Research Article

A STUDY OF SCIENTIFIC ANALYTICAL THINKING AND LEARNING ACHIEVEMENT OF TENTH GRADE STUDENTS THROUGH CONTEXT-BASED LEARNING EMPHASIZING ANALYTICAL THINKING ON SOLIDS, LIQUIDS, AND GASES

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Abstract

The objectives of this research were to compare the posttest scores of students' scientific analytical thinking and learning achievement through context-based learning emphasizing analytical thinking (CBL-EAT) on solids, liquids, and gases with pretest scores and to compare the posttest scores of students' learning achievement through CBL-EAT on solids, liquids, and gases with the 70 percent criteria. The participants were 45 tenth grade students from Assumption College Sriracha who were selected randomly using the cluster random sampling technique. The research instrument consisted of 1) CBL-EAT on solids, liquids, and gases lesson plans, 2) scientific analytical thinking test, and 3) learning achievement test. The data was analyzed by the percentage, mean, standard deviation, one sample t-test, and dependent samples t-test. The results of this study indicated that:

The posttest scores of students' scientific analytical thinking and learning achievement through CBL-EAT on solids, liquids, and gases were statistically significant higher than the pretest scores of those at the .01 level and the posttest scores of students' learning achievement through CBL-EAT on solids, liquids, and gases were statistically significant higher than the 70 percent criteria at the .01 level.

Keywords: Context-based Learning, Scientific Analytical Thinking, Learning Achievement, Solids, Liquids, and Gases

Introduction

Chemistry is often called the central science because of its role in connecting the physical sciences, which include chemistry, with the life sciences and applied sciences such as medicine and engineering. The nature of this relationship is one of the main topics in the philosophy of chemistry and in scientometrics. (Brown & LeMay, 1977). Thus, learning management should be promoted and opportunities for students to learn chemistry continuously to provide students with a better understanding of chemistry should be beneficial. However, researchers found that learning management in chemistry was not as successful as it should have been. Data obtained from the report of the Ordinary National Educational Test: O-NET of twelfth grade students in the academic year 2017, it was found that Assumption College Sriracha students had an average score of 31.66 point in science, which was lower than the average score of 34.46 points (Academic Department, Assumption College Sriracha, 2017). Also, the results of the solids, liquids, and gases test in chemistry of tenth grade students in the academic year 2016 had an average score of 60 points, which was well below the 70 percent criteria. The results showed that the students' learning achievement is not satisfactory. Therefore, it should be accelerated and improved. This information showed that the learning process on solids, liquids, and gases remained a problem that should be fixed.

Moreover, analytical thinking ability is one of the components of the person that is essential, so it is a desirable feature of today's society and is an important skill for students in the 21st century as well as being one of the higher order thinking (Brookhart, 2010) that is a consciousness that must be developed while students are in school to learn content and principles. Analytical thinking is one of the most important features associated with the ability of a person to identify similarities and differences between knowledge components, to organize knowledge into meaningful categories, to recognise logic, reasonableness or accuracy of knowledge, to construct new generalizations from information that is already known or observed, and to generate new applications of a known generalization or principle. Marzano identifies five cognitive processes as analysis: matching, classifying, analyzing errors, generalizing, and specifying (Marzano & Kendall, 2007, pp.44-50).

However, Thailand participates in the Programme for International Student Assessment (PISA) conducted by the Organisation for Economic Co-operation and Development: OECD (2015) with the aim of assessment of students' knowledge and skills which encourage students to think analytically and solve problems. In 2015 the PISA survey focused on science, with reading, mathematics, and collaborative problem solving as minor considerations. The assessment results under PISA found that the mean science score in PISA 2015 of Thailand is 421, which is lower than the OECD average science scores of 493 (OECD, 2016). It reflects that Thai students have low analytical thinking skills, consistent with the results of the external evaluation of the Office for National Education Standards and Quality Assessment (ONESQA) that found in the countrywide overview of assessment of learners' ability in analytical thinking they have the lowest score (ONESQA, 2012).

In this research, the researchers are interested in the study of scientific analytical thinking, which refers to the analysis of components of events, stories, or incidents related to scientific content into subsections, and found the relationship of those, can be correctly applied within the principle leading to a conclusion.

In order to solve the problems mentioned above, teachers must find ways to train students in scientific analytical thinking and learning achievement. Kijkuakul (2012, p. 123) said that science learning management by integrating the nature of science using experiments as well as the application of science history to create interesting situations for experimentation, may be an alternative to improve students ability to learn scientific knowledge better. One of the interesting ideas is context-based learning. Context-based learning aims to increase the enthusiasm and motivation of students in learning science topics through presenting scientific concepts as a daily event (Barker, 1999). Context-based learning is a learning approach that emphasize contextual linking from the real life context to teaching, focusing on the use of situations or events. (Bennett & Holman, 2002, pp. 165-166). This is consistent with Constructivist theory. It says that constructivism is about people building “their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences” (Educational Broadcasting Corporation, 2004).

The researcher was aware of as well as seeing the importance of the problems. So, we used Gilbert's model (Gilbert, 2006), which was a simple part of constructivism based on context-based learning. The researchers developed a way to blend Gilbert's model with Marzano's analysis process which called context-based learning emphasizing analytical thinking (CBL-EAT). It consists of 4 steps:

1. Setting a focal event: The instructor offers contextual guidance so that students are aware of the need to learn. Teacher defines situations that are relevant to the students or situations in which the students are interested so that students can observe, classify, and discuss the situation with regard to where it occurred, and how. Students have to identify problems and think about solutions.

2. Learning task: At this step, students will work together in groups and communicate with other students. The aim being to study and research activities and self-activities, such activities are the

problems and solutions in the first step, going on to find answers through experimentation, problem solving, holding sub-discussions, inquiring and roleplaying. This will help students to discover new knowledge or ideas.

3. Learning key concept: Students will learn about key ideas from the activity, in this step. We should provide an opportunity for students to analyze data. Then find the relationship of the data through matching, classification, comparison of data, as well as a summary of knowledge or ideas from self-discovery to present their findings to other students. Other students share the error analysis and participate in questionable questioning. Teachers keep adding or correcting missing or misleading information so students learn the core concepts correctly.

4. Re-contextualise: This is the final step, the teacher offers contextualized searching to motivate students to apply knowledge. Teachers organize activities to encourage students to apply the knowledge or concepts involved in other situations or their application in daily life including guessing events that may occur in the future.

Research Objectives

The Objectives of the study are summarized as follows:

1. To compare the posttest scores of students' scientific analytical thinking through CBL-EAT on solids, liquids, and gases with the pretest score.
2. To compare the posttest scores of students' learning achievement through CBL-EAT on solids, liquids, and gases with the pretest score.
3. To compare the posttest scores of students' learning achievement through CBL-EAT on solids, liquids, and gases with the 70 percent criteria.

Research hypotheses

Depending on the above listed objectives the hypotheses of this study are determined as follows:

1. The posttest scores of students' scientific analytical thinking through CBL-EAT on solids, liquids, and gases are higher than the pretest score with a statistically significant difference.
2. The posttest scores of students' learning achievement through CBL-EAT on solids, liquids, and gases are higher than the pretest score with a statistically significant difference.
3. The posttest scores of students' learning achievement through CBL-EAT on solids, liquids, and gases are higher than the 70 percent criteria with a statistically significant difference.

Research Methodology

The design of the study is quantitative methods. We collected quantitative data by using the scientific analytical thinking test and learning achievement test. A quasi-experimental research design with one-group pretest-posttest (Cohen, Manion, & Morrison, 2007) was used in this study, as illustrated in Table 1. The students in the experimental group were taught using CBL-EAT.

Table 1 One-group pretest-posttest design

Group	Pretest	Treatment	Posttest
Experimental	O_1	X	O_2

Note: O_1 = pretest, O_2 = posttest, and X = CBL-EAT

Participants

The participants of the study consisted of a class of 45 tenth grade students who were studying in the second semester of the academic year 2017 in Assumption College Sriracha who were selected randomly using the cluster random sampling technique.

Conceptual Framework

From the literature review of context-based learning, analytical thinking, and learning achievement, the conceptual framework of this research was developed to blend the context-based learning models of Gilbert's model with Marzano's analysis process, based on relevant ideas, theories, and studies as shown in Figure 1.

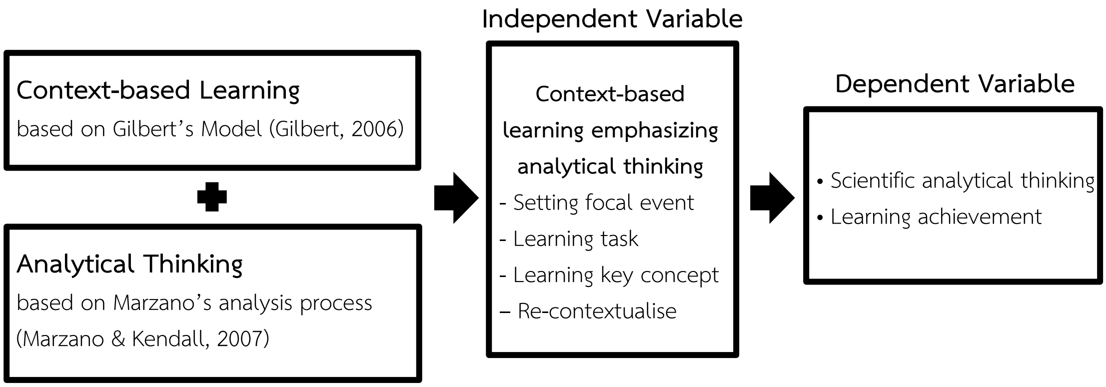

Figure 1 Conceptual framework

Research Instruments

In this study, there are three research instruments which are CBL-EAT on solids, liquids, and gases lesson plans, scientific analytical thinking test, and learning achievement test. All instruments were developed by researchers and 5 experts in science education, education measurement and evaluation, chemistry, and science teaching.

The CBL-EAT on solids, liquids, and gases lesson plans consists of 8 plans, with Index Item Objective Appropriation (IOA) of all components in every lesson plan between 3.80 and 5.00. The lesson plans were piloted with tenth grade students that were non-experimental groups in Assumption College Sriracha. Then modifications were made in terms of language and design of the activities.

The scientific analytical thinking test was measured using four multiple choice questions developed by considering the related Marzano's analysis process. The test was composed of 25 items, with an Index of an Item-Objective Congruence (IOC) between 0.60 and 1.00, an item difficulty (p) index between 0.40 and 0.74, and a discrimination index (d) between 0.35 and 0.80 respectively. The reliability of the test calculated by the Kuder-Richardson formula 20 (KR-20) was 0.939.

The learning achievement test was measured using four multiple choice questions developed by considering the related Klopfer's Taxonomy. The test was composed of 45 items, with an Index of an Item-Objective Congruence (IOC) of all items between 0.60 and 1.00, an item difficulty (p) index between 0.22 and 0.68, and a B-index (B) between 0.24 and 0.86 respectively. The reliability of the test calculated by the Lovett Method was 0.968.

Data analysis

In this research, we used the scores obtained from the scientific analytical thinking test and learning achievement test. Scores were compared with each other using a t-test. The data analysis obtained from the application was done using a computer program which was used for analyzing the data.

Research Finding

In presenting the results of data analysis, the researchers divided the analysis into three parts as follow:

Part 1: A Comparison between pretest and posttest mean score of scientific analytical thinking.

Analysis of the differences of the mean scores of scientific analytical thinking showed that the students' scientific analytical thinking posttest mean scores ($\bar{X}$ = 19.84, SD = 2.35) were higher than pretest mean scores ($\bar{X}$ = 6.02, SD = 3.33) at a statistically significant level .01 as detailed in Table 2.

Table 2 Analysis of the difference of the average scores of scientific analytical thinking (Pretest and posttest)

Analysis process	Test	n	X	$\bar{X}$	SD	df	t	p
Matching	Pretest	45	5	1.29	1.10	44	15.954**	0.000
	Posttest	45	5	4.27	0.72			
Classify	Pretest	45	5	1.24	1.05	44	13.942**	0.000
	Posttest	45	5	3.93	0.86			
Error analysis	Pretest	45	5	1.18	1.11	44	9.964**	0.000
	Posttest	45	5	3.36	1.05			
Generalizing	Pretest	45	5	1.16	0.98	44	16.968**	0.000
	Posttest	45	5	4.13	0.82			
Specifying	Pretest	45	5	1.13	1.10	44	15.401**	0.000
	Posttest	45	5	4.22	0.80			
Total	**Pretest**	**45**	**25**	**6.02**	**3.33**	**44**	**22.214****	**0.000**
	Posttest	**45**	**25**	**19.84**	**2.35**			

**p<.01

Based on the Table 2, students' scientific analytical thinking increased from pretest to posttest. In all components, scientific analytical thinking posttest scores were statistically significant higher than the pretest scores at the .01 level. Thus, we found that we successfully used CBL-EAT on solids, liquids, and gases to develop students' scientific analytical thinking in all components.

Part 2: A Comparison between pretest and posttest mean score of learning achievement.

Analysis of the differences of the mean scores of learning achievement showed that the students' learning achievement posttest mean scores ($\bar{X}$ = 36.13, SD = 2.89) were higher than pretest mean scores ($\bar{X}$ = 11.76, SD = 3.96) at a statistically significant level .01 as detailed in Table 3.

Table 3 Analysis of the difference of the mean scores of learning achievement (Pretest and posttest): consideration of each item

Learning achievement	Test	n	X	$\bar{X}$	SD	df	t	p
Knowledge	Pretest	45	10	2.87	1.39	44	17.245**	0.000
	Posttest	45	10	7.22	0.90			
Comprehension	Pretest	45	12	3.09	1.49	44	23.067**	0.000
	Posttest	45	12	9.07	1.03			
Science Process Skill	Pretest	45	13	3.13	1.78	44	27.624**	0.000
	Posttest	45	13	11.18	1.07			
Application	Pretest	45	10	2.51	1.53	44	18.854**	0.000
	Posttest	45	10	7.24	0.91			
Total	**Pretest**	**45**	**45**	**11.76**	**3.96**	**44**	**33.790****	**0.000**
	Posttest	**45**	**45**	**36.13**	**2.89**			

**p<.01

Based on the Table 3, students' learning achievement increased from pretest to posttest. In all components, learning achievement posttest scores were statistically significant higher than the pretest scores at the .01 level. Thus, the results of this study show that we have succeeded in developing the learning achievement through CBL-EAT on solids, liquids, and gases.

Part 3: A Comparison between posttest mean score and 70 percent criteria of learning achievement.

Analysis of the differences of the mean scores of learning achievement showed that the students' learning achievement posttest mean scores ($\bar{X}$ = 36.13, SD = 2.89) were higher than 70 percent criteria of total score (70% of 45 = 31.50) at a statistically significant level .01 as detailed in Table 4.

Table 4 Analysis of the difference of the mean scores of learning achievement (Posttest and 70 percent criteria)

Learning Achievement	n	Criterion	Mean	SD	df	t	P
Posttest	45	31.50	36.13	2.89	44	10.759**	0.000

**p<.01

Table 4 showed that the students' posttest mean scores of learning achievement were statistically significant higher than the 70 percent criteria at the .01 level. Thus, the results of this study show that we have succeeded in developing the learning achievement through CBL-EAT on solids, liquids, and gases.

Discussion and Conclusion

A study of scientific analytical thinking and learning achievement of tenth grade students through CBL-EAT on solids, liquids, and gases concluded that CBL-EAT activities, resulted in increased students' scientific analytical thinking and learning achievement.

Scientific Analytical Thinking

The results showed that CBL-EAT on solids, liquids, and gases can significantly enhance the scientific analytical thinking, the posttest mean scores were higher than pretest mean scores at the .01 level significance, which as a result of CBL-EAT that the researchers have blended the Marzano's analysis process in all steps of Gilbert's model to enable the students to analyze. The five Marzano's analysis processes are matching, classifying, error analysis, generalizing, and specifying. By engaging in these processes, learners can use what they are learning to create new insights and invent ways of using what they have learned in new situations (Marzano & Kendall, 2007)

The results of this part were similar to the findings of Panprueksa, et al. (2013), they used FEACA model which was based on a contextual approach in their teaching and found that it could promote conceptual understanding, analytical thinking, and application of knowledge of the participants. Correspondingly, Sudibyo, et al. (2016) found that the implementation of the context-based learning model can improve the analytical thinking skills of sports sciences' students. Research of Harris, et al. (1995); Macklin and Fosmine (2003) provide a workshop on problem-based learning which emphasized on a real life situation in their workshop and found that it could develop critical and analytical thinking of the participants. Thereby, the CBL-EAT could increase the students' scientific analytical thinking in all components of analytical thinking processes and the findings of the present study support the results of studies in the literature.

Learning Achievement

Considering the learning achievement of students who were taught with the CBL-EAT on solids, liquids, and gases, the posttest scores were higher than pretest scores at the .01 level significance. In addition, the learning achievement posttest mean scores were higher than the 70% criteria of total scores at the .01 level significance as a result of CBL-EAT that the researchers used in this research as facilitating student - centered learning (Bennett, 2003, p. 109) by using the scientific inquiry process (Taconis, et al. 2016) Gilbert's model (Gilbert, 2006) which was a simple form of constructivism, situated learning, and activity theory. This learning management provided opportunities for students to apply what they had learned in their daily lives and to anticipate what will happen in the future corresponds with Crawford and Witte (1999) who said that contextual teaching strategies: relating, relating experiencing, experiencing applying, applying cooperating, and transferring. These strategies focus on teaching transferring and learning in context—a fundamental principle of constructivism, this approach results in higher students' learning achievement.

Similar to the result of Pramchoo, et al. (2010), they conducted research about the effect of using context-based learning activities on eleventh grade students' achievement in chemistry and found that the context-based learning activities influenced students' learning achievement. Moreover, the research explained that context encouraged the development of achievement, attitudes, and science process skills (Özay & Çam, 2015).

Thus, all the results confirmed that the CBL-EAT could enhance the students' learning achievement in all components.

The results of this study showed that, the CBL-EAT could enhance the scientific analytical thinking and learning achievement of tenth grade students, and not only increased students' learning achievement but also enabled the students to make relationships between the scientific concepts and real situations. Also, when applied in a science classroom using familiar situations in everyday life. These situations helped students to think about what they have found before they learn the science, to apply the knowledge, and to focus on the activity that motivates students to think analytically based on the Marzano's analysis process.

Suggestion

Suggestions for adoption

In light of the findings of the present study, Researchers were recommended to:

1. The teacher should read and clearly understand the CBL-EAT steps before using for maximum performance.

2. In the first step of CBL-EAT, the context used should be consistent with the content and interest. For example, in the "structure of the solid" topic, the teacher exemplifies the situation related to the collapsed building. In other topics, the teacher must use a context that is consistent with the topic, perhaps a personal, local/national and global issues, both current and historical, which demand some understanding of science and technology.

3. In the second step of CBL-EAT, the students have to do group activities, which takes a lot of time. The teachers should adjust the time to suit each activity or control the time of study to be more rigorous.

4. The context used in the scientific analytical thinking test should not contain content that is short or too long because it gives the test result was not effective.

Suggestions for further research

The researchers offer suggestions for further research as follows:

1. The further research should change the subjects from chemistry to physics, biology, or any other science areas that have a similar nature of content.

2. The further research should study the other variable such as science process skills, scientific attitudes, or learning retention.

3. The further research should compare with other learning models or control group.

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