning sessions allowed enhancing the rational and critical thinking of students. In parallel, Barrett (2009) said that problem-based lea . develops problem-solving, critical thinking self-directed learning skills. As to project-based, respondents stated that the approach deepened their interest and motivation. Markham (2011) emphasized that the approach reframed education to develop drive, passion, and

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creativity of students through meaningful experiences.

2. Relationship between the respondents' perception and their mean posttest scores

Table 2
Test of Correlation between the Effectiveness of Problem-based Learning and their Mean Post-test Scores

Skills	Process		Implementation		Outcomes	
	r	*p*	*r*	*p*	*r*	*p*
Thinking Skills						
Analysis	0.550	0.002	0.550	0.002	0.558	0.001
Evaluation	0.530	0.002	0.530	0.002	0.501	0.005
Synthesis	0.498	0.005	0.498	0.005	0.465	0.009
Reasoning Skills						
Conceptual Thinking	0.490	0.006	0.490	0.006	0.516	0.003
Problem-solving	0.485	0.006	0.485	0.006	0.491	0.006
Creative Thinking	0.465	0.009	0.465	0.009	0.200	0.280

On the other hand, as to thinking skills, the r-values for *Analysis, Evaluation* and *Synthesis* as to *Process, Implementation* and *Outcomes* were all positive. The p-values were less than the significance level which indicates that the relationship between the respondents' perceptions on the effectiveness of problem-based learning and their mean posttest scores was significant. This implies that as the students find the use of problem-based learning effective, they find it as a means of improving their thinking skills. This was anchored on a study conducted by Abd El-Hay and Aboelenin (2015) stating that students' perceptions and self-evaluation on their experience with problem-based learning lead to the enhancement of problem-solving skills, critical thinking skills and self-directedness. Improved collaboration, communication and decision-making among students has become evident.

As to reasoning skills, the r-values for the *Conceptual Thinking, Information and Problem-Solving* and *Creative Thinking* as to *Process, Implementation* and *Outcomes* were all positive. Majority of the p-values were less than the significance level which implies that the relationship between the respondents' perceptions on the effectiveness of the problem-based learning and their mean posttest scores was significant, except for *Creative Thinking* and the *Outcomes*. In consonance, the study conducted by Dobbins et al. (2016) revealed that though learning outcomes were the central core of the learning experiences, still, further work was needed to create its effective use as one of the primary learning resources. Moreover, the time alloted used for problem-based learning with regard to creative thinking was not enough to attain the expected outcomes since it demands more time of completion as well as the actual application.

Table 3
Test of Correlation between the Effectiveness of Project-based Learning and their Mean Post-test Scores

Skills	Process		Implementation		Outcomes	
	r	*p*	*r*	*p*	*r*	*p*
Thinking Skills						
Analysis	0.496	0.005	0.587	0.001	0.500	0.005
Evaluation	0.110	0.560	0.534	0.002	0.439	0.015
Synthesis	0.050	0.810	0.506	0.004	0.443	0.014
Reasoning Skills						
Conceptual Thinking	0.461	0.010	0.564	0.001	0.468	0.009
Problem-solving	0.514	0.003	0.594	0.000	0.515	0.003
Creative Thinking	0.120	0.052	0.544	0.002	0.090	0.620

As to thinking skills, the r-values for *Analysis, Evaluation* and *Synthesis* as to *Process, Implementation* and *Outcomes* were all positive. Most of the p-values were less than the significance level which suggest that the respondents' perceptions on the effectiveness of the project-based learning and their mean posttest scores were significant, except for *Evaluation* and *Synthesis* in terms of *Process.*

In the article "Does PBL Teach Critical Thinking?" published by Mergendoller (2013), it was highlighted that the approach is a powerful tool that helps students to make thoughtful decisions and exercise crucial judgments. However, it did not just require them to think carefully and deliberately. Instead, it should repackage the instruction based on its context. Learners should be supported through active scaffolding and supervised modeling from teachers and peers. This allows students to

evaluate their own thinking including the arguments and reasoning of their peers. Furthermore, most of the project-based activities were always conducted in groups. There were situations where students did the tasks with less supervision of the teacher. Thus, the context of the teaching and learning should also adhere to the teachers' and peers' regulation of activities.

As to reasoning skills, the r-values for the *Conceptual Thinking, Information and Problem-Solving* and *Creative Thinking* as to *Process, Implementation* and *Outcomes* were all positive. Majority of the p-values were less than the significance level which implies that the relationships between the respondents' perceptions on the effectiveness of the project-based learning and their mean posttest scores were significant, except for *Creative Thinking* and *Process* and *Outcomes.*

In the study conducted by Ocon (2012), project-based learning is designed to teach creativity in the context of cognition. However, he stressed that learning can be more relevant and interesting if the process should be aligned to the goals of the 21st century workplace in which relevant skills are deemed vital. Thus, structured situations must be given along with the project-based activities so students can assume job-related tasks and perform significant roles. Creativity can be fully realized when owned a specific role to do task and solve problems relating to real-life challenges.

3. Significant Difference between the Pre-test and Post-test Scores of Each Group

Table 4

Test of Difference between Pre-test and Post-test Scores as to Thinking Skills

Thinking Skills	Mean Difference	SD	SEM	*t*	*p*
Problem-based					
Analysis	-20.27	2.57	0.47	-43.16	0.00
Evaluation	-19.47	1.98	0.36	-53.90	0.00
Synthesis	-21.10	2.23	0.41	-51.74	0.00
Project-based					
Analysis	-21.23	3.00	0.55	-38.74	0.00
Evaluation	-19.00	3.36	0.61	-30.94	0.00
Synthesis	-19.20	3.15	0.57	-33.44	0.00

Since the obtained t-values have p-values which were lower than the significance level, it was clearly shown that the pretest and posttest in each skill for both groups had significant difference. The results imply that the difference between the pretest and posttest scores of the respondents was significant. The results established that collaborative inquiry classroom approaches such as problem-based learning and project-based learning helped the students enhance their thinking skills.

This idea supported that of Allison and Pan's (2010) who named problem-based and project-based learning as innovative approaches that enhance critical thinking. Proper mechanisms along the context of the learning strategies to ensure and enable deeper learning must be provided. Students are expected to manifest skills that create, develop, justify, implement and evaluate ideas and solutions.

Table 5

Test of Difference between Pre-test and Post-test Scores as to Reasoning Skills

Reasoning Skills	Mean Difference	SD	SEM	*t*	*p*
Problem-based					
Conceptual Thinking	-19.70	1.54	0.28	-70.31	0.00
Problem Solving	-20.07	2.24	0.41	-49.01	0.00
Creative Thinking	-20.63	2.16	0.39	-52.39	0.00
Project-based					
Conceptual Thinking	-20.30	2.17	0.40	-51.29	0.00
Problem Solving	-19.83	2.18	0.40	-49.77	0.00
Creative Thinking	-20.70	2.07	0.38	-54.76	0.00

Since the obtained t-values have p-values which were lower than the significance level, the pretest and posttest in each skill for both groups had significant difference. This suggests that the difference between the pretest and posttest scores of the respondents was significant. The use of collaborative inquiry classroom approaches including the problem-based and project-based learning improved the reasoning skills of students.

This supported the idea of Birgili (2015) who highlighted the reinforcement of problem-

based learning in the development of creative and critical thinking skills. Problem-based learning allows learners to exercise problem-solving skills and discover new concepts, ideas and knowledge. On the other hand, the Education World (2013) cited that project-based learning helps in understanding concepts and deepening of knowldege, increasing creativity and improving problem-solving competencies of real-world disciplines. In this regard, students attain higher learning opportunities that allows them to develop scientific reasoning abilities.

4. Significant Difference between the Mean Post-test Scores of the Groups

Table 6
Test of Difference between Groups in Terms of Mean Post-test

Skill	Mean Difference	SD	SEM	t	p
Thinking Skills					
Analysis	0.27	2.56	0.66	0.404	0.688
Evaluation	0.20	2.17	0.56	0.356	0.723
Synthesis	0.37	2.42	0.63	0.586	0.560
Reasoning Skills					
Conceptual Thinking	-0.10	1.63	0.42	-0.237	0.813
Problem Solving	0.03	1.74	0.45	0.074	0.941
Creative Thinking	0.10	1.57	0.41	0.246	0.806

As to thinking skills, the computed t-values in *Analysis*, *Evaluation* and *Synthesis* skills have p-values which were higher than the significance level. This implies that the mean post-tests scores between the two approaches had no significant difference. The results suggest that both collaborative inquiry approaches can be used to improve the thinking skills of students. This idea can be anchored from the article "Project-based vs Problem-based vs X-BL" written by Larmer (2014) where he highlighted that both PBLs build 21st century skills particulary critical thinking.

Correspondingly, in a study conducted by Anazifa (2015) on the effects of problem-based learning and project-based learning, it was revealed that both learning approaches improved the the critical thinking of the students. Therefore, collaborative inquiry approaches is an effective pedagogy to develop 21st century skills among students.

On the other hand, as to reasoning skills, the computed t-values in *Conceptual Thinking, Information and Problem-Solving* and *Creative Thinking* levels have p-values which were also higher than the significance level. In relation to the study conducted by Awang and Ramly (2008), as problem-based learning was introduced in the classroom, the students learned how to think and problem-solve, and transform classroom knowledge into practice through established concepts. The students manifested creative thinking as they dealt with complex, interdisciplinary, and real-situation problems. Similarly, the idea supported the study of Tamba (2017) in which the effect of project-based learning model on creative thinking and problem-solving skills was analyzed. The results showed that the creative thinking and problem-solving skills of students performed better than conventional learning.

CONCLUSIONS

Collaborative inquiry approaches, such as problem-based and project-based learning improved the thinking and reasoning skills of students. Furthermore, based on the findings, the following conclusions were hereby drawn:

1. There is a significant relationship between the students' perceived effectiveness of problem-based learning and their mean posttest scores in critical thinking and wider thinking except for Learning Outcomes and Creative Thinking. Also, there is a significant relationship between the students' perceived effectiveness of project-based learning and their mean posttest scores in critical thinking and wider thinking except for Learning Process and Evaluation and Synthesis, and Learning Process and Learning Outcomes and Creative Thinking. Therefore, the null hypotheses posited in the study are partially sustained.
2. There is a significant difference between the pretest and posttest scores of the

students in the critical thinking and wider thinking using collaborative inquiry classroom approaches such as problem-based learning and project-based learning. Therefore, the null hypothesis posited in the study is not sustained.

3. There is no significant difference between problem-based learning and project-based learning in terms of the mean posttest scores as to critical and wider thinking. Therefore, the null hypothesis posited in the study is sustained.
4. The use of problem-based learning and project-based learning can co-exist inside the classroom in improving the thinking and reasoning skills of the students. Both of them are effective modes of teaching real-world learning and building future-ready skills.

RECOMMENDATIONS

While collaborative inquiry approaches were found relevant to improve the thinking and reasoning skills of students, the following recommendations were given for future considerations:

1. Teachers may consider using collaborative inquiry approaches in teaching science.
2. Students may be encouraged to further improve the critical thinking skills to a higher level of attainment through intensive exposure to collaborative inquiry approaches.
3. Teachers may consider using problem-based learning and project-based learning in other Science contents.
4. Time element should be a consideration in developing the thinking and reasoning skills of students. Teachers may consider extending the time of exposure to collaborative inquiry learning.
5. Further studies on collaborative inquiry learning may be conducted to further develop other 21st century skills.

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