The Development of a STEAM-Based Learning Unit to Promote High School Students' Understanding of Ceramic Concept

Wachirawit Ritmuan[1], Ratchanikorn Chonchaiya[2], Prempree Duangpummet[3]

King Mongkut's University of Technology Thonburi, Thailand[1,2,3]

Abstract

A STEAM-based learning unit was designed to promote high school students' understanding of a ceramic concept. There are four lesson plans in the learning unit that consisted of four topics of the ceramic concept: an introduction to the ceramic, properties and production processes of the ceramic, ceramic production, and a study of ceramic efficiency. Learning activities in each lesson plan were created using STEAM-based learning as a framework. The learning unit was implemented to 28 Thai high school students in the Talent Enrichment Program (TEP) who enrolled in an advanced chemistry elective course and collected data using one group pretest-posttest design. This research aims to study students' understanding of the ceramic concept after the implementation of the STEAM-based learning unit. A Ceramic Conceptual Test (CCT) was designed to be a tool for collecting data before and after implementation with a reliability score of 0.71. The descriptive statistics use in this research were mean and standard deviation. The results were interpreted using mean comparison and the relative gain scores as hypothesis statistics. The result from the mean comparison shows that the average posttest score (10.32±1.49) was significantly higher than the average pretest score (5.64±1.57), which was statistically different at the .05 level. The results for the relative gain scores indicate that the majority of the students have developed their understanding of the ceramic concept at a moderate level. This learning unit can be utilized to be a practical STEAM-based activity in chemistry for high school students.

Keywords: *Ceramic, High School Chemistry, Relative gain score, STEAM-Based learning, Students' Understanding*

1. Introduction

According to the twelfth national economic and social development plan (2017-2021), Thailand has focused on preparing the STEM workforce and empowering people of all ages to realize the importance of learning science and mathematics [1]. By focusing on the country's population to grow up with quality and develop skills relevant to the labor market needs and have the skills necessary for the 21st-century life of people of different ages as appropriate [2]. It also provides the preparation of the science and technology workforce that will change the world in the future [3].

Chemistry is a branch of science that most students find difficult. Students lack knowledge and understanding of chemistry content, and the students do not know how the chemistry they learn can be used in their daily life [4]. Students have such thinking as the result of the traditional classroom activities, with the teacher center method [5]. Moreover, students lack the opportunity to act and to express their thought

Teachers play a key role to encourage students to learn and making them realize the importance of chemistry in daily life [6]. According to the 12th national economic and social development Plan, a STEAM-based activity could be used as a model to activate students' curiosity and interest in chemistry. The STEAM stands for integrating learning activities of five disciplines: Science, Technology, Engineering, Arts, and Mathematics [7]. The STEAM-based activities can promote students' understanding of various topics of chemistry such as hydrocarbon, petroleum, solubility, thermochemistry, and acid-base [8]. Moreover, the activities could allow students to use their creativity and to recognize themselves about creativity [9]. Hence, STEAM-based learning has been one of the most active research during this decade. However, the challenge of the development of STEAM-based learning activity in chemistry is finding the context that can be harmonized with other components of the STEAM framework.

In this report, a STEAM-based learning activity using the ceramic concept was developed. Ceramic products are wildly used in Thailand. The ceramic industry is one of the main industries that increase the GDP of Thailand's economy [10]. The science behind ceramic production including inorganic compounds that can be related to many chemistry topics such as the types and properties of substances, stoichiometry, etc. The developed STEAM-based learning activity on ceramic concepts

was implemented to high school students. This study aims to examine students' understanding of ceramic after the implementation. The research question central to this study addressed was:
• Can the developed STEAM-based learning activity promote students' understanding of the ceramic concept?

2. Research methodology

2.1 Participants

The participants were 28 grade 10 students who enrolled in the Talent Enrichment Program (TEP) at Bangpakok Wittayakom School, Bangkok, Thailand, in the 2020 academic year, who enrolled in an advanced chemistry elective course selected by the purposive sampling method.

2.2 Research tools

This study was designed to be experimental research using the one-group pretest-posttest design. The treatment of this study is a STEAM-based learning activity. A Ceramic Conceptual Test (CCT) was used to be a tool for investigating students' understanding. The CCT has 15 multiple-choice questions for a pre-and-post with a full score of 15. Two experts specializing in ceramics and chemistry laboratory professionals and one expert in chemistry teaching have reviewed this test. The Kuder-Richardson 21 for the Ceramic test was 0.71, showing that it was highly reliable. From the quality measuring of instruments, difficulty levels of 0.31 to 0.72, and a discrimination power value was from 0.31 to 0.50.

2.3 Data analysis

This study used the dependent t-test for analysis of the research hypothesis was the ceramic conceptual understanding between pre-test and post-test scores, and analyzed the progress of students' understanding level after the intervention by using the Relative Gain Score.

3. STEAM-based learning unit

In the developed STEAM-based learning activity, students learned ceramic concepts step by step. Students were engaged to explore the fundamentals of ceramics, including the manufacturing process, via hands-on activities. Then, they were asked to design an experiment to investigate the efficiency of the ceramic, which could give them a better understanding of the ceramic's properties. The lesson plan was divided into four main topics which allowed students to perform a variety of learning activities based on STEAM. The time spent learning each topic about 1 hour 40 minutes and some extra time for learning activities outside the classroom to develop and study the experimental results.

Table 1. STEAM Learning Plans Presented with Relevant Topics and Students' Activities

STEAM learning Plan	Learning topic	Students' Activity
1. Introduction to the ceramic	The meaning of ceramic and the main materials in ceramic	Students design a presentation about the knowledge. "Introduction to Ceramic" in Infographic A4 media format.
2. Production processes and properties of ceramic	Ceramic properties and the production processes of ceramic	Students write a flowchart of an A4 paper lab using symbols and according to the specified conditions.
3. Preliminary ceramic production	The ceramic production processes to be able to do it in the laboratory	Students work together to find suitable ratios to produce ceramic that meet certain conditions.
4. A study of ceramic efficiency	The test of the ceramic performance related to their thermal conductivity and porosity	Students adapted the results from the experiment to optimize the heat resistance of ceramic.

4. Results and discussion

A result from the CCT pre-and post-test of 28 students showed that the mean of the post-test score (10.32±1.49) was significantly higher than the mean of pre-test score (5.64±1.57), which was statistically different at 95% confidence (see Table 4). The pre-and post-test scores of individual

students and a percentage of the relative gain score and their interpretation are shown in Table 3. The relative gain score results show that 25 out of 28 students have developed their understanding of the ceramic concept at a moderate or upper level. This might because the STEAM-based learning activity made students engaged and provided them an opportunity to perform various hands-on activities for constructing knowledge about ceramic under teacher guidance. In addition, lesson plans 3 and 4 provided the students like a real scientist by planning their experiment, analyzing data obtained from the experiment, finding a conclusion, and discussing the results based on knowledge of the ceramic they have gained. This indicates that lab work and hands-on activities are beneficial to help students understand concepts [11,12].

Table 3: Student Results from the Ceramic test and Relative Gain Score

No.	[a]Test score		Relative Gain Score (%)	[b]Interpretation	No.	[a]Test score		Relative Gain Score (%)	[b]Interpretation
	Pre-test	Post-test				Pre-test	Post-test		
1	6	11	55.56	High	15	7	10	37.50	Moderate
2	6	11	55.56	High	16	6	10	44.44	Moderate
3	4	9	45.45	Moderate	17	7	11	50.00	Moderate
4	7	11	50.00	Moderate	18	6	12	66.67	High
5	7	12	62.50	High	19	5	10	50.00	Moderate
6	7	12	62.50	High	20	5	10	50.00	Moderate
7	4	9	45.45	Moderate	21	6	9	33.33	Moderate
8	5	8	30.00	Moderate	22	7	9	25.00	Low
9	5	10	50.00	Moderate	23	7	8	12.50	Low
10	4	8	36.36	Moderate	24	3	10	58.33	High
11	5	14	90.00	Very high	25	8	12	57.14	High
12	6	12	66.67	High	26	3	8	41.67	Moderate
13	6	10	44.44	Moderate	27	2	10	61.54	High
14	5	11	60.00	High	28	7	9	25.00	Low

Table 4: The mean of the Ceramic test pre-and post-test and Relative Gain Score

[a]Pre-test	[a]Post-test	Relative Gain Score (%)	[b]Interpretation
5.64±1.57	10.32±1.49	49.50±15.77	Moderate

[a]The CCT has a full score of 15 points.
[b]The interpretations are based on the following criteria: very high-level (75−100), high-level (50 – less than 75), middle-level (25 – less than 50), and Early-level (0 – less than 25) [13].

5. Conclusion

The results of the ceramic conceptual test showed the majority of students had developed a better understanding of the ceramic concept after the intervention at a moderate level. The results clearly indicated that the learning unit is effective in terms of promoting students' understanding of the concepts. This learning unit can be utilized to be a practical STEAM-based activity in chemistry for high school students.

6. Acknowledgment
This research could not be accomplished without the scholarship from Mr.Nandana Indananda, the suggestion of Dr.Kullatat Suwatpipat, and research facilities from the faculty of science.

References
[1] National Academies of Sciences, E. and Medicine. “Developing a national STEM workforce strategy: A workshop summary”, National Academies Press, 2016.
[2] Prinsley, R. T. and K. Baranyai. “STEM skills in the workforce: what do employers want?”, Office of the Chief Scientist, 2013.
[3] Pharanat W, Nuangchalerm P, Sonsupap K. “Promoting Reasoned Argumentation in Science for Lower Secondary Students”,Educ. Res. Rev. 10(3), 2015, pp 357.
[4] Woldeamanuel, M., et al. "What makes chemistry difficult?", African Journal of Chemical Education 4(2), 2014, pp 31-43.
[5] Mascolo, M. F. "Beyond student-centered and teacher-centered pedagogy: Teaching and learning as guided participation.", Pedagogy and the human sciences 1(1), 2009, pp 3-27.
[6] Bennett, J. and F. Lubben. "Context-based chemistry: The Salters approach.", International journal of science education 28(9), 2006, pp 999-1015.
[7] Ozkan, G. and U. Umdu Topsakal. "Investigating the effectiveness of STEAM education on students’ conceptual understanding of force and energy topics.", Research in Science & Technological Education, 2020, pp 1-20.
[8] Allina, B.. "The development of STEAM educational policy to promote student creativity and social empowerment.", Arts Education Policy Review 119(2), 2018, pp 77-87.
[9] Seedee, R., M. Sulaiman and I. Ismail. “Best business practices and performance in ceramics industry in Thailand”, 9th Global Conference on Business and Economics, 2009.
[10] Acar, B. and L. Tarhan. "Effect of cooperative learning strategies on students' understanding of concepts in electrochemistry.", International Journal of Science and Mathematics Education 5(2), 2007, pp 349-373.
[11] Khammani, T. “Science of teaching: knowledge for effective learning process”, Bangkok, Darnsutha Press. (In Thai), 2013.
[12] Wood, E. "Laboratory Work in Biochemical Education: Purpose and Practice.", Biochemical Education 24(3), 1996, pp 132-137.
[13] Ahlee-Ae, S. “Effects of Science, Technology, Society and Environment Approach on Chemistry Achievement, Problem Solving Ability and Instructional Satisfaction of Grade 12 Students”, ,Songkla University, 2014.