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Learners' Knowledge, Attitude, and Practices (KAP) in the Hypothesis-Based and Problem-Based Classroom

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A B S T R A C T

This study aimed to evaluate students' scientific inquiry skills and investigate the efficacy of inquiry-based learning for ninth-grade students. A quantitative quasi-experimental research design was employed. This only concentrated on students' scientific inquiry skills and included 80 Grade 9 students from Pacita Complex National High School (PCNHS). The scientific inquiry skills of the two student groups were evaluated in terms of scientific knowledge, scientific attitude, and scientific practices using frequency, percent, mean, standard deviation, and paired sample t-test. Additionally, the effectiveness of the inquiry-based learning methodologies was evaluated. Findings reveal that students perform poorly on the pre-assessment in terms of scientific knowledge, moderately observed scientific attitude and rarely practicing scientific inquiry skills. On the other hand, the post-assessment performance of the students reveal that they are very good in terms of scientific knowledge, observed scientific attitude and practicing scientific inquiry skills for problem-based learning (PBL) and hypothesis-based learning (HBL).

The pre-assessment categories of PBL and HBL do not differ significantly from one another. However, in the post-assessment category, there is a significant difference. Furthermore, pre- and post-assessments of PBL and HBL also differ significantly from one another. This implies that both teaching strategies can improve the performance of the students. However, it was observed that PBL is effective compared to HBL Thus, the hypothesis positing that there is no significant difference in the pre- and post- assessment reflection of both PBL and HBL in the study is not sustained.

Keywords: *Hypothesis-Based Learning (HBL); Problem-Based Learning (PBL); Scientific Inquiry Skills (SIS); Scientific Knowledge; Scientific Attitude; and Scientific Practices*

1. Introduction

The main goal of scientific education is to improve the scientific literacy of students, so that they can develop into logical and contributing members of the community who can make well-informed decisions and evaluations concerning the application of scientific knowledge that could potentially impact health, the environment, or society (Department of Education, 2016).

The integration of science and technology is important across all domains of human existence (The Scientific World, 2021). With this, the scientific curriculum recognizes the importance of technology and science in relation to day-to-day problems faced by people.

The integration of science and technology encompasses several dimensions of societal, economic, personal, and ethical domains. An efficacious curriculum offers educators, learners, educational administrators, and community stakeholders with a quantifiable blueprint and framework for dispensing a high- quality education. The curriculum delineates the desired learning goals, standards, and basic competencies that students are required to exhibit prior to progressing to the subsequent level.

There has been an increasing trend in science curricula over the past few years towards the adoption of inquiry-based learning, worldwide research and development initiatives, and educational practices. One of the fundamental factors contributing to its enhanced efficacy is the notable advancements in technology, which enable the facilitation of the inquiry process through electronic learning environments. A typical structure for inquiry-based learning is an inquiry cycle, which consists of multiple inquiry phases. Pedaste et al. (2015) found additional iterations of the inquiry cycle within the existing body of literature.

Meanwhile, the purpose of Knowledge, Attitudes, and Practices (KAP) survey aims to gather a thorough grasp of a certain subject within a target group. It seeks to gather information regarding knowledge, attitudes, and practices pertaining to the subject matter.

Thus, the K to 12 science curriculum is designed to prioritize the learner's needs and interests, while also promoting inquiry-based learning. The use of evidence in the formulation of explanations is emphasized by this method. A spiral progression strategy is used in the curriculum to introduce concepts and skills in Earth Sciences, Physics, Chemistry, and Life Sciences at each grade level in an organized manner. This approach ensures that the complexity of these concepts and skills gradually increases as students go through the curriculum. Consequently, this pedagogical method facilitates a more profound comprehension of the fundamental principles underlying these scientific disciplines. The incorporation of several scientific subjects and interdisciplinary approaches will result in a profound comprehension of concepts and their practical implementation in real-world scenarios.

The implementation of the science curriculum in the Philippines aims to cultivate people who possess scientific literacy, enabling them to make informed and responsible decisions, as well as effectively utilize scientific knowledge in addressing community issues. Nevertheless, according to the most recent findings from the Programme for International Student Assessment (PISA) 2022, Philippines ranked 77 out of 81 participating countries. This indicates that the Philippines is still in the lowest rank among the nations that participated in the assessment which is about the same in the result of PISA 2018.In Science, the Philippines ranked third from the bottom with an average score of 356. The initial involvement of the nation in the PISA has served as motivation for the Department of Education to put forth more initiatives aimed at remedying below normal academic achievement and enhancing the standard of education in the Philippines. In addition, the swift transformation facilitated by Industry 4.0 poses a problem for those responsible for implementing science education. It is imperative for the nation to guarantee its ability to adjust to developing technologies such as artificial intelligence and robotics. The Science Education Institute and the Department of Science and Technology implemented many initiatives through their customized and adaptable programs and projects (Dela Cruz, 2022).

Moreover, while there is some ambiguity concerning the definition of 21st century learning, many academics and researchers agree that it encompasses the ability to engage in data collection, sense-making from a variety of learning resources, and collaboration. There is a growing emphasis on these ranges of abilities in society due to the increased acknowledgement of the significance of solving complex problems in the field of space practice (Mainert et al., 2019). Given the powerful idea of area practice, teachers are searching for ways of bettering foster critical thinking inside K-12 study hall settings. One of the most widely recognized techniques problem-based learning (PBL), which provides students with the invaluable opportunity to address the sorts of issues that habitually happen inside the classroom. Even though PBL's unique execution is hard to follow, many concur that McMaster College was among the first to approve it as an instructional program for the entire framework (Moallem et al., 2019).

Furthermore, a recent psychological study by Cyr and Anderson (2018) found out that participants who guessed during a test had a higher recall rate than those who did not guess. This suggests that it can help students to remember information better because it forces them to think about the material and make connections to what they already know. If the guess is incorrect, it can also help students identify gaps in their knowledge and motivate them to learn more. First, guessing forces students to actively engage with the material. When students guess, they are trying to interpret the data and relate it to their prior knowledge. This process of retrieval and elaboration can strengthen the neural pathways associated with the information, making it more likely that it will be retained in memory for a long time. Second, guessing can help students to identify gaps in their knowledge. When students make a guess and it is incorrect, they are essentially giving themselves feedback that they need to learn more about the topic. This feedback can then motivate students to seek out additional information or seek help from a teacher.

Thus, the study aimed to assess the scientific inquiry skills and test the effectiveness of inquiry-based learning to Grade 9 students.

Objectives of the Study

The study aimed to assess the students' scientific inquiry skills and to test the effectiveness of inquiry-based learning: hypothesis-based and problem-based learning in teaching Science 9.

II. Research Methodology

This chapter discusses the researcher's methodology and research design, as well as the study's participants, sampling strategy, tools, process, statistical analysis of the data, and data collection methods.

Research Design

The study utilized a quantitative quasi-experimental research design. Though, it does not randomly assign individuals to conditions or randomize the order in which treatments are presented, quasi-experimental research does intentionally manipulate an independent variable.

Since quasi-experimental research incorporates independent variable manipulation, it effectively addresses the directional problem. As this approach does not include random assignment to various circumstances, the problem of confounding variables is still unresolved. For a variety of reasons, internal validity in quasi-experimental research is generally higher than in correlational studies—though still lower than in original experiments.

Since two sets of students were exposed in the experiment, it is applicable to do a quasi-experimental research approach.

Respondents of the Study

The study began with the participation of the four (4) sections of the Basic Education Curriculum (BEC) from Pacita Complex National High School, Division of San Pedro City in which two groups were identified based on their pre-test scores. They were paired two meet the desirable characteristics of the paired sample groups.

They were chosen to be the respondents of the study because, in contrast to the STEMP (Science Technology, Engineering and Mathematics Program) which focuses more on Science and Technology, BEC students need to have programs that could improve their knowledge, attitude and practices towards Science subject and related courses for them to apply them in real-life situations.

Sampling Technique

Out of 1106 Grade 9 students, under the Basic Education Curriculum (BEC). Two sections with 80 students were the study's subject. The researcher used a paired sampling technique in this study. It is also known as matched pairs or dependent sampling, a research technique used to compare two related samples. This method involves pairing each subject in one sample with a similar or the same subject in the other sample. The pairing is done based on specific criteria to control for confounding variables and reduce variability, allowing for more precise comparisons.

Research Instruments

The study had two phases. One was all about the application of treatments, and the other was a survey questionnaire wherein the students gave their perceptions on their scientific inquiry skills.

The researcher utilized four daily lesson logs in Science 9, Quarter 3, particularly on Unit 1: Volcanoes and Unit 2: Climate. Two inquiry-based learning strategies were applied, hypothesis-based and problem-based learning. The researcher introduced the hypothesis-based learning to the first section while the second section was exposed to problem-based learning. Pretests and posttests were administered while the respondents are under the experiment to assess their scientific inquiry skills.

To evaluate the students' perceived abilities in scientific inquiry in terms of scientific practices, scientific knowledge, and scientific attitude, a modified questionnaire was also utilized. The survey questionnaire consisted of twenty-eight items, nine items of which were intended to assess the scientific knowledge, fourteen items for scientific attitude and five items for scientific practices. Lesson plan, and survey questionnaire were validated by experts to make sure the set of questions would be reliable for collecting and processing data.

Research Procedure

To make sure that the idea under inquiry was of high enough quality to meet the requirements for the degree, the researcher adhered to the recommendations provided by the dean's office. The proposal was submitted and defended in front of a panel of experts. The foundation for honing the paper's content was laid by all the recommendations and remarks made throughout the defense.

Following the acceptance of this research proposal, the researcher sought the permission of authorities to proceed with the study.The experiment was conducted using the selected students as the respondents after permission was secured. The study was conducted in a duration of four weeks. One week was allotted for each topic namely: volcanoes, geothermal energy, factors that affect climate and climate change. On the first day, pre-tests on knowledge and pre- assessment reflection on scientific inquiry skills were conducted to determine the least mastered competencies. On the next day, the researcher instructed the first group using a hypothesis-based learning technique and the second group using a problem-based learning strategy. For problem-based approach, the students are given real-world issues that are connected to volcanoes, geothermal energy, factors that affect climate and climate change. Like for instance, in the topic climate change, the students imagine that they are part of a local environmental organization tasked with addressing climate change in their community. Their team has been asked to create a comprehensive plan to reduce the carbon footprint of your community. You need to identify the major sources of carbon emissions and propose solutions for mitigation. However, for the hypothesis-based approach, students develop, and test hypotheses based on observations or prior knowledge. For example, each student or group of students should formulate hypotheses related to carbon emissions and their impact. These hypotheses can be framed as cause-and-effect statements. For example, "I hypothesize that reducing car travel by 20% will result in a 10% reduction in my carbon footprint.". After all the topics were discussed using the hypothesis-based and problem-based learning, a post-test was administered, and the questionnaires were disseminated. After that, the post-test paper and the accomplished questionnaire were collected. The researcher began collecting and tabulating the data for statistical treatment, with assistance of her statistician. After which, the researcher sent a copy of the data matrix and other supporting documents to the Statistics Center in the Graduate School where she is enrolled.

Statistical Treatment of Data

Data in the form of test results were subjected to statistical tests, specifically: normality and correlation tests. To assess the scientific inquiry skills on scientific knowledge, scientific attitude, and scientific practices of Grade 9 students, frequency and percent counts, mean and standard deviation were computed. On the other hand, to investigate whether the assessment reflection of the students in Science 9 differs significantly from one another when exposed to PBL and HBL approaches, paired sample t-test was employed.

III. Results and Discussion

This chapter includes the study's tabulated data and results, as well as the analysis and interpretation of the data resulting from the statistical procedures employed.

Table 1 Students' Pre-Test Scores in Scientific Inquiry Skills Test in terms of Scientific Knowledge

Scores	Problem-Based Learning		Hypothesis-Based Learning		Level
	F	%	f	%	
21-25	–	–	–	–	E
16-20	–	–	–	–	VG
11-15	12	30	18	45	G
6-10	27	67.5	21	52.5	P
1-5	1	2.5	1	2.5	VP
Total	40	100	40	100	

Legend: *21-25 Excellent (E); 16-20 Very Good (VG); 11-15 Good (G); 6-10 Poor (P); 1-5 Very Poor (VP)*

Table 1 shows students' pre-test scores in the scientific inquiry skills test in terms of knowledge. It indicates that there are no students who got the level of very good and excellent in the pre-assessment. However, 30% of students under the Problem-based Learning group and 45% in the Hypothesis-Based Learning group received scores in the designated range for the good category. According to the learners, they got a score of 11-15 because they had read in advance their lesson. Prior to the intervention, majority of students in both groups were categorized as poor. As evidenced by their test results, these students struggle to analyze material, particularly when it comes to discussing the variables influencing the climate of an area and the viscosity of lava. This is because they are still learning about volcanoes and climate. This means that students' knowledge level on science concepts were not that enough According to them, the exam is difficult because they can no longer recall these topics. This also supports the idea that there was an intervention that should be done to improve students' scientific inquiry skills in terms of scientific knowledge.

Punwati et al. (2021) stated that improving students' scientific inquiry skills is necessary as the science learning experience has not been optimal. The student learning experience is considered a significant component that impacts students' deficiency in scientific inquiry skills.

Table 2

Students' Pre-Assessment Reflection on their Scientific Inquiry Skills in terms of Scientific Knowledge

Statements	PBL		VI	HBL		VI
	Mean	SD		Mean	SD	
1. I document the knowledge that I have.	2.38	0.59	P	2.58	0.75	G
2. I store the knowledge I have.	2.50	0.64	G	2.60	0.67	G
3. I share the knowledge that I have.	2.30	0.69	P	2.33	0.76	P
4. I gain knowledge from experiences.	2.35	0.66	P	2.38	0.67	P
5. I do problem-solving techniques which are applicable to different situations.	2.23	0.62	P	2.20	0.56	P
6. I experience hardships in sharing my knowledge to others.	2.33	0.53	P	2.25	0.74	P
7. I do experiments to acquire more knowledge.	2.02	0.77	P	2.42	0.59	P
8. I use my senses to observe my surroundings and gather information.	2.55	0.75	G	2.60	0.63	G
9. I do assumptions and logical deductions.	2.08	0.73	P	2.52	0.75	G
Overall	**2.30**	**0.30**	**P**	**2.43**	**0.29**	**P**

Legend: *4.50-5.00 Excellent (E); 3.50-4.49 Very Good (VG); 2.50-3.49 Good(G); 1.50-2.49 Poor (P); 1.00-1.49 Very Poor (VP)*

Table 2 illustrates students' pre-assessment reflection on their scientific inquiry skills in terms of scientific knowledge. Students in both PBL and HBL strategies have good ratings in terms of storing knowledge and using their senses in observing the surroundings. However, students in both categories generally fall into the poor category when it comes sharing knowledge, gaining knowledge through experience, doing problem solving techniques, conducting experiments for knowledge acquisition, and encountering difficulties in sharing knowledge.

Generally, students' overall self-reflection on knowledge across both learning techniques need to be improved, as seen by the mean ratings for PBL (2.30) and HBL (2.43), which are both in the poor range. Based on observations, these lower self-ratings are caused by lack of practice opportunities, a lack of exposure to a variety of learning experiences, poor teaching strategies, communication barriers and difficulties translating theoretical knowledge into real-world applications. Their poor ratings in these areas could also be attributed to cognitive difficulties, resource constraints, and communication problems.

The results imply that before the intervention, both groups perceived that they have poor levels of reflection in their scientific inquiry skills in terms of scientific knowledge likewise with their test scores in terms of scientific knowledge. Fernandez, et al. (2022) cited that high school students do not learn much about developing scientific inquiry skills and have a hard time understanding what they mean in the science books they read in class. Some of the reasons this might be happening are investigated in this paper, along with some ideas on how to teach the skills needed better.

Table 3

Students' Pre-Assessment Reflection on their Scientific Inquiry Skills in terms of Scientific Attitude

Statements	PBL Mean	SD	VI	HBL Mean	SD	VI
1. Reporting what happened, even if this conflicted with expectations	2.48	0.72	RO	2.83	0.87	MO
2. Querying and checking parts of the evidence which do not fit into the pattern of other findings.	2.42	0.64	RO	2.55	0.78	MO
3. Querying an interpretation or conclusion for which there is insufficient evidence.	2.35	0.77	RO	2.67	0.80	MO
4. Setting out to collect further evidence before accepting a conclusion	2.67	0.62	MO	2.58	0.71	MO
5. Treating every conclusion as being open to challenge by further evidence	2.52	0.68	MO	2.70	0.79	MO
6. Being prepared to change an existing idea when there is convincing evidence against it.	2.50	0.60	MO	2.63	0.59	MO
7. Spontaneously seeking alternative ideas rather than accepting the first one which fits the evidence.	2.50	0.64	MO	2.48	0.64	RO
8. Relinquishing an existing idea after considering evidence.	2.52	0.75	MO	2.50	0.60	MO
9. Realizing that it is necessary to change ideas when different ones make better sense of the evidence.	2.50	0.68	MO	2.73	0.75	MO
10. Willingness to review what they have done to consider how to improve.	2.48	0.60	RO	2.75	0.67	MO
11.Considering alternative procedures to those used	2.50	0.75	MO	2.58	0.68	MO
12. Considering the points in favour and against how an investigation was carried out.	2.48	0.60	RO	2.58	0.55	MO
13. Spontaneously reflecting on how the procedures might improve	2.67	0.66	MO	2.65	0.80	MO
14.Considering alternative procedures at the planning stage and reviewing those chosen during an investigation, not just at the end.	2.42	0.64	RO	2.55	0.85	MO
Overall	2.50	0.67	MO	2.63	0.34	MO

Legend: 4.50-5.00 Highly Observed (HO); 3.50-4.49 Observed (O); 2.50-3.49 Moderately Observed (MO); 1.50-2.49 Rarely Observed (RO); 1.00-1.49 Not Observed (NO)

Table 3 shows the students' pre-assessment reflection on their scientific inquiry skills in terms of scientific attitude. Both PBL and HBL show moderately observed levels of scientific inquiry skills across most variables. Based on observations, both groups can spontaneously reflect on how the procedures might improve, relinquish current idea after examining the evidence, recognize that when new theories make more sense of the available data, it is vital to modify one's original perspective., set out to collect further evidence before accepting a conclusion, consider each conclusion to be open to refutation by more data, consider alternatives to the current processes and being willing to modify an existing idea in the face of substantial proof to the contrary.

Furthermore, the overall scientific attitude toward scientific inquiry skills of the PBL and HBL group were moderately observed. This implies that both groups were of the same level and need improvement in their scientific inquiry skills in terms of scientific attitude.

Process skills are a way to learn that uses students' scientific and intellectual skills to find facts and build ideas and concepts (Desnita. F, et al., 2017). Students are pushed to think like scientists when they are learning by doing things that require them to use process skills. They learn how to think critically about proof, ask questions, and change what they think they know when new information comes in. This helps people understand scientific ideas better and develops a good mindset for scientific inquiry and finding. This means that including process skills in learning helps develop and maintain students' scientific attitude.

Table 4

Students' Pre-Assessment Reflection on their Scientific Inquiry Skills in terms of Scientific Practices

Statements	PBL		VI	HBL		VI
	Mean	SD		Mean	SD	
1. **Questioning:** At the start of each unit or lesson, asking an open-ended question or using a real-life problem that hook my interest.	2.17	0.64	RP	2.55	0.82	MP
2. **Critical thinking and problem-solving:** Challenging us to analyze information, evaluate evidence, solve complex problems and draw conclusions based on evidence.	2.25	0.63	RP	2.30	0.61	RP
3. **Collaboration:** Encouraging us to work together to solve problems, sharing ideas, and learning from each other's perspectives.	2.23	0.58	RP	2.30	0.69	RP
4. **Scaffolding:** Providing support and guidance as needed, but gradually reducing support as we become more independent in our inquiry process	2.27	0.68	RP	2.48	0.60	RP
5. **Real-world connections:** Connecting the content to current events, issues, or community problems to make it more relevant and meaningful.	2.45	0.68	MP	2.52	0.88	MP
Overall	2.27	0.30	RP	2.43	0.42	RP

Legend: 4.50-5.00 Highly Practiced (HP); 3.50-4.49 Practiced (P); 2.50-3.49 Moderately Practiced (MP); 1.50-2.49 Rarely Practiced (RP); 1.00-1.49 Not Practiced (NP)

Table 4 portrays students' pre-assessment reflection on their scientific inquiry skills in terms of scientific practices. Indicative statements including problem-solving and critical thinking, teamwork, and scaffolding, for example, display mean scores classified as rarely practiced for both PBL and HBL. The rarely practiced level of critical thinking and problem-solving abilities indicates that students need more practice in information analysis, evidence evaluation, and conclusion-making. For scaffolding, students in both settings have an RP level, indicating that although they got help when they need it, the progressive withdrawal of support should be improved as students grow more self-sufficient in their quest for knowledge.

It is interesting that students from both PBL and HBL classrooms have a marginally higher mean score in real-world building connections, indicating a moderately practiced (MP) level. This implies that, although there is still opportunity for development, students show some aptitude for making connections between scientific knowledge and current events, concerns, or community challenges.

Overall, the results show that students are at a rarely practiced (RP) level in terms of pre-assessment reflection on their scientific inquiry skills in terms of scientific practice. These results highlight how crucial it is to improve teaching strategies to encourage students to apply their scientific inquiry skills and become more actively engaged.

Practical tasks are rarely done because the laboratory equipment is broken and missing parts. Because of this, changes need to be made in the learning area. It is believed that using the scientific inquiry learning methodology will improve students' scores on the SPS. Students can be involved in truly original investigation problems with the scientific inquiry model, which shows other students' investigations, helps them find methodological and conceptual issues in the field, and requests that they devise solutions for these issues. (Fitriani, et al., 2020; Siregar, et al., 2020).

Table 5

Students' Post- Test Scores in Scientific Inquiry Skills Test in terms of Scientific Knowledge

Scores	Problem-based Learning		Hypothesis-Based Learning		Level
	F	%	F	%	
21-25	20	50	11	27.5	E
16-20	17	42.5	22	55	VG
11-15	3	7.5	7	17.5	G
6-10	–	–	–	–	P
1-5	–	–	–	–	VP

Legend: 21-25 Excellent (E); 16-20 Very Good (VG); 11-15 Good (G); 6-10 Poor (P); 1-5 Very Poor (VP)

Table 5 shows students' post-test scores in the scientific inquiry skills test in terms of knowledge, it indicates that there are no students who got the level of very poor and poor in the post-assessment. The proportion of students who scored in the very good and excellent categories combined was 92.5% in the PBL group and slightly lower at 82.5% in the HBL group. However, most students involved to problem-based learning (PBL) got excellent level of knowledge while those of hypothesis-based learning (HBL) mostly got good performances. This shows that both teaching strategies have been successful in helping students acquire scientific knowledge, with PBL showing a marginally larger percentage of students obtaining top marks than HBL. Indeed, students involved in PBL performed better in the knowledge test because during Science class, students are allowed to interact directly with scenarios or problems from the real world which promotes learning retention and a deeper comprehension rather than the HBL wherein the formulation, testing, and validation of hypotheses are frequently the main goals of HBL, which may not always be in line with the cognitive or preferred learning styles of the students.

Aisyah et al. (2020) claimed that compared to the conventional learning model, the scientific investigation model was more effective at teaching science process skills. It was also said that students with higher logical thinking skills had better science process skills than students with lower logical thinking skills. Science process skills are impacted differentially by the traditional learning approach and the scientific inquiry model.

Table 6

Students' Post-Assessment Reflection on their Scientific Inquiry Skills in terms of Scientific Knowledge

Statements	PBL		VI	HBL		VI
	Mean	SD		Mean	SD	
1. I document the knowledge that I have.	4.00	0.75	VG	4.08	0.86	VG
2. I store the knowledge I have.	4.20	0.79	VG	4.17	0.64	VG
3. I share the knowledge that I have.	4.17	0.75	VG	3.88	0.69	VG
4. I gain knowledge from experiences.	4.55	0.80	E	4.03	0.53	VG
5. I do problem-solving techniques which are applicable to different situations.	4.13	0.56	VG	3.67	0.66	VG
6. I experience hardships in sharing my knowledge to others.	3.75	1.03	VG	3.67	0.62	VG
7.I do experiments to acquire more knowledge.	3.83	0.78	VG	3.73	0.55	VG
8. I use my senses to observe my surroundings and gather information.	4.30	0.72	VG	4.35	0.53	VG
9. I do assumptions and logical deductions.	4.15	0.77	VG	3.90	0.87	VG
Overall	4.12	0.27	VG	3.94	0.22	VG

Legend: 4.50-5.00 Excellent (E); 3.50-4.49 Very Good (VG); 2.50-3.49 Good (G); 1.50-2.49 Poor (1.00-1.49 Very Poor (VP)

Table 6 illustrates students' post-assessment reflection on their scientific inquiry skills in terms of knowledge. It shows that the PBL group's perception that they gained knowledge from experiences was excellent while students exposed in HBL group perceived themselves as very good.

Both groups perceived themselves as very good in terms of gaining, documenting, sharing knowledge, doing problem solving techniques, experiencing hardships in sharing knowledge, doing experiments to acquire more knowledge, doing assumptions and logical deductions, and using the senses in observing the surroundings to gather information.

Furthermore, both PBL and HBL groups demonstrated a significant increase in students' capacity for scientific inquiry because of the instructional interventions as shown in the mean. Overall, both groups perceived themselves very good in terms of scientific knowledge, however PBL has a higher mean of 4.12 and 3.94 for HBL. Based on observations, students who were exposed in the PBL approach were able to understand the lesson being discussed because of the use of real-life applications and gaining knowledge from experiences. These results demonstrate how well both teaching strategies support the students in documenting, storing, sharing, and gaining knowledge from experiences and emphasized the need of keeping the focus on active participation and the use of scientific inquiry skills throughout the learning process.

According to Hutape, et al. (2021), it is possible that students' expertise in the scientific process can be improved by the implementation of the phases that are included in the scientific inquiry learning model.

Table 7

Students' Post-Assessment Reflection on their Scientific Inquiry Skills in terms of Scientific Attitude

Statements	PBL		VI	HBL		VI
	Mean	SD		Mean	SD	
1. Reporting what happened, even if this conflicted with expectations.	3.67	0.73	O	3.92	0.62	O
2. Querying and checking parts of the evidence which do not fit into the pattern of other findings.	4.00	0.85	O	3.90	0.81	O
3. Querying an interpretation or conclusion for which there is insufficient evidence.	3.77	0.89	O	3.73	0.78	O
4.Setting out to collect further evidence before accepting a conclusion	4.10	0.81	O	3.90	0.74	O
5. Treating every conclusion as being open to challenge by further evidence	4.20	0.69	O	3.77	0.77	O
6. Being prepared to change an existing idea when there is convincing evidence against it	4.35	0.89	O	3.67	0.73	O
7. Spontaneously seeking alternative ideas rather than accepting the first one which fits the evidence.	4.00	0.78	O	3.67	0.66	O
8.Relinquishing an existing idea after considering evidence.	4.03	0.66	O	3.73	0.68	O
9.Realizing that it is necessary to change ideas when different ones make better sense of the evidence	4.38	0.67	O	3.80	0.61	O
10.Willingness to review what they have done to consider how to improve.	4.40	0.74	O	4.10	0.63	O
11. Considering alternative procedures to those used.	3.92	0.69	O	4.10	0.63	O
12. Considering the points in favour and against how an investigation was carried out.	4.03	0.62	O	3.80	0.56	O
13. Spontaneously reflecting on how the procedures might improve.	4.15	0.77	O	4.00	0.78	O
14. Considering alternative procedures at the planning stage and reviewing those. chosen during an investigation, not just at the end.	4.03	0.77	O	4.20	0.76	O
Overall	**4.07**	**0.36**	**O**	**3.86**	**0.42**	**O**

Legend: *4.50-5.00 Highly Observed (HO); 3.50-4.49 Observed (O); 2.50-3.49 Moderately Observed (MO); 1.50-2.49 Rarely Observed (RO); 1.00-1.49 Not Observed (NO)*

Table 7 portrays students' post- assessment reflection on their scientific inquiry skills in terms of scientific attitude. It merely shows that students learn that when alternative theories make more sense of the available data, it is vital to modify one's original views. and be prepared to change an existing idea when there is convincing evidence against it were both observed in the PBL group while examine alternate methods during the planning phase and not only at the conclusion of an investigation and the willingness to review what they have done to consider how to improve were both moderately observed in the HBL group.

Furthermore, the overall attitude toward scientific inquiry skills of both groups was observed with a total mean score for PBL (4.07) and HBL (3.86) This means that after the intervention, both groups showed that they had developed the attitude towards scientific inquiry skills.

Younis (2017) cited that students' attitudes toward chemical reactions and higher order thinking skills can be effectively promoted through scientific inquiry simulations, which are effective learning settings.

Table 8

Students' Post-Assessment Reflection on their Scientific Inquiry Skills in terms of Scientific Practices

Statements	PBL			HBL		
	Mean	SD	VI	Mean	SD	VI
1. **Questioning:** At the start of each unit or lesson, asking an open-ended question or using a real-life problem that hook my interest.	4.15	0.77	P	4.28	0.64	P
2. **Critical thinking and problem-solving:** Challenging us to analyze information, evaluate evidence, solve complex problems, and draw conclusions based on evidence.	4.28	0.68	P	4.00	0.68	P
3. **Collaboration:** Encouraging us to work together to solve problems, sharing ideas, and learning from each other's perspectives	4.35	0.80	P	3.92	0.73	P
4. **Scaffolding:** Providing support and guidance as needed, but gradually reducing support as we become more independent in our inquiry process.	4.35	0.66	P	3.75	0.74	P
5. **Real-world connections:** Connecting the content to current events, issues, or community problems to make it more relevant and meaningful.	4.30	0.72	P	3.73	0.75	P
Overall	**4.29**	**0.47**	P	**3.94**	**0.46**	P

Legend: 4.50-5.00 Highly Practiced (HP); 3.50-4.49 Practiced (P); 2.50-3.49 Moderately Practiced (MP); 1.50-2.49 Rarely Practiced (RP); 1.00-1.49 Not Practiced (NP)

Table 8 illustrates students' post-assessment reflection on their scientific inquiry skills in terms of practices. It shows that questioning, critical thinking and problem-solving, cooperation, scaffolding, and making connections to the real world whose mean scores are classified as observed for both PBL and HBL. This suggests that students in PBL and HBL groups engage in these practices frequently.

Furthermore, the overall mean scores for PBL and HBL are both within the observed range, demonstrating how well instructional strategies work to encourage students to actively participate in scientific inquiry practices. These results highlight the value of creating an atmosphere that promotes and facilitates students' participation in scientific inquiry activities, hence improving their capacity to apply scientific knowledge and abilities in real-word settings. Scientific practices improved the scientific inquiry skills of the students through connecting the topic to real-life situations in the community,challenging the students to analyze information and to work together to solve problems as shown in the results.

Sinatra, et al. (2015) mentioned that when learners actively participate in their own education, they get many rewards, such as higher inspiration and success. However, there is little consensus regarding the clear meaning of engagement or a good way to measure it.

Table 9

Test of Difference in the Scientific Inquiry Skills of the Students as to the Pre-Assessment of the Two Groups of Students

Scientific Inquiry Skills	PBL		HBL		Mean Diffe-rence	T	Df	Sig. (2-tailed)	VI
	Mean	SD	Mean	SD					
Knowledge test	9.22	2.26	10.15	2.47	**0.93**	-1.75	78	0.084	Not Significant
Perceived Knowledge	2.30	0.30	2.43	0.29	0.13	-1.93	78	0.058	Not Significant
Attitude	2.49	0.29	2.63	0.34	0.14	-1.91	78	0.06	Not Significant
Practices	2.27	0.30	2.43	0.42	0.15	-1.90	78	0.061	Not Significant

Legend: Sig (2-tailed) ≤ .05 (Significant); Sig (2-tailed) ≥ .05 (Not significant)

Table 9 shows test of difference in the scientific inquiry skills of the students as to the pre-assessment reflection of scientific knowledge, scientific attitudes, and scientific practices of the two groups of students. The results support the hypothesis that the pre-test category ratings for the two groups did not differ significantly. With a mean difference of 0.93 for pre-assessment knowledge, the mean scores for PBL and HBL do not differ significantly from one another, indicating comparable levels of knowledge acquisition prior to the instructional interventions. With mean differences, the perceived scientific knowledge, scientific attitude, and scientific practices also do not demonstrate any noticeable variations between the two groups. The results show that all the categories were of the same in level.

Science process skills in the experimental class can be improved if the scientific inquiry learning model is applied (Ulfah, et al., 2018)

Table 10

Test of difference in the Scientific Inquiry Skills of the Students as to the Post- Assessment of the Two Groups of Students

Scientific Inquiry Skills	PBL		HBL		Mean Difference	t	Df	Sig. (2-tailed)	VI
	Mean	SD	Mean	SD					
Knowledge test	20.70	2.72	18.45	2.73	2.25	3.7	78	<.001	Significant
Perceived Knowledge	4.12	0.27	3.94	0.22	0.18	3.18	78	0.002	Significant
Attitude	4.07	0.36	3.86	0.42	0.22	2.48	78	0.015	Significant
Practices	4.29	0.47	3.94	0.46	0.35	3.35	78	0.001	Significant

Legend: Sig (2-tailed) ≤ .05 (Significant); Sig (2-tailed) ≥ .05 (Not significant)

Table 10 shows the test of difference in the scientific inquiry skills of the students as to the post-assessment of the two groups of students, it shows that all the categories showed significant differences. Significant variations are shown in all three areas based on the results. First, the post-assessment shows a statistically significant difference regarding scientific knowledge between the PBL and HBL groups, with a mean difference of 2.25 This shows that students' scientific inquiry skills have been affected differently by the instructional interventions in terms of knowledge acquisition, with PBL students demonstrating noticeably higher levels of knowledge than HBL students. Second, there are notable variations between the two groups in terms of perceived scientific knowledge and scientific attitude as well. This suggests that, in comparison to the HBL students, PBL students have far higher sense of their own knowledge and show more positive attitude for scientific investigation. Third, is the scientific practices, it also shows a significant difference between PBL and HBL groups. This implies that compared to HBL students, PBL students engage in scientific inquiry activities to a higher degree.

Overall, these results highlight the differences in the effects of instructional interventions on scientific inquiry skills between PBL and HBL groups, emphasizing the role that PBL plays in helping students acquire more knowledge, perceived more knowledge, have more positive attitudes, and engage in scientific inquiry practices. During the implementation, students who were exposed in PBL were able to apply the topics in real-life scenarios which enables them to understand better the topic while students exposed to HBL were able to make hypotheses regarding the topic, however, the scope is limited.

According Wahdaniyah et al. (2023) claim that problem-based learning is a successful strategy for raising students' critical thinking abilities. The skills of critical thinking and scientific research are closely linked because they both involve careful examination, problem-solving, communication, and the careful evaluation of evidence. People who work on these skills are better able to do scientific research and make smart choices in a variety of situations.

Table 11

Test of Difference between the Pre- and Post-Assessment Reflection of Students *(Problem-Based Learning)*

PBL	Test	Mean	SD	t Stat	df	Sig	VI
Knowledge Test	Pre-test	9.225	2.258744				
	Post-test	20.7	2.719351	-20.5297	78	0.010	S
Perceived Knowledge	Pre-test	2.302778	0.301927				
	Post-test	4.119444	0.271452	-28.2986	78	0.010	S
Attitude	Pre-test	2.501786	0.290477				
	Post-test	4.073214	0.36223	-21.4049	78	0.010	S
Practices	Pre-test	2.275	0.302765				
	Post-test	4.285	0.470434	-22.7233	78	0.010	S

Legend: *Sig (2-tailed) ≤ .05 (Significant) (S); Sig (2-tailed) ≥ .05 (Not significant) (NS)*

Table 11 shows the result of the test of difference between pre- and post- assessment reflection of students involved in PBL with an emphasis on how the study affected the participants' knowledge, attitude and practices. Pre- and posttest results are shown for each of these domains, showing significant improvements after the PBL intervention. Participants showed notable improvements in all assessed variables, including knowledge test, perceived knowledge, attitude, and practices. Similar patterns were seen in perceived knowledge, attitude, and practices. For example, mean scores in the knowledge domain increased dramatically from 9.225 in the pre-test to 20.7 in the post-test. Based on observation, the scores of the students increased because of the nature of PBL wherein students are engaged in real-life situations which enables them to retain and comprehend knowledge. Just like in the topic, climate change, the students were tasked watch a short motivational video clip. Then, based on the video, they state the reason why they think this is a significant issue and they are to relate it to their observations in their community. The results indicate that problem-based learning successfully enabled participants to develop positive attitudes, practical skills, and a thorough comprehension of the subject matter. This demonstrates how effective PBL is as a teaching strategy.

Table 12

Test of Difference between the Pre- and Post- Assessment Reflection of Students (Hypothesis-Based Learning)

HBL	Test	Mean	SD	t Stat	df	Sig	VI
Knowledge Test	Pre-test	10.15	2.465662				
	Post-test	18.45	2.726414	-14.28022611	78	0.000	S
Perceived Knowledge	Pre-test	2.430556	0.292556				
	Post-test	3.941667	0.225036	-25.89347295	78	0.000	S
Attitude	Pre-test	2.625	0.339201				
	Post-test	3.855357	0.420401	-14.405318	78	0.000	S
Practices	Pre-test	2.43	0.416456				
	Post-test	4.285	0.470434	-13.2893507	78	0.000	S

Legend: *Sig (2-tailed) ≤ .05 (Significant) (S); Sig (2-tailed) ≥ .05 (Not significant) (NS)*

Table 12 shows the result of the test of difference between pre- and post- assessment reflection of students involved in hypothesis-based learning (HBL) with an emphasis on how the study affected the participants' scientific knowledge, scientific attitude and scientific practices. Likewise, with PBL, HBL showed a significant improvement in every domain. This implies that participants' attitudes, practical application of newly learned concepts, and comprehension of the subject matter were all positively impacted by hypothesis-based learning. Overall, the findings illustrate the potential value of hypothesis-based learning in educational contexts by demonstrating how effective it is as a pedagogical strategy for developing thorough learning outcomes and encouraging active engagement with the subject matter. This means that students tend to use guesses to have a better understanding of the said concepts.

Jan, et al. (2023) remarked that the act of guessing is an important part of learning in many areas. Scientific research is iterative, exploratory, and creative, which is like the idea that guessing is a good way to learn. People can develop skills necessary for useful scientific discovery and exploration by being open to guessing.

Conclusion

The study's findings led to the formulation of the following conclusions.

1.There is no significant difference between the pre-assessment reflection of the two groups of students as to their scientific inquiry skills in terms of scientific knowledge, scientific attitude, and scientific practices, thus the null hypothesis posited in the study is therefore sustained.

2.There is a significant difference between the pre-assessment reflection of the two groups of students as to their scientific inquiry skills in terms of scientific knowledge, scientific attitude, and scientific practices, thus the null hypothesis posited in the study is not sustained.

3.There is a significant difference between the pre- and post-assessment reflection of the students as to their scientific inquiry skills when grouped according to problem and hypothesis-based learning, thus the null hypothesis posited in the study is not sustained.

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