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Research paper

Incorporating Research in Chemistry Courses: Research Data-Based Learning

Is Fatimah *, Argo Khoirul Anas

Chemistry Department, Universitas Islam Indonesia, Kampus Terpadu UII, Jl. Kaliurang Km 14, Sleman, Yogyakarta, Indonesia, 55584
**Corresponding Author E-Mail: Isfatimah@Uii.Ac.Id*

Abstract

Kinetic Chemistry and Catalysis Chemistry courses were conducted. Aim of the project is to evaluate the effectivity of the model in improving student learning outcome in both courses which are included in the physical chemistry scheme. The courses are getting important attention in difficultness level since those are topics with the abstract and mathematically delivered. In the program students have some individual and group tasks based on research data-simulations to be finished until pass the such level for the completion standard learning outcome and for brief application of the topics in both lecturers visiting professor lectures were given. The teaching model was evaluated based on the difficultness level of each topic and also the percentage of student passing learning outcomes. The results showed that the model was sufficiently give positive impacts. In this project, a teaching-learning model of research data-based learning (RDBL) model for to the students and teaching learning process since more than 80 % were successfully passed the standard. The program was recommended for other courses.

1. Introduction

Department of Chemistry, Faculty of Mathematics and Natural Sciences is one of study program trying to improve the quality of learning through a number of programs generally consists of strengthening the curriculum, strengthening local genius as well as improvement of academic atmosphere. Increased academic atmosphere are in line with capacity building, curriculum on the suitability of the national qualifications framework based on Indonesia (KKNI) as well as the direction of improving the status of an international study program that is attempted to be accredited by the Royal Society of Chemistry (RSC). Accordingly, the Program has designed a comprehensive curriculum that supports the achievement of learning outcomes and competence of graduates, and no less important is the mastery of the content as the standard RSC. However, some technical and conceptual obstacles to learning some subjects are still faced refer to the breadth of basic competencies required to be achieved by each subject in a clump of chemical scientific basis. According to the RSC, chemical core curriculum broadly classified into three (3) fields of the organic chemistry, inorganic chemistry and physical chemistry. Organic chemistry and inorganic chemistry courses give emphasis to the material structure of organic and inorganic types, while the discussion of biochemistry as the interface of chemistry is in relation to the field of life sciences such as biology, pharmacy and medicine. Physical chemistry is a field of science might be explained in detail as studies that include atomic, macroscopic, atomic particles and sub-topics in chemistry. Physical science applied to concepts, principles and practice of energy, time, motion, thermodynamics, dynamics, style, statistical mechanics and quantum chemistry.
Within the basis of physical chemistry, kinetic chemistry and catalysis chemistry courses are the topics as compulsory and elective courses respectively. Both courses are interconnected with the different characteristic in that kinetic chemistry is the basis of catalysis course subject to diagram in Figure.1. Kinetic chemistry presents the topics related to the basic theory of chemical reaction, order and kinetic constant of reaction, mechanism, collision theory and molecular dynamic, catalysis and its application, while catalyst chemistry course provides the topics in catalysis from the basic to application and from homogeneous catalysts to heterogeneous catalysis as well as biocatalysts (enzyme). Due to the load of theoretic and philosophical concept of kinetic chemistry especially for the mathematical approach in order and kinetic constant topics, some problems which related to calculation may affects the misconceptions. In other side, the application of kinetics is actually very wide including catalysis for industrial and environmental applications. The teaching model was aimed to explore the future applications of topics in both lecturers by designing a research data-based learning. The method loads the individual and group tasks to activate classroom and for confirmation and future perspective, lecturers from visiting professor were conducted.

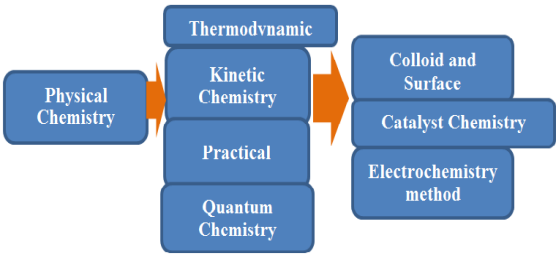


Fig 1: Course Positioning in Physical Chemistry Subject

2. Literature review

Physical chemistry courses have specific difficulties related to the contents which are abstract and usually delivered by mathematical approach. Generally, some problem faced in physical chemistry

courses are as follow: (1) Interest of learners is low due to student perception for general physical chemistry courses. Concepts and theories presented in the course of Chemical Kinetics always been considered a difficult material to students, while the course concepts and theories should be presented numerical examples. This makes learners quickly lose interest in learning because learning materials into something abstract. To overcome this, it would need to consider the characteristics of faculty course content and method of presentation that attract learners (Goodsell et al., 1992). (2) The learning materials are abstract and difficult to correlate with real applications directly, including in relation to other subjects, including the latest research in the field of application. This directly makes the learner not fully follow the direction and purpose of learning.

Based on the challenge to take application of catalysis chemistry topics in between catalysis course and kinetic chemistry courses, the potential college in the theme becomes important reasons to intensification of the courses by instructional design. The principles of instructional design itself consist of: a.) Propose and expose of the theory with questions / issues, b.) Propose and expose of the theory of the case study, c.) Propose and expose of the theory as part of the Long-term Project, d.) Multi-project in an integration in the curriculum. e.) Accommodate the ability of learners (Sokrat et al., 2014). In order to facilitate the development of teaching methods in the field of Chemical Physics delivery of material, some learning methods have been reported to contribute and excellence achievement of learning outcomes. Among these methods constructivism approach is widely used by a variety of methods such as problem-based learning (PBL) or in some cases the so-called Case-Based Learning (CBL), Research-Based Learning (RBL) contributing to increasing the effectiveness of learning teach. PBL, CBL and RBL are constructivist approach by organizing the curriculum, teachers and students one of them through the issues / problems are structured and specifically RBL take the case or the issues of research results (Woldeamanuel et al., 2014). In the third method, the teacher role designing and facilitate the achievement of learning outcomes while students develop critical thinking, problem solving through the identification of problems, formulate solutions. PBL allows learners take important topics related to complexity, relevance and enjoy the learning process and increase the capacity to resolve the problem with the knowledge achieved in real problems. In relation to the scientific development continuously, Chemical Kinetics subjects related to other academic subjects are more applicable, among others Chemical Catalysts, Colloid and Surface Chemistry, Electrochemistry. Material in Chemical Catalysts taking a big portion in conjunction with the reaction mechanism, order and dynamics of molecules studied in Chemical Kinetics.

On the other hand, cooperation with the Chemistry Study Program Chemical Engineering Department, Curtin University, Australia is one of the opportunities for study program for use in the development of learning. One staff Chemistry Dept. Curtin University, Prof. Dr. Shaobin Wang is an active lecturer and researcher has a very good track record in data management kinetics of various experimental research related to the field of catalysis. In these things; PBL is a potential method for constructing materials in order to bridge and provide alternative teaching methods and the potential for linking the topics related to the course of Chemical Catalysts. The resources for several topics in the course can be obtained comprehensively from research data so hereinafter it called as Research Data-Based Learning (RDBL). RDBL will use a comprehensive study with the data research papers relevant to learning some of these meetings / topics for the corresponding courses in this subject Chemical Catalysts. For kinetic chemistry subjects, research data are utilized to extract the content of order and kinetics constant topic and learning outcome.

The learning objective that can be extracted from the program is related to the ability of students to follow the development of technology, language skills and international communication as presented in learning outcome of the study program. RDBL method is a new method that will be tested within the scope of Chemistry Study Program, a classroom action research conducted with the formulation of the problem as follows:

a) How is RDBL contribution to the teaching-learning process in Kinetic Chemistry and Catalysis Chemistry courses?

b) How is RDBL contribution to the achievement of the learning by visiting professor?

3. Methods and materials

Please Instructional method and the combination of student-centered learning and teacher center learning were used. The model consists of four parts:

a) Initial evaluation: Initial evaluation to the students was conducted by questionnaire method. The questions were related to student perception and motivation for passing the lecturers.

b) RDBL model in teaching-learning: In this model some topics were delivered by individual and group tasks using simulation from research data. Lecture evaluated the presentation of the task until students pass such level. During the simulation exercise lecture gave some clues for directing student's activity. For catalysis courses, students learn the topics by discussion, presenting and evaluating presentation each other based on research data gave to each group.

c) Lectures from visiting professor.

d) Final evaluation. The final evaluation was conducted based on student difficulty performance and percentage of student's achievement in learning outcome fulfilment regarding to learning outcome indicator (LOI).

4. Results and findings

RDBL is a constructivist approach by organizing the curriculum, teachers and students through the issues / problems that are structured. Constructivism approach itself has the following characteristics:

1 Not only depend on the climate of learning but also knowledge of learners
2 The learning load of construction materials
3 Construction is continuous learning content, updates and active
4 Lecturer evaluate each process
5 Learners are responsible to their learning outcomes
6 Learners can combine the experience of lectures with real world / update.

In achieving the learning outcomes, knowledge "which can be categorized into three types:

1 Know-what: related concepts, facts and descriptions. Knowledge created through "learning-by-using" approach or learning from doing / using its own. In this case looping and identification becomes an important concept.
2 Know-how: This relates to the type of skills / skills, procedures and methods. Knowledge is built through "learning-by-doing" the practice, applying the experience it yourself.
3 Know-why: this type with regard to competence, theory and experiment. Knowledge will be established through "learning-by-studying" (to understand and apply the principles phenomena through new contexts).

"Know-what" will be closely related to knowledge of the surface (the surface of knowledge) while the "know-why" digging aspects of the application. In some studies, the planting concept of theoretical, type "know-why" is more appropriate in higher education. However, the practice three types of learning approaches will be a synergistic effect (Cook, 2006). The third category of "knowledge" would be used by making the topic interesting and applicable. Descriptively, RDBL approach to related topics in the course of Chemical Kinetics and Chemical Catalysts presented through learning scheme in Figure. 2 and an example for RDBL topic is as presented in Figure.3.

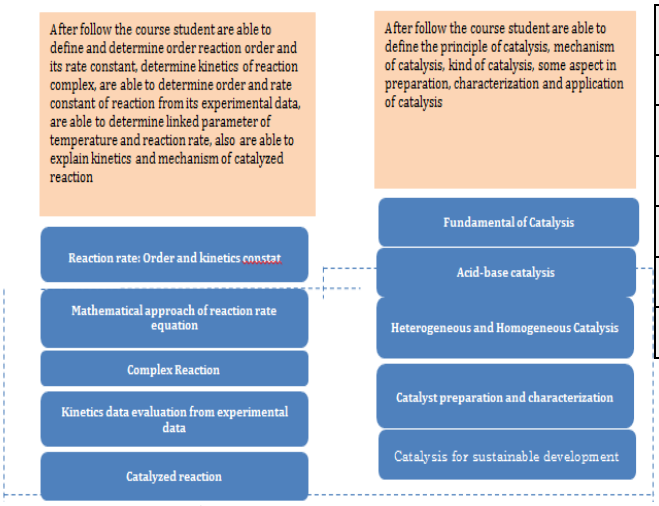


Fig 2: RDBL approach for kinetic chemistry and catalyst chemistry courses

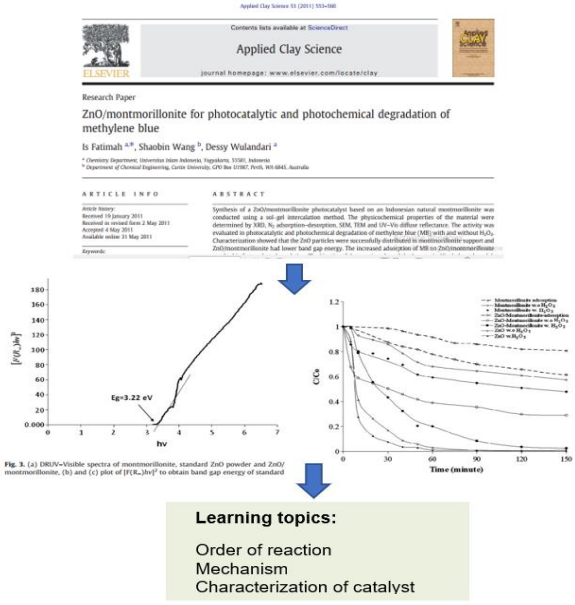


Fig 3: Schematic of example topic in RDBL

The steps of action:

a) Preliminary evaluation of students-Evaluation was related to the prior knowledge related to general chemistry course.
b) RDBL topic in collective module – group and individual tasks
c) Intensive tutorial

Characteristic of student in the program is listed in Table 1

Table 1: Characteristic of students

Class	Students	Cumulative Index
Kinetics A	55	3.55
Kinetics A	57	3.37
Kinetics A	20	3.32

The capabilities of most students range between "adequate (IP=2)" and "excellent (IP=4)". However, the specific capability of student was not very good as deemed to be the ability to take notes (45.2%, 29.0%), to understand English (33%) and mathematical reasoning ability (33.4%). The characteristics of this sample show the very medium or low level of most students enrolling in the faculty. Preliminary evaluation data is listed in Table 2.

Table 2: Preliminary evaluation data

Question	Score				
	1	2	3	4	5
Kinetic chemistry is related to physical chemistry	34.375	43.75	21.875	0	0
Kinetic chemistry course is difficult topic	15.625	43.75	34.375	6.25	0
The difficulties are related to mathematical equation	18.75	56.25	25	0	0
Kinetic chemistry is not in relation with industrial application	0	12.5	28.125	34.375	25
Tutorial activity is needed	56.25	25	9.375	6.25	3.125
Visiting professor will help the achievement	15.625	40.625	28.125	15.625	0
Tutorial activity is problem	6.25	15.625	12.5	46.875	18.75
Ability to pass the course successfully	0	15.625	12.5	50	21.875
Minimum score is B	28.125	56.25	15.625	0	0

Score: 1 = very good --- 5: very bad

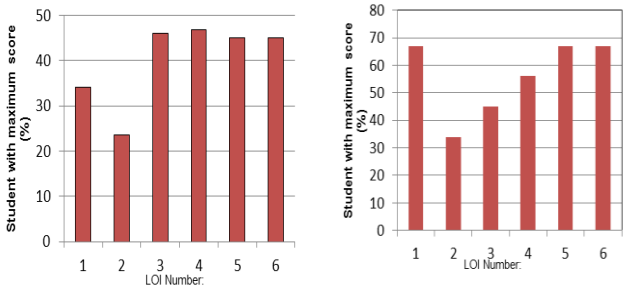
Due to the preliminary evaluation, it is concluded that most student need tutorial activity to increase their ability for passing course successfully and most student are aware with the position of kinetic chemistry in physical chemistry teaching as well as the presence of visiting professor for their performance as chemist. Student difficulty performance after the program is described in Table 3.

Table 3: Student difficulty performance

Topics	Order of reaction	Order of reaction from experimental data	Catalysis	Visiting Professor lecturer	Group Task	Individual Task	Tutorial
1	5.6	11.1	6.3	0	0	0	0
2	22.2	5.6	43.8	17.6	17.6	23.5	22.2
3	61.1	61.1	31.3	41.2	64.6	58.5	44.4
4	11.1	22.2	18.8	23.5	11.8	17.6	5.6
5	0	0	0	17.6	5.9	0	0

Score: 1 = very easy --- 5: very difficult

From the data, it is found that kinetic order and catalysis course get attention more in easy score rather that difficult and very difficult as well as the difficulty in group and individual task in same pattern. From the data it is also noted that tutorial activity is important activity needed. From further exploration survey from the visiting professor activity, most student from all classes agree with the program due to the expertise of the lecturer and the lecture gives opportunity to look the application site of catalysis and kinetic chemistry. Description of the achievement of learning outcome indicator is determined by the percentage of student with maximum score as displayed in Figure 4.



LOI Number: 1 – Order and Kinetic Constant
Number: 2 – Determination of Order from Experimental Data
Number: 3 – Kinetics of Complex Reaction
Number: 4 – Collision Theory
Number: 5 –Catalysis
Number: 6 –Complex Reaction

(a)

LOI Number: 1 – Fundamental of Catalysis
Number: 2 – Kinetic and Thermodynamic of Catalysis
Number: 3- Classification of Catalyst
Number: 4 – Catalyst Preparation
Number: 5 –Catalyst Characterization
Number: 6- Catalysis for Sustainable Development

(b)

Fig 4: (a) The achievement of learning outcome indicator from kinetic

chemistry classes. (b) The achievement profile of learning outcome indicator from catalysis chemistry class.

5. Conclusions

The difficulties encountered in dealing with kinetic chemistry and catalysis chemistry curses can be covered by RDBL teaching method due to several factors consist of the nature of the concept obey some applications to be realized, the visiting professor expertise and tutorial activity help the achievement.

Acknowledgments

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