

Implementation and the Impact of Constructivism-Based Module on Students' Academic Achievement

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ABSTRACT

This study aims to develop a constructivism-based module on rate of reaction and chemical equilibrium topics for the eleven graders and assess its impact on students' academic achievement. The development of the constructivism-based module adopted the Rowntree and Tessmer models, and the validation assessment by the experts uses Cohen's Kappa interpretation. The constructivism-based module was implemented to 189 eleven graders in Palembang, and was studied in a quasi-experimental manner. A total of 89 experimental group students used the constructivism-based module, while 100 control group students were taught using a conventional approach. Cohen's Kappa approval for matter, pedagogy, and design, on average, equals 0.736, meaning this module is valid in terms of these aspects. Findings from one-on-one testing and small group assessment showed the constructivism-based module is practical to guide students to learn chemical equilibrium and rate of reaction with the average score 4.33 and 4.32, respectively, based on Likert scale. The average gain score of posttest and pretest is equal to 0.73, the effectiveness of the high-qualified module. This study has very significant results and is expected to help students to understand the concept of chemistry more easily, can be used by teachers as a manual for learning process, and to change from teacher-centered to student-centered learning situations.

Keywords: *The constructivism-based module, Academic achievement.*

1. INTRODUCTION

The 2013 curriculum emphasizes the importance of student-centered learning. Students are encouraged to engage directly in the learning process by contributing ideas, giving views and raising issues. They are no longer blank papers in that only the teacher needs to fill, but act as a discussion partner on the learning that takes place in the classroom [1]. The observations of three schools in Palembang differ in reality from what is based on the government curriculum. Essentially, the process of learning in schools is still centered on teachers. Teachers assume that students are like blank papers, not knowledgeable about the lessons they will learn so that teachers teach and provide knowledge to students. Teachers in this context, fill in the blank papers (the students' brain) with the contents (knowledge) regardless of student's prior knowledge [2]. This teaching style is one-way and authoritative. This situation makes the students passive and decreases their ability to explore their potential. Some students feel chemistry is an easy

subject, when teachers teach chemistry interesting and trigger students' curiosity. Students feel chemistry is a difficult subject, especially when they are faced with abstract and elusive chemical concepts [3]. Then the students felt chemistry is a difficult subject, due to its abstract and difficult to understand the concepts [4].

Students in high school earn a sufficient average score on the National Exam and low for chemistry subject, which is meant that the students have not fully understood the chemistry concepts conveyed by the teachers. Based on observations in three high schools in Palembang, it is found that the learning process of science subjects including chemistry is using teacher-centered method rather than on students [5].

The learning process focuses on the students behind the theory of constructivism. The theory of constructivism states that knowledge can not be transferred intact from the teacher's thoughts to the students, but is actively awakened by the students themselves through impacting experiences [6]. The

constructivism model gives several opportunities for teachers to overcome various problems of low quality of learning process. This model fosters students' thinking skills during teaching. The theory of constructivism states that learning is the development of new science by individuals who constructed the interaction of their initial knowledge with new knowledge [2],[7-10]. Researchers conducted interviews with teachers and students about the method of teaching chemistry at school. The result obtained one of the factors that influence the teacher-centered teaching style is the content of textbooks of chemistry used in schools. Textbooks generally represent the content of the subjects that the student needs to learn and they become the main reference teacher in delivering the lessons to the students.

Government policy encourages teachers to implement student-centered learning processes, while writing a chemical textbook does not describe the policy. The presentation of materials in chemistry textbooks in schools tends to be full of facts about concepts that students need to understand and learn, but are less involved with activities that enable students to think and look for the facts given to them. In this situation, it is no wonder why it is difficult for teachers to implement a student-centered learning process because their primary reference manual does not emphasize the importance of teachers helping students build their own science. For the teacher, everything in the textbook is complete, then their task only needs to convey the content. For students also, looking at all the contents of the lesson in the text book is complete, then they just need to memorize and train how to answer the exam well. Clearly here for teachers and students, the process of thinking in teaching and studying chemistry is not necessary in the classroom learning process [11].

Researchers also provided questionnaires to students and chemistry teachers to get one of those elusive chemical topics. The topic of rate of reaction and chemical equilibrium in the eleventh grade have been chosen as the focus of this study. Researchers developed a module of these topics based on the theory of constructivism for the eleventh grade.

Modules are defined as self-contained complete unit and comprises a series of learning activities designed for helping students achieve a number of objectives that are formulated specifically and clearly. Lestari argues that the module is a learning aid developed with the aim that students can learn independently with or without direct guidance from the teacher. The module will encourage students to be more responsible for their learning, as students need to achieve and complete their learning tasks individually [12-14].

Student academic achievement is defined as the extent to which students can master the concept of the lessons received within a certain time [15]. The constructivism approach in education is an innovation of

the present style of teaching and learning. The constructivism approach is a teaching process that explains how knowledge is organized into the minds of students. Knowledge is actively developed by the students themselves and is not passively accepted from the environment. This means teaching is the result of the student's own efforts and not transferred from the teacher to the student [16].

Learning according to constructivism is a conceptual change, which can be either the development of new ideas or the conversion of pre-existing ideas. This theory takes an estimate that knowledge is available and students process it in the classroom. This initial knowledge is gained by students from their interaction with their environment [8]. The teaching method of the Five-phase constructivism of Needham consisting of the following phases: (1) Orientation: Teacher provides a teaching atmosphere to stimulate and increase students' interest in learning. Various ways are done to get students' attention. Among them are video, carta, puzzle, drama and simulation. (2) Ideas Generation: Teachers stimulate various forms of activity such as group discussions, using concept map methods and create reports by linking initial knowledge with new knowledge they will learn. The learners will discuss in the same group of experiences as well as the interactions that meet their fellow. Teachers need to play the role of facilitator by completing the given problem-solving or problem-based teaching materials. (3) Reorganization of initial ideas: Teachers provide activities or provide structured assignments to allow students to pinpoint their original idea or idea and develop their own meaningful and memorable knowledge. In this phase, language proficiency will help students to make the alteration or initial compilation of ideas following the action, and every single idea has a continuity of ideas that seem to be structured and designed. The role of the teacher also is to confirm the concept or the right idea to the students. (4). Application of ideas: students will apply new knowledge by solving problems in a new situation. This situation can realize a new understanding and promote inquiry process in students. (5). Reflection: Learners compare their prior knowledge with new knowledge and reflect back on the teaching process that causes change to their idea. Students may also make reflections to see to what extent their original idea has changed. Teachers may use their own writing methods, group discussions and student personal notes to research or monitor the stage of understanding of their students [21]. This study aims to develop a constructivism-based module on rate of reaction and chemical equilibrium topics for the eleven graders and assess its impact on students' academic achievement.

2. METHOD

2.1. Study Contexts

This research is a study of development of the Five-phase constructivism of Needham (5FCN)-based module for the topic of rate of reaction and chemical equilibrium. This research also examines the impact of 5FCN module on the academic achievement of eleven graders in Palembang. Six groups of students (3 control groups and 3 experimental groups) from 3 public high schools in Palembang (A, B and C) were involved in the study. Each school has a representative of a control group and one experimental group. The experimental group studied using the 5FCN module, while the control group learned to use the materials or books provided at the school. As many as three teachers involved in the research. The chemistry teacher 1 teaching experimental group and control group of school A, chemistry teacher 2 teaching experimental group and control group of school B and chemistry teacher 3 teaching experimental group and control group of school C.

The population of this research is class XI Junior High School, Department of Natural Sciences. The experimental group, students of class XI IPA1, from school A was chosen, while the students of class XI IPA2 was selected as a control group. The experimental group, students of class XI IPA1, from school B was selected, while students of class XI IPA2 was chosen as a control group. The experimental group from the school C was students of class XI IPA2, while the students of class XI IPA3 were as a control group. Once the respondents were determined, the researchers ran a preview to the experimental class and control class to gain initial achievement and test the homogeneity of the respondent group. Pre-examination scores showed no significant difference in variance between control and experiment groups indicating that both study groups were homogeneous. Teachers sampled in this study were also selected because they had the same criteria. The characteristics are focused on teaching experience, graduation, rank, and professionalism.

2.2. Study Contexts

This study employed Rowntree model modified with Tessmer's formative evaluation [13]. Rowntree model consists of three stages: planning, development, and evaluation. In planning stage, the researchers conducted needs assessment through interviews, observation, and questionnaires shared to students and teachers, and constructed learning objectives. In the development stage, the researchers developed prototype and evaluated its validity, practicality, and feasibility in the evaluation stage. Tessmer's formative evaluation consists of self-evaluation, expert review, one-to-one, small group, and field testing.

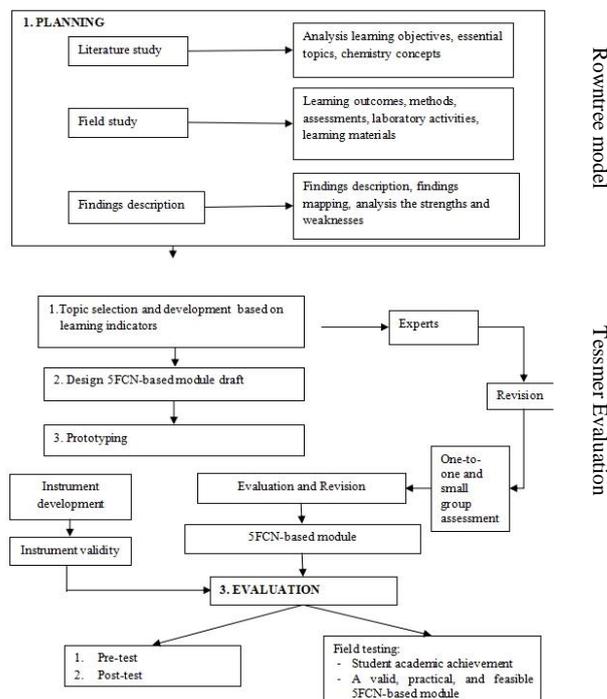


Figure 1. Research design

2.3. Data Collection

Instruments used in this study were interview sheet for needs assessment, questionnaires shared to students and teachers to find out the difficulty level of understanding certain chemistry topics, questionnaires for expert reviews, one-to-one and small group assessment, and pre-test and post-test questions to figure out student achievements using in field testing (Table 1).

Table 1 Summary of data collection and analysis

Variable	Instruments	Data sources	Data analysis
Literary study	Artifacts	Artifacts	Qualitative descriptive
Development of the 5FCN-based module	Learning materials Questionnaires Kappa's interpretation	Experts of content, pedagogy, and design	Qualitative descriptive and quantitative
One-to-one and small group assessment	Questionnaires The 5FCN-based module	Students Teachers	Qualitative descriptive and quantitative
Academic achievement	Pre-test and post-test questions	Students	Quantitative

2.4. Data Analysis

To examine the impact of the 5FCN-based module, this study used the form of quasi-experimental design (Table 2).

Table 2 Quasi-experimental design

Groups	Pre-test	Intervention	Post-test
Control	O ₁	X ₁	O ₂
Experimental	O ₁	X ₂	O ₂

Note:

O₁ – Pre-test

O₂ – Post-test

X₁- lesson using chemistry textbooks provided by school

X₂- lesson using the 5FCN-based module

3. RESULT AND DISCUSSION

3.1. Planning stage

In this stage, interviews were conducted with chemistry teachers and students at school A, B, and C related to textbook used in chemistry learning. There were several information gathered from the interviews as follows: (1) students found difficult to understand the content of textbooks, (2) teachers and students did not utilize module during learning and students sometimes used student worksheets during chemistry learning, (3) teachers only emphasized the delivery of knowledge or facts without thinking about how students comprehend chemistry concepts contained in the textbooks easily, (4) students were capable to express their ideas during learning, (5) the concepts contained in the textbooks were insufficient connected to real-world examples or daily lives, and (6) teachers still used a traditional approach, teacher-centered and the existing teaching materials have not supported learners to develop their analytical and critical thinking skills. Teacher-centered approach emphasizes content delivery and algorithmic questions solution. As a result, chemistry becomes a boring and less desirable subject. In addition, the existing learning sources have not facilitated learners to build their knowledge, find their own conceptions, understand the concepts conveyed, and present their opinions or beliefs.

Findings from questionnaires shared to students regarding the degree of difficulty to learn chemistry in class XI can be seen in Table 3. Students perceived chemical equilibrium topic as the most difficult topic to understand (mean= 3.0464, SD = 0.6320), followed by rate of reaction (mean= 3.0087, SD = 0.4130), solubility (mean= 2.8841, SD = 0.587), electrochemistry (mean= 2.8191, SD= 0.3783), carbon compounds (mean= 2.6969, SD= 0.4340), acid-base (mean= 2.5202, SD= 0.3414), and colloid (mean= 2.3348, SD= 0.5696).

Table 3 The degree of difficulty of chemistry topics in class XI based on student responses

	N	Minimum	Maximum	Mean	Std. Deviation
Carbon compounds	115	1.00	4.00	2.6969	0.4340
Electrochemistry	115	1.60	4.20	2.8191	0.3783
Rate of reaction	115	1.57	5.00	3.0087	0.4130
Chemical equilibrium	115	1.00	4.67	3.0464	0.6320
Acid-base	115	1.64	3.73	2.5202	0.3413
Solubility product	115	1.00	4.00	2.8841	0.5187
Colloid	115	1.25	4.25	2.3348	0.5696
Valid N (listwise)	115				

Furthermore, findings from questionnaire of teacher perceptions regarding the difficulty level of understanding certain topics in XI chemistry class can be seen in Table 4. There is a similarity view between teachers and students about the difficulty of chemistry topic. The data showed the most difficult topic is rate of reaction (mean= 3.1667, SD = 0.40825), followed by chemical equilibrium and the solubility product. Both teachers and students reported that topic of carbon compounds is easier to understand than other topics.

Table 4 The degree of difficulty of chemistry topics in class XI based on teacher responses

	N	Minimum	Maximum	Mean	Std. Deviation
Carbon compounds	6	2.00	2.60	2.1667	0.26583
Electrochemistry	6	2.60	3.00	2.9333	0.16330
Rate of reaction	6	3.00	4.00	3.1667	0.40825
Chemical equilibrium	6	3.00	3.00	3.0000	0.00000
Acid-base	6	2.00	3.00	2.6667	0.51640
Solubility product	6	3.00	3.00	3.0000	0.00000
Colloid	6	2.00	3.00	2.4167	0.46547
Valid N (listwise)	6				

Based on questionnaire findings, topics of rate of reaction and chemical equilibrium are difficult to understand, both by students and teachers. Therefore, the development of the Needham's five-phase constructivism module is worth to try to overcome the problem and help students in learning chemistry especially in both topics. The module is expected to be used as an alternative instructional material, provides several opportunities for teachers to address various issues related to the poor quality of process and learning outcomes, and helps students to express their ideas or opinions and practice analytical thinking skills in order to enhance their understanding and build their own knowledge. Padmapriya argued that learning by module allows students to actively engage in learning chemistry along with their friends, while the teacher checks intensively and aids students who have difficulty in learning concepts contained in the module independently [19].

3.2 Development Stage

In this stage, the authors determined the strategy of organizing the contents, the delivery, and the module design. The module components are (1) the introduction, (2) the learning section (content description, examples,

exercises, instructions and rubrics for answering questions, summary), (3) test formative and key answers, and (4) bibliography. The strategy of delivering the contents of module used a constructivism approach.

There were six learning activities for rate of reaction topics: the definition of rate of reaction, collision theory, concentration and temperature factors influencing rate of reaction, surface area factor influencing rate of reaction, catalyst as a factor influencing rate of reaction and its application in industry, and the equation of rate of reaction and reaction order. There were four learning activities for chemical equilibrium topic namely dynamic equilibrium, equilibrium constant (K_c and K_p), equilibrium shift, and chemical equilibrium in industry.

3.3 Evaluation Stage

This stage aimed to find out whether the product is eligible to use. The module was assessed in terms on its content, pedagogical, and design aspects through expert reviews. The validity of module, on average, equals to 0.736 meaning that this module is feasible to be used in the next process. Experts also suggested to revise this module in terms of the chemical reaction equation, the clarity and accuracy of content, the appropriateness of figure representing the content, chemical terms, and content presentation and structure.

Furthermore, findings from one-on-one testing and small group assessment showed the 5FCN-based module is practical to guide students to learn chemical equilibrium and rate of reaction with the average score 4.33 and 4.32, respectively, based on Likert scale. Several suggestions for this module revision were related to examples of concepts and sentence structure, chemical reaction equation, and picture explanation.

In field testing, students achievement were measured before and after they finished their learning activities. The statistical analysis (independent t-test) of the students' achievement is summarized in the Table 5.

Table 5 Independent t-test of student academic achievement.

Class	N	Mean	n-gain	T	Sig 2-tailed
Experimental	89	64,63	0,56	2,830	0,006
Control	100	51,83	0,41		

Since $p < 0.05$, the authors reject the null hypothesis, the authors find evidence for a significant difference in mean of achievement score between students in experimental group who used the 5FCN-based module during learning rate of reaction and chemical equilibrium and those in control group who used chemistry textbooks provided by school. The experimental group has a higher academic achievement than the control students. This means that used the 5FCN module can make the learner understand better the chemical reaction rate and chemical equilibrium, compared to the control. The experimental group got an average posttest score of 86.60 and 64.63 in

rate of reaction and chemical equilibrium topics respectively, compared to the average control score of 80.40 and 51.83 in rate of reaction and chemical equilibrium topics respectively (Figure 2).

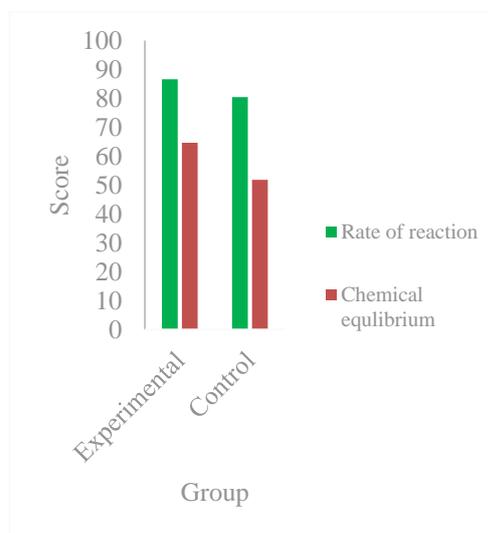


Figure 2. Student achievement in rate of reaction topic

The achievement of the experimental group is higher than the control group because the former group has more activities during chemistry learning than the control students. The 5FCN-based module provides five main activities during learning namely orientation, ideas generation, structuring ideas, ideas application, and reflection. This shows that using the 5FCN-based module gives positive impact on learning achievement [20-21].

4. CONCLUSION

This study shows that the developed 5FCN-based module gives positive impact on student achievement. There were significant differences in student academic achievement between the experimental group who used the 5FCN-based module and the control group who used chemistry textbooks provided by school, in which the experimental group obtaining a higher academic achievement improvement than the control group. However, this study was conducted on the topics of rate of reaction and chemical equilibrium and only involved three high schools, by means of which research could be extended to other schools, to gain wider impact such as academic achievement, attitudes, interests, student perceptions. Also, the authors found that other topics, electrochemistry and acid-base, are also considered as difficult topics to learned from the perspective of teachers and students. Thus, further research can be extended to these topics and involves a larger number of respondents.

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