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Case and Project-Based Learning Lessons in Enhancing Science Process Skills

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Abstract

The purpose of this study was to determine the significant difference in the pre-assessment and post-assessment performance of the students as to their science process skills and to assess the feedback of case and project-based learning lessons in enhancing the science process skills of the Grade 9 Students. The study used the descriptive-experimental methods of research with selected 70 Grade 9 students as participants. In line with the findings of the study, the students' pre-assessment performance revealed that they are "moving toward mastery" as to their basic science process skills and are at "low mastery" level as to their integrated science process skills while the post-assessment performance revealed "mastery" and "near mastery" levels as to their basic and integrated science process skills, respectively. Therefore, there is significant difference in the pre- assessment and post-assessment performance of the students as to their science process skills in terms of basic and integrated science process skills. Align with this, the respondents perceived case and project- based learning strategy as highly effective. Based on the conclusion laid, teachers may consider the use of lesson exemplar with case and project- based learning strategies as a mode of assessing and improving students' science process skills.

Keywords: *basic science process skills, case-based learning, integrated science process skills, project-based learning*

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1. Introduction

In the Philippines, the new science education framework focuses on students' development of 21st century science process skills, where students are expected to be confident, with skills, attitudes and capacities to be globally competitive. Furthermore, the science curriculum was created to produce scientifically literate individuals capable of making responsible decisions and applying scientific knowledge to community problems. A scientifically literate individual who has mastered these skills can comprehend the very nature of science, thus increasing the standard and quality of his life and allowing him to survive the challenges of everyday life. As a result, these process skills have an impact on an individual's personal, societal, and global lives as they offer the necessary tools to address everyday problems, conduct scientific research, and generate novel scientific knowledge and information. Individuals can learn these skills through well-designed science activities (Derillo, 2019).

The National Scientific Teachers Association (2018) states that the science curriculum should focus on developing learners' science process skills. In general, research shows that learners can gain science process skills when they are planned a specified outcome in science curriculum. Subsequently, Basic Education programs tend to bring out the best education that the learners have, especially about how they learn. It asserts that people build their own knowledge and understanding via personal experience and reflection. When learning something new, students have to reconcile it with prior beliefs and knowledge that may require revising opinions or disregarding the new information as unimportant. In any case, they actively create the knowledge that they have. To do this, they must investigate, evaluate current knowledge, and raise new ones. It is with regard to the modification of the strategies and instruction for the learners to give their best of understanding to the lesson. While the content of the Basic Education leads to the best generation of the 21st Century learners, a science teacher guides and instructs students to explore and understand key ideas in science, such as how to solve problems and gather data to back up theories or conclusions (Quia & Chua, 2022).

According to Darmaji et al. (2019), science process skills are the capacity for processing scientific ideas as well as the capacity for processing actions to create a comprehension of scientific concepts. The scientific process skills of students are crucial skills that need to be cultivated in the classroom (Maison et al., 2020). Process skills are another type of scientific approach that is used to teach students how to conduct experiments and find things. The ability to employ scientific procedures in the development of science is essential for all students since they are expected to learn new information or advance their existing knowledge.

Science classes should include science experiments to help students learn the subject. Science experiments conducted in labs help students develop their science process skills. These abilities are classified as basic science process skills and integrated science skills by NARST (2020). Observing, measuring, classifying, and predicting are basic science skills while controlling variables, formulating hypotheses, interpreting data, and defining operationally are all examples of integrated science skills. However, a prevalent issue as seen in educational contexts is that science process skills acquisition is hindered by some circumstances, such as the methods used to generate skills in scientific classrooms (Derillo, 2019). Science Education Institute-Department of Science and Technology reports that Filipino students struggle to retain concepts, have weak analytical and reasoning abilities, and have poor communication skills (they cannot express ideas or explanations of events and phenomena in their own words).

Children should learn through making connections between concepts and real-world examples from their surroundings and their course material. For example, a project-based learning is a type of activity-based education that exposes students to real-world scenarios. Align with this is another strategy that is related and supported the context-based learning; the case-based learning. It uses cases the hypothetical, or real-life problems that will supplement theoretical knowledge. In this learning strategy, students are given cases to solve, allowing practical application of the concepts learned in class (Professional Learning Board, 2022).

According to studies, the conventional strategy (COS) should only be used sparingly during the teaching and learning process because it prevents students from developing conceptual understanding and problem-solving skills, making chemistry teaching and learning challenging, boring, and irrelevant to learners' real-life experiences (Jodi, 2010). This has caused some students to believe that science is a body of information that must be memorized without deep comprehension (Okafor, 2014). In addition, Ambag (2018) stated that science is not always engaging because of the theories and terminologies that Filipino students are constantly exposed to. Scientists ask questions, make predictions, and actually carry out experiments rather than simply memorizing and regurgitating information.

Aligned with all the problems encountered in teaching-learning process in science, this study aimed to determine how effective in enhancing the science process skills of Grade 9 students using the case and project-based learning lessons. This study determined the significant difference in the pre-assessment and post-assessment performance of the students as to their science process skills and assessed the feedback of case and project-based learning lessons.

2. Literature review

2.1 Science Process Skills

As expressed in the investigation of Mulyeni et al. (2019), dominating the science process skills is significant for future comprehension in science and these abilities are gainful in day-to-day existence for tackling issues as well (Charlesworth & Lind, 2010). According to Aka et al. (2010), the foundation of a student's understanding of the science process and ability to solve problems lies in their early education. Students benefit from the science process skills by being able to comprehend phenomena, respond to inquiries, construct hypotheses, and discover information (Martin, 2009). They are fundamental in creating thoughts (Harlen & Qualter, 2004) and they increment scholastic accomplishment in science. According to a study by Ozgelen (2012), science process skills are linked to cognitive development while Ismail and Jusoh (2001) confirmed that these abilities are correlated with logical thinking abilities.

Science process skills are one of a set of high-order thinking skills, abilities, and learning dispositions that students must master in order to be prepared for a technologically advanced society (CEMASTEA, 2017), often referred to as skills for the 21st century. As anchored by Turiman et al. (2019), science process skills are used as a teaching approach in science teaching and learning. Science process skills are behaviors that encourage the development of skills used to acquire knowledge and then disseminate it, thereby increasing the use of optimal mental and psychomotor skills. By comprehending the nature of science, every individual could use these skills in of his/her daily life to increase the quality of life and become scientifically literate. Moreover, scientists use science process skills to build knowledge, solve problems, and carry out experiments (Okafor et al., 2015). Students in these classes pay attention to their instructors and take notes, but they rarely ask questions or make comments. There are two types of science process skills: Basic and Integrated Science Process Skills.

Integrated science process skills are a definitive ability for taking care of issues and leading logical investigations. According to Mutlu and Temiz (2013), integrated science process skills are science process skills that combine or make use of a variety of underlying these skills, these are high-level cognitive skills. However, basic science process skills, focuses on where the students use observing, measuring, classifying, and predicting as foundational tools in learning science.

2.2 Case-Based Learning

Case-based learning refers to a strategy that helps the students to understand the lesson by relating the topics to real-life scenario. Nkhoma (2016) found that the Revised Bloom's Taxonomy attached the knowledge dimension to the skeletal structure, which formed the intersection of knowledge and cognitive process categories, to support the development of learning strategies and facilitate learning assessment. To help with academic skills including case analysis, evaluative judgment, and case solution, the Revised Bloom's Taxonomy has been offered. As explained by Schadt (2021), students are encouraged to use their critical thinking abilities through case studies to identify and narrow a problem, create and assess potential solutions, and build alternatives.

Ellet (2015) describes case analysis as an educational tool used to instruct students on how to evaluate and think critically about a real-world, practical issue that arises in an organizational setting. In almost all cases, teacher provides and even writes the case for case analysis assignment. Either everyone in the class is given the case to analyze alone or in small groups, or the students choose a case to study from a predetermined list. A case analysis requires simply laying the foundation for analyzing a scenario in practice; as a result, it might be fully made up or partially or entirely modified from an actual circumstance.

Evaluative judgment, according to Tai et al. (2018), is the capacity to conclude the character of one's work as well as that of others. In their study, they proposed that increasing students' evaluative judgment should be a goal of higher education: a requirement for graduates. This would assist students better their work and satisfying their future learning demands. Investigating evaluative judgment inside an instructional technique discussion as opposed to primarily within an evaluation discussion is one way to incorporate and coordinate a variety of educational approaches.

Beghetto (2021) explains that creative learning by giving creative solution in schools is a particular type of learning that incorporates creative expression within the framework of academic learning. Larger-scale initiatives that can have a positive and long-lasting impact on people's learning and live both inside and outside of classrooms and schools are also possibilities for students to engage in creative learning. These opportunities can range from smaller-scale curricular experiences that are beneficial to their own and others' learning to larger-scale initiatives. In this approach, initiatives that encourage creative learning serve as an essential component of positive education.

2.3 Project-Based Learning

Project-based learning (PBL) are typically neither teacher-led, scripted, or packaged (Thomas, 2022). PBL projects do not result in predetermined courses or outcomes but offer students significantly more autonomy, choice, unsupervised work time, and responsibility than traditional instruction and projects.

Projects are pragmatic as opposed to scholastic. The characteristics that venture show give them a genuine vibe to understudies. The subject, the assignments, the roles that students play, the setting in which the work is done, the mentors who work with students on the project, the final products, the audience for the final products, or the standards by which the final products or performances are evaluated are all examples of characteristics of a project. As explained by Renton Prep Christian School (2019), in its purest form, during PBL, both the teacher and the student are involved. Students actively investigate problems found in the real world using this method. It is a dynamic process that involves an instructional method to create a product or presentation. Additionally, PBL adheres to general principles where students collaborate to research and address a real-world, challenging subject. Use of technology, collaboration, creativity, communication, and critical thinking are all 21st century skills that authentic tasks should require.

PBL emphasizes student participation in a project. The term "project" in this context refers to a task that requires students to conduct inquiries into problems, work independently to acquire their own expertise, and ultimately produce tangible deliverables. Nuraini (2019) stated in his study that each PBL stage's product features are as follows: (1) start with an essential question; (2) build a plan for the project; (3) establish a schedule; (4) keep track of the students and the project's progress; (5) evaluate the result; and (6) evaluate the experience. In addition, Ark (2018) argues that PBL is a crucial method of instruction. It enables students to master intellectual achievements and subject-matter knowledge, acquire skills essential for future success, and develop the personal agency required to face difficulties in life and the wider world.

Harsma et al. (2021) states that the students are provided with problems or issues throughout class that must be resolved utilizing the knowledge they are learning. They decide together what they already know about the topic, what they need to know to address the problem, how to apply the answers, and how to evaluate the outcomes. Case-based learning (CBL) is an educational paradigm that is similar and related to the project-based learning (Williams, 2022). This PBL method uses contextualized questions that are based on "real-life" issues that might be clinical or non-clinical. It is andragogical (adult teaching/learning).

A case, problem, or inquiry is used to promote and support the development of knowledge, skills, and attitudes. This is one of the primary characteristics of CBL that derives from PBL. Cases are typically written as problems that give the learner background information about a patient or other clinical setting. Cases place occurrences in a context or environment that supports authentic learning. Recent research articles, vital signs, clinical signs and symptoms, and laboratory data are all supplied as supporting evidence. CBL enables learners to adopt a cooperative, team-based educational philosophy (Williams, 2022).

Proponents of CBL believe that CBL still offers an open-ended approach to problems, encouraging discussion, debate, and addressing ambiguity, while providing students with more structure in an efficient and purposeful way. However, while PBL is an easy way to tackle a student with a serious challenge, it requires a well-structured, continued, and supported experience to reap all possible benefits.

2.4 Conceptual Framework

As for the background knowledge and ground principles, there are varieties of concepts, theories and studies were explained to discern the objectives of this research. The study included the case and project-based learning and its components, as the independent variables and for the dependent variables, it includes science process skills and feedback for using case and project-based learning.

Padilla (2005 as cited by Ediyanto et al., 2018), there are two types of science process skills; the basic and integrated science process skills. Basic science process skills include observing, measuring, classifying and predicting. Integrated science process skills include controlling variables, formulating hypotheses, interpreting data and defining operationally. Align with this, Okafor et al. (2015) explains that in order for the learners to foster skills acquisition, learners should engage in creating pattern of relationship and thinking by actively participating and constructing meaning from their interactions in the environment and relate them to the previous experiences. Moreover, Holbrook (2014) proposes a context-based learning to scientific instruction that could encourage creativity and the development of basic and integrated science process skills by relating the lessons in real-life situation. Real life learning activities may be designed as inquiry activities to be completed as group work, and the approach may overlap with project-based (Taber, 2022).

According to Nkhoma (2016), who examined the benefits of creating case-based learning activities based on Bloom's Taxonomy of thinking skills, this strategy promotes deep learning through critical thinking: Evaluative judgment positively increases skills in creative solution, case analysis positively increases skills in evaluative judgement, and knowledge application positively increases skills in case analysis. However, with the support of the Project Management Institute Education Foundation and the William and Flora Hewlett Foundation, the Buck Education Institute uses Getting Smart to create a 27-member Steering Committee and a 90-member Advisory Board, and convened a framework for project-based learning. was developed. This framework includes his six criteria designed to serve as a foundation for educators, organizations, parents and students. Technology integration, public products, working in team, intellectual challenge, reflection, and project management. Integrating all these benefits of deep learning into projects and ensuring a quality student experience requires a holistic approach.

3. Methodology

3.1 Research Design

This study used descriptive-experimental research design. Experimental method was used in determining the mean mastery level of science process skills among the respondents and significant difference between the pre and post-assessment performances of the groups of students as to their science process skills in terms of basic process and integrated process skills. This method shows an information-gathering experiment described as having a variation present or not, and it must be carried out entirely within the researcher's control. Typically, controlled experiments use this term. To make the results more reliable, these tests minimize the impacts of the variable. In this design, a group of people, plants, animals, etc. may participate in an experimental unit's procedure (Byjus, 2022).

The descriptive method, on the other hand, was applied in determining the association of respondents’ case and project-based learning and science process skills. According to Mc Combes (2019), a group, situation, or phenomenon is intended to be accurately and systematically described by a descriptive research design. What, where, when, and how questions can be answered, but why questions not. Descriptive research strategies allow him to explore one or more variables using a wide range of research techniques.

3.2. Participants of the Study

The study involved the participation of Grade 9 students from a public high school during the School Year 2022-2023, composed of 70 students. All the students in a single group were given pre-assessment and post-assessment. The study was conducted during March and April 2023. Respondents were selected by purposive sampling. Purposive sampling, also known as judgmental, selective, or subjective sampling, is a sequence that relies on the researcher's judgment in selecting study units (participants, cases, tissues, events, data points, etc.) (Sharma, 2017).

3.3. Research Instruments

The instruments used in the study to gather data were lesson exemplar aligned in case and project-based learning, modified and adapted pre-assessment and post-assessment in DepEd learner's module with researcher-made table of specification (TOS), and a survey questionnaire.

The researcher administered two kinds of assessment and those are as follows:

A. Pre-Assessment and Post-Assessment

Basic and Integrated Science Process Skills. The researcher provided the pre-assessment and post-assessment with a total of 80-item questions for basic science process skills and integrated science process skills; 40-item for basic science process skills and 40-item 40 for integrated science process skills. The assessment was aligned and adapted to the Most Essential Learning Competencies (MELC) of DepEd. The pre-assessment and post-assessment were given and administered to the selected Grade 9 students to determine students' mastery of basic and integrated science process skills.

B. ***Feedback on using Case and Project-Based Learning***

A survey questionnaire was given to selected Grade 9 students of participating school. The indicators included were adapted from Ark's (2018) Framework of Project-based Learning. The purpose of the questionnaire was to get feedback from the respondents on how effective the case and project-based scenario was in enhancing the science process skills. To ensure the accuracy of the instruments, the researcher submitted the questionnaires through external and internal validation. After the instruments were validated, the instruments were modified based on the comments and suggestions of the validators.

3.4. Research Procedure

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

Implementation**:** Immediately after validation of the copies of the questionnaires, the researcher gave a request letter asking permission through the Schools Division Superintendent, from the principal of the participating school and to the 70 respondents to conduct a study by performing a face-to-face discussion of the lesson using lesson exemplar, distributing preassessment and post-assessment and a survey questionnaire.

The researcher implemented a face-to-face discussion with the 70 students using the case and project-based learning lessons. The researcher taught first the single group of students the topics of weather using case-based learning, and after the two sub-lessons related to weather being taught to the Grade 9 students, the same single group where the subjects to the discussion of the two sub-lessons for climate using another strategy, which is the project-based learning. The researcher administered the 80-item adapted-modified-pre-assessment to the students before the face-to-face discussion of the lesson using the learning strategies, case and project- based learning to measure and assess the prior knowledge of the students to the lesson. The researcher assessed and analyzed the basic and integrated science process skills of the students in a face-to-face learning modality within almost a month to determine how effective the case and project-based learning lessons were in enhancing the science process skills of grade 9 students. In this study, the researcher administered the 80-item adapted post-assessment and modified to DepEd Learner’s Module for Basic and Integrated Science Process skills to the respondents after teaching the lesson covered in the third quarter, of School Year 2022-2023.

Data Analysis. After the implementation of the strategy and survey, the questionnaires were collected and tallied immediately, and gave the data to the statistician for treatment. The data were statistically computed, interpreted, and verbally analyzed.

Ethical Consideration. With utmost confidentiality, the researcher assured that all the respondents’ information and results were accessible only to the researcher and the thesis adviser.

3.5. Statistical Treatment of Data

The following statistical tools were utilized in providing solutions and analysis to the problem of the research: mean and standard deviation; and t-test.

4. Findings and Discussion

Table 1 presents the mastery level of basic and integrated science process skills in pre-assessment performance. The computed overall mean for basic science process skills is

17.90 that shows students “moving toward mastery” level in observing, measuring, classifying and predicting, However, in integrated science process skills, students’ falls under “low mastery” level in controlling variables, formulating hypothesis, interpreting data and defining operationally with overall mean of 18.56.

Table 1.
Mastery Level of Students in Basic and Integrated Science Process Skills in Pre-Assessment Performance

Science Process Skills	Pre-Assessment Performance		
	Mean	SD	Remarks
Basic Science Process Skills			
Observing	4.40	1.601	Low Mastery
Measuring	4.37	1.416	Low Mastery
Classifying	4.27	1.483	Low Mastery
Predicting	4.86	1.311	Moving Toward Mastery
Overall	**17.90**	**4.334**	**Moving Toward Mastery**
Integrated Science Process Skills			
Controlling variables	4.69	1.291	Moving Toward Mastery
Formulating hypothesis	4.19	1.448	Low Mastery
Interpreting data	4.73	1.318	Moving Toward Mastery
Defining operationally	4.96	1.268	Moving Toward Mastery
Overall	**18.56**	**2.733**	**Low Mastery**

Legend: 0-2 (No Mastery); 3-4 (Low Mastery); 5-6 (Moving Toward Mastery); 7-8 (Near Mastery); 9-10 (Mastery)

This shows that during the actual learning process, students struggle to develop comprehensive science process skills. This skill is usually more difficult to develop because they are not used to being taught, and students struggle to answer questions related to unfamiliar job application questions. One of the reasons for this, in addition to the fact that hands-on activities are not always carried out due to time constraints, it is difficult for teachers to observe each student's new science process competencies, especially their overall science process competencies (Sulistri, 2019).

On the other hand, table 2 presents that in post-assessment performance, the overall remarks of Grade 9 students in basic science process skills shows that students have “mastery” in observing, measuring, classifying and predicting. However, in overall remarks, integrated science process skills such as controlling variables, formulating hypothesis, interpreting data and defining operationally, the students’ considered in the level of “near mastery”.

Data reveal that after the influence of case and project- based scenario in the learning process, students’ basic science process skills have highly increased, most especially in observing skill. Observing is the most significant skill of science process wherein collecting information using senses will help students to gain knowledge about the world and make learning experiences stored in their long-term memory (Mulyeni et al., 2019).

Table 2

Mastery Level of Students in Basic and Integrated Science Process Skills in Post-Assessment

Science Process	Post-Assessment Performance		
	Mean	SD	Remarks
Basic Science Process			
• Observing	9.57	.809	Mastery
• Measuring	8.87	1.062	Mastery
• Classifying	8.87	1.048	Mastery
• Predicting	8.86	1.026	Mastery
Overall	**36.17**	**2.126**	**Mastery**
Integrated Science Process Skills			
• Controlling variables	8.16	1.337	Near Mastery
• Formulating hypothesis	8.74	.988	Mastery
• Interpreting data	8.97	.884	Mastery
• Defining operationally	9.30	.768	Mastery
Overall	**35.17**	**2.071**	**Near Mastery**

Legend: 0-2 (No Mastery); 3-4 (Low Mastery); 5-6 (Moving Toward Mastery); 7-8 (Near Mastery); 9-10 (Mastery)

In measuring skill, the result may imply that students mastered the different measuring instruments in science and they also understand the concept of solving conversion of units. Through observation, students increased their classifying skills. The students improved in this area by understanding the essence of grouping objects or events into categories based on characters or properties of objects or events. Students can strengthen the ability to classify objects with practice and appropriate coaching. On the other hand, the predicting in basic science process skills indicates that students improved their educated guess about what’s likely to happen when you introduce changes in the given problem.

It can be seen also in the data that all the subskills in integrated science process skills have increased. The result in controlling variables may imply that students clearly identify the relationship between an independent variable and a dependent variable after engaging in lesson that will enhance their skills by making excellent way of determining relationships between variables that can be later validated in real world settings through descriptive or comparative studies.

Furthermore, this means students are better able to prove their predictions and answer the student worksheet questions provided by the teacher when forming hypotheses. This is consistent with research of Hirca (2015), who states that if individuals can prove their predictions, they reach a position where they can stimulate further thinking. Based on Piaget's theory, students can formulate problems and form hypotheses. Similarly, based on Piaget's cognitive development, high school students are in the formal operational phase. This allows students to form problems and hypotheses. During the ideation and reconstruction stages, an assimilation process occurs as students interact with their environment through observation, hands-on activity, and discussion.

In the aspect of interpreting the data, the students are able to connect the results of observations and solve problems as it is displayed on tables, figures or graphs. The increase in this subskill indicates that students do well after applying case and project-based scenario.

In defining operationally, students developed the “mastery” level. This implies that students gained and improved their skills by formulating operational definitions based upon the observable characteristics of the given problem in the post-assessment and during the implementation of the lesson.

Table 3.

Summary Table on the Feedback of the Respondents on Case-Based Learning

Indicators	Mean	SD	Verbal Interpretation
Case Analysis	3.45	0.49	Highly Effective
Evaluative Judgment	3.43	0.47	Highly Effective
Creative Solution	3.39	0.53	Highly Effective
Overall	**3.42**	**0.45**	**Highly Effective**

Legend of the Verbal Interpretation of the Weighted Mean: *1.00 to 1.74 -Not Effective, 1.75 to 2.49 -Slightly Effective, 2.50 to 3.24-Effective, 3.25 to 4.00 - Highly Effective*

Table 3 shows feedback after using case-based learning lessons in enhancing science process skills. The overall weighted mean distribution in case analysis, evaluative judgment and creative solution is 3.42, interpreted as highly effective.

The data revealed that after using case-based strategies to improve skills in the science process, students are able to reflect on the relationship between the facts described in the cases and critical incidents, this is supported by Ellet (2015). Case analysis places students in “real world” situations and critiques complex scenarios within organizational settings in order to apply reflection and critical thinking skills on appropriate solutions, decisions, or recommended solutions. It is a problem-based teaching and learning method that analyzes systematically. This is considered a more effective teaching method than classroom role-plays and simulation activities.

The result in the actual study shown that the students assigned in an active role in applying standards while accumulating knowledge. Such student involvement in understanding and applying standards is consistent with current definitions of evaluative judgment as “the ability to make decisions about the quality of one's own and others' work” (Tai et al., 2018). Students develop the quality and formation of evaluative judgments so that they can act independently considering all kinds of information and feedback comments on future occasions without explicit external guidance from a teacher or teacher-like person need to understand.

This implies also that the students can more easily and effectively identify their own questions to address after discussing the lessons in the actual study, develop their own understanding of new and different ways to address those questions, and share and get feedback on their original ideas and insights. Explanation problems are the best teaching strategy for enhancing explanatory knowledge (Orias & Chua, 2021). According to Beghetto (2021), semi-structured learning experiences that require students to meet learning goals in novel and different ways help to ensure that students are developing academically and personally meaningful understandings. These experiences also give students the chance to possibly advance their peers' and teachers' understanding.

The students are better prepared to evaluate and explain complex issues as a result of case-based learning. The students were able to come up with varieties of solutions fit in the case scenario given by the teacher. Additionally, Harman et al. (2015) demonstrate how case-based learning mixed with group problem-solving improves the development of professional abilities. In view of this, case-based learning is thought to have a great potential for fostering systematic analysis, problem-solving abilities, and suggested courses of action. The teacher is responsible for helping students diagnose issues and offer workable solutions.

Table 4.

Summary Table on Feedback of the Respondents on Project-Based Learning

Project-Based Learning	Mean	SD	Verbal Interpretation
Intellectual Challenge	3.41	0.50	Highly Effective
Working in Team	3.49	0.55	Highly Effective
Technology Integration	3.36	0.56	Highly Effective
Public Product	3.32	0.62	Highly Effective
Reflection	3.44	0.64	Highly Effective
Project Management	3.43	0.57	Highly Effective
Overall	**3.41**	**0.50**	**Highly Effective**

Legend of the Verbal Interpretation of the Mean: *1.00 to 1.74 -Not Effective, 1.75 to 2.49 -Slightly Effective, 2.50 to 3.24-Effective, 3.25 to 4.00 - Highly Effective*

Table 4 presents feedback of the respondents after using project-based learning in enhancing science process skills. The overall weighted mean distribution of the respondents in intellectual challenge, working in team, technology integration, public product, reflection and project management is 3.41 which is interpreted as highly effective.

This implies that the participants in the study were better able to work on tasks that had personal significance and were important to their education. A high-quality project necessitates that student engage in critical thought over a difficult topic, question, or matter that has several solutions before working on it for days, weeks, or even months. Students must acquire crucial academic knowledge, ideas, and abilities in order to properly complete a project. Additionally, they should be encouraged and supported as they work to produce the best-quality work possible.

The data shows also that the students worked well as a team to accomplish the learning objectives. During the implementation of activities, each member from different groups did the activity cooperatively and asked suggestions to other members to perform successfully. As Jaiswal et al. (2021) point out, when students are engaged in problem-solving, working in teams enables them to cooperate with one another. Students need to learn how to work in teams, especially when they are working with groups from different fields. Students improve their motivation, persistence, and professional skills as they collaborate in groups. Cooperation abilities allude to all characteristics and capacities that empower people to work actually with their friends when taken part in cooperative exercises like gatherings or ventures.

In the actual study, the students improved in integrating technology in making a successful project. Most of the students, expound their explanation by means of using different designs offered by the computer. According to research, children acquire technology skills as they work on projects like writing scientific reports and drawing cartoon stories. When children learn computer skills in solitude, it may not be engaging for them and may not fulfill their specific needs. Students perform technology projects with a focus on problem-solving activities through project-based learning (Love, 2011). Moreover, the students improved in making a public product or artifact that demonstrates knowledge to a real audience is a crucial component of project-based learning as supported by Wilson-McCain (2021). This shows that the pupils were successful in tying what they learned in school to difficulties, issues, or obstacles that they would encounter in the real world.

The students are able to recognize and articulate the reasons behind their actions and how they contribute to their final result or project. When students can relate personally to the work they are doing, it becomes more authentic and fosters greater student ownership and engagement. Students build a personal connection to the work and are nearly always more involved in the project when they are reflecting on their own work and the work of their group around a public project they are developing.

In project management, the students were seen engaged in lessons and hands-on activities and considered as effective for students' success in attaining learning goals. Aligned with this, project management offer a standard way for executing projects, exactly the way that researchers use the logical strategy as an aide while performing tests. According to Liegel (2004), this enables the students involved to concentrate on the content of the project rather than how to complete it. Because it also involves individuals who make up teams or work groups, teamwork and team or group learning are mentioned prior to working on learning in project management because they serve as a reference for learning and development in project management. Group learning is much of the time conceptualized as a ceaseless course of activity and reflection through which groups procure, consolidate, and apply information. This cycle is firmly connected with exercises like getting clarification on pressing issues, looking for input, making do, examining mistakes, testing fundamental suspicions, and pondering explicit results or surprising outcomes (Gil & Mataveli, 2018).

This implies that the students acquire and develop more understanding of the lesson and improve science process skills using the categories under project-based learning on which students learned how to find information, use resources, combine what they find, and evaluate their findings critically. As seen in this study, the use of the project-based learning strategies is observed and effective to increase students' science success and support the results of this study (Ergül & Kargın, 2014).

Table 5.

Significant Difference between Pre and Post-Assessment in Basic and Integrated Science Process Skills

Science Process Skills	**Pre-Assessment**		**Post-Assessment**		**Mean Difference**	**T**	**Df**	**Sig. (2-tailed)**
	Mean	**SD**	**Mean**	**SD**				
Basic Science Process Skills								
Observing	4.40	1.601	9.57	.809	5.171	23.910	69	.000
Measuring	4.37	1.416	8.87	1.062	4.500	24.609	69	.000
Classifying	4.27	1.483	8.87	1.048	4.600	26.386	69	.000
Predicting	4.86	1.311	8.86	1.026	4.000	25.377	69	.000
Overall	**17.90**	**4.334**	**36.17**	**2.126**	**18.271**	**37.254**	**69**	**.000**
Integrated Science Process Skills								
Controlling variables	4.69	1.291	8.16	1.337	3.471	17.622	69	.000
Formulating hypothesis	4.19	1.448	8.74	.988	4.557	20.917	69	.000
Interpreting data	4.73	1.318	8.97	.884	4.243	22.298	69	.000
Defining operationally	4.96	1.268	9.30	.768	4.343	24.339	69	.000
Overall	**18.56**	**2.733**	**35.17**	**2.071**	**16.614**	**15.785**	**69**	**.000**

***Significant at .01 level*

Table 5 shows that there is significant difference in the level of students' science process skills before and after assessment.

It can be seen that in the actual conduct of study, all the categories for basic and integrated science process skills have significantly increase from pre-assessment to post-assessment. The result reveals that after the use of case and project-based learning lessons in teaching students to enhance their science process skills, students improve and learn to think critically and use information creatively. As supported by Charlesworth and Lind (2010), mastering the science process skills is crucial for future scientific comprehension, and using these skills to solve problems in daily life is also helpful. Students can build on their initial learning to gain a deeper understanding of the science process and problem-solving skills (Aka et al., 2010). Students that are proficient in the science process skills are better able to comprehend facts, find information, and formulate theories. They improve scholastic success in science learning and are crucial in the development of concepts (Harlen & Qualter, 2004), and they increase academic achievement in science learning.

Table 6

Post-Assessment Performance of the Groups of Students as to their Basic and Integrated Science Process Skills

	Basic Science Process Skills		**Integrated Science Process Skills**		**Mean Difference**	**T**	**Df**	**Sig. (2-tailed)**
	Mean	**SD**	**Mean**	**SD**				
Post-Assessment	36.17	2.126	35.17	2.071	1.678	2.942	69	.004

Table 6 shows that there is significant difference in the level of students' science process skills in post-assessment. Basic science process skills show significant difference over integrated science process. This implies that in post-assessment, the students are able to grasp the different science process skills. This indicates also that the students improved a lot in integrated science process skills since the students engaged in the actual or hands-on activity even there are two different lessons and learning strategies being applied in the learning process. Moreover, the data reveals that using case and project-based learning strategy, it helped the students learned not just the concept of science but also how the science works using different process skills.

5. Conclusion

Findings of the study showed significant difference in the pre- assessment and post-assessment performance of the of the students as to their science process skills in terms of basic and integrated science process skills. Similarly, there is significant difference in the level of students' science process skills in post-assessment. Basic science process skills show significant difference over integrated science process. Hence, teachers may consider the use of lesson exemplar with case and project- based learning strategies as a mode of assessing and improving students' science process skills since the findings of student's mastery level in basic and integrated science process skills are said to be nearly mastered.

References

Ambag, R. (2018, August 3). *Teaching Science in The Philippines: Why (And How) We Can Do Better*. FlipScience - Top Philippine Science News and Features for the Inquisitive Filipino. https://tinyurl.com/yrj59pwj

Aka, E., Güven Y. & Aydoğdu, M. (2010). Effect of Problem Solving Method on Science Process Skills and Academic Achievement. *Journal of Turkish Science Education*. 7.

Ark, T. (2018). *Introducing a Framework for High Quality Project Based Learning*. Getting Smart. https://tinyurl.com/4dxjmudz

Beghetto, R. A. (2021). Creative Learning in Education. *The Palgrave Handbook of Positive Education*, 473–491. https://doi.org/10.1007/978-3-030-64537-3_19

Charlesworth, R., & Lind, K. K. (2010). Math & Science for Young Children (6th ed.). *Belmont, CA: Wadsworth, Cengage Learning.*

Charm, N. (2019, December 5). *PISA 2018 results. BusinessWorld*. Business World. https://www.bworldonline.com/pisa-2018-results/

Darmaji, D., Kurniawan, D. A., Parasdila, H., & Irdianti.(2018). "Deskripsi Keterampilan Proses Sains Mahasiswa pada Materi Termodinamika". *Berkala Ilmiah PendidikanFisika*, Vol. 6, No. 3, pp.345–353. https://doi.org/10.20527/BIPF.V6I3.5290

Derilo, R. (2019). *Basic And Integrated Science Process Skills Acquisition and Science Achievement of Seventh-Grade Learners*. 6. 281-294. 10.5281/zenodo.2652545.

Ediyanto, E., Atika, I., Hayashida, M., & Kawai, N. (2018). A Literature Study of Science Process Skill toward Deaf and Hard of Hearing Students. *Proceedings of the 1st Annual International Conference on Mathematics, Science, and Education* (ICoMSE 2017). https://doi.org/10.2991/icomse-17.2018.23

Ellet, W. (2015). The Case Study Handbook: A Student's Guide. Revised Edition. Boston, MA: Harvard Business School Publishing, 2018; Christoph Rasche and Achim Seisreiner. *Guidelines for Business Case Analysis. University of Potsdam*; Writing a

Case Analysis. Writing Center, Baruch College; Volpe, Guglielmo. "Case Teaching in Economics: History, Practice and Evidence." *Cogent Economics and Finance 3* (December 2015). https://doi.org/10.1080/23322039.2015.1120977.

Ergül, N. R., & Kargın, E. K. (2014). The Effect of Project based Learning on Students' Science Success. *Procedia - Social and Behavioral Sciences*, *136*, 537–541. https://doi.org/10.1016/j.sbspro.2014.05.371

Fiegel, G. L. (2013). Incorporating learning outcomes into an introductory geotechnical engineering course. *European Journal of Engineering Education*, 38(3), 238–253.

Gagne, R. (1987). Instructional Technology Foundations. *Lawrence Erlbaum Assoc*.

Gil, A. J., & Mataveli, M. (2018). Project Management and Learning: The Learning Project. Human Capital and Competences in Project Management. *Intechopen.* https://doi.org/10.5772/intechopen.72051

Hamilton, J., & Klebba, J. (2011). Experiential Learning: A Course Design Process For Critical Thinking. *American Journal of Business Education (AJBE),* 4(12), 1–12. Al-Jabar: Jurnal Pendidikan Matematika Volume 12. https://doi.org/10.19030/ajbe.v4i12.6608

Harlen, W.& Qualter, A. (2004). The Teaching of Science in Primary London: *David Fulton Publishers.*

Harman, T., Bertrand, B., Greer, A., Pettus, A., Jennings, J., Wall-Bassett, E., & Babatunde, O. T. (2015). Case-based learning facilitates critical thinking in undergraduate nutrition education: Students describe the Big Picture. *Journal of the Academy of Nutrition and Dietetics*, 115(3), 378–388. http://doi.org/10.1016/j.jand.2014.09.003

Harsma, E., Manderfeld, M., & Miller, C. L. (2021). Problem-based Learning and Case-based Learning. *Mlpp.pressbooks.pub*. https://mlpp.pressbooks.pub/mavlearn/chapter/teaching-strategies-problem-based-learning-and-case-based-learning/

Hirca, N. (2015). Developing a Constructivist Proposal for Primary Teachers to Teach Science Process Skills: "Extended" Simple Science Experiments (ESSE). *Asia-Pacific Forum on Science Learning and Teaching*, 16(1): 345-450.

Holbrook, J. (2014). A context-based approach to science teaching. *Journal of Baltic Science Education*, 13(2), 1648-3898.

Ismail, Z. H., & Jusoh, I. (2001). Relationship Between Science Process Skills and Logical Thinking Abilities of Malaysian Students. *Journal of Science and Mathematics Education in S.E. Asia*, XXIV(2), 67–77.

Jaiswal, A., Karabiyik, T., Thomas, P., & Magana, A. J. (2021). Characterizing Team Orientations and Academic Performance in Cooperative Project-Based Learning Environments. *Education Sciences*, 11(9), 520. https://doi.org/10.3390/educsci11090520

Lau, P.; Kwong, T.; Chong, K.; Wong, E (2013). Developing students' teamwork skills in a cooperative learning project. *Int. J. Lesson Learn.* Stud., 3, 80–99, d

Liegel, K. M. (2004, October 26). *Project-Based Learning and The Future Of Project Management*. Paper presented at PMI® Global Congress 2004—North America, Anaheim, CA. Newtown Square, PA: Project Management Institute.

Llego, M. A. (2020, June 30). *DepEd Self-Learning Modules (SLM) for School Year 2020-2021*. TeacherPH. https://www.teacherph.com/deped-self-learning-modules/

Love, C. (2011, August 8). *Technology Integration and Project Based Learning*. TechnoKids Blog. https://technokidsblog.azurewebsites.net/teaching-strategies/project-based-learning/

Maison, Dr., Darmaji, Dr., Aatalini, Dr., Kurniawan, D. A., Haryanto, Dr., Kurniawan, W., Suryani, A., Lumbantoruan, A., & Dewi, U. P. (2020). Science Process Skill in Science Program Higher Education. *Universal Journal of Educational Research*, *8*(2), 652–661. https://doi.org/10.13189/ujer.2020.080238

MINNESOTA. (2013). *Learning and Innovation Skills | Authentic Learning@UMN*. Authenticlearning.umn.edu. https://authenticlearning.umn.edu/21st-century-skills/21st-century-skills

Mirana, V. (2019). Attitude towards Science and Process Skills of Junior High School Students. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3389072

Mulyeni, T., Jamaris, M., & Supriyati, Y. (2019). Improving Basic Science Process Skills Through Inquiry-Based Approach in Learning Science for Early Elementary Students. *Journal of Turkish Science Education*, 16(2), 187-201.

Mutlu, M., & Temiz, B. K. (2013). Science Process Skills of Students Having Field Dependent and Field Independent Cognitive Styles. *Educational Research Reviews*, 8, 766-776.

Nkhoma, M., Lam, T., Richardson, J., Kam, K., & Lau, K. H. (2016). *Developing case-based learning activities based on the revised Bloom's Taxonomy. Proceedings of Informing Science & IT Education Conference (InSITE) 2016*, 85-93. Retrieved from http://www.informingscience.org/Publications/3496

Nuraini, Umi & Nuris, Dudung & Nagari, Primasa. (2019). Developing Learning Process Scenario: Project-Based Learning in Economics for Senior High School. *International Journal of Education, Psychology and Counseling*. 33-43.

Okafor, N. (2021). Enhancing Science Process Skills Acquisition in Chemistry among Secondary School Students through Context-Based Learning. *Science Education International*, 32(4), 323–330. https://doi.org/10.33828/sei.v32.i4.7

Orias, J., & Chua, E. (2021). *Problem-Based Learning Method and The Learning Outcomes in Science 9*. https://doi.org/10.5281/Zenodo.5171634

Özgelen, S. (2012). Students' Science Process Skills within a Cognitive Domain Framework. *EURASIA Journal of Mathematics, Science and Technology Education*, *8*(4). https://doi.org/10.12973/eurasia.2012.846a

Padilla, M. (2005). The science process skills. *Research Matters-to the Science Teacher. No. 9004*. Retrieved 2005 from https://www.narst.org/publications/research/skill.cfm,

Padilla, M. J., & Padilla, R. K. (2018). Thinking in Science: The Science Process Skills. In *ERIC*. https://eric.ed.gov/?id=ED277549

Professional Learning Board. (2022, July 31). *What is Case-Based Learning?* K12teacherstaffdevelopment.com.https://k12teacherstaffdevelopment.com/tlb/what-is-case-based-learning/

Quia, D., & Chua, E. (2022). Reflective and Pragmatic Learning Modes in Enhancing Grade 7 Students' Engagement and Thinking Skills. *International Journal of Research Publications*, *106*(1). https://doi.org/10.47119/ijrp1001061820223712

Renton Prep Christian School. (2019, August 19). *Addressing Project-Based Learning and Problem-Based Learning in the Classroom*. Renton Prep Christian School. https://rentonprep.org/project-based-learning/

Rogayan Jr, D. V. R., & Bautista, J. R. (2019). Filipino Students' Preferred Motivational Strategies in Science: A Cross-Sectional Survey. *Indonesian Research Journal in Education*, *358-372*, 358–372. https://doi.org/10.22437/irje.v3i2.6828

Schadt, S. (2021, January 27). *Case Based Learning | Center for Excellence in Teaching and Learning*. University of Connecticut. https://tinyurl.com/vn48ry2p

Sharma, G. (2017). Pros and cons of different sampling techniques. *International journal of applied research*, 3(7), 749-752.

Srinivasa, K. G., Kurni, M., & Saritha, K. (2022). Context-Based Learning. *Springer Texts in Education*, 87–115. https://doi.org/10.1007/978-981-19-6734-4_5

Sulistri, E. (2019). Students' Integrated Science Process Skills Through CLIS Model. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *4*(1), 39. https://doi.org/10.26737/jipf.v4i1.945

Tai, J., Ajjawi, R., Boud, D., Dawson, P., & Panadero, E. (2017). Developing evaluative judgement: enabling students to make decisions about the quality of work. *Higher Education*, *76*(3), 467–481. https://doi.org/10.1007/s10734-017-0220-3

Turiman, P., Omar, J., Daud, A. M., & Osman, K. (2012). Fostering the 21st Century Skills through Scientific Literacy and Science Process Skills. *Procedia - Social and Behavioral Sciences*, *59*, 110–116. https://doi.org/10.1016/j.sbspro.2012.09.253

Williams, B. (2005). Case based learning--a review of the literature: is there scope for this educational paradigm in prehospital education? *Emergency Medicine Journal*, *22*(8), 577–581. https://doi.org/10.1136/emj.2004.022707

Wilson-McCain, C. (2021). What type of public products can students create during PBL? 50+ ideas.ImpactfulPBL. https://tinyurl.com/mtpab2w6

Zeidan, A. H., & Jayosi, M. R. (2014). Science Process Skills and Attitudes toward Science among Palestinian Secondary School Students. *World Journal of Education*, *5*(1). https://doi.org/10.5430/wje.v5n1p13