

The Development of Basic Chemistry Courses Program Based Problem Solving to Improve Student's Critical Thinking Skills

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Abstract. This research is a research and development that aims to produce of Basic Chemistry Courses Program to improve Students' Critical Thinking Skills. This research was used Thiagarajan Research and Development model which consists of four stages: define, design, develop, and disseminate phases. The Basic Chemistry courses program include of syllabus, lesson plan, work sheet, hand book, and critical thinking skills test. Limited trial conducted in science education programe of UNM on 2015/2016. The instrument used to collect validation data consists of: 1) sheet validation learning device (syllabi, lesson plan, textbook, students work sheet, and critical thinking skills test), 2) research observation device sheets, 3) learning management observation sheets, 4) student activity observation sheets, 5) questionnaire responses of students, and 6) critical thinking skills test. The program was validated by expert judgment. The critical thinking skills indicator was identified in this research consists of: 1) basic clarification, 2) the basis for decision, 3) inference, 4) advanced clarification, 5) supposition and integration, and auxiliary abilities, not constitutive of critical thinking. The results showed that the Basic Chemistry courses model based on problem solving to improve the students critical thinking skills is valid category. The limited trial results showed that the learning device that have been developed are in practical category and effective in terms of the results of students' critical thinking skills test.

Keywords: Problem Solving, Critical Thinking Skills.

INTRODUCTION

On the Science Education Programe, Basic Chemistry course was given in the first semester as a foundation of Advanced Chemistry lectures such as Solution, Analytical Chemistry and Organic Chemistry subject. Basic Chemistry provides knowledge of the chemical content that will be used by students in understanding and teaching integrated science in science programe. In studying Basic Chemistry, students need to use their critical thinking skills of their entirety in order to resolve the chemical problems in learning and critical issues related to daily life. The fact shows that the problems of chemical given to students can not be completed correctly. It is evident from the average of chemistry student learning outcomes at the Basic Chemistry of Science Education Programe students FMIPA UNM subject on 2013 and 2013 were moderate.

The impotance of critical thinking skills test in science learning standard has mentioned in teaching science which suggests that the activity in teaching science should be included of critical thinking and creative, and not to limit the routine or rote learning. By critical thinking, allowed students to study the problems systematically, facing immense challenges in organized manner, formulate questions and devise solutions (Johnson, 2012).

Improved critical thinking skills of learners into learning process is one of the very important efforts, due to their critical thinking skills, students can understand the concepts of learning which can be applied to solve the problems. Critical thinking is reasonable and reflective thinking focused on deciding what to believe or do (Ennis, 2011). The critical thinking skills can be identified with the following abilities: 1) basic clarification, 2) the basis for decision,

3) inference, 4) advanced clarification, 5) supposition and integration, and auxiliary abilities, not constitutive of critical thinking (Ennis, 2011).

Critical thinking skills can be trained through problem solving model, because in this learning model the students are trained to solve problems by using the concepts that have been mastered. Through conceptual and critical questions given through lecturing process encourage the students to use the skills intellectual disposition to identify the problems, analyze, and devise the problem. Problem solving is the highest level of type of study and complex compared to the other types of learning (Gagne in Martinis, 2009), because the students can only solve the problem if it has a lot of concepts, rules, or specific rules on various aspects (Thoifuri, 2008). According to Polya (1957), teaching model of problem solving, the students are required to be able to identify problems, devise plan, implementation planning solutions, and look back / evaluation. The steps can be only done by the students if they can think critically.

The problem of the research about how is the process of Development Basic Chemistry lecture program based problem solving to improve students' critical thinking skills in science education programe of UNM that valid, practical, and effective?

MATERIAL AND METHODS

Research Types

The research is a development research (Research and Development), it is course development Basic Chemistry Program Based on Problem Solving which can improve students' critical thinking skills in science education programe.

Procedure of Device Development

The development of the lecture program using 4-D models developed by Thiagarajan et al. (1974). The development research consists of four stages: definition stage, design stage, development stage, and disseminate stage.

1. Stage I Define

The define stage is the stage for establishing and defining the terms of the learning. Define phase includes five main steps, namely a preliminary analysis of the end (front-end analysis), analysis of learners (learner analysis), analysis of the task (task analysis), analyzes the concept (concept analysis) and formulating learning goals (specifying instructional objectives).

2. Stage II Design

The design phase aims to design a learning device. Four steps that must be done at this stage, namely: (1) Constructing criterion-referenced test, (2) media selection in accordance with the material characteristics and learning objectives, (3) format selection, which examines the formats of existing teaching materials and teaching materials set the format that will be developed, (4) initial design, according to the selected format. An initial draft that purposed of this research is the design of the syllabus, lesson plans, Textbook, worksheet, and Critical Thinking Skills Test.

3. Stage III Develop

The development phase is the stage to produce a product development conducted through two steps, namely: 1) expert appraisal followed by a revision, and 2) development testing. The purpose of this development phase is to produce a product learning device final form Basic Chemistry lecture program based problem solving to improve students' critical thinking skills of science education.

4. Stage IV Disseminate

Dissemination phase aims to get input, corrections, suggestions, assessments, to enhance the development of the final product to be ready to be adopted by the users of the product.

Research Instruments

The research instrument was developed to obtain information about the quality of the research product. Instruments developed in this study were: 1) sheet validation learning device (syllabi, lesson plans, textbook, students worksheet (LKM), and Critical Thinking Skills Test), 2) research observation device sheets, 3) learning

management observation sheets, 4) student activity observation sheets, 5) Questionnaire responses of students, and 6) Critical Thinking Skills Test.

Method of Collecting Data

The data collected in this research are the validation result of feasibility learning device and research instruments, the data of Basic Chemistry based problem solving learning device implementation, and students' critical thinking skills test results.

The assessment of all learning device format based on assessment criteria by using 1-4 scale, as the details which are not good (score 1); less good (score 2); excellent (score 3); and very good (score 4). This assessment was given to each indicators: feasibility content, language, and grain.

Data Analysis

The data have been collected by using research instrument, further analyzed qualitatively to determine the validity, practicality and effectivity.

1. Data analysis of validity learning device. The step to determine the validity is recapitulate of assessment results about: a) the aspect (A_i), b) criteria (K_i), c) the results of the assessment validator (V_{ij}); so make the average of the results of assessment for each criterion, using the formula:

$$\bar{K}_i = \frac{\sum_{j=1}^n \bar{V}_{ij}}{n}$$

With: \bar{K}_i = the average of criteria i
 V_{ji} = scores the results of a study of criteria to-i by Assessor to-j
 n = the number of assessors

- 1) The average of each aspect according to the formula:

$$\bar{A}_i = \frac{\sum_{j=1}^n \bar{K}_{ij}}{n}$$

With: \bar{A}_i = the average of aspect i
 \bar{K}_{ij} = the average for all aspects of i criteria i to j
 n = the number of assessors

To determine of the average total (\bar{X}) with the formula:

$$\bar{X} = \frac{\sum_{i=1}^n \bar{A}_i}{n}$$

With: \bar{X} = total average
 \bar{A}_i = average of i aspect
 n = the number of aspect

Determining the validity for each category, or mean aspect \bar{A}_i , or mean total \bar{X} with a predetermined validation category. Validation Category (Nurdin, 2007) as follows: $3,5 \leq \bar{X} \leq 4$ (very valid); $2,5 \leq \bar{X} < 3,5$ (valid); $1,5 \leq \bar{X} < 2,5$ (quite valid); $\bar{X} < 1,5$ (invalid).

2. Data analysis practicality

The data practicality learning device obtained the result observations of the feasibility research. Data analysis steps: 1) to recapitulate the observations research devices include: aspects (A_i), and criteria (K_i); 2) calculate the average every aspect of observation for each meeting; 3) look for total average \bar{X} ; 5) determine the category of the overall feasibility of each aspect or all aspects; $1,5 \leq \bar{X} \leq 2$ (implemented entirely); $0,5 < \bar{X} < 1,5$ (implemented partially); $0,0 \leq \bar{X} < 0,5$ (not implemented).

3. The effectiveness of data analysis.

To determine the effectiveness of the learning device analysis; 1) the result of learning outcomes; 2) the activity data of learners; 3) the response of learners; and 4) management of learning data.

RESULT AND DISCUSSION

Result of Research

Validity of Learning Device

Validity of Lesson plan (RPP) includes of the aspects of objectiveness, content and learning activities, language, time, facilities and teaching aids. Validator scoring average is four (4) of valid categories.

Validity of students work sheets (LKM) includes of format, language, the content of LKM, and time. The average assessment validator equal with 4 (four) of valid category.

Validity of Textbooks includes of textbooks format, content, language, and the benefit or usefulness of the book. The average result is 3.89 of valid category.

Validity of Critical Thinking Skills Test consist of the material aspects, language, construction, and time. The average assessment result is 4 (four) of valid category.

In addition of validation device, also conducted by validation of the entire instrument that will be used in this research. The tests showed that the student questionnaire responses instruments, research sheet observation devices, observation sheet student activities, and instrument validation of all the devices in a valid category.

Practicality Learning Device

Practicality of Basic Chemistry based problem solving learning devices, assessed from the observations of the feasibility lecture which consists of several components: 1) learning syntax that includes of feasibility of each phase in lesson plan (RPP); 2) social system that consist of interaction or multidirectional communication, active learners and provide the opportunities for learners to be active in learning process; 3) The principle reactions include of: lecturer ability to create conducive atmosphere, provide and manage the learning resources, guiding students, and provide positive reinforcement; and 4) support system that includes of learning device. Scoring average learning device of the research is 1.90, the category is entirely implemented.

The effectiveness of learning device

The learning device effectiveness assessed on the activity of learners .The observer wrote the keypad category of student activity in the group dominant appear in learning activities on the model of learning based on problem solving. The average percentage of agreement about 80.84 %. This shows that the basic chemistry based problem solving learning device are at good category.

The effectiveness of learning device also assessed the ability of the lecturer to manage learning process. The average of the observations obtained the value included in the height of 2.90. The components are assessed the management of the early activity, the core activities, the activities, and the atmosphere in the classroom.

The analysis of student learning response based on the implementation of the problem solving obtained 90.80 % students give a positive response. Student response to the textbook and students work sheet (LKM) is 97.30 % and 95.63 % respectively give positive response . The analysis results obtained students' critical thinking skills is 69.56 % of students achieving complete category.

Discussion

The result of validity, practicality, and effectiveness analysis of Basic Chemistry based problem solving learning device are in valid, practical and effective category based on the result of some instrument assessment. Basic Chemistry based problem solving learning device can improve students' critical thinking skill because in solving problems, the student using the ability of analysis in order to solve given problem.

The following example are given about chemistry test and its completion on Table 1.

Problem Solving	Critical Thinkig Skills Indicators
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<p>Example 1 Ascorbic acid (vitamin C) cures scurvy. It is composed of 40.92 percent carbon (C), 4.58 percent hydrogen (H), and 54.50 percent oxygen (O) by mass. Determine its empirical formula. (Chang, 2008)</p>	
<p>First Principle: Understand the problem In a chemical formula, the subscripts represent the ratio of the number of moles of each element that combine to form one mole of the compound. How can we convert from mass percent to moles?</p>	<p>Keep the question and situation in mind Follow problem solving steps</p>
<p>Second Principle: Devise a Plan If we assume an exactly 100-g sample of the compound, do we know the mass of each element in the compound? How do we then convert from grams to moles?</p>	<p>Identify or formulate criteria for judging possible answers</p>
<p>Third Principle: Carry out the plan If we have 100 g of ascorbic acid, then each percentage can be converted directly to grams. In this sample, there will be 40.92 g of C, 4.58 g of H, and 54.50 g of O. Because the subscripts in the formula represent a mole ratio, we need to convert the grams of each element to moles. The conversion factor needed is the molar mass of each element. Let n represent the number of moles of each element so that:</p> $n_C = 40.92 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 3.407 \text{ mol C}$ $n_H = 4.58 \text{ g H} \times \frac{1 \text{ mol H}}{1.008 \text{ g H}} = 4.54 \text{ mol H}$ $n_O = 54.50 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 3.406 \text{ mol O}$ <p>we arrive at the formula $C_{3.407} H_{4.54} O_{3.406}$, which gives the identity and the mole ratios of atoms present. Chemical formula</p> $C: \frac{3.407}{3.406} \approx 1 \quad H: \frac{4.54}{3.406} = 1.33 \quad O: \frac{3.406}{3.406} = 1$ <p>Because 1.33×3 gives us an integer (4), we multiply all the subscripts by 3 and obtain $C_3H_4O_3$ as the empirical formula for ascorbic acid.</p>	<p>Make material inferences Ability to give reasons Identify and handle irrelevance How does that apply to this case</p>
<p>Fourth Principle: Look Back Examine the solution obtained. Can you check the result? For example, We can check the formula of ascorbic acid is $C_6H_8O_6$. the number of atoms in an empirical formula is half of the number of atoms in the molecular formula.</p>	<p>Monitor their own thinking (that is, engage in metacognition)</p>

CONCLUSION

Basic chemistry based problem solving lecture courses (syllabus, lesson plans, students work sheet, textbooks, and critical thinking skills tests) that can improve students' critical thinking skills have a valid category, practical, and effective.

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