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Enhancing Student Creativity in Applied Physics through RO Filter and Heating Filament Learning Media Development

Muhammad Zaky[1]*, Ketut Alit Adi Untara[2], Miftah[3], Ashari[4], Brian Muhammad Larate[5]
Physics Education Study Program, Tadulako University, Palu, Indonesia[1,2,3]
Student Physics Education Study Program, Tadulako University, Palu, Indonesia[4,5]
zaky.fkip@untad.ac.id*

Abstract: Applied physics courses require students to produce applied products. In theory, this course teaches students to use and apply physics knowledge in a practical physics product. However, students have low creativity, so students' outcomes and ideas are limited. it is necessary to have a learning media that is beneficial to society in the current situation, and this media must be able to change and enhance student creativity so that, in the end, it also improves student learning outcomes. One learning media that will be developed is an RO filter combined with heating filaments. The development of RO filters is based on the problem of the quality of drinking water in the community. This research is a Research and Development. Development research time for eight months. The subjects of this study were physics education students who were programming applied physics courses. The changes measured are the validation values of learning media development from expert respondents to increase student creativity it is measured through a creativity questionnaire.. The results of this study indicate that the development of this media has succeeded in increasing students' creativity. In conclusion, the use of this innovative learning media is not only useful in improving students' understanding of applied physics, but also provides a positive contribution to the quality of drinking water in the community.
Kata kunci: Heating Filaments, RO Filters, Creativity, and Media Development

Peningkatan Kreativitas Siswa pada Materi Fisika Terapan melalui Pengembangan Media Pembelajaran RO Filter dan Filamen Pemanas

Abstract: *Mata kuliah fisika terapan menuntut mahasiswa untuk menghasilkan produk terapan. Secara teori, mata kuliah ini mengajarkan mahasiswa untuk menggunakan dan mengaplikasikan ilmu fisika dalam suatu produk fisika yang praktis. Akan tetapi, mahasiswa memiliki kreativitas yang rendah, sehingga hasil dan gagasan mahasiswa terbatas. Untuk itu diperlukan suatu media pembelajaran yang bermanfaat bagi masyarakat pada situasi saat ini, dan media tersebut harus mampu mengubah dan meningkatkan kreativitas mahasiswa sehingga pada akhirnya juga meningkatkan hasil belajar mahasiswa. Salah satu media pembelajaran yang akan dikembangkan adalah filter RO yang dikombinasikan dengan filamen pemanas. Pengembangan filter RO ini didasari oleh permasalahan kualitas air minum di masyarakat. Penelitian ini merupakan penelitian pengembangan. Waktu penelitian pengembangan selama delapan bulan. Subjek penelitian ini adalah mahasiswa pendidikan fisika yang sedang memprogram mata kuliah fisika terapan. Perubahan yang diukur adalah nilai validasi pengembangan media pembelajaran dari responden ahli untuk meningkatkan kreativitas mahasiswa yang diukur melalui angket kreativitas. Hasil penelitian ini menunjukkan bahwa pengembangan media ini telah berhasil meningkatkan kreativitas mahasiswa. Kesimpulannya, penggunaan media pembelajaran inovatif ini tidak hanya bermanfaat dalam meningkatkan pemahaman siswa terhadap fisika terapan, tetapi juga memberikan kontribusi positif terhadap kualitas air minum di masyarakat.*
Keywords*: Filamen Pemanas, Filter RO, Kreativitas, dan Pengembangan Media.*

1. Introduction

The need for healthy drinking water that is free of microbes, viruses, and chemicals is important today. In the Covid 19 pandemic, the health and hygiene of refilled drinking water are one of the main factors that are sometimes overlooked. In big cities, especially in Palu, refilled drinking water or gallon water is a basic need and has become a habit for people's consumption. Some of the problems encountered

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with this refilled drinking water are business owners who rarely clean the water filter regularly. The UV sterilization lamp does not function properly, the appearance of moss in gallons of drinking water after several refills, and the most dangerous is the lack of drinking water sellers who do health protocols, especially washing hands before and after touching a gallon of bottled water as standard protocol during the covid pandemic.

This problem can be solved by changing people's habits to boil raw water and using it as drinking water. The conversion of raw water into cooking water is carried out without neglecting the chemical content of water, namely high levels of lime and magnesium so that the conversion of raw water into drinking water is carried out by utilizing a series of water filters, RO filters, ion resins and most importantly, the use of heating filament components. Boiling raw water into cooking water is vital, ensuring that viruses and bacteria die immediately. Reverse Osmosis (RO) is a method for obtaining pure water from water containing salt by osmosis (Ahuchaogu et al., 2018).

Reverse osmosis can remove many types of suspended species from water, including bacteria, and is used in both industrial processes and drinking water production. The result is that the solute is retained on the pressurized side of the membrane, and the pure solvent is allowed to pass to the other side. The membrane is very selective, not allowing large molecules or ions to pass through the pores (holes) but can allow smaller solute components (such as solvent molecules) to pass freely, which in this case is pure water (Warsinger, Tow, Nayar, & Maswadeh, 2016). The RO filter removes all of the cloid solid material and separates it from the water (Skuse, Gallego-Schmid, Azapagic, & Gorgojo, 2021).

In the osmosis process, the solvent naturally moves from a region of low solute concentration, through a membrane, to an area of high solute concentration. The driving force for solvent movement is the reduction in system energy when the difference in solvent concentrations on the two sides of the membrane is reduced, resulting in osmotic pressure as the solvent moves to a more concentrated solution. Reverse osmosis also involves diffusion, making the process dependent on pressure, flow rate, and other conditions (Crittenden, Trussell, Hand, Howe, & Tchobanoglous, 2012).

A simple RO design consists of a filter, CTO, and activated carbon. For feed water, it is necessary to provide pre-treatment to remove inorganic and suspended solids using a high-pressure pump fed through a semi-permeable membrane (Garud, Kore, Kore, & Kulkarni, 2011). Ro-filtered water will undergo PH adjustment and disinfection because microbes cannot be passed. The type of membrane can be spiral or hollow fiber (Djebedjian, Gad, Khaled, & Abou Rayan, 2006). The membrane usually consists of a 0.25-micron skin and a 100-micron backing layer. The skin is normally a barrier that allows only water molecules to pass through. (Murthy & Chaudhari, 2009) reported on "Treatment of Distillery Spent washes", in which ultra-filtration and reverse osmosis membranes are used for water purification by removing color and contaminants. Several studies, such as (Bellona, Drewes, Xu, & Amy, 2004) and (Xu et al., 2005), have also reported the application of reverse osmosis membranes to remove organic matter such as chemical endocrine disruptors, plastic additives, pesticides, active pharmaceutical compounds, benzene, and toluene. All filter equipment is made portable so that it can be easily and practically completed by the public.

On the other hand, in lectures, there are applied for physics courses; this course is a very important subject because it requires students to produce used products. In theory, this course teaches students to apply and apply physics knowledge to a practical physics product. However, in teaching and learning activities in class, students have low creativity, so students' outcomes and ideas are limited. Most of them could be more useful in applying physics, especially for society. Creativity can be generated through learning so that through knowledge, creativity can be formed in students (Kupers & van Dijk, 2020). These two problems have a very urgent meeting point where it is necessary to have a learning media that benefits the community in the current situation. This media must be able to change and enhance student creativity so that, in the end, it also improves student learning outcomes (Jarnawi & Untara, n.d.). One learning media that will be developed is an RO filter combined with heating filaments. This development is summarized in research entitled development of learning media RO filters combined with heating filaments to increase student creativity in applied physics material. This research is expected to increase student creativity in understanding the importance of applied physics and can be applied to help the community in meeting household drinking water needs.

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2. Research Method

This research was conducted in the Physics Education Study Program, Faculty of Teacher Training and Education, Tadulako University. The time required for this development research was approximately eight months, namely from April 2021 to November 2021. The subjects of this study were physics education students taking applied physics courses. The changes measured are the validation values of learning media development from expert respondents and students. To increase student creativity is measured through a creativity questionnaire. This research includes a type of research known as Research and Development (R&D), a research model used to produce certain products and test the effectiveness of these products (Sugiyono, 2013).

In research on the development of learning devices using the steps of the research and development model by Sugiyono (2011) [12] states that the steps in R & D research consist of 10 steps as follows: (1) Potential and problems; (2) Data collection; (3) Product design; (4) Design validation; (5) Design revision; (6) Product trials; (7) Product revision; (8) Trial use; (9) Product revision; and (10) Mass production. Filter media design, Filter design as a medium for developing student creativity consists of RO filters and water pump sediments, resin, and heating filaments.

Data collection techniques are ways of performing or capturing the results of the work of the mind, which are operationalized at a realistic empirical level. To obtain reliable data, a good data collection method is needed. The data used are as follows:

A questionnaire is a data collection tool that contains several questions or statements that research subjects must answer. Questionnaires can reveal many things so that a lot of data/information is obtained in a short time. Based on its shape, questionnaires can be opened and closed. In this study, a closed questionnaire was used with a Likert scale type with a scale of 1 to 4. Very good is worth 4, good is worth 3, poor is worth 2, and very poor is worth 1. Closed questionnaires have answers that have been provided and do not allow respondents to add other information (Endang, 2011).

Observation is a way of collecting information material (data) carried out by systematically observing or recording the phenomena being targeted for observation. Observations were made when the learning took place. Observations were made directly to determine the effectiveness of product development.

The data analysis technique used in this research and development is the collection of data through instruments and then carried out according to research and development procedures. The data analyzed in the development of learning tools and media are quantitative data and qualitative data.

Quantitative data is in the form of scoring scores for all parts and functions of the tool based on the results of a validity test questionnaire with a Likert scale of numbers 1,2,3 and 4. Qualitative data is an evaluation from the validator in the form of responses, criticisms, input, and suggestions listed in the questionnaire or direct discussion used as consideration for product revision.

The data analysis technique used to analyze the validation data is calculating the average value. The total score obtained is divided by the number of respondents who answered the assessment questionnaire to find out the final score rating for each research questionnaire. To get a formula for calculating the average value in equation 1

$$X = \Sigma x/n \quad (1)$$

Remark:

X : the average value in each question
Σx : the total value of all assessments in each question
n : the number of respondents who answered the assessment questionnaire

Assessment category with the following provisions:

Table 1. Assessment category

Value score	Interpretation
3,25 < X ≤ 4,00	Very Good
2,50 < X ≤ 3,25	Good
1,75 < X ≤ 2,50	Poor
1,00 ≤ X ≤ 1,75	Very Poor

Analysis of student respondent data is similar to the analysis of the quality of product assessment. The average score of the response questionnaire was then converted into a qualitative form based on the following criteria:

Table 2. Assessment category

Value score	Interpretation
3,25 < X ≤ 4,00	Very Good
2,50 < X ≤ 3,25	Good
1,75 < X ≤ 2,50	Poor
1,00 ≤ X ≤ 1,75	Very Poor

For additional analysis in seeing changes in students' creativity and curiosity were analyzed using gain analysis

With the N-gain acquisition category: High: g > 70; medium: 30 ≤ g 70 and low g < 30.

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3. Result and Discussion

The research stages follow the steps of the R&D model outlined by Sugiyono (2013). which includes the following stages.

The first step is Potential and Problems. At this stage, researchers identified the potential and problems in physics learning in the classroom. Researchers conducted surveys and interviews with students, teachers, and lecturers to find out the challenges faced in understanding applied physics material. The results of the study showed that 72% of students had difficulty in applying physics knowledge practically, while 78% of lecturers reported that the lack of innovative learning media was one of the factors causing low creativity and student learning outcomes. Based on the interview results, lecturers also stated that the limitations of aids in physics practice often hindered students' understanding in real contexts. Thus, the development of innovative learning media such as RO filters is expected to overcome these problems and improve students' understanding..

The second step is Data Collection. This stage involves collecting more in-depth information about student needs and classroom learning characteristics. Researchers collected data through questionnaires and observations to analyze how students interact with physics materials. The results of the analysis showed that students needed more interactive and applicable media to understand physics concepts, especially those related to applications in everyday life, such as drinking water quality.

The third step is Product Design. After collecting data, the researcher designed a learning media product, namely an RO filter combined with a heating filament. This design aims to create a tool that not only functions as a learning medium, but also provides real solutions to drinking water quality problems in the community. The initial prototype of this media was designed by considering functional and educational aspects.

The fourth step is Design Validation. At this stage, the product design that has been created is validated by experts and respondents from among students. Researchers ask for input regarding the effectiveness and feasibility of the learning media developed. The validation results show that this media has the potential to increase student creativity and can be used in applied physics learning. The assessments that have been carried out by the validator are as follows.

Validity Results = 32/40 x 100% = 0.80 x 100% = 80% It can be seen in Table 3 that the results of the expert design validator's assessment obtained a percentage of 80% with a valid category. The learning media is suitable for use with revisions according to suggestions. The suggestions that have been given are to replace the category or description of the validity assessment scale.

Table 3. Validation Results by Design Expert Validator

No	Assessment Item	Score	Description
1	The display of this learning media is visually appealing	4	Very Good
2	Learning media can be used anytime flexibly	4	Very Good
3	Using learning media makes learning physics fun	4	Very Good
4	Learning media can be used to explain physics concepts	4	Very Good
5	Learning media is easy and practical to use	3	Good
6	Learning media does not pose a risk of danger	3	Good
7	Colors on the media are used to highlight important parts	3	Good
8	Learning media is designed to withstand repeated use	2	Poor
9	Learning media is designed to withstand environmental conditions	2	Poor
10	Measurements that are easy to read and interpret	3	Good
Total		32	Good

The fifth step is Design Revision. Based on the validation results, the researcher revised the design to improve the quality and effectiveness of the learning media. This revision includes improving the visual and functional appearance of the product to better suit students' needs. Selecting more durable materials, especially for components that are frequently used and prone to wear. Replacing materials that are more resistant to changes in temperature, humidity, and other environmental conditions, so that the learning media can still function optimally in various conditions. Adding clearer indicators or labels, so that students do not have difficulty in understanding the data presented. Revisions to

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these aspects will have a significant impact on increasing the effectiveness and durability of the learning media.

The sixth step ist Product Trials. After the revision, the researcher tested the product in class. Students were given the opportunity to use the RO filter and heating element in learning activities. The results of the trial showed that students were more enthusiastic and creative in understanding physics material, and were able to relate the concepts learned to real applications in everyday life.

The seventh step ist Product Revision. Based on feedback from the trial, the researcher revised the learning media product again. This revision includes improving the design and adding features that can better support the learning process. The results of the revision showed an increase in the effectiveness of the learning media.

The research only reached the 7th stage of Product Revision because this revision stage was considered sufficient to prove the effectiveness and feasibility of the product in the learning environment. At this stage, the researcher has obtained evidence that the learning media is able to increase students' enthusiasm, creativity, and understanding of physics concepts, as well as enable the application of physics concepts in everyday life. Other considerations did not proceed to the next stage because this stage requires additional time and resources, including collaboration with other parties in mass production, which is beyond the scope and initial objectives of the research.

From the results of the research that has been done, it is obtained that the RO filter learning media is a combination of heating filaments to increase student creativity. This learning media is made and designed so water with a high lime content can be removed as much as possible. The Ro water filter consists of a 0.5-micron sediment filter, activated carbon, RO Pump Carbon CTO, RO filter, and heating filament. From the research results, the first stage of PDAM water that enters the media will pass through a 0.5-micron sediment filter. This filter serves to filter sediment up to a size of 0.5 microns. Filters of this size effectively remove dirt, rust, and grit particles, which affect water's taste, smell, and color. After that, the water will enter the activated carbon filter. This filter functions to neutralize chemicals that are still carried away from the Municipal Waterworks. This filter can get rid of 99% chlorine and organic chemicals. Also works well in reducing disturbing taste, smell, and color. Get rid of fungicides, pesticides, insecticides and herbicides. This is in line with research conducted by al (Al Ashhab, Sweity, Bayramoglu, Herzberg, & Gillor, 2017) and by (Vrouwenvelder et al., 1998) regarding fouling and its impact on membrane processes, specifically nanofiltration (NF) and reverse osmosis (RO). These researchers studied various types of impurities (e.g., biofouling, organic and colloidal impurities) and the mechanisms by which contaminants are formed, which can be separated from water upon using RO (Al Ashhab et al., 2017) (Vrouwenvelder et al., 1998)

A Ro pump pulls water that has passed through the activated carbon with a voltage of 220-240 V, 0.2 Amperes, 0.3 GPM, and a pressure of 120 PSi. This water is then imputed into the RO filter so that small particles, chemicals residue including lime, sediment with a size of 0.0001 microns, viruses, and bacteria are filtered and discharged into the final sewer (bacteria size is 0.2 to 1 Micron, and viruses are between 0.02 to 0.4 Microns). This RO filter is a Thin Film Composite (TFC) membrane, a high-quality membrane capable of flowing 50 gallons of quality drinking water per day. In addition to the above functions, this membrane can also remove harmful contaminants such as lead, copper, barium, chromium, mercury, sodium, cadmium, fluoride, nitrite, nitrate, and selenium. Get rid of bacteria, E. Coli, giardia, cryptosporidium, and others.

The ratio of filtered water can be seen in the comparison of water before and after being filtered in Figure 1 below.

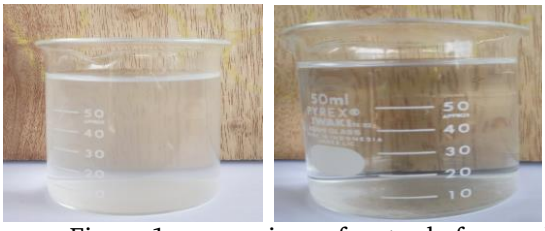

Figure 1. comparison of water before and after being filtered

After the water has passed through the RO filter, the clean water is pumped into the CTO Carbon Cartridge. The CTO functions to improve the taste of water, so it doesn't have an unpleasant or amber taste. From the CTO, the water then goes back to the final heater filament. This filament serves to heat water. Water is heated to meet the drinking water requirements that must be boiled. After the water passes through the heating filament, this water can be consumed or at least can be used for food raw water.

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In using this RO tool, some things concern usage limits because each piece of equipment has a usage limit. RO filters can be used for a year because there will be sediment in the RO filter after exceeding the usage limit. From several recent studies, this process of forming precipitates can be reduced by adding anti-deposit through surface modification to control precipitate formation (Bucs et al., 2017) (Rana & Matsuura, 2010). In addition, many studies have developed optimal feed spacers (Abid, Johnson, Hashaikeh, & Hilal, 2017) and pre-treatment measures (Prihasto, Liu, & Kim, 2009) to prevent and reduce fouling. Mathematical models have also been developed to improve understanding of the mechanism of deposit formation and predict the impact of deposits on membrane performance (Radu, Van Steen, Vrouwenvelder, Van Loosdrecht, & Picioreanu, 2014) (Picioreanu, Vrouwenvelder, & Van Loosdrecht, 2009).

After the tool is made and tested for the function, which shows maximum results, then the RO filter combination of heating filaments is used as a learning medium to increase student creativity in applied physics material. After being used as learning media along with modules and materials, the expert validation team validated the media that contains modules and materials. The eligibility is obtained to be used as teaching media.

Following the stages of R&D research, the media that has been validated is then subjected to a limited test on students to see the feasibility and students' responses to the press made. The number of students who participated in the test was ten people. Around 87% responded that filters could be used as learning media for applied physics in class, with a total score of 3.5 or a very decent category. To test changes in the creativity and curiosity of participants in limited trials, quite good improvement data were obtained. The results of the creativity pre-test data obtained an average value of 60, and the post-test data obtained an average value of 87, so the N gain was 68, which means that the use of media resulted in N creativity gains in moderate or good enough category. While the results of the curiosity pre-test obtained an average value of 57, and the post-test data obtained an average value of 88, so the N gain was 72, which means it is in the high category.

From the data obtained, it can be stated that the development of RO filter learning media with heating film combinations can increase student creativity in the medium category and student curiosity in the high category.

The outputs that have been achieved can be seen in Figure 2 below

Figure 2. Applied Physics Learning Media

4. Conclusion

From the research results, the RO filter learning media combined with heating filaments can be developed into learning media in applied physics material. RO filter learning media combined with heating filaments can increase student creativity in applied physics material. As a suggestion, it is hoped that in future studies, an additional number of sediment filters will be carried out, and greater production can be carried out.

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