

The Development of Grade 8 Student Analytical Thinking and Learning Achievement Using the Integrated Problem-Based Learning and Think-Pair-Share Technique

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Abstract

The purposes of the current study include (1) to examine the effect of integrated problem-based learning and Think-Pair-Share technique on the development of grade 8 students' analytical thinking and (2) to examine the effect of integrated problem-based learning and Think-Pair-Share technique on the development of grade 8 students' science learning achievement. The participants were 42 students in a school in Thailand. The purposive sampling method was employed. The instruments include a learning management plan of force and movement, analytical thinking test, and a learning achievement test. The data were analyzed using percentages, mean scores, standard deviation, and a paired samples t-test. The results of the study could be concluded that the integration of problem-based

learning and Think-Pair-Share collaborative learning strategies was beneficial in both developing processes of thinking and improving students' knowledge of class contents. The results of the study could also illustrate how learners gained benefits from the integrated methods and imply how they should be useful in the pedagogical and academic setting.

Keywords: Problem-based learning, Think-Pair-Share, Analytical thinking

1. Introduction

Analytical thinking skill is one of the important skills in 21st-century learning. Knowing how to analyze data is crucial in information processing. It helps learners to differentiate between what could be useful in their learning processes and a set of data that is not beneficial (Elder & Paul, 2019). This skill is demanded in science classrooms where learners need to evaluate the information in all processes of learning. Students with greater analytical skills could set appropriate hypotheses, employ systematic experimental methods, and draw a clear conclusion using scientific evidence (Santos, 2019). Therefore, it is not a surprise that students with effective analytical thinking tend to have greater learning achievement in science classes.

However, analytical thinking is not simply established as it takes factors to develop the skill in school students. Budsankom et al. (2015) suggested that the classroom environment and psychological and intellectual characteristics of students are factors affecting students' high order thinking skills. Therefore, it takes both teacher and student's readiness to establish a science class with an analytical learning environment. To simplify, teachers should provide a learning environment that supports the development of analytical thinking skills. At the same time, students should also practice themselves to sharpen their analytical minds.

At a contextual level, analytical thinking is one of the crucial educational problems in developing countries. For example, Aksornkan (2019) claimed that Thai students have serious problems in developing analytical thinking, and it affected their learning as a whole. The author suggested that the teaching method that focused on lecturing and memorizing and the learning culture that perceived questioning as a class disobedient manner were the main causes of the failure in developing analytical thinking in the country. This also affects the quality of the whole education system as Thailand was in the bottom half rank in the PISA test (Unicef, 2014).

As mentioned classroom environment plays a great role in developing students' analytical skills. A class should provide activities that encourage the processes of systematic thinking. At this point, problem-based learning (PBL) was introduced as an approach that could help students develop their systematic approach to processing information (Barrel, 2007). Egel (1991) described the characteristics of PBL to be cumulative, integrated, progressive, and consistent. In detail, a class with a PBL approach repeatedly reintroduces material at increasing depth, applies inter-disciplinary learning, encourages learners to develop themselves, and focuses on a clear goal. In this approach, students can develop their analytical thinking by hierarchically learning from various materials from an integrated field that provides opportunities to ask questions and analytically process input to provide answers.

Moreover, the processes of PBL can also be improved by the integration of collaborative learning. In detail, in a PBL class, students are usually asked to provide answers to the questions using systematic thinking. In this case, Think-pair-share, a collaborative learning strategy could be used to encourage students to share their ideas with the class or a partner. This would maximize participation, focus attention, and engage students in comprehending class content Kagan (1991). According to Nasr (2003), Think-Pair-Share is one of the collaborative learning techniques that could bring about students' active learning behaviors which is beneficial for the development of analytical thinking.

Therefore, problem-based learning was integrated with Think-Pair-Share techniques in this study to help learners in a science class develop their analytical skills and learning achievement. With the nature of PBL that encourages questioning and systematical thinking and the collaborative learning that focuses on idea sharing, students should gain benefits in both the improvement of thinking processes and the comprehension of class content. The purposes of the study include 1) to examine the effect of integrated problem-based learning and Think-Pair-Share technique on the development of grade 8 students' analytical thinking, and 2) to examine the effect of integrated problem-based learning and Think-Pair-Share technique on the development of grade 8 students' science learning achievement.

2. Literature Review

2.1 Analytical Thinking Skills and Science Classes

According to Bloom's (1956) Taxonomy of information processing, analysis is placed in the top three along with synthesis and evaluation of the hierarchy. This could be implied that a student with a better process of thinking could analyze the information, synthesize, and evaluate it before taking any actions. It could be claimed that analytical thinking skills consist of the characteristics of data analysis, synthesis, and evaluation (Kennedy et al., 1991). Moreover, analytical thinking could be illustrated by the processes a person deal with information and situation. For example, a person with analytical thinking skills should be able to analyze arguments, claims, and evidence by making inferences using inductive or deductive reasoning to evaluate them and use them in making decisions to solve problems (Choowong & Worapun, 2021; Ennis, 1985; Facione, 1990; Willingham, 2007). Art-in (2017) presented 3 dimensions of analysis of elements, analysis of relationships, and analysis of organizational principles to describe analytical thinking. To explain, learners should develop skills such as recognizing unstated assumptions, distinguishing facts from hypotheses, comprehending the interrelationships among the ideas, detecting logical fallacies in arguments, and recognizing the point of view or bias of a teacher in a historical account, etc. These skills are important in science studies as students need to learn to set hypotheses, evaluate data to utilize appropriate experimental elements, systematically analyze and synthesize results of the experiments, and logically present and evaluate them.

2.2 Problem-Based Learning and the Development of Analytical Thinking

The development of analytical thinking needs a learning environment that supports information processing and analytical cognitive processes in selecting actions that could

respond to the problems effectively. According to Egel (1991), Problem-based learning can be described as cumulative, integrated, progressive, and consistent learning. In detail, learners would encounter reintroduced material at increasing depth in interdisciplinary contexts to let them take control of their learning to develop both processes and outcomes of learning. The problems need to be understood in terms of their underlying theoretical explanations. Students can garner understanding by discussing the problem with their fellow students and proposing possible explanations or solutions during the so-called tutorial meetings. Newman (2005) introduced 5 core principles of the Problem-based learning (PBL) curriculum including student centralization, explicit facilitation, problem-based instruction, collaborative learning, and systematical evaluation. To simplify, a course with PBL should change teachers' roles from lecturers to facilitators and encourage explicit facilitation methods. Problems should be introduced to start a discussion among students in small groups, and evaluation should be both on processes and outcomes of learning. This should allow students to self-practice analyzing data in the processes of problem-solving and develop their analytical thinking skills.

2.3 Think-Pair-Share Techniques

Think-Pair-Share is one of the collaborative learning strategies used in classes to encourage interaction between students. According to Robertson (2006), 3 stages are important for the strategy. First, teachers could provoke students to *think* using a question, prompt, or observation. The students should be given time and opportunities to consider factors and the possibility of the answers to the question. Secondly, students can be paired as a partner. The *Pair* discuss the answer each came up with. They compare their replies and choose the most reasonable answers. Lastly, the pairs *share* their answers with the class. At this point, they could learn both from their partner and their classmates. Kagan (2001) claimed that the interaction between partners and peers could trigger analytical thinking. However, teachers should take the role of a facilitator who makes sure that all students in the class are thinking and sharing their ideas.

2.4 Previous Studies

Due to the importance of analytical thinking in the science classroom and the potential of PBL in the development of skills, studies (Akçay, 2009; Birgili, 2015; Kong et al., 2014; Perdana & Isrokatun, 2019; Perdana et al., 2020; Raiyn & Tilchin, 2015) have been conducted to prove the effects of the instructional method on the development of analytical thinking and other high order thinking skills such as critical thinking and evaluation skills. For example, Perdana et al. (2020) applied the PBL to develop analytical thinking skills and scientific argumentation of 28 grade 11 students in Indonesia. The study confirmed the effectiveness of PBL on both processes of thinking and scientific argumentation as the class outcomes. Moreover, the Think-Pair-Share has also been applied in science classes to stimulate class interaction and develop students' cognitive processing behaviors. For example, Ahmed (2016) found that the TPS positively affected students' science knowledge retention. In addition, TPS was also found to encourage participation in classes (Mundelsee & Jurkowski, 2021; Worapun, 2021). It could be noted from the previous studies that both

PBL and TPS seem to be beneficial in science classes where information processing and systematical thinking are encouraged. Furthermore, the processes of the two methods can be integrated as they emphasize student-center and collaborative learning. Therefore, the current study aims to apply PBL and TPS to develop learners' analytical thinking and learning achievement in a science classroom. The research questions are (1) What are the effect of integrated problem-based learning and Think-Pair-Share technique on the development of grade 8 students' analytical thinking? and (2) What are the effects of integrated problem-based learning and Think-Pair-Share technique on the development of grade 8 students' science learning achievement?

3. Methodology

3.1 Participants

The participants were 42 students in a school in Thailand. The purposive sampling method was employed. The participants were in Mathayomsuksa 2 (grade 8) and took a general science class. The focus of the class was on force and movement topic. All participants were treated anonymously.

3.2 Instruments

The research instruments include a learning management plan of force and movement, analytical thinking tests, and a learning achievement test. In detail, the learning management plan was designed using the integration of problem-based learning and the Think-Pair-Share method. The management plan includes 9 lesson plans taking 13 hours in class. The analytical thinking test consists of 15 multiple choice question items. The learning achievement test consists of 20 multiple choice question items.

3.3 Data Analysis

The data were analyzed using percentages of the students' average scores and standard deviation of pretests and posttests in both analytical thinking skills and learning achievement. Since the students were assessed using the homogenous tests before and after the treatment, a paired sample t-test was assigned.

4. Results

Table 1. The effectiveness of the integrated problem-based learning (PBL) and Think-Pair-Share (TPS) learning management on the participants' analytical thinking

Analytical thinking	N	\bar{X}	S.D.	t	P
Pre-test	42	6.92	1.85	-16.664	0.00*
Pos-test	42	12.19	1.58		

Note. * $P < 0.05$.

The result of the study indicates that the learning management designed using the integrated problem-based learning (PBL) and Think-Pair-Share (TPS) technique positively affected students' analytical thinking. A paired t-test shows that the participants' performance after using the learning management ($\bar{x} = 12.19$, S.D. = 1.58) was significantly higher than before the treatment ($\bar{x} = 6.92$, S.D. = 1.85). $t = -16.664$, $p = 0.00$, it could be interpreted that learning was beneficial in the development of students' analytical thinking.

Table 2. The effectiveness of the integrated problem-based learning (PBL) and Think-Pair-Share (TPS) learning management on the participants' learning achievement

Learning achievement	N	\bar{X}	S.D.	t	P
Pre-test	42	9.33	2.51	-14.314	0.00*
Pos-test	42	15.69	2.62		

Note. * $P < 0.05$.

The result of the study indicates that the learning management designed using the integrated problem-based learning (PBL) and Think-Pair-Share (TPS) technique also positively affected students' learning achievement. A paired t-test shows that the participants' performance after using the learning management ($\bar{x} = 15.69$, S.D. = 2.62) was significantly higher than before the treatment ($\bar{x} = 9.33$, S.D. = 2.51), $t = -16.664$, $p = 0.00$, it could be interpreted that the participants comprehend the course content of force and movement learning with the integrated problem-based learning (PBL) and Think-Pair-Share (TPS) technique.

5. Discussion

The results of the study indicate that integrated problem-based learning (PBL) and Think-Pair-Share (TPS) learning management was beneficial in developing participants' analytical thinking and learning achievement. The results of the study lead to the issues discussed below.

It could be seen that the integration of PBL and TPS positively affected students' processes of thinking and comprehension of the class content. The results add more evidence to the benefits of both methods in science classrooms. The results of the study were related to Akçay (2009) who pointed out the benefit of PBL in science education. In the current study, PBL successfully helped students to comprehend the content of force and movement in the General Science subject. The results of the study also joined the other studies that supported the effectiveness of the PBL and TPS (Ahmed, 2016; Birgili, 2015; Kong et al., 2014; Mundelsee & Jurkowski, 2021; Perdana & Isrokatun, 2019; Perdana et al., 2020; Raiyn & Tilchin, 2015; Thangjai & Worapun, 2022).

Therefore, the results also confirm the principle of PBL as using problems as a starting point for class discussions led to the continuous practice of thinking and eventually a higher quality

of thinking process. In this study, students could develop their analytical thinking because learning in a problem-based curriculum encourages them systematically process information to think about the possible answer to the leading questions to share with the class. This confirms Birgili (2015) who also claimed the benefits of problem-based discussion in developing high-order thinking skills.

Moreover, it is noteworthy that the processes of TPS could support PBL by increasing levels of class discussion. In this study, the students were assigned to be in pairs, and they share answers to the leading questions with their partners first and then share them with the whole class. The processes of idea exchanges encouraged them to practice thinking reasonably and logically. Therefore, the students not only process information from their knowledge but are also driven to process information in classmates' answers. The results went in line with Kagan (2001) who also supports the benefit of TPS in developing thinking processes.

Consequently, the results of the study confirm the relationship between analytical thinking and learning achievement in science subjects. According to Santos (2017), critical thinking and other high-order thinkings are important for science classes as they help learners logically evaluate data to set reasonable hypotheses, execute experiments, and present data. These processes are important in learning science, and it is not a surprise that the students in the current study could acquire learning achievement in the Force and Movement course after developing analytical thinking skills.

6. Conclusion

The current study was conducted with the idea to integrate problem-based learning and Think-Pair-Share collaborative learning strategies to develop student's analytical thinking and learning achievement. The results of the study could be concluded that the integration of problem-based learning and Think-Pair-Share collaborative learning strategies was beneficial in both developing processes of thinking and improving students' knowledge of class contents. The results of the study could also be discussed to illustrate how learners gained benefits from the integrated methods and imply how they should be useful in the pedagogical and academic setting. In terms of instructional implications, teachers could use PBL, TPS, or the integration of both methods in any science classes as they would allow the students to improve their thinking processes and eventually use them to learn scientific concepts. Moreover, educators should note that developing high-order thinking skills such as analytical thinking, critical thinking, and systematic information processing are as important as instructing the contents in science classes. Therefore, teachers should apply the instructional methods that allow their students to think. In terms of academic implications, the study encourages the integration of other collaborative learning techniques in problem-based learning. This would widen the possibility of using PBL in research in science education.

In terms of recommendations for further studies, the integration of PBL and TSP is recommended in other science concepts as it was proved to be useful in developing analytical thinking—an essential skill in science classes. Moreover, further studies might employ other collaborative learning strategies in integration with PBL and compare their effects on students' thinking skills. Furthermore, the results of the current study could be a guidance for

further studies that seek to investigate the relationship between high-order thinking skills and students' scientific learning achievement.

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