International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Exploratory and Explanatory Case-Based Learning and the Scientific Investigation Skills of Grade 9 Students

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DOI: https://doi.org/10.55248/gengpi.5.0624.1471

ABSTRACT:

The study aimed to determine the effect of the implementation of investigative case-based learning in the scientific investigation skills of the grade 9 students of Bignay National High School for the school year 2023-2024. It attempted to identify the pre- and post-performance scores of the students and its significant difference as to their scientific investigation skills in science in terms of initiating and planning, performing and recording, analyzing and interpreting, and communication skills. Furthermore, it aims to determine the significant differences between the post-assessment performances of the two groups of students exposed to exploratory and explanatory case-based learning. The study utilized descriptive-experimental research. Two groups of Grade 9 students served as the respondents of the study which were selected through purposive sampling based on the total enrollment of grade 9 students enrolled for the school year 2023-2024 handled by the researcher. The result indicated that there is a significant difference between the pre- and post-performance scores of the two groups of students exposed to exploratory and explanatory case-based learning. Since there is a significant difference between the pre- and post-performance scores of the two groups of students, the null hypothesis is not supported. Likewise, there is a significant difference between the post- and post- performance scores except for their initiating and planning skills, the null hypothesis is partially not supported. In conclusion, teachers may consider the use of Lesson Exemplar with Exploratory and Explanatory Case-based Learning strategies as the mode of assessing and improving student's scientific investigation skills.

Keywords: *case-based learning, explanatory case-based learning, exploratory case-based learning, scientific investigation skills*

Introduction:

Science education is significant to student's lives for it helps them to be equipped with lifelong skills that require problem solving and critical thinking skills to cope with the rapid advancement of society. Helping students to improve and develop their technological literacy, critical thinking, and problem-solving skills through science education provides them with the skills and knowledge they need to succeed in school and beyond (Arrieta, et. Al., 2020).

The K to 12 Science basic education curriculum aims to create students that are scientifically literate who can make critical judgement and wise decisions while applying their scientific knowledge in social, health, and environmental aspects. However, in the latest results of Programme for International Students Assessment (PISA) 2022, the Philippines ranked second to the last among the participating countries in which Science was one of the subjects tested. In response to this, the Department of Education recognized the urgency to address issues and gaps in attaining quality basic education in the Philippines.

Despite numerous teaching approaches and processes, case-based learning is one of the most appropriate approaches to require students to possess a diverse range of skills, including critical thinking skills, analytical reasoning, and problem solving. These skills can be difficult to develop, particularly in traditional classroom settings, where students are often passive recipients of information rather than active participants in the learning process.

Schadt (2021) emphasized the use of cases in learning has encouraged students to use critical thinking skills to identify and narrow an issue, develop, and evaluate alternatives, and offer a solution in a given real-life problem. These cases are in-depth examinations of a person, a group, or an event that typically depict a past or present problem or a realistic, hypothetical scenario. As a learning technique that requires students to apply what they have learned to a case, it also requires skills like application of knowledge to real or hypothetical scenarios and critical thinking and analytical skills.

Nkhoma (2016) studied the value of developing cased-based learning activities based on Bloom's Taxonomy of thinking skills and suggests that this approach encourages deep learning through critical thinking. Bonney (2015) studied on student's studying science and investigated the benefits of learning through reading or class discussion versus learning through case studies. The evidence suggested that student results and performance were higher for the topic that was taught through case studies.

Cherry (2024) stated that there are several different types of case studies, and each type differs from each other based on the hypothesis and/or thesis to be proved. Exploratory case study is a type of case study used to have an in-depth understanding and comprehension of a certain topic through literature search, focus group interview, and case studies. Explanatory case study focuses on explanation for a question or a phenomenon by conducting a causal investigation through experimentation.

This research aims to determine the effect of the implementation of exploratory and explanatory case-based learning in the scientific investigation skills of Grade 9 students in science class. Also, to provide basis for teachers in developing an intervention program and educational strategies. In the use of these two approaches, the researcher expects students to be active participants of the teaching-learning process and be part of scientific inquiry, research, and investigation while learning science.

What is Investigative Case-based Learning (ICBL)

Investigative Case-based Learning (ICBL) is a type of Problem-based Learning (PBL) that utilizes real life context cases with the investigative approaches. Students act as active participants of learning where they learn to organize and analyze information, make rational solutions to the problems, use scientific inquiry strategies and approaches, and support their conclusion with evidence making them wise decision makers. It involves problem posing, problem solving, and peer persuasion.

The use of cases in learning has been an established bidirectional active learning approach where students learn concepts by solving cases or problems under the guidance of a facilitator (Das et. al. 2021). Kantar and Massouh (2015) emphasized that Case-based Learning (CBL) combines the constructivist and experiential perspectives where professional skills developing from theories are immaculate, such as problem-solving, clinical reasoning, and knowledge transfer. According to Harsma et. al. (2021), students must be provided with problems or issues throughout the class and resolve them by using their gained knowledge while learning. They decide together on what they already know about the topic, what problem they need to address, how to apply resolutions, and how to evaluate outcomes.

The explanatory case studies deal with the causal investigations in which the researchers are interested in looking for factors that may have caused certain things to occur (Cherry, 2022). In this type of case study, students or researchers are expected to conduct experiments to know the effect of specific changes among two or more variables (Nicolas, 2022). The primary focus is to explain "why" and "how" certain conditions come into being, that is, why certain sequences of events occur or do not occur (Priya, 2022).

On the other hand, exploratory case studies are sometimes utilized as a prelude to further, more in-depth research that allows researchers to gather more information before developing their research question and hypotheses (P, 2023). Students are expected to use literature search, a focus group discussion, or reading of other case studies to solve certain problems. The goal is to formulate hypotheses, clarify concepts, form hypotheses, research questions to be answered, and or design options to be used in a more focused and in-depth subsequent study (Brown, 2020).

What is Scientific Investigation Skill?

As stated in the K to 12 basic education science curriculum framework (2013), science education aims to create students that are scientifically literate who can make critical judgement and wise decisions while applying their scientific knowledge in social, health, and environmental aspects. Scientific literacy pertains to an individual's understanding of scientific concepts, phenomena and processes, and their ability to apply this knowledge to new and, at times, non-scientific situations (PISA, 2018). Improving students' literacy in science will help them to better develop their scientific understanding and scientific inquiry skills, which increases their scientific literacy.

Science investigation is a process of searching answers to questions using different research methods. It usually started with observation leading to questions with unknown answers, followed by further observation and experimentation to test hypotheses, gather and analyse data, and present the finding that may answer the questions. (Indeed Editorial Team, 2023)

De la Cruz (2015) reiterated that scientific investigations give students an opportunity to undergo a process of investigation using the scientific method. This demands skills specifically for investigations. Scientific investigation skills are science process skills utilized in conducting science investigation that involves making observations, asking specific and measurable questions, creating hypotheses, conducting experiments, and analysing the results. Nowak (2015) categorized scientific investigation skills into initiating and planning, performing and recording, analysing and interpreting, and communicating.

Methodology:

This study utilized descriptive-experimental research designs. Experimental design involves a process of planning and conducting scientific experiments to investigate a hypothesis or research question (Hassan, 2022). In this type of research design, it is important to carefully design an experiment that can test the hypothesis and identify variables that will be manipulated or measured. It is the strongest way to test cause-and-effect relationships without the risk of other variables influencing the results (Bhandari, 2023; McCombes, 2021). Relatively, the study involved gathering of data respondents and interpreting these data through tables and graphs after exposing them in a controlled experiment. The descriptive method was then applied in determining the association of respondent's case-based learning and scientific investigation skills. Ms Combes (2019) stated that a descriptive research design is intended to accurately and to systematically describe a group, a situation, or a phenomenon. This research design lets the researcher explore one or more variables using a wide range of research techniques.

Respondents of the Study:

The respondents of the study were selected by purposive sampling. Shamra (2017) defines purposive sampling which is also known as judgmental, selective, or subjective sampling, as a sequence that relies on the researcher's judgments in selecting study units. The eighty (80) students were the total population of Grade 9 students of Bignay National High School, Sariaya, Quezon enrolled during the school year 2023-2024.

The respondents were 56 males and 24 females under the three sections of Grade 9 students handled by the researcher. They were divided into two groups, one group for exploratory case-based learning and the other group for explanatory case-based learning. Each group was given pre-assessment and post-assessment. The study was conducted during the February and March of 2024.

Research Instruments

The research instruments of used in the study to gather data were Lesson plan aligned in Explanatory and Exploratory Case-Based learning, modified, and adapted Pre-Assessment and Post-Assessment in DepEd Learner's Material with supported researcher-made Table of Specification (TOS).

Pre/Post Assessment for scientific investigation skills assessment

The researcher provided the Pre-assessment and Post-assessment with a total of 30-item consisting of a table for data recording, guide questions, graph making, conclusions, and lab quiz. The assessment was aligned and adapted to the Most Essential Learning Competencies (MELCs) of DepEd. The Pre-assessment and Post-assessment were given and administered to the selected Grade 9 students of Bignay National High School- Sariaya, Quezon, to determine the student's level of scientific investigation skills before and after exposure to exploratory and explanatory case-based learning.

To guarantee the accuracy and validity of the instruments, the researcher submitted the research instruments to external and internal validation. Signed letters to the principal and the validators were secured, rubrics for validation were disseminated, and comments and suggestion sheets were given to validators. External validators were five (5) Master Teachers and one (1) Teacher III in Science, and one (1) English major. Once the instruments were validated, scores to the rubrics were tallied and overall weighted mean was totaled. The validators' comments and suggestions were considered and incorporated in the final copy of the instruments.

Research Procedure

The stages of conceptualization were followed while conducting the study. The procedure of this study was as follows:

Implementation

The researcher conducted the research immediately after the validation of the instruments. The researcher gave request letter asking permission through the Schools Division Superintendent, from the Principal of Bignay National High School, Sariaya, Quezon, and to the eighty (80) respondents to conduct a study by performing a face-to-face discussion of the lesson using Lesson plan and distributing of pre-assessment and post-assessment.

The researcher implemented a face-to-face discussion with the eighty (80) students using the Exploratory and Explanatory Case-based learning. The researcher taught each group separately based on the type of case-based learning assigned to them. The lessons taught to the Grade 9 students were focused on the Climate, Factors affecting the climate, and Climate change.

The researcher administered the adapted and modified 30-item Pre-Assessment to DepEd Learner's Material for scientific investigation skills to the respondents before the face-to-face discussion of the lesson using the case-based learning strategies, Exploratory and Explanatory case-based learning to measure and assess students' level of scientific investigation skills of the students related to the lesson.

The researcher assessed and analyzed the scientific investigation skills of the students in a face-to-face learning modality, within almost a month to determine the effect of implementation of exploratory and explanatory case-based learning lessons in improving the scientific investigation skills of Grade 9 students.

In this study, a 30-item Post-Assessment that was modified and adapted to DepEd Learner's material for scientific investigation skills was administered by the researcher to the respondents after teaching the lesson covered in the third quarter of the S.Y. 2023-2024.

Data Analysis

After the implementation of the study, the pre- and post-assessment scores were collected and tallied immediately and gave the data to the statistician for treatment. The data were statistically computed, interpreted, and verbally analyzed. To interpret the result of the respondent's pre-assessment and post-assessment performance scores, the following scale will be used as a reference.

The researcher used the scale based from DepEd Order No. 73., s. 2012. Guideline on the Assessment and Rating of Learning Outcomes Under the K to 12 Basic Education Curriculum." It indicates the level of proficiency corresponding to each score of the pretest and posttest scores.

Percentage Score	Qualitative Description
75 and below	Beginning
76 – 80	Developing
81-85	Approaching Proficient
86-90	Proficient
91 and above	Advanced

Ethical Consideration

With utmost confidentiality, respondent's information and results were assured by the researcher limiting its access only to the researcher and the thesis adviser.

Statistical Treatment of Data

The following statistical tools were used in providing solution and analysis to the problem of the research.

Mean and standard deviations were utilized to: a). Determine the level of students' scientific investigation skills using the exploratory and explanatory case-based learning lessons; and b). analyze the results of Pre-Assessment and Post-Assessment performances of students' as to their scientific investigation skills. Student's scores in the Scientific Investigation Skills Assessment were categorized based on their scores' range.

To evaluate students' scientific investigation skills, the significant difference between the pre-assessment and post-assessment performance mean scores of the students was also determined using the t-Test Difference for an independent sample.

Objective:

1) What is the pre-performance and post-performance mean scores of the two group of students on their scientific investigations skills;
   1.1 exploratory case-based learning; and
   1.2 explanatory case-based learning;
2) Is there a significant difference in the pre-performance and post-performance mean scores of scientific investigation skills of the two groups of students;
   2.1 exploratory case-based learning; and
   2.2 explanatory case-based learning;
3) Does a significant difference exist in the post-performances of the two groups of students exposed to exploratory and explanatory case-based learning as to their scientific investigation skills in terms of;
   3.1 initiating and planning
   3.2 performing and recording
   3.3 analyzing and interpreting; and
   3.4 communicating

Results

Table 1 presents the Pre-Performance Mean Scores of students in Scientific Investigation Skills Assessment using the exploratory case-based learning and explanatory case-based learning. The focused skills are initiating and planning, performing and recording, analyzing and interpreting, and communicating skills.

Table 1 *Pre-Performance Mean Scores of Students in Scientific Investigation Skills Assessment*

Scientific Investigation Skills	Exploratory Case-based Learning			Explanatory Case-based Learning		
	Mean	SD	VI	Mean	SD	VI
Initiating and Planning	78.80	5.68	D	80.75	5.55	AP
Performing and Recording	85.73	5.18	AP	86.08	4.36	P

Analyzing and Interpreting	80.40	7.31	D	81.70	6.09	AP
Communication	81.35	6.02	AP	83.08	6.28	AP
Overall Mean	81.75	6.05	AP	82.90	5.57	AP

Legend: 91.00 and above (A- Advanced); 86.00 – 90.00 (P-Proficient); 81.00 – 85.00 (AP-Approaching Proficient); 76.00 – 80.00 (D- Developing); 75.00 and below (B-Beginning)

The table shows the pre-performance mean scores of the students under exploratory case-based learning is approaching proficiency in performing and recording and communicating, and developing in initiating and planning, and analyzing and interpreting. This indicates that many of the students have no prior knowledge in exploratory case-based learning and cannot use reliable sources and descriptive words in the science concepts when investigating.

The pre-performance mean scores of students under explanatory case-based learning revealed that the students are proficient in performing and recording, and approaching proficiency in initiating and planning, analyzing and interpreting, and communicating. This suggests that many of the students have prior experience in conducting hands-on activities and can perform investigations through experiments with minimal errors. The table further showed that the results of both groups were approaching proficiency in terms of their overall scientific investigation skills. It can be perceived that the students under exploratory case-based learning got an overall mean of 81.75 (SD= 6.05) while the learning under explanatory case-based learning got an overall mean of 82.90 (SD=5.57). There was a mean difference of 1.15, and it showed that explanatory case-based learning has a higher mean during the pre-assessment. It was manifested that performing and recording in explanatory case-based learning has the highest mean result which was 86.08 (SD=4.36).

Table 2. *Post-performance Mean Scores of Students in Scientific Investigation Skills Assessment*

Scientific Investigation Skills	Exploratory			Explanatory		
	Mean	SD	VI	Mean	SD	VI
Initiating and Planning	87.48	5.79	P	89.88	5.98	P
Performing and Recording	88.38	5.86	P	91.25	6.43	A
Analyzing and Interpreting	85.70	5.63	P	89.18	6.47	P
Communication	84.65	5.78	AP	89.08	6.60	P
Overall Mean	86.55	5.77	P	89.85	6.37	P

Legend: 91.00 and above (A); 86.00 – 90.00 (P); 81.00 – 85.00 (AP); 76.00 – 80.00 (D); 75.00 and below (B)

Table 2 presents the post-performance mean scores of students in scientific investigation skills assessment using exploratory and explanatory case-based learning.

The table shows the post-performance of the students in their scientific investigation skills using exploratory and explanatory case-based learning and shows that students' performance in their scientific investigation skills are proficient except for performing and recording in explanatory case-based learning which is advance and communication in exploratory case-based learning which is approaching proficiency.

In the exploratory case-based learning group, students were asked to perform an investigation through literature review such as reading books, modules, articles, e-book or review other case-study, See Appendix F (lesson exemplar for exploratory case-based learning) while in explanatory case-based learning group students were tasked to perform hands-on activities and utilized different laboratory equipment as means of their investigation, See Appendix G (lesson exemplar for explanatory case-based learning).

It was presented on the table that the overall mean scores of the two groups has a verbal interpretation of Proficient, as it was shown that the group in exploratory case-based learning got the mean score of 86.55 (SD=5.77) while students in explanatory case-based learning got the mean score of 89.85 (SD=6.37). Moreover, in both case-based learning, students' scientific investigation skills were improved specifically their performing and recording skills which has the highest mean scores of 88.38 (SD=5.86) in exploratory and 91.25 (SD=6.47) in explanatory case-based learning.

The data above revealed the influence of exploratory and explanatory case-based learning in scientific investigation skills of students. The data imply that case-based learning has improved students' scientific investigation skills in terms of initiating and planning, performing and recording, analyzing and interpreting, and communicating. It is aligned in the claim of Nkhoma et. al. (2016) that case-based learning activities based on Bloom's Taxonomy of thinking skills promotes deep learning through critical thinking. That evaluative judgement has positive effect in increasing skills in creative solutions, that case analysis increases skills in evaluative judgment, and application of knowledge increases case analysis skills positively.

Table 3 *Significant Difference between the Pre-performance and Post-performance Mean Scores as to Scientific Investigation Skills of Exploratory Case-based Learning*

Scientific Investigation Skills	Exploratory Case-based Learning				t	df	Sig. (2-tailed)
	Pre-performance		Post-performance				
	Mean	SD	Mean	SD			
Initiating and Planning	78.80	5.68	87.48	5.79	-6.574	39	0.000
Performing and Recording	85.73	5.18	88.38	5.86	-2.024	39	0.049
Analyzing and Interpreting	80.40	7.31	85.70	5.63	-3.440	39	0.001
Communication	81.35	6.02	84.65	5.78	-2.435	39	0.019

***Significant at 0.05 level*

Table 3 shows that there is significant difference in the students' Pre-performance and Post-performance Mean Scores as to their Scientific Investigation Skills in Exploratory Case-based Learning. The table shows that there is a significant difference between the pre-assessment and post-assessment scores of the students exposed to exploratory case-base learning. It shows that all scientific investigation skills of students have significantly improved since students were provided with learning strategies aligned with exploratory case-based learning that intended to improve learning.

It manifested in the results that after the use of exploratory case-based learning in teaching students, they improve and learn to gather data, to critically think how to use information productively, and to relate their experiences in exploring real-world scenarios. It was aligned to the statement of Anon (2017) that exploratory case studies offer a practical way to explore real-world situations, sharpen analytical skills, and communicate findings effectively. It was emphasized that it is a powerful tool for students and professionals as they were tasked to identify and scrutinize the issues and provide appropriate responses, preventive measures, or solutions.

Table 4 *Significant Difference between the Pre-performance and Post-performance Mean Scores as to Scientific Investigation Skills of Explanatory Case-based Learning*

Scientific Investigation Skills	Explanatory Case-based Learning				t	df	Sig. (2-tailed)
	Pre-performance		Post-performance				
	Mean	SD	Mean	SD			
Initiating and Planning	80.75	5.55	89.88	5.98	-9.673	39	0.000
Performing and Recording	86.08	4.36	91.25	6.43	-4.148	39	0.000
Analyzing and Interpreting	81.70	6.09	89.18	6.47	-4.948	39	0.000
Communication	83.08	6.28	89.08	6.60	-4.274	39	0.000

***Significant at 0.05 level*

Table 4 shows the significant difference between the students' Pre-performance and Post-performance Mean Scores as to their Scientific Investigation Skills in Explanatory Case-based Learning. The table shows that there is a significant difference between the pre-assessment and post-assessment scores of the students exposed to explanatory case-based learning. It shows that all scientific investigation skills of students have significantly improved since students were provided with learning strategies aligned with explanatory case-based learning that intended to improve learning.

It exhibited in the results that after the use of explanatory case-based learning in teaching students, they improve and learn to gather data through hands-on activities and to perform causal investigation to solve real-life problems or case scenarios. The result affirmed the statement of De Guzman (2022) that hands-on activities have been proven to be more effective compared to traditional teaching where the teacher unilaterally instils knowledge.

Table 5 *Significant Difference between the Post-performances of two groups of students*

Independent Samples Test						
Scientific Investigation Skills	Case-based learning	M	SD	t	df	Sig. (2-tailed)
Initiating and Planning	Exploratory	87.34	5.80	-1.709	78	0.091
	Explanatory	89.59	5.97			
Performing and Recording	Exploratory	88.19	5.86	-2.110	78	0.038

	Explanatory	91.09	6.45			
Analysing and Interpreting	Exploratory	85.66	5.63	-2.498	76.638	0.015
	Explanatory	89.03	6.43			
Communication	Exploratory	84.53	5.83	-3.095	78	0.003
	Explanatory	88.84	6.60			

***Significant at 0.05 level*

Table 5 shows the significant difference between the post-performances of two groups of students. The table showed that there is a significant difference between the post-performances of students after exposure to exploratory and explanatory case-based learning except in their Initiating and Planning skills. This may indicate that exploratory and explanatory case-based learning have both significant effect on students' initiating and planning skills. As shown above, students exposed to explanatory case-based learning performed better to all scientific investigation skills especially in communication.

This confirmed the statement of De la Cruz (2015) who mentioned that scientific investigation that involves experimentation helps students to develop critical thinking and science process skills. It can be inferred that the use of exploratory case-based learning is a promising tool to improve students' scientific literacy and way of learning science.

Conclusion

Findings showed that there is a significant difference between the pre- and post-performance mean scores of the two groups of students exposed to exploratory and explanatory case-based learning. Thus, the null hypothesis is not supported. Based on the result of the study, there is a significant difference in the post-performance mean scores of the two groups of students exposed to exploratory and explanatory case-based learning as to their scientific investigation skills except for their initiating and planning skills. Thus, the null hypothesis is partially not supported.

Since the study revealed that exploratory and explanatory case-based learning has improved the scientific investigation skills of the students, teachers may consider the use of Lesson Exemplar with Exploratory and Explanatory Case-based Learning strategies as a mode of assessing and improving student's scientific investigations skills.

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