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Development of Used Cooking Oil Circulation Reactor for Biodiesel Production as Learning Media of Vocational Mechanical Engineering Student

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Abstract

This study aimed to develop and test the feasibility of a waste cooking oil-based biodiesel reactor prototype media used as a learning medium with a circulation system. The method in this research is Research and Development using the Waterfall model. The stages in the waterfall development model are (1) requirements definition including (needs analysis, analysis of used cooking oil characteristics, analysis of renewable energy, hardware requirements), (2) implementation and unit testing, (3) integration and system testing including: (testing the reactor, and testing the appropriateness of the media and materials), (5) operation and maintenance include: (testing the biodiesel reactor to students). The research subjects were three lecturers as material expert validators and media experts and ten mechanical engineering vocational students as users to test the product's feasibility. The research results are as follows; development of biodiesel reactor media and results of feasibility research by media experts got an average score of 4.48 with the category "very feasible." Assessment by material experts got an average score of 4.5 with the category "very feasible," and ratings from users got an average score of 4.095 with the category " decent."

Keywords: Biodiesel, Used cooking oil, Learning media, Reactor circulation

INTRODUCTION

The issue of energy conversion is the search for alternative energy to substitute energy from fossil fuels which are expected to run out soon if used continuously. The uncontrolled use of energy from petroleum fuels besides impacting on the world energy crisis, also results in air pollution from the exhaust of combustion gases. One of the fuels that contribute significantly to air pollution is petrodiesel.

In several developed countries, an effort has been developed to find alternative energy to replace petrodiesel which is more environmentally friendly and originates from renewable natural resources. (Mayasari et al., 2019). The fuel in question is known as biodiesel. This fuel is made from plant oil through a chemical reaction from renewable natural resources, so developing this alternative energy will guarantee energy conservation and be environmentally friendly (Zahan & Kano, 2018) .

The tools for converting used cooking oil into biodiesel and glycerol on the market are not easily accessible to households or small entrepreneurs. These tools are expensive, making it difficult for the general public to buy them (Xing et al., 2021) . In addition, the tools on the market cannot be carried freely. Furthermore, the volume of used cooking oil required according to the specifications of the conversion device is too large compared to the availability of used cooking oil at the household or small entrepreneur level. This research is a design of a portable circulation reactor to produce biodiesel and glycerol with the characteristics of being easily duplicated by the general public, can be used in bulk, and being cheap and environmentally friendly.

Theory and practice are combined in a balanced manner during vocational education, with an emphasis on the graduates' readiness for the workforce. One of the benefits of this vocational education is that students can directly develop their skills in accordance with the demands of the industry or line of work they will be entering (Mahfud et al., 2020).

Renewable Energy is a subject in the Department of Mechanical Engineering Vocational Education, at one state university in Banten, Indonesia, and is mandatory for students. Based on student observations and the results of discussions with vocational course lecturers, it is known that students tend to be passive and only a few are active during vocational learning. Therefore it is necessary to apply an interesting learning model. The teaching and learning process needs a media that can increase understanding of the material. Effective media be accessed anywhere and anytime because the media has an important role in teaching and learning. Students sometimes feel that vocational material could be more exciting, so later, students will be able to study the material, not have to be in class, and break the notion that courses are challenging and tedious.

The research objective to be achieved in this research is to develop a biodiesel reactor as a tool to convert used cooking oil into biodiesel and to know the level of feasibility of a biodiesel reactor as a learning medium in the Renewable Energy course in the Department of Mechanical Engineering Vocational Education, at one state university in Banten, Indonesia

METHOD

Research and Development with the waterfall development model was the research methodology used in this study (Petersen et al., 2009). The waterfall process has five stages: requirements definition, system and software design, implementation and unit testing, integration and system testing, and operation and maintenance. At one state university in Banten, Indonesia, the Department of Mechanical Engineering Vocational Education

conducted this study. 20 farmers served as the study's participants. Observation, interviews, and questionnaires were used as the research methods and data collection tools.

Surveys were distributed to media experts, material experts, and users. Three elements make up the media expert questionnaire: media design, technical, and benefits. The user's questionnaire has four components: media design, technical, material, and benefits. The material expert questionnaire has two components, namely material and benefits.

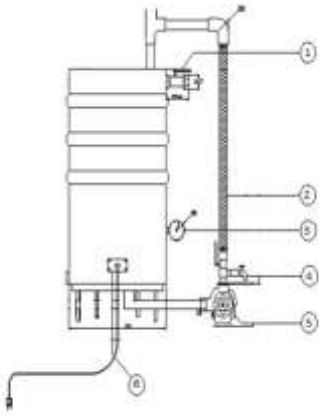
o ensure that a questionnaire is valid, it must be tested using instruments that were created in consultation with supervisors or subject-matter experts (expert judgment). The expert-validated questionnaire instrument's reliability was then determined using the Alpha Cronbach formula (de Vet et al., 2017). The data analysis employed is descriptive. Using a questionnaire with four options on a Likert scale—Strongly Agree, Agree, Disagree, and Strongly Disagree—experts and users evaluated the product's viability. Once the data is collected, convert the qualitative information into quantitative information using a scale of 1 to 4. After further analysis and classification in accordance with the assessment criteria, the product's quality predicate is determined based on the transformation of quantitative data into qualitative data (Widoyoko, 2012). Table 1 is a conversion of quantitative to qualitative data used to interpret product feasibility.

Table 1. Conversion of quantitative data to qualitative

Formula	Average Score	Classification
$X > \bar{x}i + 1.8 \times sbi$	>3.4	Very Good/Very Decent
$\bar{x}i + 0.6 \times sbi < X \leq \bar{x}i + 1.8 \times sbi$	$2.8 < X \leq 3.4$	Good/Decent
$\bar{x}i - 0.6 \times sbi < X \leq \bar{x}i + 0.6 \times sbi$	$2.2 < X \leq 2.8$	Enough
$\bar{x}i - 1.8 \times sbi < X \leq \bar{x}i - 0.6 \times sbi$	$1.6 < X \leq 2.2$	Not enough
$X \leq \bar{x}i - 1.8 \times sbi$	≤ 1.6	Very less

The biodiesel reactor as a learning media developed from stainless steel. A total volume of 60 liters and a production capacity of 20 liters contains fluids, namely waste cooking oil, methanol (21 – 25 weight percent of used cooking oil), and sodium hydroxide (5-gram weight). The biodiesel reactor can be seen in Figure 1 and Figure 2. The reactor tube is heated at a temperature of 60 - 70°C with heating coils made of copper and temperature control using thermocouples made of steel. The fluid in the reactor tube flows downward towards the centrifugal pump, which functions to drain fluid from the reactor tube to form a circulating fluid flow that passes through the centrifugal pump. The fluid flow control valve is made of PVC, the pipe is made of steel, and it returns to the reactor tube. The flue gas that arises during the reaction in the reactor tube will be released through the exhaust gas safety valve made of PVC. Fluid agitation in the reactor tube due to fluid circulating flow flowing out

from under the reactor tube and re-entering from the top of the reactor tube with the help of a centrifugal pump. During the esterification process in the reactor tube, two layers of fluid are formed, the top layer is golden yellow, and the bottom layer is dark brown.



Description

1. Pressure Gauges
2. relief valves
3. 3/4 inch pipe
4. relief valves
5. relief valves
6. Coil heaters

Figure 1. Circulating Biodiesel Reactor Circuit

Figure 2. Biodiesel Reactor

RESULTS AND DISCUSSION

In this study, the learning media developed is a biodiesel reactor as a tool to produce biodiesel using the circulation method for students in the Department of Mechanical Engineering Vocational Education, at one state university in Banten, Indonesia.

1. Development of learning media

The research model used by the Biodiesel Reactor for development is ADDIE (Analyze, Design, Development, Implementation, Evaluation).

a. Requirements Definition

This phase has three stages: needs analysis, renewable energy analysis, analysis of used cooking oil characteristics, and hardware requirements. In the needs analysis stage, researchers conducted observations and interviews with students in the Department of Mechanical Engineering Vocational Education, at one state university in Banten, Indonesia. Based on the observations and interviews results, it was found (1) that in the Department of

Mechanical Engineering Vocational Education, no learning media is suitable for Renewable Energy Course Achievements, (2) based on research results, people only throw away consumable oil which can cause damage to the environment. In energy analysis, researchers observe the potential for used cooking oil in Indonesia, which is very large, so it can be utilized as an alternative energy.

b. Design

Designing a product tailored to the needs in the form of hardware design is an overview of the product to be made (seen in Figure 1 and Figure 2).

c. Implementation and Unit Testing

The Implementation and Unit Testing can be seen in Table 2.

Table 2. The Implementation and Unit Testing

Sample	Observation result
Early Cooking Oil (1 kg technical KOH and 4.2 L technical methanol)	The resulting biodiesel is reddish in color and viscous. Sample: Biodiesel Yield: 5 Liters  

d. Operations and maintenance

For one week, the operation and upkeep arrange is carried out by applying biodiesel reactor media to understudies within the Office of Mechanical Designing Professional Instruction, at one state college in Banten, Indonesia. At that point a survey was given to discover out the user's reaction in surveying the achievability of the media.

2. Feasibility of learning media

a. Feasibility assessment by media experts

The assessment of the created nursery media was evaluated by three media specialists, to be specific two speakers in Mechanical Building Instruction and one speaker in Mechanical Designing. Specialists evaluate all viewpoints, to be specific media plan, detail, and benefits. The taking after scores of evaluations by media specialists can be seen in Table 3.

Table 3. Media Expert Eligibility Assessment Score

No	Aspect	Average Score	Category
1	Media Design	4.5	Very Good/Very Decent
2	Technical	4.35	Very Good/Very Decent
3	Benefits	4.6	Very Good/Very Decent
	Average	4.48	Very Good/Very Decent

Based on the appraisal of the three speakers in media plan, they got an normal of 4.5 with the category "exceptionally good/very conventional." On the specialized perspective, they got an normal of 4.3, 5 with the category "exceptionally good/very not too bad," and finally, on the angle of media benefits, get an normal score of 4, 6 with the category "exceptionally good/very better than average." The evaluation of all perspectives gotten a add up to normal score of 4.48 with the category "exceptionally good/very conventional." Taking after are the comes about of the achievability evaluation by media specialists within the frame of a bar chart, as appeared in Figure 3.

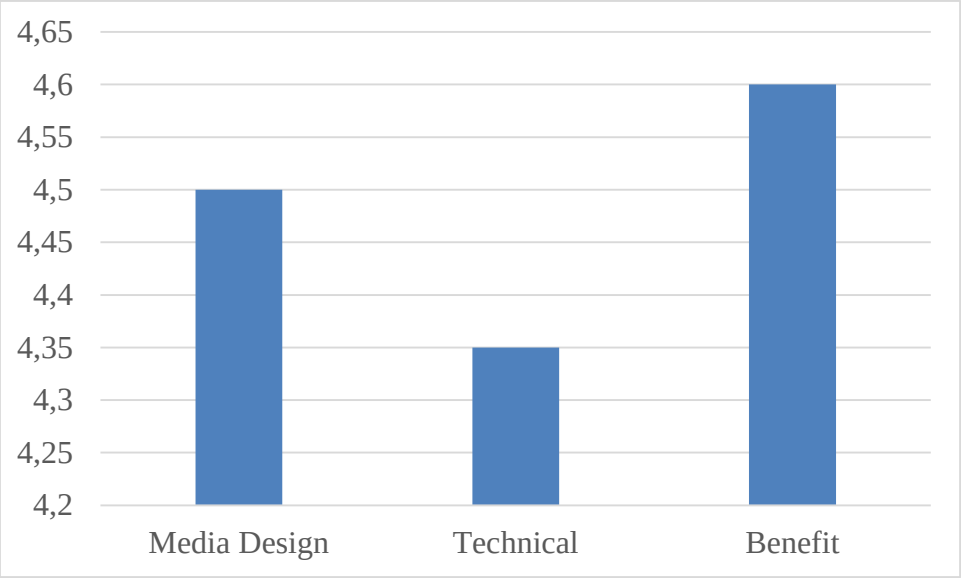


Figure 3. Media Eligibility Level Bar Graph

b. Feasibility assessment by material experts

The created biodiesel reactor media was evaluated by three media specialists, to be specific two teachers in Electrical Building Instruction and one speaker within the Workforce of Building, Division of Mechanical Building. Specialists survey all angles, specifically fabric and benefits. The taking after scores of evaluations by media specialists can be seen in Table 4.

Table 4. Feasibility Assessment Score By Material Expert

No	Aspect	Average Score	Category
1	Theory	4.5	Very Good/Very Decent
2	Benefits	4.5	Very Good/Very Decent
Average		4.5	Very Good/Very Decent

Based on the comes about of the evaluation of three teachers as subject matter specialists, within the fabric viewpoint, they got an average of 4.5 within the category " Exceptionally Good/Very Better than average. " Within the perspective of benefits, they got an normal of 4.5 within the category " Exceptionally Good/Very Conventional. " Evaluation of all perspectives to urge a add up to normal score of 4.5 with the category " Exceptionally Good/Very Better than average. " Taking after are the comes about of the possibility evaluation by fabric specialists within the frame of a bar chart, as appeared in Figure 4.

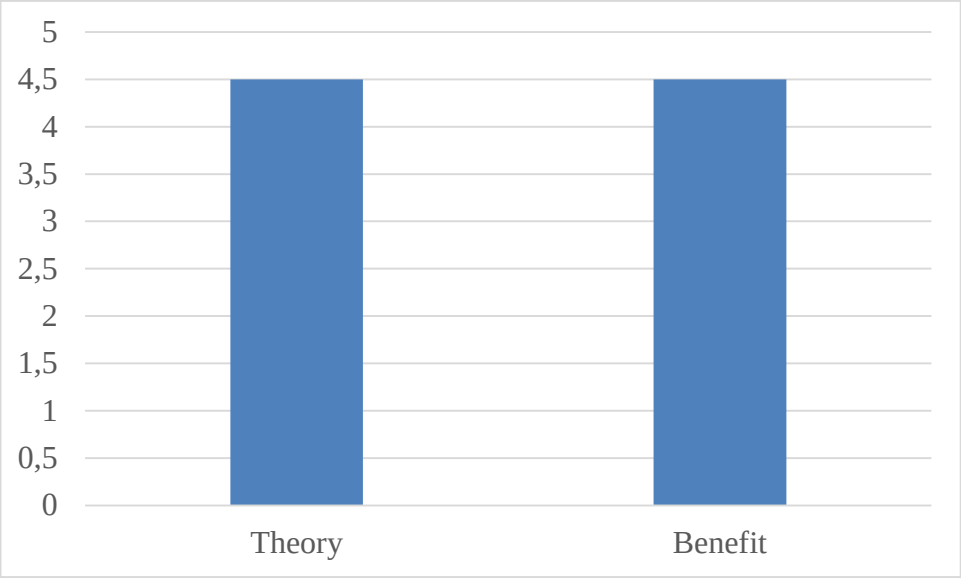


Figure 4. Material Feasibility Level Bar Graph

c. Feasibility assessment by users

Client testing was carried out on farmer's arrive with ten respondents. In client testing, there are four evaluation viewpoints: media plan, specialized, fabric, and benefits. The achievability appraisal score by the client can be seen in Table 5.

Table 5. User Eligibility Assessment Score

No	Aspect	Average Score	Category
1	MediaDesign	3.97	Good/Decent
2	Technicall	4.2	Good/Decent
3	Theory	4.13	Good/Decent
4	Benefits	4.08	Good/Decent
Average		4.095	Good/Decent

Based on user assessment results, the media design aspect got an average of 3.9 7 in the " Good/Decent " category. In the technical aspects, it got an average of 4.2 in the "Good/ Decent " category. In the material aspect, it got an average score of 4.1 3 with the category " Good/Decent," and the aspect of benefits got an average score of 4.0 8 with the category " Good/Decent. " Assessment of all aspects to get a total average score of 4.0 95 with the category " Good / Decent ". The following scores of feasibility assessments by the user can be seen in Figure 5.

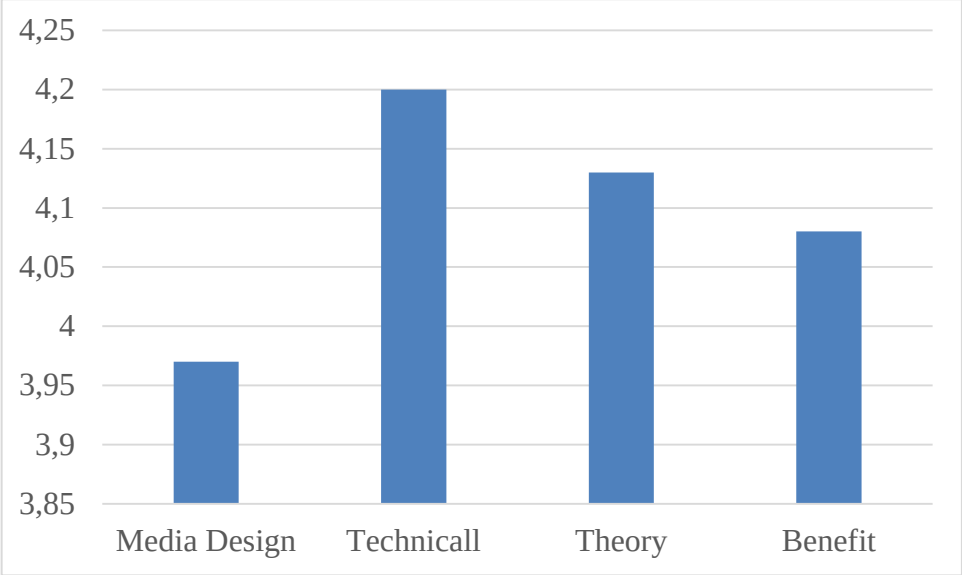


Figure 5. Bar Graph of User Eligibility Rate

CONCLUSION

Media development uses the waterfall model. The level of feasibility of greenhouse media by media experts in media design, technical and benefits aspects gets an average score of X = 4.48 with the category "Very Good/Very Feasible." In the assessment of the guidebook by material experts in terms of material aspects and benefits, get a value of X = 4.5 with the category "Very Good/Very Decent." User ratings in media design, technical, material, and benefits get a value of X = 4.095 with the category "Good/Decent."

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