Asia Pacific Journal of Advanced Education and Technology
Special Issue, September 2022 / P- ISSN 2815 – 245X / E – ISSN 2815 – 2468 / www.apjaet.com

Project-Based Learning Strategies in Science and the Metacognitive Skills among Grade 5 Pupils

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DOI: https://doi.org/10.54476/apjaet/54260

Abstract

This study aimed to investigate the effect of project-based learning strategies on the metacognitive skills of Grade 5 students at Sumagonsong Elementary School during the School Year 2021-2022. This is an experimental research design that utilized the pre-test and post-test assessments. Sixty (60) grade 5 students were used as a respondent from two heterogeneous sections which were selected through matched-pairing using their second-quarter grades as a basis. The first group received case-based instruction, while the second group received just-in-time instruction. In this study, a 45-item validated metacognitive test was employed to assess whether there was a significant difference between the pre-test and post-test scores of the two groups. The study revealed that the pre-test scores of the respondents in the two experimental groups as to their metacognitive skills in terms of planning, monitoring, and evaluating were at the beginning and developing level, indicating that students possessed poor metacognitive skills. The post-test results of the respondents in both groups revealed that they performed better after the treatment, which indicated that they had acquired enhanced metacognitive skills. Likewise, a significant difference was found between the pre-test and post-test scores of both groups exposed to project-based strategies. However, there's no significant difference in the effectiveness of case-based teaching and just-in-time teaching in enhancing metacognitive skills such as planning, monitoring, and evaluating.

Keywords: Project-Based Learning Strategies, Metacognitive Skills, T-test, Philippines

Introduction

In the midst of the COVID-19 pandemic, the ability to learn independently and to be lifelong learners are essential. When students are unaware of their learning experiences, they are less likely to independently assess and evaluate themselves, as awareness of their learning experiences is a crucial aspect of learning. (Salim, Susilawati & Hanif, 2021)

Antonio and Prudente (2021) pointed out that students must develop metacognition to acquire knowledge independently. Metacognition is essential to successful learning because it enables students to better regulate their cognitive abilities and recognize their deficiencies, which can be remedied by acquiring new skills. Students in the 21st century must possess the lifelong skill of learning how to learn.

This competency requires metacognition, which is regarded as a crucial component of effective and successful learning.

According to Naimnule and Corebima (2018), teachers and educators realized that it is beneficial to enhance students' metacognitive skills. Students who can effectively control their cognitive processes, including their thinking abilities, will be more likely to achieve academic success. This is because the development of strong metacognitive abilities will help students become self-directed, autonomous learners.

Given how important metacognitive skills are, it is significant to come up with new ways to teach and learn that help students develop these skills. Innovative learning strategies are one way that elementary school students can learn to think about how they think. The innovative learning strategy that is used must have learning steps that encourage students to be active, and creative, solve problems, and come up with new ideas. In this regard, Project-based learning is one way to improve students' thinking skills and get them to be more active, creative, and good at solving problems and thinking critically. (Hendriani, Herlambang & Setiawan, 2020)

Phillips (2020) asserts that project-based learning (PBL), regardless of where or how children study, is a means of fostering an explorer's mindset. The Buck Institute for Education, (2015) defines project-based learning as a mode of instruction in which students acquire knowledge and skills through in-depth investigation and response to an authentic, engaging, and complex problem, question, or challenge. As an active learning strategy, the majority of the world's leading educational systems have adopted project-based learning. PBL offers authentic learning that targets 21st-century skills. It provides students with the opportunity to develop essential life skills, such as the metacognitive ability. (Rubrica, 2018).

Tosun and Senocak (2013) highlighted that Project-based Learning (PBL) is the best student-centered method for teaching people how to learn on their own and for the rest of their lives. It helps people develop their metacognitive skills and find different ways to solve problems they face or might face in everyday life. When faced with a new problem, a person should be able to use metacognitive skills to plan, come up with different solutions, analyze and synthesize, present the different solutions, and evaluate the process. However, according to Hendriani, Herlambang & Setiawan (2020), although study on metacognition has been conducted in the past by a number of scholars, metacognition research is still conducted only very infrequently, particularly at the elementary school level. Therefore, this study focused on enhancing the metacognitive skills of Grade 5 pupils at Sumagonsong Elementary School utilizing project-based learning strategies.

Objectives of the Study

This study aimed to investigate the effectiveness of project-based learning strategies in improving the metacognitive skills of Grade 5 pupils. Specifically, to 1) determine the Metacognitive skills scores in terms of planning, monitoring, and evaluating; 2) determine the effect of project-based learning strategies through case-based teaching and just-in-time teaching in the student's metacognitive skills ;3) identify which project-based learning strategies had more effect on the student's metacognitive skills.

Methodology

This is an experimental study that used pre-test and post-test assessments to investigate the effectiveness of project-based learning strategies such as case-based teaching and just-in-time teaching in

improving the metacognitive skills of Grade 5 students. Sixty (60) grade 5 students were used as a respondent from two heterogeneous sections which were selected through matched-pairing using their second-quarter grades as a basis. The first group was exposed to case-based teaching and the second group was exposed to just-in-time teaching.

Different tools were used in the study to get the information needed to answer the research questions. These are a pre-test and a post-test for metacognitive skills, as well as two types of lesson exemplars: one for case-based teaching and the other for just-in-time teaching. The pre-test and post-test assessments are composed of 45 items based on the most essential learning competencies. Questions are constructed based on the three metacognitive skills namely: planning, monitoring, and evaluating. The lesson exemplar covered the following topics: Open and Closed Circuits, Series and Parallel Circuits, and Electromagnetism selected from the Grade 5 PIVOT 4A module in the third grading period. The research instruments prepared by the researcher went through both external and internal content validations. The instruments were validated by a panel of experts such as a Master Teacher, School Head, Science Teacher, College Instructor, and English Teacher. Their comments and suggestions were assimilated for the finalization of the instrument.

Before the experimental phase, a pre-test was conducted to assess the respondents' metacognitive skills. Then, the teacher-made lesson exemplar was executed in limited face-to-face classes using two project-based strategies in the experimental groups. It was administered within five weeks in the month of April-May during the third quarter of SY 2021-2022. After the execution of the lesson, students answered the post-test prepared by the researcher. Results were collected, tallied, and tabulated for statistical analysis. The study utilized descriptive statistics such as frequency and percentage which were used to interpret the pre-post test scores. The t-test for dependent samples was used to compare respondents' pre-and post-test scores on metacognitive skills like planning, monitoring, and evaluating. Independent samples t-test was used to compare pre-and post-test results of students exposed to case-based teaching and just-in-time teaching.

Results and Discussion

1. Pre-test Assessment of the Metacognitive Skills of the Two Groups

The table shows the distribution of the pre-test scores of the two groups of students in the metacognitive skills test employed. It reveals that most of the students from the two groups obtained scores from the pre-test which fall under the "Beginning" and "Developing" level

In planning skills, the majority, or 46.7 percent of the students from case-based and just-in-time teaching classified in the "Developing" level before the intervention. This means that students already develop an initial awareness of how to plan to achieve the specific goal but have only a limited understanding regards to the topic such as open and closed circuits, series and parallel circuits, and electromagnetism. They still find it hard to apply their knowledge to come up with concrete reasoning that will support their conclusions about the concept. Students under this skill are expected to choose suitable strategies and distribution of intellectual resources, putting goals in place and time allocation to every task assigned to them.

In monitoring skills, 46.7 percent of the students from just-time teaching and 50.0 percent from case-based teaching are categorized in the "Beginning" level. This can be inferred that the two groups of students exhibit unawareness of the different concepts and ideas about electricity and they are mostly incapable of identifying the underlying characteristics of monitoring skills where they were expected to

understand their task performance and keep track on their own actions while doing the learning activities included in the lesson.

Table 1
Pre-test Scores of the Two Groups of Students as to their Metacognitive Skills

Pre-test Scores	Planning		Monitoring		Evaluating		VI
	f	%	*f*	%	*f*	%	
Case-Based Teaching							
13-15	0	0	0	0	0	0	**A**
10-12	3	10.0	1	3.3	2	6.7	**P**
7-9	5	16.7	8	26.7	2	6.7	**AP**
4-6	14	46.7	6	20.0	11	36.7	**D**
0-3	8	26.7	15	50.0	15	50.0	**B**
Just-In-Time Teaching							
13-15	0	0	0	0	0	0	**A**
10-12	1	3.3	1	3.3	2	6.7	**P**
7-9	7	23.3	6	20.0	6	20.0	**AP**
4-6	14	46.7	9	30.0	7	23.3	**D**
0-3	8	26.7	14	46.7	15	50.0	**B**

In evaluating skill, the two groups of students from case-based teaching and just-in-time teaching obtained scores (50.0 percent) which fall under the category of "Beginning" level. It was observed that most of them have not yet developed this skill where they were expected to assess which learning techniques are more effective and how they are implemented by reviewing the learning outcomes and conclusion for each strategy. Students were unfamiliar with the context of evaluating questions indicating that they were not engaged before in the process that regulates learning.

Being included in the "Beginning" and "Developing" level indicates that the students possessed poor metacognitive skills. According to Naimnule and Corebima (2018), learning should prioritize the development of metacognitive skills. Students who can develop strong metacognitive skills will be more successful learners because these skills will help them become self-directed students who can exercise control over their cognitive processes, which includes their ability to think critically. On the other hand, Hirca (2013) mentioned that it is worthwhile to promote the metacognitive skills of students because, with metacognitive skills, students can organize information and behavior, and they can finish the learning activities more easily. This is why it is worthwhile to promote the metacognitive skills of students.

2. Post-test Assessment of the Metacognitive Skills of the Two Groups

The table reveals the distribution of post-test scores of the two groups of students in the metacognitive skills test employed. It shows that upon the exposure of the two groups of students to different project-based learning strategies, significant improvements occurred in their metacognitive skills which lead them to reach the "Approaching Proficiency" and "Proficient level".

In terms of planning, the majority of the students from the two groups were categorized in the "Approaching Proficiency" level. It can be inferred that upon the application of project-based learning, students were able to develop the skill in determining the learning objective, learning sequence, learning methodologies, and anticipated learning time. During the engagement activities, the learners were grouped according to their learning area. In that case, the learners were able to finish their learning task even though they were in their place. It was observed that learners talked and discussed enthusiastically with their group mates about how they will start their tasks, and they set their goals and deadlines. It was seen that they were excited to carry out the project. They even started to outline what they needed to accomplish and determine how much time to spend on the project. Some of the members, went back to the books/modules to read further about the concepts. Here, the learners in case-based teaching and just-in-time teaching developed the skill of planning since they can think and manage given tasks to achieve specific goals with the help of any available resources.

Table 2
Post-test Scores of the Two Groups of Students as to their Metacognitive Skills

Post-test Scores	Planning		Monitoring		Evaluating		VI
	f	%	*f*	%	*f*	%	
Case-Based Teaching							
13-15	1	3.3	1	0	1	3.3	**A**
10-12	7	23.3	8	26.7	9	30	**P**
7-9	14	46.7	10	33.3	10	33.3	**AP**
4-6	6	20	7	23.3	6	20	**D**
0-3	2	6.7	4	13.3	4	13.3	**B**
Just-In-Time Teaching							
13-15	1	3.3	1	3.3	1	3.3	**A**
10-12	7	23.3	12	40	12	33.3	**P**
7-9	15	50	6	20.0	6	20.0	**AP**
4-6	7	23.3	9	30.0	9	30	**D**
0-3	0	0	2	6.7	4	13.3	**B**

In terms of monitoring, most of the students from the group exposed to just-in-time teaching achieved "Proficiency" which is considerably higher than a group of case-based teaching only achieved "Approaching Proficiency". This indicates that this set of students made progress in their ability to comprehend tasks as seen by their capacity to analyze, connect, and apply their knowledge to solve problems. Having been exposed to group investigation or an experiment (*Build a circuit, construct an electromagnet model)* instructed them to establish a problem-solving strategy, which included identifying

the necessary tools and materials. It helped them to monitor their work by checking/ reviewing their learning task if they followed the procedures, and used the right tools and materials thus, enabled them to moderate the current progress of learning. However, in CBT, learners were exposed to case stories that learners simulated in courtroom sessions and where case questions were tackled. This kind of activity helps the learners to analyze, link and apply the knowledge they have in problem-solving but not enough to reach the "Proficiency" and "Advanced" level since they were inconsistent in tracking their actions while doing the learning activities.

In terms of evaluation, the majority of the students who are exposed to just-in-time teaching achieved the "Proficient" level compared to case-based teaching reached "Approaching Proficient" only. This demonstrates that this group was able to assess their knowledge, learning objectives, learning strategies for creating concepts, and reflective assessment during the thinking and learning process, it has been observed when the groups presented their output or end product (e.g. simple lamp using batteries; posters showing safety precautions and a design of a unique electromagnet model). They shared their experiences, learnings, and realizations on how well did they do, what they did learn, did they get the results they expected, and what could have they done differently during the development of their learning task. Through this, the students learned how to evaluate because they can figure out which learning strategies work best, how to use them, and how to respect themselves after learning or finishing an assignment. Likewise, learners in case-based teaching shared their learning experiences, challenges, impressions but still some student in this group were not fully learned how to adjust the result of an evaluation which is why they reach only the "Approaching Proficient" level.

3. The Test of Difference in the Pre-test and Post-test Scores of Respondent

Table 3
Test of Difference in the Pre-Test and Post-Test Scores of Students Under Case-based Teaching

Case-based Teaching	Pretest		Posttest		T	df	Sig. (2-tailed)
	M	SD	M	SD			
Planning	5.23	2.76	7.73	2.55	-7.626	29	.000
Monitoring	4.43	2.70	7.30	3.09	-8.939	29	.000
Evaluating	3.93	2.75	6.77	2.96	-7.754	29	.000
Total	13.60	6.98	21.80	6.60	-19.962	29	.000

Table 3 shows the test of difference in the pre-test and post-test scores as to the metacognitive skills of the students exposed to project-based learning strategies through case-based teaching.

The table reveals that there is a significant difference in the pre-test and post-test scores of students in terms of planning, monitoring, and evaluating. This implies that project-based learning strategies through case-based teaching improved students' metacognitive skills in Science.

It has been observed in case-based teaching that learners showcased active participation in the discussion during the courtroom session. They were able to answer the case questions, play a role found in the case and understand the points of view of the stakeholders involved. They enjoyed the role-playing. Additionally, because of the variety of performance tasks provided, they have developed a better understanding of how to design, monitor, and evaluate their learning experiences. Significant changes in

their metacognitive skills were observed such as being able to synthesize, evaluate and apply the information and concepts learned in the process of problem-solving.

According to the Center for Teaching and Learning (2022) cased-based teaching/case method (which links theory to practice) encourages the development of metacognitive skills as students apply their knowledge of the course material, consider what they have learned, and consider how they are analyzing and making sense of the case.

Table 4
Test of Difference in the Pre-Test and Post-Test Scores of Students Under Just-In-Time Teaching

Just-In-Time Teaching	Pretest		Posttest		T	df	Sig. (2-tailed)
	M	SD	M	SD			
Planning	4.93	2.70	8.10	2.43	-8.18676	29	0.000
Monitoring	4.40	2.61	7.93	3.45	-8.46809	29	0.000
Evaluating	4.53	2.78	7.80	3.39	-8.14718	29	0.000
Total	13.87	7.22	23.83	7.63	-20.9466	29	0.000

Table 4 shows the test of difference in the pre-test and post-test scores as to the metacognitive skills of the students exposed to project-based learning strategies through just-in-time teaching.

The table reveals that there is a significant difference in the pre-test and post-test scores of students in terms of planning, monitoring, and evaluating. This implies that project-based learning strategies through just-in-time teaching resulted in enhanced metacognitive skills in Science.

In the Just-In-Time-Teaching, it was observed that learners were enabled to appreciate and develop a genuine interest in the topic. They came to class more prepared since they can complete their warm-up activities. Students recognized that their effort outside of class had a significant impact on what transpired in class, which was therefore geared toward solving their most pressing learning obstacles. The experiment and the learning task help them to be more skilled in planning, monitoring, and evaluating. They confidently shared their learning experiences and were not reluctant to spill how much they learn. Upon more exposure to this strategy, noticeable changes in the practices of their metacognitive thinking occur such as being able to understand what they know and what they don't know, the gap between them, and how to connect the dots.

According to Llanos et al, (2021), JITT develops cognitive and metacognitive skills in students because it is used to assess prior knowledge and/or eliminate misconceptions by linking students' work before, during, and after a lecture, and it encourages students to engage in continuous and autonomous work, which increases their interest and satisfaction.

The students' metacognitive skills are empowered as a result of the implementation of project-based learning strategies, which trained them to be independent learners in the planning of the project, responsible for the implementation of the project, and responsible for reporting the results/products obtained. The students' metacognitive skills were improved as a direct result of their participation in the project-based learning methodologies. These skills help students become more independent, plan effectively, take responsibility for their actions, and evaluate the outcomes of their work. The students' metacognitive abilities are refined and improved as a result of this activity. This is because the technique of project-based learning emphasizes the actions of the students as well as their cognitive constructivism.

Rumahlatu and Sangur (2019) conducted a study on this subject and came to the conclusion that implementing a project-based learning strategy can aid students in developing their metacognitive skills, as well as their capacity to comprehend new concepts and remember biodiversity-related information. This is demonstrated by the variations in the notation, which imply that project-based learning can greatly increase metacognitive skills, concepts, and retention when compared to conventional learning, which is carried out by the instructor.

4. Test of Difference on the Mean Pre-test and Post-test Scores of the Two Groups

Table 5
Test of Difference between the Mean Pre-Test Scores of the Two Groups of Students Exposed to Project-Based Learning Strategies

	Case-based		Just-In-Time		T	df	Sig. (2-tailed)
	M	SD	M	SD			
Planning	5.23	2.76	4.93	2.70	.425	58	.672
Monitoring	4.43	2.70	4.40	2.61	.049	58	.961
Evaluating	3.93	2.75	4.53	2.78	-.841	58	.404
Over-all	13.60	6.98	13.87	7.22	-.145	58	.885

Table 5 shows the test difference between the pre-test scores of the students as to their metacognitive skills after exposure to project-based learning strategies through case-based teaching and just-in-time teaching.

Based on the table, results revealed that there was no significant difference between the pre-test scores of the two groups of students as to their metacognitive skills in terms of planning *(p=0.672),* monitoring *(p= 0.961),* and evaluating *(p=0.404).* This implies that before the conduct of the study, the two groups of students have the same level of ability to answer the given metacognitive question.

Maybe they have insufficient knowledge about topics such as open and closed circuits, series and parallel circuits, and electromagnetism since we were in the spiral curriculum. It was supported by table 1 which revealed that most of the students from the two groups obtained scores from the pre-test which fall under the "Beginning" and "Developing" level.

It is noted during the actual conduct of the pre-test, the majority of the students from the two groups found it hard to answer the metacognitive test. They answered the pre-test more than the allotted time. It was noticed that they were not acquainted with how the metacognitive test was constructed since it has five choices as well as not the same as the summative test or periodical test they usually encountered which assess only factual knowledge. They appeared to be unfamiliar with many scientific terms or vocabulary mentioned about the topic. Some raised questions on what was the meaning of the terminologies used in the sentence and even requested them to translate it in Filipino to understand it.

Table 6
Test of Difference between the Mean Post-Test Scores of the Two Groups of Students Exposed to Project-Based Learning Strategies

	Case-based		Just-in-time		T	Df	Sig. (2-tailed)
	M	SD	M	SD			
Planning	7.73	2.55	8.10	2.43	-.571	58	.570
Monitoring	7.30	3.09	7.93	3.45	-.749	58	.457
Evaluating	6.77	2.96	7.80	3.39	-1.259	58	.213
Total	21.80	6.60	23.83	7.63	-1.104	58	.274

Table 6 shows the test difference between the post-test scores of the students as to their metacognitive skills after exposure to project-based learning strategies through case-based teaching and just-in-time teaching.

Based on the table, results revealed that there was no significant difference between the post-test scores of the two groups of students as to their metacognitive skills in terms of planning *(p=0.570)*, monitoring *(p=0.457*), and evaluating *(p=0.213)*. This means that case-based teaching and just-in-time teaching were both strategies that can enhance metacognitive skills.

Though the mean of just-in-time teaching in metacognitive skills in terms of planning, monitoring, and evaluating is higher than case-based teaching, the difference in the mean was not enough to significantly improve the metacognitive skills of this group the other.

Nonetheless, different strategies were applied but the assimilation activities in the lesson exemplar were the same. Students of the two groups both created simple lamps, made posters showing safety precautions when using electricity, and designed unique electromagnet models. During this phase, students' metacognitive skills were developed since it was observed that they learned how to plan and select more appropriate strategies for their projects, monitor the process of their learning, and analyze and reflect on the effectiveness of their used strategies in making their output.

In the introduction phase, both strategies have priming activities. This may also be the reason of their indifference. There were warm-up questions at JIIT that students had to answer outside of class. Some of them were open-ended questions about circuits, while others were true or false questions about the lesson. Learners were asked to read the preview materials or look for answers on the Internet as part of this activity. From their answers, the teacher was able to figure out which ideas were not clear. McGee, Stokes, and Nadolsky (2016) wrote in their paper that students are strongly affected by what they already know about the subject. When they are wrong, they often don't realize it, and their beliefs get in the way of their ability to learn new things. Experiments in education have shown that for teaching to be effective, these pre-existing misunderstandings need to be actively brought up and fixed. So, asked students what they don't understand or what is not clear/ is not enough. The purpose of the warm-up questions is to get this information. Moreover, in Case-based Teaching, there was brainstorming which helped the learners to think about the information or ideas associated with the given central concept (e.g. circuit), unlocking of difficulties for a difficult lesson which provided a scaffold to the learners, and completing the KWL chart which asked about the things they know and they want to know about electricity and magnetism and writing their learnings after going through the lesson.

The student grasps the subject through active learning and stimulating activities. Learners kept track of their progress and digested and accommodated their information through a meaningful learning process. Metacognitive skills are created when learners reflect on their learning and construct meaningful knowledge. According to Muhlisin et al., (2018), metacognition occurs in the usage of prior knowledge to plan strategies to do tasks, take the necessary steps to solve the problem and reflect and evaluate the outcome.

The similarity in the context of the lesson plan as shown above could be a contributing factor to the result of the study.

Conclusions

Based on the findings the following conclusion was drawn.

1. There is significant difference between the pre-test scores and the post-test scores of the two groups of students exposed to different project-based learning strategies in terms of planning, monitoring, and evaluating. Thus, the null hypothesis postulated in the study was not sustained.
2. There was no significant difference in the pre-test and the post-test scores between the two groups of respondents exposed to case-based teaching and just-in-time teaching. Thus, the null hypothesis postulated in the study was sustained.
3. Case-based teaching and just-in-time teaching are both excellent ways for strengthening metacognitive skills within the context of project-based learning.

Recommendations

Based on the findings and conclusion, the researcher formulates the following recommendations:

1. Teachers may consider using project-based learning strategies in teaching Science for it promotes the enhancement of students' metacognitive skills.
2. Teachers may explore the use of project-based learning strategies to other subjects or fields of discipline to determine their effectiveness in other areas.
3. Future researchers may explore a similar study on project-based learning strategies but not limited to case-based teaching and just-in-time teaching.
4. School heads and school administrators are may support and implement Project-Based Learning Strategies in their respective schools to enhance and improve the student's metacognitive skills.

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