

The Development of Innovative Learning Material With Problem Based Approach to Improve Students Competence in The Teaching of Physical Chemistry

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Abstract — Innovation learning material with problem based approach is believed to be applicable to improve students' competence as required by the Implementation of Indonesian National Qualifications Framework (*Kerangka Kualifikasi Nasional Indonesia*, KKNI) curriculum on the teaching of Physical Chemistry. This research aimed to develop an innovative learning material with problem based approach to be used as a learning resources to improve students competence on Physical Chemistry. The research is conducted in Department of Chemistry Universitas Negeri Medan. The steps to be followed are including enriching of chemistry learning material on Physical Chemistry, setting the chemistry material in problem based approach, integration of laboratory experiment and learning activities, and implementation of innovative learning material in the class. The results obtained in the study has provided a standard and innovative learning package that are designed in problem based approach has been developed successfully that is suited to the KKNI curriculum. The problem based approach provided in the learning material is found to be able to guide the students to learn independently in Physical Chemistry. The students are found be able to construct the relationship between chemistry concept with daily life application. Integration of multimedia in the learning material has motivated the students to learn the topics and Physical Chemistry easy to learn. Innovative learning material has been proven to be able to improve students' competence since they are forced to do the work independently. The facility available in a learning package has adequate to guide the student for self learning.

Keywords— *Innovative, Learning Material, Problem based, Physical Chemistry*

I. INTRODUCTION

National education in Indonesia has been set as one of the national development sectors to educate the life of the nation has a vision in the realization of an educational system as a powerful and authoritative social institution to empower all Indonesian citizens to become qualified human beings, so as to be able and proactive to answer the challenges of the ever-changing era. The current development of science and technology has led to the enactment of Indonesian National Qualification Framework (KKNI) Curriculum in universities that aim to develop students' potential optimally. Therefore, to improve the students 'competence in the field of knowledge, attitude and skills, it is necessary for students to learn independently and continuously [1,2] Additionally it is necessary the relevant learning materials and easily understood by students in accordance with the applicable curriculum demands. Good learning materials should be able to present the subject matter in accordance with the demands of the curriculum, the development of science and technology, and can bridge learning in order to achieve the established competencies [3]. In addition, innovation in learning materials should provide opportunities in the formation of student characters to be skilled at building their knowledge capacity independently through high-level thinking skills, such as critical thinking, creative and decision making, as well as solving problems [2,4]. Critical thinking is thought to help in solving problems and making decisions, whereas problem solving is the process by which individuals try to overcome

the problems faced to achieve goals. It relates to how we think rather than what we think [5].

Physical Chemistry course is one of the compulsory subjects in Chemistry Department. The studies discussed in Chemical Physics include Chemical Kinetics and Equilibrium. The number of concepts involving the calculation and understanding of diagrams or curves in Physical Chemistry material causes the need for students to learn about critical thinking and problem solving skills so as to acquire essential knowledge and concepts from the subject matter [6]. In addition, the learning model should be student-centered, so that students are given the opportunity to work autonomously to construct their learning methods, and the lecturer only is functioned as a motivator and facilitator [7]. Physical chemistry learning has been given both in the form of theory and practicum, but it has not been fully integrated, so it has not been able to make the students master the competence set, especially the low-ability students, besides the highly skilled students also have not obtained optimal learning service [6]. Therefore, in an effort to improve students' competence in Physical Chemistry course, it needs learning materials with problem based approach, known as Problem Based Learning (PBL).

The students involved in a PBL is encouraged to become independent learner. The PBL approach are empowering the students to conduct research, integrating theory and practice, and applying knowledge and developing feasible solutions for problem solving, and preparing individuals for self-sustaining and self-sustaining learning [2,7]. The PBL is a pedagogical approach based on recent advances in cognitive science research in the learning process, which is organized as a collaborative problem-solving activity, and it provides a context for learning and discovery [8]. This approach lead the students learn in the context of problems to solve, so that the responsibility for learning is in the students, not within the facilitator [9]. There are 5 stages to be followed in the PBL process, they are introduction, inquiry, self-study, hypothesis review, and evaluation. This study aims to produce innovative learning materials using problem-based approaches to improve student competence in physical chemistry course.

II. LITERATURE REVIEW

A. Innovative Learning Material

Learning materials are part of a learning resource that contains materials or lecture materials used by students and lecturers in the lecture process. Learning materials have a systematic structure and sequence, explain the objectives to be achieved, and help students to be able to learn independently, so that the accumulative able to master the competence as a whole and integrated.

Innovative learning materials are learning materials that are more flexible in accordance with the needs of students. Flexibility considers and takes into account various aspects that include student characteristics including intellectual, emotional and spiritual abilities as well as obstacles in learning [10]. Innovative learning materials should provide instruction and practice and feedback, so it is interactive,

which allows students to learn the material presented. To develop innovative learning materials, the lecturers must understand how far the interests and talents of students, so that students are motivated to learn independently so as to be able to control the competencies that have been determined.

B. Problem Based Approach

The general approach to learning can be interpreted as a perspective (point of view) theory that might be used as a basis in selecting models, methods and techniques of learning. Learning approach is a process or deeds used by lecturers to present the lesson material and serve as a starting point or point of view of the learning process [11]. The paradigm shift of learning focus from teacher centered learning to learning centered on students (student center learning) is one of the efforts to improve the quality of process and learning outcomes [12]. One of the appropriate approaches is the problem-based approach, which is an approach that empowers students to undertake research, integrate theory and practice, and apply knowledge and ability to develop viable solutions to problem solving, and be able to prepare individual self-sustaining learners [2,13].

A problem-based approach is learning that uses problems as a focus for developing problem-solving skills, materials and self-regulation [8,14]. This means that PBL is a learning model based on the principle of using the problem as a starting point and integration of new knowledge. In problem-based learning, problem-solving is defined as a process or attempt to get a real-time task and situation settlement as a problem by using known rules [15]. The PBL process begins with an unstructured problem and the student must be able to resolve the issue. After understanding the problem, the student will identify the information already known and the information needed to be learned in order to find the solution of the problem. There are three main components required in PBL, students as learners, instructors or lecturers as tutors, and problems such as context [5,16]. PBL uses real-world problems as a context for students to learn about critical thinking and stimulate high-level thinking in problem-oriented situations, and to acquire essential knowledge and concepts from instructional materials [17].

III. RESEARCH METHODOLOGY

A. Research Design

Research conducted is Research and Development (R & D) by the development of an innovative learning material with problem based approach to be used as a learning resources to improve students competence on Physical Chemistry. The development is conducted to provide chemistry learning material in problem based approach on Physical Chemistry as models to be used in the class to improve students competence on Physical Chemistry [18,19]. An innovative learning materials with problem-based approach for Physical Chemistry course are dealing with enriching chemistry learning material and combining the subject with problem for Physical Chemistry topic of kinetics, chemical equilibrium and phase equilibrium and its application in the science of daily life. The stages of the research are: (1) development of

learning materials through the enrichment of materials based on basic knowledge, (2) preparation of standard problem and evaluation grids, (3) integration of package of practicum activities and learning activities, (4) feasibility study of learning materials, and (5) implementation of learning materials [20]. The research instruments composed consist of (1) assessment sheets (Validation) of textbook adapted from National Education Standards Agency (BSNP) [21], and (2) a test instrument to measure student learning outcomes of course materials provided in the learning process.

B. Design of Learning Material

The development of innovative learning materials with problem-based approaches conducted in this study is divided into 3 (three) stages. The first stage is the needs analysis phase. At this stage will be identification and analysis of Physical Chemistry material characteristics based on basic knowledge [20]. The second stage is the design stage of learning materials products. Activities in this stage is the preparation of learning materials through description of material based on the Curriculum of KKNi, the concept of delivery and organizing the material with a problem-based approach, the type of task, worksheet and practice questions. The third stage is the validation and analysis stage. This stage is a series of product development assessment stage. Thus validation results was analyzed and made revisions based on input or suggestions so that the learning materials developed into products that were suitable for use. The tool of the assessment of learning materials consisted of a suggestion sheet and comments and questionnaires in the form of written questions that were used to obtain information from respondents, in the form of assessment form of the reviewer. The instrument of feasibility of learning materials was obtained by using questionnaire with the questions are raised in multiple choice options, starting from strong opinion with positive response of very good (score 5), down to a very low opinion with negative view of very poor/bad (score 1) [22]

C. Learning Material Implementation

Implementation of learning materials with problem-based approach in the learning process aimed to obtain the quantitative data research from the results of students learning. Thus, learning result of data obtained through the implementation of learning materials in the process of learning in Physical Chemistry courses were tested on the students of chemistry education program Faculty of Mathematics and Sciences of State University of Medan in academic year 2016/2017. For the experimental class, learning process was done with the instructional materials that already prepared, while for the control group, learning was through without using the instructional materials that prepared. Before the learning process begins, pretest was administered and after the learning process done the posttest was given. Analysis of learning outcomes was done by pretest-posttest of control group design technique

IV. RESULT AND DISCUSSION

The research undertaken was basically to develop learning materials through the enrichment of materials, along with the

preparation of a grid of standard practice and evaluation. The results of learning materials development were tested based on the feasibility test and the implementation of learning materials to improve students' competence in Physical Chemistry course in the university. The study material in Physical Chemistry conducted in this research consists of 3 (three) parts, they are chemical kinetics, chemical equilibrium and phase equilibrium. The first step in this research was the revision of material identification based on basic knowledge, consisting of chapter / sub-chapter, basic competency, learning output and learning outcomes and learning method [20]. The next step of the instructional description followed by the analysis of learning materials. Learning material descriptions were developed through material enrichment, practice questions, the integration of systematic and structured package of practicum and evaluation activities. The analysis of learning materials was based on the validation result done by the KDBK of Physical chemistry lecturer by using the instrument in the form of validation sheet of learning materials. The components of the validated learning material include several things: (1) the content feasibility component, (2) the language component, and (3) the component of the serving technique, and (4) the component of the graphic [21]. Learning outcomes are analyzed based on initial ability (pretest) and end-ability (posttest).

A. Learning Material Description

The instructional materials are based on the competence that must be achieved in Physical Chemistry learning in accordance with the KKNi curriculum requirements applicable in the educational program of Chemistry of Faculty of Mathematics and Sciences State University of Medan. The learning materials were developed through material enrichment, the preparation of the standard training and evaluation grid, and the integration of the practical activity and learning activities, structured in a systematic and structured way to support the theory of Physical Chemistry. Inside the material was equipped with contextual examples, drawings, and examples of problems and solutions that were applied in everyday life. In addition, there was provided a search link address which could be used as an additional reference. In general, the composed learning materials are summarized in Table I.

TABLE I. MATERIAL DESCRIPTION OF PHYSICAL CHEMISTRY

No	Material Description	
	Subject	Description Subject
1	Introduction	Presented general material descriptions, prerequisites, instructional use of materials, expected competencies and concept maps for each subject
2	Chemical Kinetic	Enrichment of chemical kinetics materials, integration of PBL, demonstration activities,

No	Material Description	
	Subject	Description Subject
		animation and ppt media settings, laboratory activities, presentation of experimental data for analysis, examples of various forms of integration, exercises and examples of applications in everyday life.
3	Chemical Equilibrium	Enrichment of learning materials, integration of PBL for open system disclosure and linkages to free energy changes, examples of equation related cases of extent of reaction and reaction isotherms, ppt media settings, and presentation of sample questions and exercises. Integration of laboratory activities, and example of the concept of equilibrium shift and relation to K.
4	Phase Equilibrium	Enrichment of phase equilibrium learning materials, integration of PB, analysis of diary, binary and ternary system phase models, TX and PX diagrams, cases of eutectic, congruent and incongruent systems, integration of laboratory activities in the form of case studies in daily life, the presentation of the decline of equations in the form of sample questions and exercises with examples in life and discussion.

B. Learning Material Validation

After the preparation of learning materials has completed, then the review of learning materials with the results of the validation was presented in Table II. Validation was done by lecturer of KDBK Physical chemistry by using instrument in the form of validation sheet of learning materials. The components of the validated learning materials include several things, (1) the content feasibility component, (2) the language component, and (3) the components of the presentation technique, and (4) the feasibility component of graphic. From the results of the analysis of learning materials, it could be seen that the validators provided a good category assessment of the compiled learning material shown by the average score of all components is average 4.15 (It categorised as very good)

TABLE II. RESPONDENTS OPINION TO THE DEVELOPED LEARNING MATERIAL OF PHYSICAL CHEMISTRY

No	Description Criteria of Innovative Learning Material		
	Assessment Components	Score	Range Criteria
1	Content	3.89	Very good and unnecessary to be revised
2	Language	4.25	Very good and unnecessary to be revised
3	Technique of Presentation	4.50	Very good and unnecessary to be revised
4	Graphic	3,96	Very good and unnecessary to be revised
	Average	4.15	Very good

Based on the assessment score in the learning material components, in which the respondents gave very positive opinion (average 4.15) that were assigned to be very good [3,18]. The results in the learning package has met the standard requirements given by BSNP criteria in parameters of the content, language, technique of presentation, and graphic [22]. This means that the instructional materials were suitable

to be used for the study of Physical Chemistry materials because they fell into the valid criteria according to BSNP standard and is ready to be implemented in the teaching and learning activities.

C. Learning Outcome

A set of developed learning material in PBL was implemented in the class for experimental class and existing learning was utilized in a control class. Pretests is carried out for both class before teaching and learning activities are being started, and followed the posttest after the teaching treatments. The result of pretest is needed to investigate the students' early ability and posttest result aimed to know the students learning result of each sample class. Learning result on the students performance from pretest and posttest is presented in Table III.

TABLE III. PRE-TEST AND POST -TEST SCORES OF PHYSICS CHEMISTRY

Treatment Class	Average learning outcome (Score) in Evaluation Test	
	Pret Test	Post Test
Experimental Class	29.64±5.19	89.97±7.56
Control Class	31.21±6.07	80.42±4.23

The results on students achievement in Table III shows that before the learning was done, the students' in experimental and control class are having inadequate knowledge in Physical Chemistry topic, those are viewed from low score obtained in pretest for both for control group (31.21±6.07) and experiment group (29.64±7.28). Evaluation by using *t*-test showed that the two sample classes were not significantly different ($t_{\text{count}} 0.982 < t_{\text{table}} 1.695$). This means that all students in experimental and control class are having initial relatively same ability to solve Physical Chemistry evaluation test. After learning activities have been carried out, the students ability to solve Physical Chemistry evaluation test have been demonstrated as presented in Table III. All students improve their ability in Physical Chemistry course for both classes and the students achievements are significantly increased compared to pretest result. The learning result of experimental class students that used learning materials with problem based approach (89.97±7.56) was higher than that obtained in control class learning result (80.42±4.23). The t_{test} results showed that the two sample classes were significantly different ($t_{\text{count}} 2,364 > t_{\text{table}} 1,695$). Based on the data achieved by the students, it could be stated that the difference of Physical Chemistry study result between the experimental class and the control class was caused by the use of learning materials with problem based approach in learning. This is because the learning activities undertaken were able to develop problem-solving skills and motivated students to do self-study [13,23] and facilitates students in learning the material presented, so as to improve students' competence.

V. CONCLUSION

An innovative learning material with problem-based approach has been developed suited to KKNI curriculum and has been used as a learning resource to improve students' competence on Physical Chemistry. The learning packages have been enriched with standard chemistry subjects and equipped with adequate instruction to be followed for PBL learning. The PBL activities in the learning material led students to do self-study and motivate themselves to master the topic. The learning activities in the PBL have brought the students to make a link of chemistry concept and theory into everyday life. Implementation of innovative learning materials in the class has proven that Physical Chemistry course with PBL becomes easy to learn. Learning results have shown that students' achievement in experimental class with PBL (89.97 ± 7.56) was higher than that obtained in control class (80.42 ± 4.23), and both classes are significantly different ($t_{\text{count}} 2.364 > t_{\text{table}} 1.695$).

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