The Innovation of STEM-PjBL-based Chemistry Practicum Guide to Improve Science Process Skills and Learning Outcomes of Class XI Students

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Abstract. The current state of education in Indonesia is still a gap between the skills and the competencies required by the market. STEM-based learning is expected to be a reform of education that can improve the excellence individual in the era of technology and information. The aim of investigation is to obtain authentic and appropriate STEM-PjBL-based chemistry practicum guidebook for class XI according to the BSNP standard, to find out the improvement of student learning results and impact of learners science process competence using the developed practicum guide. This investigation utilizes the R&D method with the ADDIE development model. The data were analyzed utilizing the normality check, homogeneity check, hypothesis check with the independent sample T-check, and N-gain check. The output indicated that the developed STEM-PjBL-based chemistry practicum guidebook was categorized as valid and suitable to support the chemistry learning in schools.

Keywords: Chemistry practicum guide, STEM, Project Based Learning (PjBL), Science Process Skills (KPS), learning outcomes, ADDIE.

1 Introduction

Practical activities affect chemistry learning where students will demonstrate and be challenged in understanding or proving a chemical concept. Currently, chemistry learning has been accompanied by practical activities in 2013 curriculum. However, the improvement in student learning outcomes is still limited to knowledge competence, has not been able to help students to learn actively and creatively so that the competence of students' attitudes and skills is still low [1].

According to Puspita [2], science process skills can help students to have direct experience of a surrounding phenomenon and change perceptions about important things into something meaningful, involving cognitive or intellectual skills, manuals, and social skills. Practicum standard guidelines according to BSNP are very much needed by students to get an overview of the objectives, benefits and processes of practicum activities to be carried out [3]. A good

AISTEEL 2022, September 20, Medan, Indonesia

DOI 10.4108/eai.20-9-2022.2324592

practicum guide must be arranged systematically, attractively, clearly, and can be used by students independently at any time according to their needs [1].

Based on the results of observations on the implementation of practicum in schools where chemistry learning is accompanied by practicum, but only on certain materials that are adapted to the tools and materials available in the laboratory, there is no chemistry practicum guide, and there are no laboratory personnel with special expertise in their fields. So far, the value of students' cognitive learning outcomes in practicum-based learning has increased, but affective and psychomotor assessments are still low, it is necessary to develop an innovative chemistry practicum guide that meets the standards of the National Education Standards Agency (BSNP) [4,5]. It can direct students to perform the correct procedure and increase students' critical thinking power [6].

The application of science process competence in chemistry literature is very necessary because students have different potentials and the teacher's task is to provide convenience to students by creating a conducive environment so that all participants can develop their potential optimally [7]. The aim of investigation is to obtain a valid and appropriate STEM-PjBL-based chemistry practicum guidebook for class XI according to the BSNP standard, to find out the advancement of graduate training result and impact of graduate science process competence untilizing the developed practical guide.

2 Methods

The investigation utilize a Research and Development (R&D) advance with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). These steps include (1) Analysis (inspect the properness of existing practicum guide books), (2) Design (compassionate and assortment the basic ammount or ammount design of STEM-based chemistry practical guide books), (3) development (developing a product design for a STEM-based chemistry practical guide book), (4) Implementation (using a STEM-based chemistry practicum guide developed in classroom learning), (5) Evaluation (measuring the feasibility and effectiveness of the product in developing graduate training result).

The population in the investigation were all learners of class XI IPA MAN Insan Cendekia Aceh Timur. The sample in the nvestigation were 2 students of class XI which were divided into a control class and an experimental class using purposive sampling. The validators in this study are chemistry lecturers and teachers who have a minimum qualification of a bachelor's degree (S1) and are actively involved in the laboratory. The device was utilized to accumulate data with the ratify sheet and a properness survey be based the BSNP criteria and an objective check of training results. Then the data were analyzed descriptively based on the average score of training results. Then, the presumed statistical check was enforced with a t-check, starting with the prerequisite test, namely the normality check and homogeneity check.

3 Results and discussion

STEM is an combination between four concepts, namely science, technology, engineering, and mathematics in an integrative advance and is enforced based on absolute-world contexts and problem-based learning [8]. STEM learning includes demanding intelligent, analysis, and concert processes in which students integrate processes and concepts in real-world contexts from science, technology, engineering, and mathematics [10]. The Characteristics of STEM Learning are Increase students' ability to design designs, Guide students in solving problems, Increase students' sensitivity to real-world issues, Involving students in inquiry learning, Give students the opportunity to express their opinions, Guide students to apply STEM understanding, and Engaging students in productive group work.

3.1 Feasibility analysis of the practical guide

The ivestigation begins with an reasoning of the practicum guides used in schools today to regulate the properness of the practicum guides circulating in schools and the STEM-PjBL-based chemistry practical guides that have been developed. The questionnaire utilized to regulate the properness of the advanced practicum guide is the BSNP (National Education Standards Agency) survey with 4 eligibility criteria, namely content properness, language properness, presentation properness, and graphic properness [11]. The average value of each aspect will indicate the level of validity of the advanced practicum guide. Properness analysis of practicum guidelines currently used in schools. The data obtained from the analysis of the guidebooks used in schools to support the current practicum can be book A (properness of content = 1.78, properness of language = 3, properness of presentation 2.33, and feasibility of graphics = 2.5), while book B (properness of content = 1.91 , language properness = 3.33, presentation properness =2.22, and graphic properness = 2.4). So that the average feasibility of the guidelines used in schools is obtained a score of 2,397 which is included in the less valid category and needs to be revised. The eligibility criteria are based on a feasibility analysis instrument according to the BSNP standard [13].

3.2 Design of a STEM-PjBLbased chemistry practicum guide

Analysis of the suitability of learning competencies (KI & KD) with the syllabus and analysis of the titles of practical substance and learning models that can be utilze for developing practical guides in further research. The following are the results of the analysis of learning competencies as well as the adjustment of models and materials that will be developed in the design of the STEM-PjBL-based chemistry practicum guide in table 1.

Table 1. Analysis of learning competencies and developed design of practicum guidelines

KD	Subject Matter	Indicators of Competence Achievement	Developed design of practicum
4.10	Acid-Base Solution	Make acid-base indicators from natural materials	Make the natural indicator materials
4.11	Ionic Equilibrium in a salt solution	Predict the pH of a saline solution with and report the result	Preparation of calcium acetate salt
4.12	Buffer Solution	make a buffer solution with a certain Ph	Preparation of buffer solutions for plants
4.13	Titration	Carry out acid-base titration experiments and report experimental results	Calculating the concentration of acid-base titration
4.14	Colloid	Make products with colloidal principles	Preparation of a dish soap from natural ingredients

Be based the results of the analysis, it is acknowledged that every basic knowledge competency (KD.3) in chemistry learning is always accompanied by a basic skill competency (KD.4). In addition, chemistry is also a study of microscopic science that requires various models, methods and learning media so that the delivery of material can be carried out optimally to students [14]. Therefore, chemistry tutor are renforced to always be ingenious and contemporary in designing active and innovative teaching and learning processes to increase students' motivation and learning outcomes in chemistry, both in the cognitive, affective and psychomotor domains [8].

3.3 Development of a STEM-PjBLbased chemistry practicum guide

The practicum guide advanced consists of 5 experiments, according to the basic competencies of skills contained in the syllabus. The practicum guide components developed include: (1) the identity of the experiment in the form of core competencies and basic competencies; (2) indicators; (3) laboratory rules; (4) work safety guidelines; (5) Chemical laboratory equipment, containing pictures and their uses; (6) practical material; (7) the format for writing reports and assessments; (8) Bibliography; (9) Glossary; (10) Periodic Table of Elements.

The validation of the feasibility of the chemistry practicum guide advanced was imposed by two chemistry teachers from the school where the research was conducted and two chemistry lecturers from Medan State University. The feasibility level of the STEM-PjBL-based chemistry practicum guide developed is described in **Figure 1** as follows:

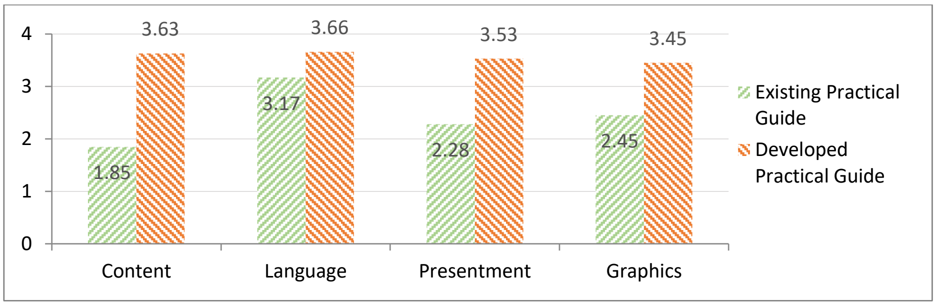

Fig. 1. Graph of the output of the analysis of the developed practical guide

The results of the validation carried out by chemistry teachers and lecturers on the STEM-PjBL-based chemistry practical guide book that was advanced showed an average result of 3.5, which means that the criteria are very suitable to be used. The results of the feasibility of the development were tested with the BSNP feasibility standard, it was found that the category was suitable for use and did not need to be revised.

3.4 Implementation of a STEM-PjBLbased chemistry practicum guide

The implementation of the STEM-PjBL-based chemistry practical guide that was developed was carried out in 2 groups of classes, namely the authority class and the preliminary class. The STEM-PjBL-based chemistry lab guide that was developed was used in the preliminary class, while the authority class used a chemistry guide commonly used in schools. The recapitulation of the pretest and posttest output in both classes can be seen in the **Figure 2.**

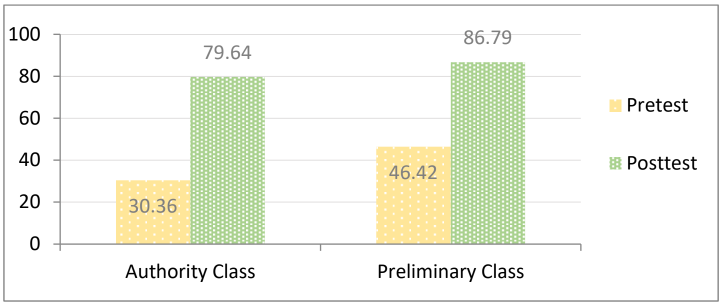

Fig. 2. Graph of the recapitulation of pretest and posttest

From these data it can be seen that there is a difference in the average value between the two classes, with the lowest posttest score being in the au class. it can be concluded that there is an increase in student learning result after being applied using the advanced chemistry practicum guide. Theoutput of the normality and homogeneity check of all data showed that all the data obtained were normally distributed and homogeneous with the value of $t_{count} < t_{table}$.

3.5 Evaluation

Independent test was conducted to see the improvement or difference in learning result. The results obtained showed that the data in the experimental class got a significant value of 0.01 and t_{count} 2.838 with the conclusion that there were differences in the experimental class and authority class. This shows that learning using a STEM-PjBL-based chemistry practical guide advanced on acid-base solution material is more able to improve graduate learning output compared to the use of a practical guide book used by students on the same material. The difference in learning activities in the preliminary class and the authority class can be seen in **Figure 3.** below:

(a) **(b)**

Fig. 3. (a) Learning activities in the the authority class, (b) Learning activities in the the experimental class

The **Figure 3a.** shows the situation of authority class, the students are accustomed to doing practicum in accordance with the detailed procedures provided so that students can work actively but are less creative in conveying what they have learned. Whereas in the **Figure 3b.** which is the preliminary class that uses a STEM-PjBL-based practicum guide, students can work actively and creatively because the practicum instructions given are limited to general steps but require students to get more literature, prepare, and estimate the final results that can be achieved. In addition, the use of natural ingredients also stimulates students' curiosity to try again with different materials and procedures.

Science Process Competence are the overall directed scientific skills used to find facts, concepts, or theories. This ability will make students have direct experience of a phenomenon around them and change the perception of important things into something meaningful [2]. Therefore, the teacher acts as a facilitator who can create student learning conditions through the implementation of fun learning activities with a variety of sequential activities according to the indicators listed so that students understand a learning not only on the results but accompanied by the process [13]. Both of classes showed an increase in learners' science process competence, but in the preliminary class the increase was higher than in the authority class.

The comparison of the average value of the science process competence of learners in the two classes shows that the components that have been integrated into the STEM-PjBL-based chemistry practicum guide can make students more active in carrying out the practicum. the average value obtained in the preliminary class is 80.14 while in the authority class is 75. the magnitude of the role of science process skills on student learning results in the preliminary class that uses a STEM-PjBL-based chemistry practicum guide is 48% and the pausing 52% is determined by by other factors.

4 Conclusion

Based on the results and discussion of the investigation described, it can be definited: (1) The STEM-PjBL-based practicum guide that has been advanced appearance an average value of 3.5 which is included in the category convinient for apply in chemistry learning and does not need to be revised; (2) the effectiveness test shows that the learning results learners of s who are taught with a STEM-PjBL-based practicum guide are better than learner who are taught with a chemistry practicum guide commonly used in schools; (3) The results of the validation and effectiveness of improving learning outcomes indicate that the STEM-PjBL-based practicum guide advanced is feasible to be applied as a training medium for high school learners.

Acknowledgement. The author would like to thanks Dr. Ajat Sudrajat, M.Si, and Dr. techn. Marini Damanik, M.Si. who have agreed to become expert validators. The authors also thank the principal and chemistry teacher of MAN Insan Cendekia Aceh Timur for their participation in this study.

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