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DEVELOPING SMALL SCALE CHEMISTRY PRACTICUM MODULE TO IDENTIFY STUDENTS' ABILITY IN PREDICT-OBSERVE-EXPLAIN (POE) IMPLEMENTATION

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ABSTRACT

Chemistry practicum does not have to be complicated and requires expensive apparatus and chemicals, and is considered not environmentally friendly. The concept of small scale chemistry practicum is one of appropriate technology that is packaged elegantly to introduce and embed the principles of green chemistry in every chemistry experiments, and also to enhance the concepts of chemistry through verification and scientific discovery. This study aims to create the newest product, the small scale chemistry practicum module to identify the ability of the students of chemistry education study program, Sanata Dharma University, Yogyakarta in formulating predictions on phenomenon based on the insights they have, making direct observations through small scale chemistry practicum, and explaining the results of observations and emphasis on concepts in detail and depth. This research is the development research with the model of Analysis, Design, Develop, Implement, and Evaluate (ADDIE). Data were analyzed by descriptive analysis and Rasch Model. The results of the study show that the product developed has a perfect and feasible level of readability to be tested. From the content aspect, it presented in perfect criteria, as well as the construction aspect and aspect of language, also shows good value. The students already have quite an excellent ability to predict (average score= 76), observe (average score= 88.5), and explain (average score 87.5). Also, it was noted that students enthusiastically applied POE, and the results of POE students show good person reliability value (0.88) in small scale chemistry experiments. The product developed has been valid, effective, and practical for use in experiments according to experts and teachers, and good student responses (Cronbach's alpha value= 0.92) to the product.

***Keywords**: small scale chemistry, practicum module, predict-observe-explain*

INTRODUCTION

Practicum is characteristic of subjects such as biology, chemistry, and physics. Especially in chemistry, general experimental activities are carried out at school laboratories and use apparatus and chemicals. Unfortunately, the needs in the chemical laboratory are not as complete as thought. There are still many high schools in Indonesia that lack facilities to support these experimental activities. Research findings in Jambi, Indonesia reveal that lack of facilities

in chemical laboratories is prevalent, but need to support and help chemistry teachers to innovate in learning [1]. Besides that, other data, like five high schools in Bangli Regency, that the number of chemical laboratory equipment was inadequate [2]. So, by utilizing materials in the surrounding environment, educators and students can still be creative in building an understanding of chemistry through simple and fun chemistry practicum.

The concept of small scale chemistry practicum is easy to do. We can make a simple kit for the needs of practicum in chemistry labs by utilizing materials in the environment [3]. An initial feasibility study needs to be done for each chemical material to experiment and the readiness of the chemistry teachers and school students. The existence of small scale chemical practicum is not merely an ornament to make chemistry fun but also helps remind us of the principles of green chemistry. Previous authors [4] explained that the introduction of environmentally friendly chemistry learning that promotes green chemistry as an innovation in chemistry learning is both applied in order to students are accustomed to studying the use of apparatus, materials, and procedures used. Previous authors [5] revealed that the wastes from chemical experiments that are only collected and stored in the laboratory could endanger laboratory conditions and the environment so that intensive treatment is needed. Reagents and waste produced must be reduced as much as possible to prevent misuse in every chemical practicum and in accordance with the principles of green chemistry, which are applied through the use of small scale chemistry practicum kit. That way, the management of chemical laboratories is increasing, and practicum can still be carried out safely and not damage the environment. Small scale chemistry practicums need to be maintained in any condition and can be developed for the learning needs of high school and vocational high school.

In chemistry experiments, including small scale practicum, the ability to Predict, Observe, and Explain commonly known as POE is an important part to be analyzed. Competence in POE emphasizes individual participation to be active in building conceptual understanding and skills [6]. Through prediction, students can strive to provide an overview and linkages with practicums carried out, make observations according to facts, and explain phenomena that occur [7]. Furthermore, these three abilities become part that is able to describe the phenomena that occur. Previous authors [8] revealed that all three activities in the POE were very useful in building student activities, and connectivity was formed between new knowledge and things observed during the experiment.

The small scale practicum that has been determined needs to be designed procedurally and fulfilling the requirements. For this reason, the authors took the initiative to develop products in the form of a small scale chemistry practicum module to assist students in understanding the practicum, as well as identifying the ability of POE students during conducting chemistry experiments.

METHODS

This research is development research that adapts the Analysis, Design, Develop, Implementation, and Evaluation (ADDIE)

models. The research was conducted from May 2018 to January 2019, which was trial tested with 35 students of Chemistry Education Study Program, Sanata Dharma University, Yogyakarta, who took part in this small scale chemical experiments.

The product was developed is consists of ten small scale chemistry experiments, which were supported by expert judgment consisting of one expert in the field of chemistry education, one expert in chemistry, and three chemistry teachers. The validation sheet contains an assessment of the chemistry concepts, construction, and language aspects for each practicum. Test instruments amounting to ten essay questions (each practicum only one essay questions) were developed to assess students' POE abilities. At the end of the research, a questionnaire was given to analyze students' responses to the product and its implementation during the practicum.

Analysis of the results of the validation by the experts was done using Aiken's V calculation by calculating the score of each rater from the validation results, then entered into the formula Aiken's V, while the analysis of the results of POE test by students and the questionnaire responses to the product were analyzed with the Rasch Model (analysis by Winstep Program and see the summary statistics result, especially in person reliability, item reliability, and Alpha Cronbach's value). Descriptive analysis is also used in describing the results of validation and the students' POE ability.

RESULTS AND DISCUSSION

The development of small scale chemistry practicum module is designed by adapting the structural ADDIE model in managing development research activities previous author [20] which in this paper were developed as follows:

1. Analysis

a. Need Analysis

In this step, an analysis of the research needs is carried out. The small scale chemistry practicum module will provide innovation in green chemistry-based practicum by utilizing materials from the surrounding environment. Based on the consideration of researchers regarding the ease of obtaining apparatus and materials, as well as some contents in basic chemistry course that have been studied, we decided to package ten small scale chemistry practicums in the product such as the relationship between volume and temperature, gas diffusion, silver mirror formation reactions, making pH meter, electrolysis, hydrogen-oxygen fuel cell, neutralization reaction, Voltaic cell, the effect of concentration on kinetics reaction, and the effect of catalyst for kinetics reaction. After that, developing test instruments in trials that can measure the ability to predict, observe, and explain in these practices, and prepare questionnaires to analyze student responses while using modules and carrying out practicum.

b. Analysis of Students' Characteristics

This analysis was conducted to determine the interest of students to get to know more about chemistry practicum. Our students are individuals who are active and have a high curiosity about something new, especially regarding chemistry practicum. Based on the results of interviews with all

students, 95% of students have already carried out chemistry practicum while in high school, but have not implemented small scale practicum, while the other 5% claimed to have never carried out chemical practicum in high school because of the constraints of apparatus and materials in their school laboratories. All students were enthusiastic about finding out more about small scale chemical practicum and were willing to be involved in the implementation of the practicum. This is important to do because the chemistry practicum activities also influence students' interest in learning chemistry.

c. Analysis of Prerequisite Ability and Prior Knowledge

This analysis is to investigate the learning needs and development of small scale chemistry practicum for senior high school. Based on the final result of the Basic Chemistry Course, was obtained information that all randomly selected student samples had very good (80-100), good (70-79) and were quite good (56-69) basic chemistry competencies. It can be assumed that students can take part in the experiments contained in the practicum modules developed.

d. Analysis of Learning Environmental

Based on the observation in our study program during the study, the culture of learning also influences students in small scale chemical practicum. The role of conscience and compassion applied at Sanata Dharma University also invites students to help together friends who are still lacking in understanding the materials. High curiosity and facility support are important for carrying out small scale chemical practicums.

2. Design

This research is based on the emphasis on the meaningful and interesting topic of contextual chemistry, which can be used as an innovative small scale chemistry practicum and packaged into small scale chemistry practicum module. The design of the experiments in the product of the practicum module (the experiments have been mentioned in the part of need analysis) adjusts to the apparatus and materials in the environment that are easily obtained and developed.

Based on need analysis, the experiments in the module are designed and arranged systematically with components such as experimental title, experiment's objective, theories, materials and apparatus, procedures, observational data, post-experimental questions, and references.

3. Develop

After designing, the product of the small scale chemistry practicum module is printed to be a module with A4 size with art paper, softcover, and finishing with doff lamination. The product that was developed was then validated by two experts and three chemistry teachers. In terms of the chemistry content in this practicum module, it has been very good (average validity coefficient = 0.94). The experts state that the types of experiments are quite varied and can help teachers and students continue to be able to carry out small scale simple experiments. The teachers add that the experiments in this module are increasingly attracting interest and enthusiasm in carrying out small scale practicum, it can be useful for students to introduce various chemistry practicums and

green chemistry principles early on, and in the future, teachers can develop other types of experiments.

The construction aspect in compiling this module obtained an average validity coefficient of 0.90 and was classified as very good. The experts explain that sentence construction was good, could be summarized even shorter, and could be revised again. Meanwhile, the teachers state that sentence construction was good and ready to be applied.

For the language aspect, obtained an average coefficient of the validity of 0.88 and suggestions for revising the language in Draft 1. The experts state that there were some parts of the grammar used that were still revised, so it was necessary to reduce some terms that were too difficult to understand. Meanwhile, the teachers explain that the language aspects are good enough and give additional information to provide certain explanations. The product had been rated well in Draft 2.

After revising, the product that has been developed is valid in terms of product development. In addition, according to experts and chemistry teachers, the product can be practical and effective to be applied in small scale chemistry practicum. The product is considered good for the attractive and innovative small scale chemistry practicum based learning design, and it is also recommended to further develop it in various chemistry learning models that are in accordance with the 2013 Curriculum.

4. **Implement and Evaluate**

The validated product is then implemented to the small scale chemistry practicum. Through practicum to try out this product, students will learn many things that can verify things found in POE. Previous authors [9] states that practicum makes students more trust in truth based on experiments rather than information from teachers or books, observes every phenomenon, enriches experiences, and shapes scientific attitudes. POE also helps in the chemistry practicum, as expressed [10] that integration of POE in a practicum can increase curiosity and chemistry learning achievement.

The practicum module developed contain chemistry experiments with their respective codes which include the relationship of volume and temperature (A), gas diffusion (B), silver mirror formation reaction (C), making pH meters (D), electrolysis (E), hydrogen-oxygen fuel cell (F), neutralization reaction (G), Voltaic cell (H), the effect of concentration on the kinetics reaction (I), and the effect of the catalyst on kinetics reaction (J).

The implementation of the product developed involved 35 students. There are ten essay questions, each of which represents ten experiments, then followed by analyzing the students' abilities in predicting, observing, and explaining.

a. Predictive Ability

Predicting is an activity in an effort to reach C5 cognitive level. This ability is indeed needed to develop students' self-evaluation abilities of experiments given.

Based on the chemistry experiments that have been carried out, the results obtained from the analysis of the ability of students to predict are as follows.

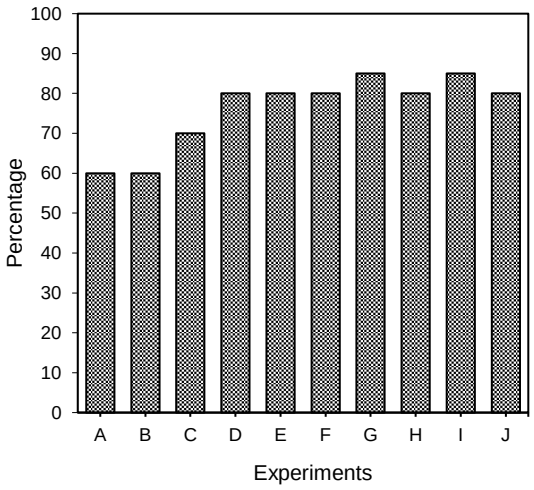

Figure 1. Predictive Ability of Students

Figure 1 shows that the average ability of students to predict (before carrying out experiments) is good with average score 76 (70-79 is a range for good ratings)This ability is dominant in experiments C until J, although in experiments A and B students found difficulty. This predicting stage is what was desired before this small scale chemistry experiment, and further previous authors [11] revealed that the predicting stage sought to explore students' initial knowledge, explore their abilities, and of course, provide information on these abilities to the teachers. Previous authors [12] emphasizes that the predicting stage gives students the opportunity to explore their knowledge independently of things not previously encountered. Thus, the predicting stage becomes an important part of linking students' initial abilities to new phenomena and experiences and strengthening skills during small scale chemistry experiments.

b. Observing Ability

In this research, all students have good observation skills. This is indicated by the complete observation data that is filled in observing each phenomenon. Also, students are very closely observing the changes that occur.

Based on the chemistry experiments that have been carried out, the results obtained from the analysis of students' ability to observe are as follows.

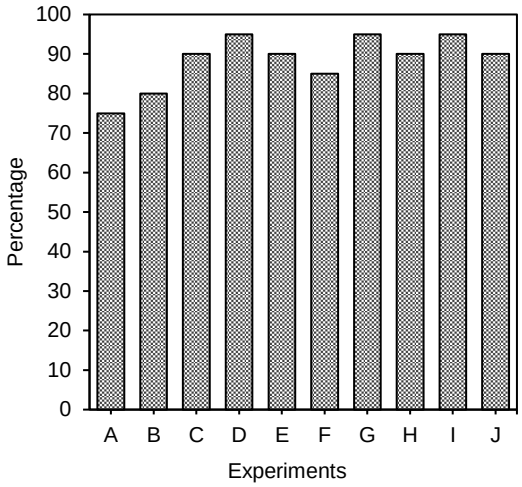

Figure 2. Observe Ability of Students

Figure 2 shows that the average ability of students to observe was classified as very good, with an average score 88.5 (80-100 is a range for very good ratings). This ability stands out in experiments C, D, E, G, H, I, and J. The ability in other experiments is already classified as good, and they can improve their skills in future experiments. In this section, it is observed that the results of observations are not always the same as the results of students' predictions. If the observing phase has a conflict with the initial prediction, there will be reconstruction and revision of the initial idea [13].

The stage of observing becomes an important part of every experiment and should not be ignored. As it was stated by previous authors [14] that the observation stage becomes very important in learning because it involves the process of observing

objects or phenomena. Furthermore, previous authors [15] added that discussion could strengthen students' abilities in terms of observing and predicting.

c. Explaining Ability

Previous authors [16] expressed that in the explaining stage, it was not easy for students because they had to compare the results of predictions and observations, then explain it well.

Based on the chemistry experiments that have been carried out, the results obtained from the analysis of students' ability to explain are as follows.

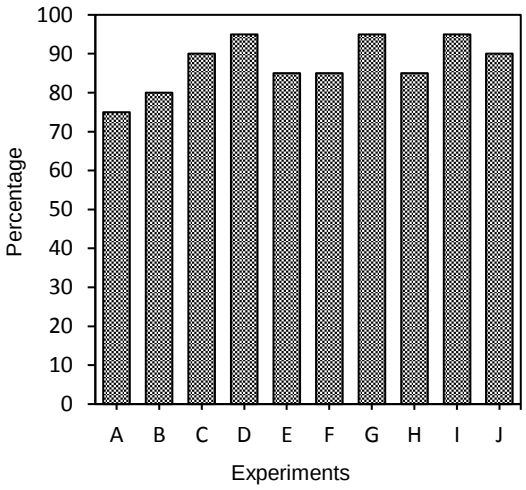

Figure 3. Explaining Ability of Students

Figure 3 shows that the average ability of students to explain is classified as very good with an average score of 87.5 (80-100 is a range for very good ratings. This ability is dominant in experiments C, D, G, I, and J. The ability in other experiments is already classified as good and can be continuously improved by mastering much of the experimental material.

Students are classified as good average in explaining every phenomenon in small scale chemistry practicum. Students can explain well the relationship between volume and temperature in practicum using straws heated at different temperatures, differences diffusion of ammonia gas and concentrated hydrochloric acid using well plates, differences in the formation of silver on bottles and mirrors, color changes in various indicators of acid-base in the making pH meter from several acid-base indicators, the ratio of the height of hydrogen and oxygen gases in straw during the electrolysis process, temperature changes in the neutralization reaction, and the effect of variations in concentration and catalyst in kinetics reaction.

The Rasch model also supports the results of the analysis of students' abilities in predicting, observing, and explaining. POE assessment containing ten essay questions, each of which represents ten types of small scale chemistry experiments that were tested, gave a person a reliability value of 0.88 and showed the ability of good students. Meanwhile, item reliability of 0.94 indicates that the quality of the items used was classified as very good. This is supported by Cronbach's alpha value of 0.92, which shows good consistency. These results indicate that the essay questions tested in POE have a good effect on students' ability to make predictions, observations, and explanations. Following the statement previous author [17] that POE also helps to build constructivist strength in developing students' chemistry science process skills. POE can also stimulate scientific thinking and support to build their knowledge [18]. Besides, previous authors [19] added that the implementation of POE

could determine the ability of students to predict natural phenomenon and their reasons for making these predictions.

Students responded well to the development of this product, with the average final score of 81 being classified as very good (80-100 is a range for very good ratings). According to students, this product is interesting, innovative, practical (easy to use), and effective (more time-saving) for use in small scale chemistry experiments. Students hope to develop their POE skills even better in other chemistry experiments, and this practicum module can be disseminated at the high school level.

CONCLUSION

The conclusion is that the product (small scale chemical practice module) has fulfilled the requirements as an innovative product that is valid, practical, and effective for further implementation in chemistry learning. Experts and students in this trial rated the development of this product well. Particularly in the implementation and evaluation stages, the product can measure and describe students' abilities in predicting, observing, and explaining every chemical phenomenon encountered in several chemistry experiments conducted and continuously being improved for other chemistry experiments. Students are enthusiastic and hope to continue to hone the ability to predict, observe, and explain in-depth and continuously.

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