The Enhancement of Scientific Conceptual Understanding of Reaction rate by using 5E Model of Instruction Integrated with Cooperative Learning

Thawanrat Puangkeaw[1], Nisakorn Thongkon[2]*
[1]Department of Science Education, Faculty of Science, King Mongkut's University of Technology Thonburi, Bangkok, Thailand, 10140
[2]Department of Chemistry, Faculty of Science, King Mongkut's University of Technology Thonburi, Bangkok, Thailand, 10140
*Corresponding author

Abstract
The aim of this research was to enhance scientific conceptual understanding of reaction rate by using 5E model of instruction integrated with cooperative learning. There were 5 lesson plans which covered reaction rate in all 4 topics: a) definition of reaction rate, b) calculation of reaction rate, c) concept of reaction rate and d) factors affecting reaction rate. The research sample consisted of 41 grade 11 students at Tessaban1 (Engsiangsamakkee) School. The research was carried out using one group pretest-posttest design. Data collecting tool were 5 lesson plans and 20 items of 2-tier scientific conceptual understanding test. Data was analysed by means, percentage, standard deviation, dependent samples t-test and normalized gain <g>. The results based on dependent samples t-test that students' posttest score (13.10 ± 3.64) was significantly higher than students' pretest score (5.68 ± 2.07), which was statistically different at the .05 level. Their normalized gain <g> equalled to 0.22, which was a low level. Percentage of students in each scientific conceptual understanding included in 3 levels: correct conception (CC), alternative conception (AC), and misconception (MC). Pretest were 2.80, 24.51 and 72.69 %, respectively and posttest were 21.59, 25.24 and 53.17 %, respectively. There were noticed that students had a better understanding of scientific concepts. This research showed that 5E model of instruction integrated with cooperative learning could develop students' scientific conceptual understanding on reaction rate.

Keywords: 5E Model of Instruction, Cooperative Learning, Reaction Rate, Scientific Conceptual Understanding

1. Introduction

There are many factors for students to be successful in learning, such as the nature of the course, the attitude of the students to the course, basic knowledge of learners, learning strategies, and ability to manage the student's thought system. Therefore, the researcher wants to know if combining learning approach will improve conception of students in subject.

Learning science focuses on students' understanding of the principles and theories that are fundamental to science including the use of knowledge and scientific process skills in life (Noor et al., 2019). Therefore, everyone should learn science thoroughly. One of the most important approaches, inquiry learning, is essential to develop and encourage students to build their own knowledge through observation activities, questioning, answering questions, designing experiment, investigating, problem solving process, searching for information, discussion and communication.

One of the models used in implementing inquiry-based learning in science classes is the 5E Model. 5E learning cycle model is composed of five inquiry stages (Lawson, 1995). The stages are: engagement, exploration, explanation, elaboration and evaluation. The first stage of the 5E learning model-the stage of engagement-is to access the learners' prior knowledge and help them become engaged in a new concept through the use of short activities. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities. At the stage of exploration, it provide students with a common base of activities within which current concepts, processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation. At the stage of explanation teachers have a tough job. Students demonstrate their conceptual understanding, process skills, or behaviours by what you get from the first two steps. Students explain their understanding of the concept. At the stage of elaboration, students have the opportunity to adapt their knowledge into new situations and to use it in real life. Teachers challenge and extend students' conceptual understanding and skills. The final stage is the stage of evaluation. At this stage, it encourages students to assess their abilities to understand and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives (Bybee et al., 2006; Sen & Oskay, 2017).

There must be five key components in a group to make cooperative learning successful (Johnson et al., 1991).

1. Positive interdependence

Students are provided with work that they think can be done if all group members participate in the effort. Students understand that each of them is responsible for completing part of the task which, in turn, all must be achieved in order to achieve the group's goals.

2. Face-to-face interaction

Students are given time and space as part of the activity for meeting with group members. There is an exchange of ideas and help each other's work.

3. Individual accountability

Students first learn the material in their own hands, and then show them to their peers that they have mastered it. The group should facilitate the learning of all group members, but each group member is responsible for demonstrating their own learning.

4. Interpersonal skills
Students are given the opportunity to practice group skills such as developing trust, communicating effectively and managing conflict. Feedback should be provided so that students can develop these skills.
5. Group processing
Students are given time and space to reflect on their progress and their working relationships. Everyone in the group engages in summarizing ideas and information, participates in the discussion, and checks to see that decisions made by the group are supported by members so that enhances respect among group members from each other.
This set of components is useful in chemistry class as it helps the class to be more effective in group learning (Bowen, 2000; Gillies, 2016). It is also a group work practice to prepare students for entering a working society.
5E model of instruction integrated with cooperative learning was the organization of learning activities consisting of 5 steps, in some stage students had group activities together. The group activities chosen for teaching came from the technique of cooperative learning and adapted to suit online learning due to COVID-19 situation.
Reaction rate is an important concept because many phenomena found in the daily life of students is related to the rate of chemical reactions such as iron rusting, digestion, etc. Therefore, students need to have the correct idea of reaction rate so that they can be applied in their daily life. In addition, from past research studies, it was found that the concept of reaction rate is one concept that students have misconception. For example: reaction rate and reaction time are same thing, reaction rate changes as the reaction progresses and a catalyst increases the yield of products (Cakmakci, 2010). These problems cause a relatively low understanding of content and less of learning achievement that create an alternative conception or misconception. It is necessary for students to build their own knowledge through direct experience.
In each learning management, teachers need to know first how alternative conception or misconception on the topic. Teachers are required to validate students' prior knowledge before learning. This will give the teacher the fundamentals of students and can help them design learning activities that allow students to make connections between original ideas or new ideas to accepted scientific concepts. One of the best methods usable in creating student-center learning environments is inquiry-based learning (Marshall et al., 2010). Inquiry-based learning helps learners to develop inquiry skills, which are among the basic skills of the 21st century (Kong & Song, 2014).
From literature review, 5E model encourages students to acquire new knowledge and self-analysing knowledge then students deeply understand. Cooperative learning encourages students to learn through activities that they do with their classmates. It develops the understanding of students. Therefore, the idea was to do research on a teaching method that combines 5E model of instruction and cooperative learning.

2. Methods

This research aims to study the scientific conceptual understanding of students in the pretest and posttest from learning about reaction rate with 5E model of instruction integrated with cooperative learning. There are 41 students in grade 10 in the first semester of the academic year 2021 at Tessaban1 (Engsiangsamakkee) School. The research was carried out using one

group pretest-posttest design. Data collecting tool were 5 lesson plans and 20 items of 2-tier scientific conceptual understanding test.

There are 5 lesson plans (15 hours). The details are shown in Table 1.

Table 1 Learning activities in each lesson plan

Lesson plan	Activity	hour	Stage
1. Definition of reaction rate	Activity 1: Finding of prior knowledge by using numbered heads together technique	3	Engagement
2. Calculation of reaction rate	Activity 2: Calculation of reaction rate by using team –pair –solo technique	4	Exploration
3. Concept of reaction rate	Activity 3: You said yes, I said yes by using showdown technique	4	Exploration
4. Factors affecting reaction rate	Activity 4: You or me....who will win? by using team discussion technique	2	Exploration
5. Experiment to study factors affecting reaction rate	Activity 5: The experiment studied the effects of concentration, surface area, and temperature to reaction rate by watching video clips of experiments	2	All stages
Total		15	

As shown in Table 2, the researcher sets the criteria for scoring each scientific conceptual understanding in 3 levels that modified from Sirithorn Angkaew and others (2016) and Sontaya Bongprom (2015), including correct conception, alternative conception and misconception (Angkaew et al., 2016; Bongprom, 2015).

Table 2 Criteria for classification of science conceptual understanding test

Conception	Choice	Score	Reason	Score	Total score
Correct conception	True	1	The reason was correctly and completely written.	1	2
Alternative conception	True	1	Some of the reasons were correctly written.	0.5	1.5
	True	1	The reason was incorrectly written.	0	1
	True	1	Don't wrote the reason.	0	1
	Wrong	0	Some of the reasons were correctly written.	0.5	0.5
Misconception	Wrong	0	The reason was incorrectly written.	0	0
	Wrong	0	Don't write the reason.	0	0

3. Results and Discussion

3.1. The pretest score and posttest score of scientific conceptual understanding of reaction rate

The pretest score and posttest score of scientific conceptual understanding of reaction rate were obtained from evaluating students before and after with 5E model of instruction combined with cooperative learning. Pretest and posttest were analyzed by dependent sample t-test as shown in Table 3.

Table 3 The pretest score and posttest score of scientific conceptual understanding of reaction rate

Score	*N*	*Mean*	*SD*	*%*	*Percentage of gain*	*Normalized gain <g>*	*t*	*p*
Pretest	*41*	*5.68*	*2.07*	*14.20*	*18.55*	*0.22*	*12.39**	*0.00*
Posttest	*41*	*13.10*	*3.64*	*32.75*				

** 95% confidence level*

From Table 3, the students had the average pretest score of 5.68 (SD 2.07), representing 14.20% of the total score, and the average posttest score was 13.10 (SD 3.64), representing 32.75% of the total score, with the percentage of gain being 18.55 and normalized gain <g> being 0.22. From comparison of the statistical analysis for the average pretest and posttest score by using dependent sample t-test, it was found that the students had significantly higher posttest score than pretest score, which was statistically different at the .05 level.

3.2. Gain of scientific conceptual understanding of each topic in reaction rate

Pretest and posttest were analyzed from two-tier scientific conceptual understanding test which are the test had a total score of 40 scores and consisted of 20 items that cover a) definition of reaction rate, b) calculation of reaction rate, c) concept of reaction rate, and d) factors affecting reaction rate as shown in Table 4.

Table 4 The pretest score and posttest score of each topic in reaction rate

Topic (Scores)	Pretest			Posttest			T-test*	
	Mean	SD	%	Mean	SD	%	t	p
a) Definition of reaction rate (8)	0.98	0.85	12.25	3.72	1.39	46.50	11.46*	0.00
b) Calculation of reaction rate (12)	1.07	0.96	8.92	2.49	1.61	20.75	5.23*	0.00
c) Concept of reaction rate (10)	1.22	0.82	12.20	3.09	1.40	30.90	7.94*	0.00
d) Factors affecting reaction rate (10)	2.10	0.94	21.00	3.76	1.42	37.60	6.16*	0.00
Total (40)	5.68	2.07	14.20	13.10	3.64	32.75	12.39*	0.00

** 95% confidence level*

Considering the scores classified by content before and after study, it was found that before the learning management in topic a) definition of reaction rate, the students had a percentage of scientific conceptual understanding of 12.25, mostly from the choice. After the learning management, it was found that the students had a percentage of scientific conceptual understanding of 46.50, based on their choice and reason.

In topic b) calculation of reaction rate, it was found that before the learning management, the students had a percentage of scientific conceptual understanding of 8.92, mostly from the choice. After the learning management, it was found that the students had a percentage of scientific conceptual understanding of 20.75, based on their choice and reason.

In topic c) concept of reaction rate, it was found that before the learning management, the students had a percentage of scientific conceptual understanding of 12.20, mostly from the choice. After the learning management, it was found that the students had a percentage of scientific conceptual understanding of 30.90, based on their choice and reason.

In topic d) factors affecting reaction rate, it was found that before the learning management, the students had a percentage of scientific conceptual understanding of 21.00, mostly from the choice. After the learning management, it was found that the students had a percentage of scientific conceptual understanding of 37.60, based on their choice and reason.

Table 5 Percentage of gain and normalized gain of each topic in reaction rate

Topic	*Percentage of gain (% gain)*	*Normalized gain <g>*	*Test Results*
a) Definition of reaction rate	*34.25*	*0.39*	*Medium gain*
b) Calculation of reaction rate	*11.83*	*0.13*	*Low gain*
c) Concept of reaction rate	*18.70*	*0.21*	*Low gain*
d) Factors affecting reaction rate	*16.60*	*0.21*	*Low gain*
Total	*18.55*	*0.22*	*Low gain*

As shown in Table 5, it was found that the students' actual gain percent and normalized gain <g> equal to 18.55 and 0.22, respectively, showing a low level.
Definition of reaction rate was the topic in which students made the highest normalized gain <g> because it was a topic with uncomplicated content and students used to learn about chemical reaction in junior high school. It was easier to relate the meaning of the rate of a chemical reaction than any other topics. This topic could give students an example of daily life to make it easier for students to notice the word "rate" which was related to time, such as heart rate and speed rate of the car. At the time, examples could illustrate clearly and it would be easier to explain in other sections on the definition of reaction rate. Therefore, this may be the reason why students progress in this topic more than others. In addition, definition of reaction rate used cooperative technique in engagement stage that it was different from other topics to use in exploration stage. This may be reason why this normalized gain <g> was obtained higher than others. Engagement stage was an initiative to stimulate the interest of students. Students were curious to find answers and this leads to interest in learning the material that they were going to study further. Furthermore, this stage was also used to check students' prior knowledge, as if students were re-evaluating their knowledge. Students were able to connect old knowledge with new knowledge through group learning. Therefore, this research showed that cooperative learning was suitable for engagement stage in 5E model.

3.3. Percentage of students in classification of science conceptual understanding in reaction rate

Analysis of the students' scientific conceptual understanding was educated in 5E model of instruction combined with cooperative learning. The criteria for scoring each scientific conceptual understanding included in 3 levels: correct conception (CC), alternative conception (AC), and misconception (MC). Percentage of students of science conceptual understanding were shown in Table 6.

Table 6 Percentage of students in classification of science conceptual understanding in reaction rate

Score	*N*	*Number of item*	*Science conceptual understanding (%)*		
			Correct conception (CC)	*Alternative conception (AC)*	*Misconception (MC)*
Pretest	*41*	*20*	*2.80*	*24.51*	*72.69*
Posttest	*41*	*20*	*21.59*	*25.24*	*53.17*

From Table 6, it was found that before the learning activities, the percentage of students with correct conception (CC), alternative conception (AC) and misconception (MC) were 2.80, 24.51 and 72.69, respectively. After the learning activities, the percentage of students with correct conception (CC), alternative conception (AC) and misconception (MC) were 21.59, 25.24 and 53.17, respectively.

3.4. Percentage of students in classification of science conceptual understanding of each topic in reaction rate

Analysis of the students' scientific conceptual understanding from 2-tier conceptual test was calculated by percentages, which the test covered 4 topics as follows: a) definition of reaction rate, b) calculation of reaction rate, c) concept of reaction rate, and d) factors affecting reaction rate. The criteria for scoring each scientific conceptual understanding in 3 levels including correct conception (CC), alternative conception (AC), and misconception (MC) were shown in Table 7.

Table 7 Percentage of students in classification of science conceptual understanding of each topic in reaction rate

Topic[a] (number of item)	Pretest (%)			Posttest (%)			Differentiation (%) (posttest – pretest)		
	CC	AC	MC	CC	AC	MC	CC	AC	MC
a (4)	3.66	19.51	76.83	34.16	32.92	32.92	+30.50	+13.41	-43.91
b (6)	0.81	19.11	80.08	9.76	27.24	63.00	+8.95	+8.13	-17.08
c (5)	2.44	21.95	75.61	20.98	20.48	58.54	+18.54	-1.47	-17.07
d (5)	4.88	37.56	57.56	26.34	21.46	52.20	+21.46	-16.10	-5.06
Total (20)	2.80	24.51	72.69	21.59	25.24	53.17	+18.79	+0.73	-19.52

[a]The topic consists of a) definition of reaction rate, b) calculation of reaction rate, c) concept of reaction rate, and d) factors affect reaction rate

From Table 7, it was found category of the percentages of students in different level of scientific conceptual understanding. Before the study, it was found that the percentage of students in levels with alternative conception and misconception was much higher than the percentage of correct conception. The results showed that students had a fundamental inaccurate understanding and misunderstanding about reaction rate. After the study, it was found that the tendency of the percentage change of students in the various scientific

conceptual understanding was in a better direction. Percentage of students' posttest in correct conception was higher than percentage of students' pretest. Moreover, percentage of students' posttest in misconception was less than percentage of students' pretest. The results of the analysis showed that learning through 5E model of instruction integrated with cooperative learning was able to improve students' correct conception in reaction rate. In addition, it could be also adjusted to reduce misconception. Even if some topics, students still had high misconception and positive of alternative conception. Alternative conception and misconception may be caused by:

1) The scope of students' knowledge was such as students thought that pH cannot be used to measure reaction rate. This was a misconception. The reason came from students who have not studied in acid-base before.

2) Inaccuracy in the content was such as students thought collision of particles could occur in two cases; colliding occurred in the right direction, and particles collided by enough energy, which was alternative conception. The correct conception was that particle collisions could only react in the same way and particles collided in the right direction with enough energy too.

3) Low calculation skill was due to students doing little exercises. The teacher didn't give enough examples. Students need to practice more and know how to solve problems when they did computational exam.

However, considering the percentage of scientific conceptual understanding, it was found that the scores were still lower than 50%, it resulted from learning process during the COVID-19 situation with requiring to manage teaching and learning through the online system. This was a new situation for both teachers and students. As a result, teachers and students had to prepare for the online learning system. As a consequence, perhaps the students' perception was not as fully as expected that different from they received in the classroom.

4. Conclusion

5E model of instruction integrated with cooperative learning in reaction rate was designed for encourage grade 11 students' science conceptual understanding in the first semester of the academic year 2021 at Tessaban1 (Engsiangsamakkee) School. There was 1 classroom, 41 students using purposive sampling. Diverse group activities were used in the situation of COVID-19 with online teaching and learning. It was found that 5E model of instruction integrated with cooperative learning could enhance students' scientific conceptual understanding in reaction rate. Students had significantly higher posttest score than pretest score, which was statistically different at the .05 level. Moreover, students' actual gain percent and normalized gain <g> were 18.55 and 0.22, respectively, showing a low level from inappropriateness of activity in state of 5E model.

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