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Improving Students' Problem Solving Skills and Laboratory Performance by Sublimation Apparatus Modification Project

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Abstract: This study aims to develop a sublimation tool to improve problem solving skills and performance in the laboratory. The research method used is the Research and Development (R&D) method with a 4D model. The research sample consisted of control and experimental classes. The sampling technique used was purposive sampling. The results showed that the developed sublimation tool stated: (1) effective for use, it was obtained (1.64). In addition, the results of the development are also good in improving students' problem solving skills with n-gain (0.64) with high criteria (2) the results of responses from students' responses to the attractiveness aspect (100%), readability aspect (96.29%), and tool design (100%). Based on the results of research and development, it can be stated that the developed sublimation tool is effective for improving problem solving skills and performance in the laboratory and can be used in practical experiments in studying the material for separating mixtures with sublimation techniques.

Keywords: development, sublimation, problem solving.

Abstrak: *Penelitian ini bertujuan untuk mengembangkan alat sublimasi untuk meningkatkan keterampilan pemecahan masalah dan kinerja di laboratorium Metode penelitian yang digunakan adalah metode Research and Development (R&D) dengan model 4D. Sampel penelitian terdiri dari kelas kontrol dan eksperimen. Teknik pengambilan sampel menggunakan purposive sampling. Hasil penelitian menunjukkan bahwa alat sublimasi hasil pengembangan dinyatakan: (1) efektif untuk digunakan didapatkan sebesar (1,64). Selain itu, hasil pengembangan juga baik dalam meningkatkan keterampilan pemecahan masalah siswa dengan n-gain (0,64) dengan kriteria tinggi (2) hasil tanggapan dari respon siswa pada aspek kemenarikan (100%), aspek keterbacaan (96,29%), dan desain alat (100%). Berdasarkan hasil penelitian dan pengembangan, dapat dinyatakan alat sublimasi hasil pengembangan efektif untuk meningkatkan keterampilan pemecahan masalah dan kinerja di laboratorium serta dapat digunakan pada percobaan praktikum dalam mempelajari materi pemisahan campuran dengan teknik sublimasi.*

Kata kunci: *pengembangan, sublimasi, pemecahan masalah.*

▪ INTRODUCTION

In the 21st century, the Indonesian nation is facing global challenges. These demands include that children need thoughts, verbal and written communication, teamwork, creativity, research skills, and problem solving to compete and grow well in the future (Widowati, 2015). The science learning process emphasizes providing direct experience so that students will gain a more impressed and deeper scientific understanding (Arimbawa et al., 2013). Science subjects not only memorize but also grow real examples in everyday life (Wardani, 2019). Science problem solving ability of students is still low (Nurhadi & Senduk, 2004). The low ability to solve everyday science problems is inseparable from the learning carried out by the teacher at school.

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Most teachers have not conditioned learning that allows students to get maximum everyday science problem solving skills (Arimbawa et al., 2013). Practical activities in the laboratory are very appropriate to be applied to factual material that provides opportunities for students to find the facts themselves needed to improve their mastery and understanding of the chemical material being studied (Alfalobi & Akin bobola, 2010; Phelp & Lee, 2003).

One branch of science that cannot be separated from practical activities is science. According to Fadiawati (2014), to produce skilled students, science learning must be presented in its entirety as a process, product, and attitude. However, the fact is that practicum activities in schools are constrained by the unavailability of tools for practicum (Fadiawati, 2013; Fadiawati & Tania, 2014). Thus, the students' ability to solve science problems is still low (Nurhadi & Senduk, 2004). The low ability to solve everyday science problems is inseparable from the learning carried out by the teacher at school. In fact in the field apart from the unavailability of tools, practicum is also constrained due to the lack of knowledge and skills of teachers.

A study conducted by Hayat et al (2011) shows that practicum activities are a very important part of science learning activities. This is reinforced by the research of Sundari (2008) which states that the importance of the continuity of practicum activities is not in accordance with the facts found in the field, namely practicum activities are still rarely applied in the learning process in the classroom. The use of media in chemistry learning, especially visual media in the form of a simple practicum, can be used to demonstrate important concepts. One of them is about science concepts that have applications in students' daily lives, so that students not only learn conceptually but also learn meaningfully (Glaser & Carson, 2005).

Project-based learning according to Doppelt (2003) is a good method to improve thinking and creativity competencies students in a lesson. In addition, this statement is also confirmed by the opinion of Yalcin et al (2009) which states that project-based learning will produce a work product. This is also conveyed by Sumarni (2015) which states that project based learning is a systematic teaching method that involves students in learning knowledge and skills through research assignments, authentic questions, and well-designed products. This opinion is the same as the opinion of Thomas (2000) and Bell (2010) who say that project-based learning will be successfully applied to improve the psychomotor skills of students who work collaboratively.

Based on the results of Yaqin et al research (2019), he has conducted an experiment to design a mixture separation device, in his research it is stated that in developing a tool, it is necessary to pay attention to the components of each tool, in terms of student safety when using practicum tools and the materials used are easy to obtain. The development of practicum tools developed is able to support classroom learning so that students are introduced to phenomena in everyday life to grow problem solving skills. According to Fadiawati (2014), to produce skilled students, science learning must be presented in its entirety as a process, product, and attitude. However, what happened in schools was the lack of practicum tools or no practicum tools at all, so that for mixed separation material the practicum process was not carried out (Budiyanto, 2016). Related to problem solving, science learning in schools is usually related to natural phenomena. For example, in the separation of mixtures to get clean water in

areas where water sources are polluted, namely by utilizing filtering techniques (Rezakazemi, Khajeh, & Mesbah, 2017).

Related to this, research shows that the ability and knowledge of teachers to carry out practical activities is very lacking (Sumintono, et al., 2010). These limitations cause in science learning practicum activities are rarely carried out. Meanwhile, science learning really needs a laboratory as a place to carry out practical activities (Garnett et al., 1995; Hofstein and Luneta, 2004; Abrahams and Millar, 2008). This statement is supported by the opinion of Aksela & Juntunen (2013) which states that practical learning can improve students' psychomotor skills. Based on the description above, the researcher seeks to develop a sublimation tool to support the learning process that fosters students' problem solving skills in understanding the content of the material. Therefore, the researcher proposed the title of Development of Sublimation Tools to Improve Problem Solving Skills and Performance in the Laboratory.

▪ METHOD

The research design used in this development research is a 4D (four-D) development model, namely Define, Design, Develop, Disseminate according to (Thiagarajan, Semmel, & Semmel, 1974). In this study, there were three groups of subjects, namely, research subjects, product trial subjects, & product implementation subjects. The location of the research in the initial analysis stage was in three schools in Bandar Lampung, namely, SMP N 24 Bandar Lampung, SMP N 36 Bandar Lampung and SMP N 31 Bandar Lampung. Then at the product trial stage, MTs Assyifa Karang Sari was conducted in class VIIC with 30 students. For the subject of product implementation, it is done in class VIIA and VIIB. where class VIIA is an experimental class with 16 female students and 14 male data, while for the control class there are 17 female students and 13 male students. The instruments used in this study were test instruments, learning implementation observation sheets, and teacher and student response. The test instrument in the form of questions was developed by researchers who for the pretest 5 items and 5 posttest questions which have raised problem-solving skills for each item (Polya, 1971). A good test instrument must meet two important requirements, namely valid & reliable (Arikunto, 2006) therefore, the data processing technique used to determine the quality of the instrument used uses analysis of validity and test reliability using SPSS 25.00.

At the sublimation tool development stage and student worksheets were validated by 2 validators. The questionnaire given in the form of a questionnaire covers 4 aspects, namely aspects of content suitability, readability aspects, construction aspects, and tool design aspects. The improvement of problem solving skills is shown through the n-Gain score, which is the difference between the posttest score and the pretest score.

▪ RESULT AND DISSCUSSION

This development uses a 4D model, namely define, design, develop, and desiminate. In the define, in the initial analysis, the teacher stated that he had never done any practicum related to mixture separation material. The student analysis stage carried out resulted in information that at MTs Assyifa South Lampung for the experimental class data on women totaled 16 students and male data amounted to 14 students while for the control class obtained data on women totaled 17 students, and male data amounted to 13 students.

Task analysis is formulated on indicators of competency achievement based on the problem-solving process that refers to the problem-solving process according to Polya (1971). Indicators of achievement of written competence in LKPD as a result of development. This concept analysis is based on basic competence 3.3, namely understanding the concept of mixtures and single substances (elements and compounds), physical and chemical properties, physical and chemical changes in everyday life and basic competence 4.3 presenting research data or solution works, physics of changes and changes chemical or mixture separation.

The design of this product development includes the preparation of construction, media selection & format selection. This product consists of student worksheets and design development tools. In addition, the preparation of student worksheet construction also refers to problem solving according to Polya (1971), namely; 1. Understand the problem, 2. Plan a solution, 3. Solve the problem according to plan, 4. Re-check all the steps that have been done. The components of student worksheets consist of front cover, introduction, table of contents, indicators, instructions for using student worksheets, contents, bibliography, and back cover. For the design component of the sublimation development tool, it is shown in Figure 1.

At the design, there are components that need to be considered, namely the glass used must be transparent in order to be able to see the process of heating the sample taking place, and the glass used from heat-resistant borosilicate material, and has been given tongs to make it easier to take the glass after heating the sample is complete. In the development of student worksheets, there are suggestions for improvement by the validator, such as in the readability aspect which includes the images presented are too small, and writing on the student worksheets on the outer cover. It can be seen in Figure 2 before it was revised and Figure 3 after it was revised.

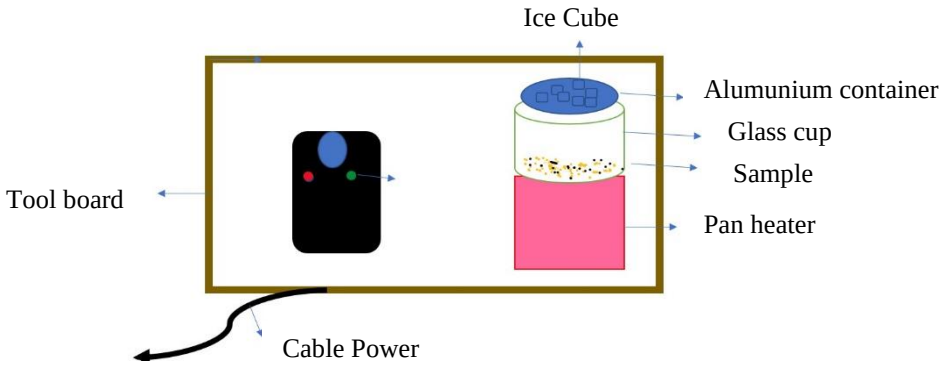

Figure 1. The design of the sublimation tool

Furthermore, in the manufacture of sublimation tools there are suggestions from experts. Suggestions include the glass in the sample must be visible, there is a temperature control. The sublimation device developed can be seen in Figure 4. The sublimation device developed for a lab scale, which can only accommodate 100gram samples and has 6 levels of temperature control from 500C – 3000C using an electric current source. After expert validation has been carried out covering aspects of content suitability, readability, construction and tool design, it can be seen in Table 1.

Figure 2. Before revision

Figure 3. After revision

Figure 4. The results of the development of the sublimation tool

Table 1. Percentage of validation results from content suitability aspects, readability

Valiadator	Aspect	Percentage	Criteria
Validator 1 Validator 2	Content suitability	100,00 %	Very high
	Legibility	92.5%	Very high
	Construction	100%	Very high
	Tool design	100%	Very high

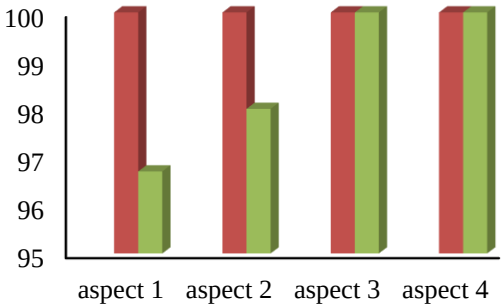

Figure 5. The results of the teacher's response (orange) and the student's response (grey) on the sublimation tool

Then a trial was conducted on the teacher's response and the student's response related to the development of sublimation and the developed worksheets. The results of

teacher and student responses to the developed sublimation can be seen in Figure 5. The results of the teacher's responses for the suitability of the content, readability, construction and design of the tool are 100% and the results of the student responses for the content suitability aspect is 96.7% and the readability aspect is 98% with very high criteria.

At the dessiminate stage, for the study there were experimental classes and control classes. Class VII A is the experimental class, and class VII B is the control class. The experimental class was given treatment in the form of developing a sublimation tool and student worksheets, and for the control class the researcher taught using the conventional method. Before the learning was carried out, the researcher gave a pretest at the beginning of the lesson and after the lesson was finished, a posttest was given. Testing the test instrument using SPSS 25 software. From the test results, the questions are valid and reliable with a reliability value of 0.685 with high criteria so that the questions on the questions can be used. Then the student answer sheet is calculated and then entered into an excel document for assessment (Erdogan, 2009).

The effectiveness of problem solving skills and performance in the laboratory is seen from several things as measured by the implementation of student worksheets, student problem solving skills, effect size, teacher response, and student response to learning. The effectiveness of student worksheets and sublimation tools can be seen from the average n-gain and effect size of the pretest and posttest scores. Based on the normality test using SPSS 25, the research data obtained were not normally distributed, then the next test was a non-parametric test. Furthermore, the n-gain test was carried out to determine the increase in the pretest and posttest scores on students' problem solving skills. The average value of the n-gain test results in the experimental class and control class is shown in Figure 6.

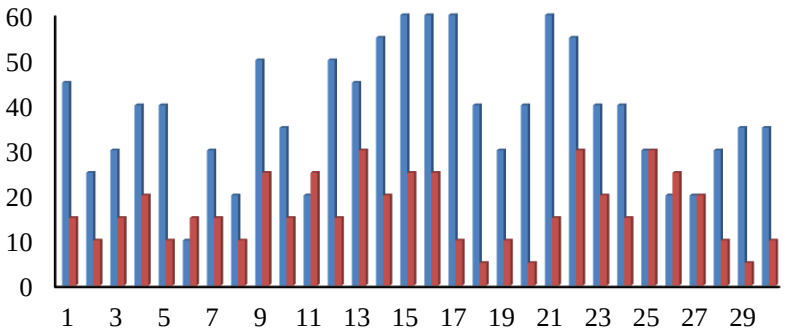

Figure 6. Comparison of n-gain pretest-posttest experimental class and control class

In Figure 6 it can be seen that in (red) the results of the n-gain for the experimental class in problem solving are higher than the control class (blue). According to Chanlin (2008) one of the learning methods that can help students understand and explore knowledge is with the help of media equipment such as practicum tools. The existence of teaching aids in learning can motivate students directly so that learning becomes more meaningful because students feel interested in following the lessons delivered. Learning in the experimental class shows that students are more active than the control class, where the experimental class is more enthusiastic

in learning when reading discourses that contain problems close to everyday life. Students have great curiosity when reading the discourse. This is in line with Fredricks et al. (2011) which states that students will be more active in the learning process.

This shows that problem solving skills in the experimental class are successful in the learning process using sublimation tools and student worksheets. This is caused by several factors, namely the student worksheets are given a learning syntax using a scientific approach. Where in the scientific approach model contains problem solving skills referring to the problem solving process according to Polya (1971). Learning that involves teaching aids such as practicum tools according to Kusairi (2018) will produce skilled students and more scientific knowledge so that students can develop their creative thinking skills to solve problems.

Previous research on the development of sublimation was carried out by Tantayanon et al. (2009) developing a sublimation device using impure acetanilide and using a suction flask, hot plate, spatula, and miniature pump. Therefore, the researchers developed a simple, practical, efficient and safe sublimation tool for students. The developed sublimation apparatus is equipped with a temperature control and is heat resistant coated. The development of this sublimation tool is effective, because it can foster problem solving skills in students so that students are able to solve problems according to problem solving steps Lubis, et al (2017).

Furthermore, the results of the two-average difference test using the Wicoxon test. This test was conducted to determine whether the average n-gain value of students' problem solving skills in the experimental class was significantly different from the average n-gain of students' problem solving skills in the control class. Because the results of the experimental class data are not normally distributed, the next step is to test using a non-parametric test using the Wilcoxon Sihn rank test. Based on the results of the Wilcoxon Signed Rank Test calculation, the Z value obtained is -4.793 with a p value (Asymp. Sig 2 tailed) of 0.000 which is less than the critical research limit of 0.05 so that the hypothesis is to accept H1 or which means there is a significant difference between the pretest and posttest groups.

Based on the analysis of the Mann Whitney test, the average posttest value is higher than the average pretest value in the experimental class. This means that there is an increase in learning outcomes from this value. Based on the calculation of the effect size, the result is 1.64 with very high criteria. These calculations provide information that problem solving skills and performance in the laboratory with mixed separation materials have a great effect on improving students' problem solving skills. Based on research from (Widiyatmoko, et al., 2015) states that the development of tools on mixed separation materials can improve problem solving skills and the learning carried out can provide opportunities for students to participate actively in increasing learning motivation and provide student experiences in everyday life. . Visualization is also important in learning because it can increase students' concentration levels by making learning more interesting and stimulating students to understand the topic (Keegan, 2007).

The weaknesses of the developed sublimation tool are the capacity of the ice cube container is small, if the electricity goes out at school, the practicum process does not run because it uses electricity. The advantages of the developed sublimation tool are

that the tool developed is practical and easy to use, safe, the practicum time used is relatively faster and there is a temperature determining indicator.

▪ CONCLUSION

Based on the results of research data analysis and discussion, it can be concluded that the sublimation tool developed is said to be valid and the development of the developed sublimation tool and LKPD can improve problem solving skills. This can be seen from the results of the teacher's response and the results of student responses to aspects of content suitability, readability aspects, construction aspects and tool design aspects which have very high criteria. The problem solving skills of students before and after using the sublimation tool have increased. This is shown from the results of the pretest and posttest scores that get n-gain results for the experimental class, before using the tool it was measured by pretest with an average result of 40.8 and for posttest results after using the tool it was measured by posttest of 79.1 with the n-gain result is 0.64 with high criteria and has an effect size value of 1.64 with high criteria. This shows that it has a "big" effect on improving students' problem-solving skills and performance in the laboratory.

With this research students are more enthusiastic in learning because learning involves everyday phenomena, but there are obstacles experienced in this research including the unavailability of adequate sources of knowledge, unavailability of practicum tools, no laboratory space so that when the implementation of the practicum is carried out in the classroom.

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