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Development of Science Learning Activities Using Inquiry-Based Learning Management to Improve the Academic Achievement of Secondary School Students

Pawanrat Sonsun[1], Chulida Hemtasin[1] & Tawan Thongsuk[1]

[1] Department of General Science, Faculty of Education and Educational Innovation, Kalasin University, Thailand

Correspondence: Chulida Hemtasin, Department of General Science, Faculty of Education and Educational Innovation, Kalasin University, Thailand.

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Abstract

The objectives of this research were as follows: (1) to develop learning activities in science and technology subjects using inquiry-based learning for seventh-grade students (12−13 years old); (2) to develop academic achievement for the topic of elements and compounds using inquiry-based learning management activities to meet the 70% requirement; and (3) to assess the satisfaction of seventh-grade students who are taught with inquiry-based learning management. The target group of this study was 24 seventh-grade students on the science and technology course. The research tools included seven inquiry-based learning management plans, an achievement test, and a satisfaction assessment. The results show that synthesizing the approach to learning management using inquiry-based learning led to the formulation of learning activities. Students had better academic achievement, with a mean score of 81.45%, which was above the 70% requirement. Students were satisfied with inquiry-based learning activities, with an average of 4.75 and a standard deviation of 0.48, which is the highest level.

Keywords: inquiry-based learning, academic achievement, science learning activity, secondary student

1. Introduction

Thailand has participated in the Programme for International Student Assessment (PISA) test since 2000. In each trial, it was found that Thailand's test results needed to be improved. According to the latest results from the Organization for Economic Co-operation and Development (OECD) (Schleicher, 2018), when looking at test scores in Asian countries, most of them scored above the OECD average. However, Thailand and Indonesia have lower standards than the OECD. In addition, a comparison of the two countries showed a higher proportion of low-achieving students with lower than basic science literacy in Thailand than in Indonesia. When comparing the average science literacy score among Thai students, the average score was 426 points (compared to the OECD average of 489 points). According to PISA 2015, it was found that science scores increased by only 4 points. Referring to statistical data, it is assumed that scientific intelligence has stayed the same compared to previous assessments. The above information reflects an urgent need for all educational institutions to solve the problem, which is a significant challenge for the country. Therefore, all teachers must be aware and work together to enhance the scientific literacy of their students.

Recently, science teaching that focuses on science achievement has not been successful. Considering the results of the Ordinary National Educational Test (O-NET) of primary school students in academic year 2021, it was found that the average test score in science subjects at the national level was 34.31%, and the average O-NET score at the Kalasin province level was 37.91%, which was still considered low. A decreasing tendency can be seen, because the average score is lower than the national average. According to the O-NET results, science subjects are at an improved level. Therefore, academic achievement in science should be developed. For these reasons, researchers apply inquiry-based learning activities to solve problems. This teaching management method is a student-centered learning process for students to practice thinking and doing, and emphasizes seeking knowledge, acting, discovering, and creating knowledge by themselves until they acquire scientific process skills.

At an individual level, students with good science knowledge can make rational decisions in daily life (Rosa et

al., 2019), pursue various fields in higher education (Castellanos Castellanos & Rios-González, 2017), and become successful in their professional life. Consequently, it has become a priority for science education to develop learners' scientific knowledge and thinking.

Over the years, researchers have included instructions in their programs for teachers to implement in science learning activities. As an example of a method proven to have outstanding results, the United States was the first to introduce a practical method to teach science in the 21st-century education curriculum. A European Commission report concluded that inquiry is an appropriate way to teach science. All science courses at the elementary level encourage teachers to practice methods such as active inquiry learning. However, science is different, because many teachers continue to teach science as they were trained at school years ago, along with traditional methods. This can be a tremendous challenge for school students (Anderman et al., 2012),

Therefore, to analyze whether the new inquiry-based learning method can positively affect children's academic performance in science, it was used in an experimental group. The results obtained from the test were compared with the results of the control group in the traditional way. The main objective of this research was to compare the integrated learning process with traditional science teaching methods in Spanish elementary schools. Secondary purposes can also be defined from the primary objective, such as determining whether students were able to follow this novel method, how to participate more in class, and whether students in the experimental group were more motivated to continue the lessons, and then to determine how the method was integrated into the child's learning process.

According to previous studies on inquiry-based learning management, there was a failure to develop academic achievement, as seen from the PISA scores of 2018. However, the scores had increased from 2015, but still needed to pass the requirement. This is also consistent with O-NET, which still must pass the set criteria. For the reasons mentioned above, this led to the design and development of learning activities to improve student achievement by using an inquiry-based learning model to create a learning atmosphere, resulting in students being able to understand the science content and taking practical action, which resulted in higher academic achievement in science subjects and proved to be beneficial in science classes in several studies (Ahmad et al., 2018; Bantaokul & Polyiem, 2022; Choowong & Worapun, 2021; Manzo et al., 2016; Ong et al., 2018; Sen & Oskay, 2016; Thangjai & Worapun, 2022). The results of the previous studies suggest that the 5E teaching model benefitted science classrooms in terms of developing students' knowledge of general science (Ahmad et al., 2018), the world and changes (Bantaokul & Polyiem, 2022), light and image (Choowong & Worapun, 2021), and neuroscience and drug addiction (Manzo et al., 2016). It could be determined from the related studies that the 5E helped to improve teachers' approach to teaching in order to meet the expectations of the science curriculum and provided a guideline for more effective teaching and learning management.

The above priorities led to the determination of the following research objectives:

1) To develop a five-step inquiry-based learning management activity in science and technology subjects for students in seventh grade.

2) To develop achievement in the topics of elements and compounds using five-step inquiry-based learning to meet the criterion of 70%.

3) To assess seventh-grade students' satisfaction with learning management using five-step inquiry-based learning.

2. Method

This type I developmental research model (Richey & Klein, 2007) includes three phases, as follows.

2.1 Research Methodology

Phase 1: Design process

1) Study current learning management problems, organize scientific learning activities, and develop five-stage inquiry-based learning management activities.

2) Design five-step inquiry-based learning activities.

3) Use the data obtained from the study of educational achievement problems to create and develop a learning management plan and tools to collect data. These will be examined by three experts.

Phase 2: Development process

1) Test the five-step inquiry-based learning management with an experimental group using seven plans.

2) Use the test to measure academic achievement.

Phase 3: Evaluation process

Organize the five-step inquiry-based learning management activities after using the official achievement test. Students are encouraged to complete an inquiry-based learning satisfaction assessment.

2.2 Samples

Phase 1 involved secondary school teachers, students, and a literature review.

Phase 2 involved (1) three experts: a content expert, a teaching expert, and a measurement and evaluation expert; and (2) 26 students in grade 7/2, semester 1, of academic year 2022, who were selected by purposive sampling.

Phase 3 involved 24 students in grade 7/1 in academic year 2022 who did not pass the science achievement test with a minimum 70% score.

2.3 Research Tools

The tools used in this experiment were as follows:

(1) Five-step inquiry-based learning plans. Unit 3: Elements and Compounds, with seven plans over 17 hours.

Plan 1: Elemental Classification and Utilization, 3 hours.

Plan 2: Boiling Points of Pure Substances and Mixtures, 2 hours.

Plan 3: Density of Pure Substances and Mixtures, 3 hours.

Plan 4: Classification and Composition of Pure Substances, 2 hours.

Plan 5: Classification and Composition of Pure Substances, 1 hour.

Plan 6: Atomic Structure, 3 hours.

Plan 7: Properties of Pure Substances, 3 hours.

It has an average of 4.50, and the suitability is very reasonable. The standard deviation is 0.41, with a consistency index of 0.5–1.00.

(2) A multiple-choice achievement test with 20 items, with conformity index determination equal to 0.80–1.00 with difficulty (P) of 0.38–0.78, classification power (R) of 0.33–0.92, and confidence value equal to 0.90, or 90%.

(3) A satisfaction questionnaire with 10 items, rated on a five-point Likert scale, with a consistency index of 0.5–1.00.

2.4 Data Collection

The data collection process was as follows:

(1) Use the official achievement test for experimental student groups.

(2) Conduct science learning activities with students using the five-step inquiry-based learning model according to learning management plans 1–7, complete all seven plans for 17 hours, collect scores after classes, and analyze the data.

(3) Conduct science learning activities with targeted students using the five-step inquiry-based learning model according to learning management plans 1–7, and complete all seven plans for 17 hours, with post-test scores.

(4) Administer satisfaction questionnaires, then collect and analyze the data.

2.5 Data Analysis

(1) The appropriateness of the learning management plan was analyzed using average and standard deviation, then the results were interpreted.

(2) The data from the achievement test after the learning activity were analyzed by finding the average, standard deviation, and the percentage of learners with scores above 70%. Scores below 70% did not meet the criteria.

(3) Student satisfaction was analyzed by average and standard deviation, and the average was interpreted in terms of five levels of satisfaction: 4.50 or more indicates very satisfied, 3.50–4.49 is satisfied, 2.50–3.49 is neutral, 1.50–2.49 is not satisfied, and below 1.50 is very unsatisfied (Harpe, 2015).

3. Results

Five-step inquiry-based learning management activities in science and technology courses for students in grade 7 were developed. A comparison between the teaching and learning activities of the school and the researchers is

presented in Table 1.

Table 1. Five-step inquiry-based learning activities (5E)

Teaching procedure	Description	Teaching methods		Instructor role
		Designed by school	Designed by researchers	
Step 1: Engagement	Instructors should generate interest and pose questions, encouraging learners to think and drawing out answers while covering relevant concepts or content	Introduction to lesson by activity, lecture, and study content.	Teacher becomes a storyteller by bringing subjects of interest to students and encouraging them to ask questions. Learners will remember what the person did, where in line with the theory of learning (Bloom et al., 1956)	Teacher acts as a facilitator and coach.
Step 2: Exploration	Encourage learners to collaborate, explore, and investigate. Observe and listen to interactions between learners. Conduct debriefing for student survey, give them time to think about questions and problems, and provide counseling.	Students make worksheets.	Use experimental activities to build knowledge for learners and group quiz competitions to review knowledge gained. Consistent with the theory of learning (Bloom et al., 1956).	Teacher acts as a facilitator, co-learner, and mentor.
Step 3: Explanation	Instructor encourages learners to explain concepts or give definitions in their own words, allowing them to provide evidence and reasons, and to describe, define, and point out parts in diagrams and use previous experience as the basis for explaining concepts.	Students make worksheet, and teacher explains conclusions of the material.	Students analyze data obtained from experiments and interpret the results. Students allowed to come to conclusions, such as through maps, drawing, and telling stories, for use in their daily lives. Consistent with the theory of learning (Bloom et al., 1956)	Teacher acts as facilitator, co-learner, and mentor.
Step 4: Elaboration	Instructors expect learners to point out components in diagrams and explain what they learned. Learners encouraged to apply what they learned or expand their knowledge and skills in new situations. They are asked about what they learned or what ideas they had.	Students make worksheets to expand their knowledge.	Teacher keeps learning and plays domino activities. When a group of students finishes playing, the teacher asks what they played. Once all classes are completed, teacher will expand their knowledge to make it more transparent for better retention and understanding of content. In line with the theory of learning (Bloom et al., 1956)	Teacher acts as facilitator and co-learner.
Step 5: Evaluation	Instructors observe learners applying new concepts and skills, find evidence that they changed their minds or behaviors, have them evaluate learning and group process skills, and ask open-ended questions.	Teachers check students' worksheets.	Teachers evaluate students using quiz activities through Kahoot app. Students learn how to use the app, and will be enthusiastic about their answers. In line with the theory of learning. (Bloom et al., 1956)	Teacher acts as co-learner, facilitator, and coach.

Developing achievement by using five-step inquiry-based learning activities for seventh-grade students to meet the 70% requirement.

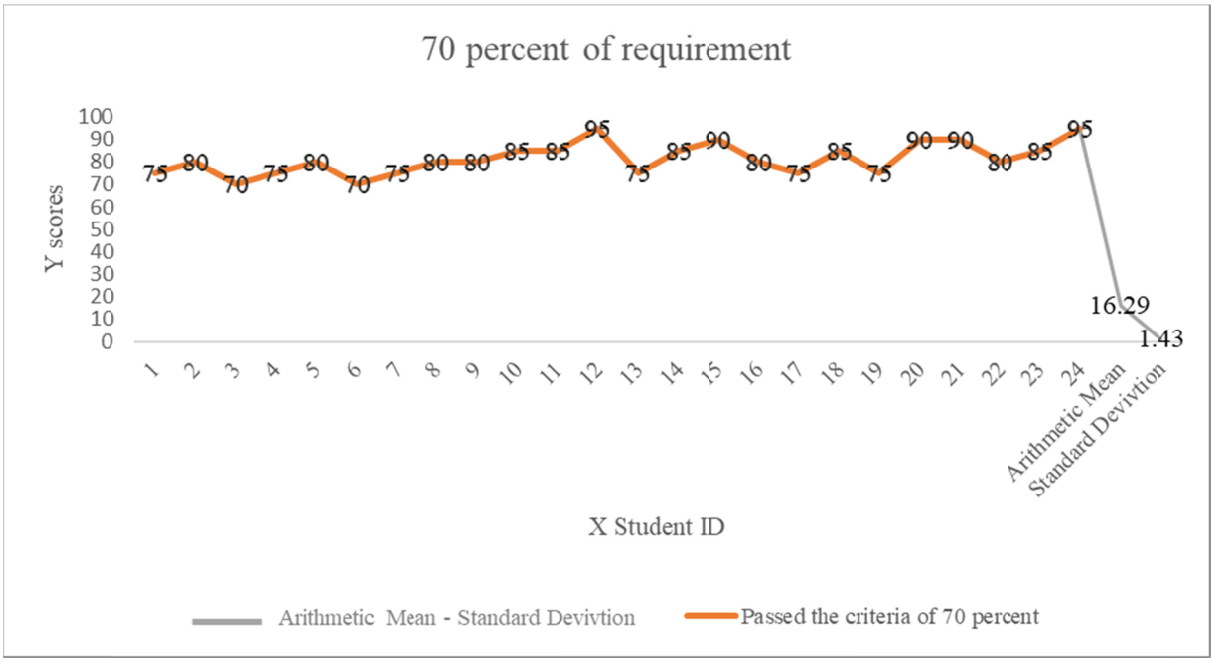

Figure 1. Results of academic achievement scores

Results of satisfaction scores on the implemented five-step inquiry-based learning management activities are shown in Table 2.

Table 2. Results of satisfaction scores.

Assessment list	Average	Standard deviation	Satisfaction level
1. Students are fully engaged in activities.	4.63	0.63	Strongly suitable
2. Teachers allow learners to participate in learning activities.	4.83	0.37	Strongly suitable
3. Students' study of various sources of knowledge is satisfied.	4.88	0.33	Strongly suitable
4. Students gain knowledge by organizing learning activities.	4.92	0.28	Strongly suitable
5. Teachers organize a variety of teaching and learning activities.	4.75	0.60	Strongly suitable
6. Teachers have an exciting way of bringing the activities into lessons.	4.54	0.71	Strongly suitable
7. Students are satisfied with the length of time the learning activity is held.	4.46	0.76	Suitably
8. Teachers use teaching materials that are appropriate to the content and help to achieve learning.	5.00	0.00	Strongly suitable
9. Students build their knowledge and understanding.	4.75	0.60	Strongly suitable
10. Students can apply their knowledge to their daily lives.	4.83	0.47	Strongly suitable
average	**4.75**	**0.48**	**Strongly suitable**

4. Discussion

The details of five-step inquiry-based learning management activities in science and technology subjects for seventh-grade students at secondary school included seven learning management plans with five learning activities (Table 1) described as follows. Step 1: Engagement. Teachers stimulate interest in storytellers by bringing stories of interest to students and encouraging them to ask questions based on what the teacher tells them. Step 2: Exploration. Use experimental activities to build knowledge for learners, along with group quiz competitions. Step 3: Explanation. Students analyze the data obtained from experiments and interpret the results of their investigations. Step 4: Elaboration. Students play domino activities. Step 5: Evaluation. Students engage in quiz activities through the Kahoot app.

Achievement of 70% on the activities was the minimum criterion. According to the results, it was found that the five-step learning management model is based on the quest for knowledge. After passing the experts and then taking the test to experiment with the sample, it turned out that the students did not meet the set criterion. For example, learners said they liked competitive activities and being grouped with their peers. Therefore, the researchers adjusted the learning management plan according to the learners' needs and tried it with the target

audience. All target groups meet the established 70% threshold using the five-step inquiry-based learning management model. This emphasizes that learners learn by doing, which allows them to learn independently. In step 1, the teacher becomes a storyteller by bringing subjects of interest to the students and providing stimulation by asking questions based on the story. Learners will remember what the person did and where. In step 2, the teacher uses experimental activities to build knowledge for learners and group quiz competitions to review the knowledge they gained in order to understand the content of the experiment.

Students analyzed the data obtained from the experiment and interpreted what they had done, asking themselves, "What is the result?" The students were allowed to come to conclusions through activities such as mapping, drawing, telling stories, etc. In step 4, the teacher plays a domino activity. When a particular group of students finishes playing, the teacher asks what they have learned. Once all the classes are completed, the teacher will expand the knowledge to make it more transparent. In step 5, teachers evaluate students using quiz activities through the Kahoot app. Students get to know how to use the app, and will be enthusiastic about their answers. As shown in Figure 1, the students developed their academic achievement.

The assessment of seventh-grade students' satisfaction with five-step inquiry-based learning activities showed an average of 4.75 and a standard deviation of 0.48, which is strongly suitable. When considering the topics of the assessment list, item 8, "teachers use teaching materials that are appropriate to the content and help to achieve learning", had the highest score, 5.00. Because researchers have a variety of teaching materials, there are more materials available, allowing people to learn more in each step.

5. Conclusion

A five-step inquiry-based learning management activity in science and technology subjects for students in grade 7 was developed. It can be seen that the design of learning activities was successful and that students had better academic achievement, meeting the criterion of 70%. The test had a mean score of 16.29 and a standard deviation of 1.43, representing 81.45%. Some of the 24 students surpassed the criterion with 100%, and the difference in test scores was between 1 and 8 points. Moreover, the satisfaction assessment found that the total satisfaction was equal to 4.75, and the standard deviation was equal to 0.48, which was the most agreeable level of satisfaction.

Recommendations

The material described above should be considered for each study lesson. Teachers should read the material and review the activities for several hours, and should learn how to choose fun and exciting activities for teenagers.

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