CONSTRUINDO UM APARELHO DE DESTILAÇÃO SIMPLES ATRAVÉS DE MATERIAIS USADOS USANDO APRENDIZAGEM BASEADA EM PROJETOS

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CONSTRUINDO UM APARELHO DE DESTILAÇÃO SIMPLES ATRAVÉS DE MATERIAIS USADOS USANDO APRENDIZAGEM BASEADA EM PROJETOS

CONSTRUCTING A SIMPLE DISTILLATION APPARATUS FROM USED GOODS BY USING PROJECT-BASED LEARNING

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RESUMO

Os alunos foram desafiados a construir um aparato simples de destilação usando o aprendizado baseado em projetos. Nesses projetos do aparelho, aplicaram-se seus conhecimentos e habilidades para buscarem ferramentas alternativas de substituição, planejar, construir e testar o funcionamento do aparelho. Um aparelho de destilação simples foi projetado e construído por estudantes onde algumas ferramentas poderiam ser substituídas por bens usados, tais como: (1) um bico de bunsen poderia ser substituído por uma lâmpada de parede espírita; (2) uma garrafa de vidro de refrigerante substitui um frasco de Pyrex como um frasco de destilação; (3) uma garrafa plástica modificada com tubo de alumínio e mangueiras de plástico substitui uma tubulação de vidro como um condensador, e (4) um dínamo modificado de brinquedos de carro foi usado como aerador com fonte de corrente elétrica de bateria, banco de potência ou telefone usando eletricidade carregador. O aparelho já poderia ser usado para purificar a água do mar que foi modelada usando água salgada. Os destilados eram mais claros e incolores comparados com a amostra, não acendiam as luzes e não havia bolhas de gás. Este projeto melhorou a compreensão dos alunos nos conceitos de destilação e aumentou as habilidades de pensamento criativo.

Palavras-chave: experimento de laboratório; equipamento de laboratório; um aparelho simples de destilação; aprendizagem baseada em projetos; aprendizagem prática

ABSTRACT

Students had been challenged to build a simple distillation apparatus by using project-based learning. In these project of the apparatus, they were applied their knowledges and skills to look for an alternative replacement tools, plan, build, and test the functioning of the apparatus. A simple distillation apparatus was designed and constructed by students where some tools could be replaced with used goods, such as: (1) a bunsen burner could be replaced with an spirit-wall lamp; (2) a soft drink glass bottle replaces a Pyrex flask as a distilling flask; (3) a modified plastic bottle with alumunium tube and plastic hoses replaces a glass tubing as a condenser, and (4) a modified dynamo from car toys was used as aerator with source of electric current from battery, power bank, or electric using phone charger. The apparatus already could be used to purify sea water that modeled by saline solution. The distillates were clearer and colorless compared to saline solution and did not conduct electricity. Based on that, the project was improved students' understanding and creative thinking skills on the distillation concepts.

Keywords: laboratory experiment; laboratory equipment; a simple distillation apparatus; project-based learning; hands-on learning

1. INTRODUCTION

Distillation is one of the techniques of separating a substance in its mixture physicaly based on the boiling point difference. In the process of separation, the mixture which has a lower boiling point will boil first then the resulting steam melts the condenser and condenses into a liquid again (Day and Underwood, 1986; Kister, 1992; Ledgard, 2006). Distillation is a difficult technique to visualize and even harder to demonstrate without specialized equipment. However, a suitable distillation apparatus easily illustrates the phenomena of evaporation and condensation (Campanizzi, et al., 1999).

According to Regulation of the Minister of Education and Culture of the Republic of Indonesia No. 37 in 2018 year, the learning material of mixed separation with distillation techniques was introduced for the first time in science subjects at the secondary school level (Author team, 2018). Secondary school students are expected to have the competence to do a separate of mixtures based on physical and chemical properties so that students can understand the characteristics of substances, as well as physical and chemical changes in substances that can be used for everyday life. Therefore, to achieve these competencies, it is necessary to carry out mixtures separation practice activities with distillation techniques in learning.

The practical apparatus is one of the supporting factors for the implementation of practice activities in schools. However, practice activities of mixtures separation with distillation techniques in schools are rarely carried out. This is due to constraints due to the lack of availability of practical apparatus. (Fadiawati and Diawati, 2011; Fadiawati, 2013; Fadiawati and Tania, 2014) A commercial simple distillation apparatus use a Pyrex flask as a distilling flask, glass tubing as a condenser, and a cup as the receiver. Components of the apparatus are made of glass, need to be assembled if you want to use, and the price is relatively expensive. In addition, the difficulty of the teacher in assembling the apparatus and the concerns of the teacher and students break the apparatus if they are not careful during practice also a reason (Retug, 2010; Maknun, et al., 2012; Sudargo dan Aisah, 2010).

Students as candidates for chemistry teachers who will later be in school must be able to develop practical apparatus. This is a challenge for the students in order the practice activities of mixtures separation by using distillation techniques in schools can be carried out.

Several studies have been conducted to modify the distillation apparatus (Campanizzi, et al., 1999; Kahl, et al., 2014). The use of modified practice apparatus in the learning process proved to be able to improve mastery of concepts and higher order thinking skills including creative thinking skills (Hooi, et al., 2014; Mott, et al., 2014; Kahl, et. al., 2014). However, these modified apparatus are not the result of copyright or creative thinking of students so that students do not have comprehensive knowledge about the usefulness of each tools and concepts that are followed in the work process of the apparatus.

In this article, we described the results of a modified simple distillation apparatus by students through project-based learning (PjBL). In these project of the apparatus, students applied their knowledges and skills to look for an alternative replacement tools, plan, build, and test the functioning of the apparatus.

Therefore, through the project of modified a practical apparatus is believed that the students' creative thinking skills can be trained (Fisher, 2006; Burke and Williams, 2009; Colcott, et al., 2009; Dyer, et al., 2009; Aubrey, et al., 2012; Diawati, et al., 2018).

This is corresponded with the globalization area, the cotemporary job market demands graduates who are able to work in an ill-defined and ever-changing environment, facing nonroutine and abstract work, make a decisions and responsibility, and working in team (Bergh, et al., 2006). Therefore, students need a number of higher order thinking skills including creative thinking skills.

Through PjBL, students have designed and built a simple and inexpensive distillation apparatus using scrapwares and sodium chloride (NaCl) sollution as the sample that it would be separated.

2. MATERIALS AND METHODS

There are five essential features of PjBL. These are projects (a) engage students in investigating an authentic question or problem that droves activities and organizes concepts and principles; (b) result in students developing a series of artifacts, or products, that address the question or problem; (c) allow students to engage in investigations; (d) involve students, teachres,

and members of society in a community of iquiry as they collaborate about the problems, and (e) promote students using cognitive tools (Krajcik, et al., 1994).

Students designed and built a simple distillation apparatus through four model stages of PjBL which are modified by Diawati, et al. (2018) for 8 weeks. These are (a) identifying and defining project; (b) planning a project; (c) implementing a project; (d) documenting and reporting project findings. Students were provided with worksheet that it contain questions as assitance to guide students to find several alternative solutions.

In the first week, students were oriented in the classroom by the lecturer. The lecturer give an explanation of the project and an importance of communicating and information sharing during collaboration with member of team and the lecturer. After that in the stage of identifying and defining project, students read the problem illustration about distillation and practice related of it in the secondary school. They were given a challenge with the problem: "What should you do so that secondary school students can do distillation experiment without any worry about breaking the apparatus while assembling the tools to complete the practical activities?"

Students planned a project outside of the classroom for 2 weeks. In this stage, students applied their knowledges and skills related to the problem. They were asked to search a simple distillation apparatus that has been developed or modified. Then, they identified the strength and weakness of it. According to the worksheet, they look for various alternative replacement tools for a heating source, a distilling flask, a condenser, and a cup as the receiver. Then, students were asked discuss with the lecture that why they choose these various alternative replacement tools.

At the stage of implementing a project, students were given 4 weeks to design, build, and test the product of a simple distillation apparatus. Regard to design, students were asked to compare with the design of a simple distillation apparatus that has been developed or modified. After students finished determining material alternative replacement tools, they drew a design of a simple distillation apparatus. Then they built and tested the apparatus. During the project, students consulted with the lecturer regularly because implementing design to be an apparatus is not one-time process.

Documenting and reporting project findings stage was done for a week. Students prepared for the project's report. At the weekend they presented the project findings in the classroom.

During the project from designed till finished the apparatus, students' creative thinking skills was assessed using process performance assessment instrument and the product a simple apparatus also was assessed using product assessment instrument.

3. RESULTS AND DISCUSSION:

According to the problem illustration about the constraint in the practice of distillation in the secondary school, students can identify the problems. From the interview, it is represented by the statements of these students:

Student 1: "Any tools of a commercial simple distillation apparatus that can be replaced with other tools?"

Student 2: "Are there alternative replacement tools for a commercial simple distillation apparatus?"

Related to the statements, the lecturer provides directive questions. For example:

Question 1: "What tools of a commercial simple distillation apparatus can be replaced?"

Question 2: "What is the function of each tool in a commercial simple distillation apparatus? Can alternative replacement tools have the same function as tools of a commercial simple distillation apparatus?"

Through reference searching, students found a simple distillation tool that has been developed or modified, such as distillation apparatus using household items (Campanizzi, et al., 1999) and used goods (Widiyatmoko and Pamelasari, 2012). According that, they were interested to modify a commercial simple distillation apparatus using used goods. The use of used goods was expected to reduce the costs, abudant and easy to obtain, and not complicated in the process of realization to become an apparatus.

There were some tools could be replaced with used goods, such as: (1) a bunsen burner could be replaced with an spirit-wall lamp; (2) a soft drink glass bottle replaces a Pyrex flask as a distilling flask; (3) a modified plastic bottle with alumunium tube and plastic hoses replaces a glass tubing as a condenser, and (4) a modified dynamo from car toys was used as aerator with

source of electric current from battery, power bank, or electric using phone charger. According to alternative replacement tools that determined by students, the lecturer give a question to look for the reason that why they choosen it.

A spirits-wall lamp was determined on the grounds that the size of the flame can be adjusted, so that the heating temperature can be adjusted as desired. The fuel used was spirits that were easily obtained, the price wass affordable, and the resulting fire was blue and did not cause soot. A soft drink glass bottle as distilling flask was choosen because transparant so that the sampel could be seen clearly. This distilling flask equipped with alcohol themometer that it was mounted on a distillation flask lid made of used rubber slippers. This used rubber slipper serves to hold the thermometer in order to stand upright and to prevent the discharge of steam. A modified plastic bottle with alumunium tube and plastic hoses was determined because heat resistant, conductor, dan corosion resistant. Modified aerator was determined in order an apparatus could be applied in any where, although in the school without an electric.

3.1. Distillation apparatus design

Design of a simple distillation apparatus using used goods was shown in Figure 1.

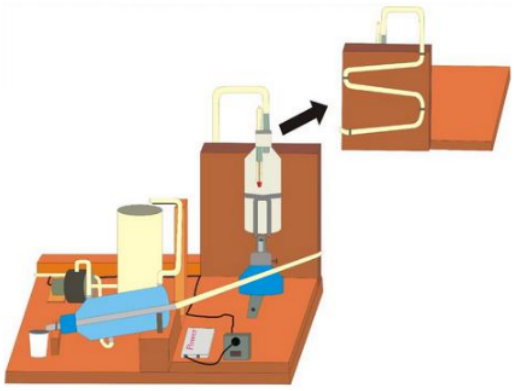
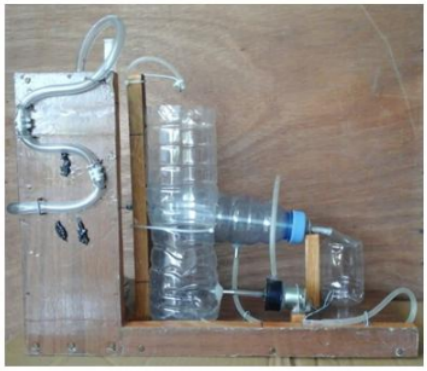


Figure 1. *Design of a simple distillation apparatus from used goods*

A simple distillation apparatus constructed by students was shown in Figure 2.

(a)



(b)

Figure 2. *Construction of a simple distillation apparatus from used goods: (a) front view and (b) back view*

All components in these apparatus were assembled into one unit, so that when used it was not necessary to assemble it first. The condenser was located lower than the distillation flask. The condenser hose was threaded and attached to the back of the vertical board where the distillation flask attaches. The condenser was equipped with water circulation. In addition, the condenser was also accompanied by a drain hose so that when finished, it could be opened the lid of the drain hose without having to disassemble the condenser.

A modified simple apparatus was safe and environmentally friendly. This apparatus can also be used in laboratories, inside and outside the classroom. The cost of this student-made a simple distillation apparatus inexpensive, ~ US$6 total (can be seen in Table 1).

Table 1. *Description of alternative replacement tools*

Component	Price/ US$
Wooden board	2.5
Wall lamp	0.5
Dynamo	0.5
Plastic hoses (0.75 inchi)	1
Alcohol thermometer (length: 30cm; Temp. Range: -10 to +110 °C	1
Cable (0.5 inchi)	0.5
Total	**6**

3.2. Performace assessment

As shown in Table 2, students have developed creative problem-solving skill during the project. According to worksheet and interview results, they have written the relevant formulation of problem, identified the function of each tools in a simple distillation apparatus, identified the tools of apparatus that can be replaced, determined and looked for various alternative replacement tools, designed, built, and tested the product of a modified simple distillation apparatus using used goods.

3.3. Apparatus performace

A modified simple distillation apparatus could already be used to purify sea water that modeled saline solution. This was indicated by obtaining distillates that were clearer and colorless compared to the sample. Test results with an electrolyte tester show that the distillate did not turn on the lights and there were no gas bubbles.

The value of the apparatus performance was shown in Figure 3 and 4.

Through this project, students gain valuable experience on how to plan the investigation, solve the problem creatively and analyze the results.

4. CONCLUSIONS:

Through project-based learning, students have successfully designed and built a simple distillation apparatus using used goods. There apparatus was safe and environmentally friendly. This project has facilitated the improvement of students' creative problem-solving skills.

Table 2. *The creative problem-solving in the project-based practice*

No	Item Indicator of Creative Problem-Solving Process	Score
1	Students write the relevant problem formulation	86
2	Students write the varied problem formulation	89
3	Students write the relevant ideas' formulation of the project's purpose	89
4	Students write the relevant ideas' formulation of the project's importance	91
5	Students write the corrected and relevant method or procedure and concept of the project	80
6	Students describe the function of each tools, determine the tools of apparatus that can be replaced, and list less-costly and no hazard alternative replacement tools	92
7	Students draw a design of the apparatus different with a commercial simple distillation apparatus	95
8	Students describe the function of each replacement tools of the apparatus	95
9	Students describe the working principle of each replacement tools of the apparatus	93
10	Students describe the operating principle of each replacement tools of the apparatus	90

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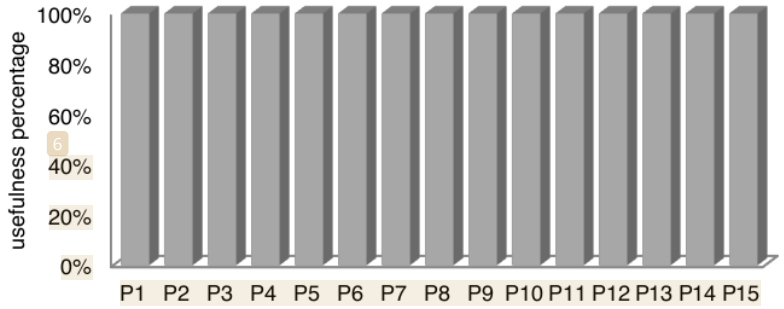

Information:
Usefulness

P1 : spirits-wall lamp
P2 : flame
P3 : soft drink glass bottle
P4 : heat resistance of glass bottle
P5 : gravel as boiling stone
P6 : thermometer
P7 : used rubber slipper
P8 : plactic hoses
P9 : condenser
P10 : water pump
P11 : electric current source
P12 : distillate
P13 : distillate cup
P14 : wooden board
P15 : electrolyte tester

Figure 3. *Graph of usefullness of a simple distillation apparatus from used goods*

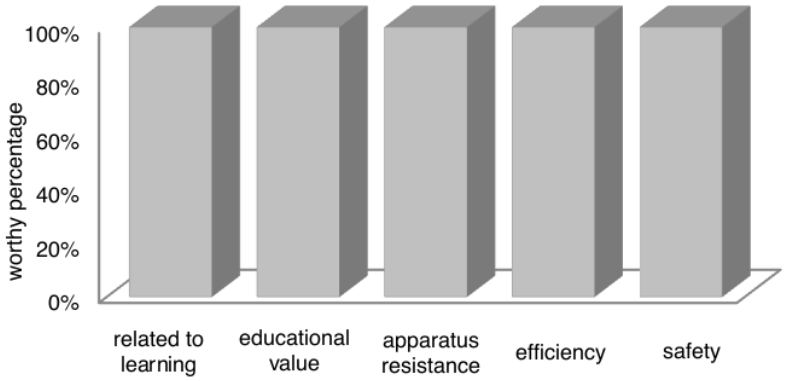

Figure 4*. Graph of worthiness of a simple distillation apparatus from used goods*

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