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Research Article

Designing of Environmental Physics Lecture Programs about Ocean Wave Energy to Enhance Students' Creative Thinking Skills

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Abstract

Various factors become obstacles to developing renewable energy technology, including people's low knowledge of renewable energy and low 21st-century skills. Therefore, designing learning that can increase understanding of renewable energy and improve 21st-century skills simultaneously is essential. This study aimed to create programs of environmental physics lectures about OWC as a renewable energy source. This research was developmental research with analysis, design, and development stages. The products in this study were test instruments to measure creative thinking skills, OWC converters prototype, and a project-based lecture program oriented towards providing creative thinking skills through a combination of lectures in the classroom, laboratory, and marine environment. Five experts validated all products. In addition, besides experts' validation, the creative thinking test instrument was tested on 17 students who had taken environmental physics lectures. In contrast, a marine engineering laboratory tested the prototype at a university in Bandung. Experts' validity data were analyzed using the content validity ratio, while the test instrument data were calculated for reliability, validity, discrimination, and difficulty levels. Based on the results of expert validation, all products are feasible to be implemented. Based on the test results, the prototype developed functions well, while for the test instrument of 10 questions developed, only eight questions were eligible to be used. All of the products produced can be used as a reference and reference for lecturers or teachers who develop learning about renewable energy and equip students with creative thinking skills.

Keywords: *environmental physics lecture; OWC; creative thinking skills*

Perancangan Program Perkuliahan Fisika Lingkungan tentang Energi Gelombang Laut untuk Meningkatkan Kemampuan Berpikir Kreatif Mahasiswa

Abstrak

Terdapat berbagai faktor yang menjadi kendala pengembangan teknologi energi terbarukan, di antaranya adalah rendahnya pengetahuan tentang energi terbarukan dan rendahnya keterampilan abad 21 yang dimiliki masyarakat. Oleh karena itu, sangat perlu di desain suatu pembelajaran yang mampu meningkatkan pengetahuan tentang energi terbarukan dan meningkatkan keterampilan abad 21 secara bersamaan. Penelitian ini bertujuan untuk merancang instrumen matakuliah fisika lingkungan tentang energi gelombang laut sebagai sumber energi terbarukan. Penelitian ini adalah penelitian pengembangan dengan tahapan analisis, desain, dan pengembangan. Produk dalam penelitian ini adalah instrumen tes untuk mengukur keterampilan berpikir kreatif, prototipe konverter energi gelombang laut, dan rencana pelakasanaan program kuliah berbasis proyek yang berorientasi pada pembekalan keterampilan berpikir kreatif melalui kombinasi perkuliahan di ruang kelas, laboratorium, dan lingkungan laut. Semua produk divalidasi oleh 5 orang ahli. Selain validasi para ahli, instrumen tes keterampilan berpikir kreatif diuji pada 17 siswa yang telah mengambil matakuliah fisika lingkungan, sedangkan prototipe diuji di laboratorium teknik kelautan pada salah satu universitas di Bandung. Data validasi para ahli dianalisis menggunakan rasio validitas konten, sedangkan data instrumen tes dihitung untuk tingkat reliabilitas, validitas, diskriminasi, dan tingkat kesulitan. Berdasarkan hasil validasi ahli, semua produk layak untuk diimplementasikan. Hasil ujicoba prototip yang dikembangkan juga berfungsi dengan baik, sedangkan untuk instrumen tes dari 10 pertanyaan yang dikembangkan hanya 8 pertanyaan yang memenuhi syarat untuk digunakan. Produk yang dihasilkan dapat dijadikan sebagai acuan dan referensi bagi dosen atau guru yang mengembangkan pembelajaran tentang energi terbarukan sekaligus membekali siswa dengan keterampilan berpikir kreatif.

Kata Kunci: *Perkuliahan Fisika Lingkungan; energy gelombang laut; keterampilan berpikir kreatif*

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I. INTRODUCTION

Exploration of new renewable energy is a solution that can be done as an alternative to fulfill electrical energy needs. Utilization of ocean wave energy (OWC) has the potential to become an alternative energy source that can be used as an energy crisis solution [1-3]. Several developed countries located in coastal areas have utilized wave energy to the fullest by converting it into electrical energy to meet the community's needs [4]. In addition, the sea is an energy source from sea-level and tidal waves. Several countries have developed tidal waves as electricity producers [5-7].

Indonesia is one of the world's countries with the largest sea area. Two-thirds of Indonesia's territory is the sea. Indonesia has the second-longest beach in the world [8]. This is an advantage for Indonesia regarding the enormous potential of marine energy.

Indonesian ocean waters along the southern coast of Java to Nusa Tenggara are locations that have considerable wave energy potential ranging from 10 - 20 kW per meter wave [9]. One study has concluded that wave energy at several points in Indonesia can reach 70 kW / m in several locations, one of which is the waters of Nusa Tenggara [10]. Even so, although it is pretty promising, Indonesia's wave energy utilization technology development still needs to be improved. Exploration of OWC is currently in its early stages, and the wave energy utilization system is only a prototype testing stage because of several obstacles, one of which is the lack of human resources who have skills in the field [11].

Various studies related to efforts to introduce the concept of renewable energy have been carried out, including Mälkki & Alanne [12] developing a life cycle assessment to be enhanced as a research-based teaching method in renewable and sustainable energy education curricula; Hammad, Al-Zoubi, & Castro [13] developed e-learning about renewable energy in the form of experiments covering the topics of wind and solar power generation, solar tracking control, hybrid energy, and fuel cells; Buldur et al., [14] developed a lecture on renewable energy with a focus on studies of hydroelectric power plants, geothermal energy, wind power, and solar energy which was carried out outside the classroom through project-based learning to increase student awareness of renewable energy; Grivokostopoulou [15] developed a renewable energy learning approach about wind energy and solar energy through 3D virtual word technology.

Besides that, Stroth et al. [16] developed blended learning on renewable energy, especially solar and wind energy. Firman [17] utilizes the computation laboratory to introduce renewable energy to students, focusing on wind and water energy. Afkar et al. [18] introduced the basic concept of renewable energy using the storytelling method. Susanti, Yunita & Setiawan [19] communicated the latest concepts and issues on renewable energy by using engineering software, which includes e-learning-based lecture videos, animated videos, and virtual environments. Keçebaş & Alkan [20] seek to improve high school students' understanding of renewable energy through education and training. Nowotny et al. [21] emphasized that it is necessary to use textbooks to help students learn about renewable energy so that students understand renewable energy more profoundly and comprehensively. Chandrasekaran [22] developed machine-learning-based hybrid renewable energy applications for mechanical engineering students. Theodorou et al. [23] developed augmented reality-based learning in environmental education lectures to explain various concepts, one of which is the concept of renewable energy.

Based on previous research, it was not found that there was an effort to comprehensively inform the OWC and its utilization as an alternative energy source. Also, it was not found involving teaching aids in the form of OWC converters to introduce how to generate electricity from OWC. OWC has excellent potential in Indonesia as an environmentally friendly alternative energy [10]. In addition, several previous studies have yet to attempt to equip students with important skills, such as creative thinking during renewable energy learning. These skills are needed when students develop various renewable energy technologies, especially for converting the OWC into electricity energy.

Therefore, in the long term, we need to communicate the concept of wave energy to people, especially the younger generation. Introduce them to knowledge and early understanding of wave and other renewable energy [24]. Knowledge about utilizing OWC as alternative energy and equipping various important skills such as creative thinking skills. In addition, it is also necessary to socialize about current research and development of renewable energy technologies through meeting indoors or outdoors. The aim is to prepare responsible and knowledgeable human resources so that one day later can advance renewable energy technology, especially in OWC field. The most important thing is to teach the concept and equip students with various skills, including creative thinking skills, which still need to improve [25] to become qualified human resources according to the demands of the times

Therefore, it is essential to do innovation or renewal in the active learning process that involves students in the process to be able to produce human resources who not only have cognitive insight into how to use ocean waves as an alternative energy source but also have various types of skills including creative thinking skills. The way is to develop lecture instruments that integrate the provision of creative thinking skills and its assessments, such as lecture programs that describe the provision of creative thinking skills, media that support the enhancement of creative thinking skills, and assessments to measure how to enhance creative thinking skills during the lecture process.

II. METHOD

This research is development research with the ADDIE model, which consists of 5 stages: analysis, design, development, implementation, and evaluation. This research developed a component of an environmental physics lecture program about utilizing OWC as an alternative energy source. This component comprises a lecture program implementation plan, OWC converter prototypes as a learning media, and a test instrument for creative thinking about utilizing OWC. In the analysis phase, a needs analysis is carried out as a background for designing new lectures. In the design stage, designing lecture programs, teaching aids in the form of OWC converter prototypes, and creative thinking tests. At the development stage, products were produced as lecture programs, prototype designs of OWC converters as teaching aids, and creative thinking tests. Then, at the implementation stage, all of the products were implemented on the 29 students in one of Teachers University in West Nusa Tenggara as long as eight meetings. In the last stage, an evaluation is conducted to see the program's implementation.

The products were validated by five experts consisting of 2 lecturers who are experts in science learning, two lecturers who are experts in OWC, and one lecturer who is an expert on renewable energy. Data from experts' validation was analyzed using Content Validity Ratio (CVR) [26], CVR formula as shown in equation (1) to find out whether the product produced is proper or not to be applied to environmental physics lecture about OWC and its utilization.

$$CVR = \frac{n - N/2}{N/2} \qquad (1)$$

where N is the number of panel experts and n is the number of panel experts who claim to be appropriate. Expert test data collection was carried out using expert validation sheets. The instrument is feasible if the calculated CVR value > critical CVR, where according to Wilson Pan and Schumdky [26] for five raters, the critical CVR value is 4.

In addition apart from expert test, a prototype was conducted laboratory test in the wave flume at the one of the university at Bandung. The testing was carried out consisting of 3 stages, namely (1) testing on waves at the period T= 1 second and wave heights H= 10 cm, 15 cm, 20 cm; (2) testing on waves at the T= 2 seconds and H= 10 cm, 15 cm, 20 cm; (3) testing on waves at the T= 3 seconds and H= 10 cm, 15 cm, 20 cm. Meanwhile, the time used to measure the resulting voltage is 60 seconds. The resulting output voltage is measured using a multimeter and oscilloscope.

Likewise, in addition to the expert test, the test instrument was tried out on 17 students of the physics education study program at a university in West Nusa Tenggara. Tests are conducted to measure the test items' validity, reliability, discrimination, and difficulty. This trial is conducted to determine the feasibility of the test being developed to implement it. The data obtained from this trial were analyzed using the instrument reliability coefficient test (Cronbach alpha) to determine the reliability of the test and the Pearson correlation test to assess the validity of the test. The test instrument is valid if the calculated correlation value exceeds the table correlation value.

Table 1. Criteria of Reliability [27]

Correlation value	Criteria
r ≤ 0.2	very weak
0.2 < r ≤ 0.4	weak
0.4 < r ≤ 0.6	sufficient
0.6 < r ≤ 0.8	high
r > 0.8	very high

The discrimination value (DF) of test was analyzed by calculating the difference between the scores of the upper group and the lower group then divided by the number of ideal scores. With discrimination criteria as shown in Table 2. The test's difficulty level was analyzed by calculating the average score divided by the maximum score, with the difficulty level (DL) shown in Table 3.

Table 2. Criteria of Discrimination Value [27]

Discrimination Value (DF)	Criteria
DF ≤ 0.1	very bad
0.11 ≤ DF ≤ 0.19	bad
0.20 ≤ DF ≤ 0.29	not good
0.30 ≤ DF ≤ 0.49	good
DF ≥ 0.50	very good

Table 3. Criteria of Difficulty Level [27]

Difficulty Level (DL)	Criteria
DL < 0.3	difficult
0.31 ≤ DL ≤ 0.7	moderate
DL > 0.71	easy

The test result data were analyzed using a normalized gain score (N-gain) to determine the increase in pre-service physics teacher creativity regarding using ocean wave energy as a renewable energy source. The N-gain value can be calculated using the formula 1 [28]. The N-gain average value that has been obtained then interpreted based on Table 4.

Table 4. Interpretation of N-gain Score

<g> Value	**Criteria**
<g> ≥ 0,70	High
0.30 ≤ <g> < 0,70	Middle
<g> < 0,30	Low

III. RESULTS AND DISCUSSION

Analysis Stages

At this stage, an analysis was conducted based on the results of field observations and literature studies, including syllabus analysis of environmental physics, lecture processes, knowledge of OWC concepts, and what types of skills are provided during the environmental physics lecture. The analysis aims to determine the existing problems and how to solve them. Based on the analysis results, lectures on environmental physics are still conducted conventionally, where students are only assigned to make papers and then present them to the class [25]. In addition, based on the results of syllabus analysis and semester lecture plans, no specific skills are provided to students, and the material about sea wave energy is taught just as an introduction. Therefore, an active lecture design that focuses on students' cognitive aspects and provides a variety of 21st-century skills is needed.

Table 5. An Example of Lecture Programs Implementation Plan Design

Outcome Learning	Indicators of PjBL	Indicators of Creative thinking skills	Learning Descriptions
• Explain the scope of ocean waves including definitions, factors that cause waves and wave theory • Identify national energy problems and link them to the renewable energy from ocean waves	*Launching the project* • Identify and define problems • Launch an interesting initial project and open-ended guide questions (Meeting) (2x50")	• *Elaboration:* elaborating explanations and responding to questions from lecturers	• Listening, elaborating, and analyzing lecturers' explanations related to the latest state of conventional energy sources data, about the geographical location of Indonesia which is an archipelago and the use of marine energy as an unlimited energy source and the potential of the Indonesian sea as a renewable energy source.
		• *Problem sensitivity*: find various problems from lecturer exposure; *Fluency*: produce several solutions	• Identify national energy problems and find various solutions
		• *Flexibility:* see a problem from various points of view.	• Asking guiding questions and project work to be done.
		• *Problem sensitivity*: able to detect, recognize, and understand a problem.	• Analyze and provide temporary answers to guide questions and project assignments to identify what needs to be known and study them from various perspectives related to the topic of investigation
		• *Elaboration:* enrich ideas through various kinds of references	• Through Assignment Sheet, students conduct literature studies to find unique ideas and ideas through various sources (international journals, national journals, online videos, related books, etc.) to open up insights on the use of the sea as a source renewable energy is then collected at the next meeting.

Design Stages

Lecture programs Implementation plan that enhance creative thinking skills

The environmental physics lecture program is designed on a project by focusing on understanding concepts and providing creative thinking skills. Project-based lecture syntax refers to the Buck Institution

Education (BIE) framework [29], namely launching the project; building knowledge, understanding, and skills; developing and revising ideas and products; and presenting products and answers to driving questions. Meanwhile, the creative thinking skills used to refer to the Guilford framework [30] are problem sensitivity skills, fluency, flexibility, originality, and elaboration. The design of this lecture program requires students to produce a product in the form of a prototype of a simple, unique, and efficient wave energy converter that involves creative thinking skills and allows for the future to be made on a larger scale so that it is helpful for the community.

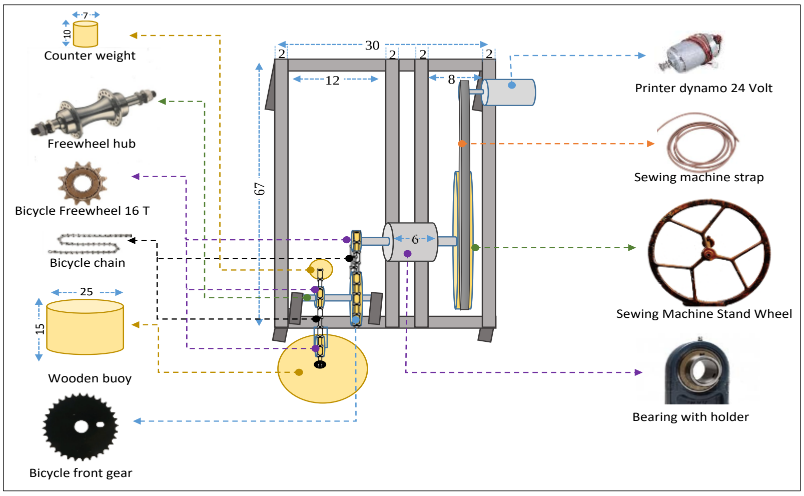
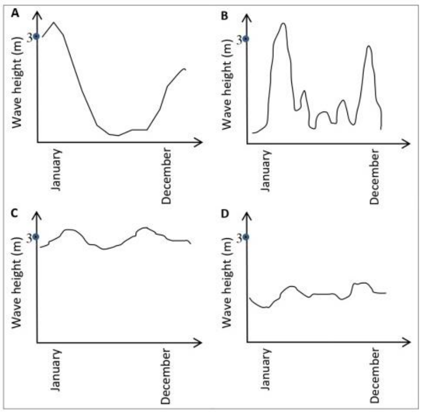


Figure 1. Design of Wave Energy Converter Prototype

Table 6. Example of Creative Thinking Skills Test

Learning outcome	**Concept mastery indicators**	**Indicators of creative thinking skills**	**Question**
Determine the location for sea wave energy utilization	Analyze data of sea wave height in several places in Indonesia that have the potential to be used as the location of sea wave energy utilization and explain the cause	*Problem Sensitivity* Able to detect, recognize, and understand problems	 The graph above shows the height of the ocean waves at four different locations in Indonesia for 1 year. Which graph shows the place where wave energy technology can be installed to produce electricity? Describe your reasons why you chose the chart!

Development stage

At this stage, the development of the lecture program, the prototype wave energy converter, and the instrument of creative thinking are done to produce the final product that can be implemented in lectures. Three steps are carried out at this stage: making products, conducting trials, and product revisions.

Lecture program implementation plan

For the lecture program, the product is produced as in the design stages shown in Table 5. Five experts' judgments were conducted.

Based on the results of expert judgment, Table 7 shows that all expert validators agreed on the lecture program that was developed, even though each validator provided notes as input. One note that needs to be considered is that learning outside of school requires special worksheets that focus on developing creative thinking skills [32]. In addition, it is also necessary to include an evaluation tool for the lecture process at each meeting.

Table 7. Results of Experts' Judgment About Lectures Program

No	Item	Validator					Amount	CVR	Interpretation
		1	2	3	4	5			
1	Learning stages adjust with project based learning	1	1	1	1	1	5	1	Proper
2	The substance of debriefing creative thinking skills	1	1	1	1	1	5	1	Proper
3	Wave energy conception	1	1	1	1	1	5	1	Proper
4	Problem context	1	1	1	1	1	5	1	Proper
5	Legibility	1	1	1	1	1	5	1	Proper

Prototype wave energy converter

The development of the prototype is based on the design, as shown in Figure 1. The purpose of developing this prototype is as a tool to describe the principle of OWC converters working and as an initial description for students in producing a prototype converter on a given project assignment. The stages of developing a prototype are divided into three steps: making prototypes, laboratory testing, and prototype revisions.

Figure 2 is a prototype of an OWC converter made based on the initial design to be tested. The trial was conducted at the Laboratory of Marine Engineering, Institut Teknologi Bandung, using the wave flume seen in Figure 3. Several deficiencies were found at the time of the first trial, including the converter's placement position, which needed to be in the direction of the dating wave.

Figure 2. Prototype Wave Energy Converter

Therefore, every time the wave spread, the connecting chain of the spacer with the driven gear was always out so that the chain protector was added so it would not come out. In addition, the buoy mass is too light to make the converter not function optimally so that the load on the buoy is added. Based on the results of trials, the prototype functions well, where the converter can produce voltages up to 19-volt for a wave height H=20 cm with a wave period T=1 second. The working principle of the prototype is influenced by the wave-period and wave-height [33,34].

<u>Wave energy concepts tests instrument integrated creative thinking skills</u>

Wave energy concept tests were developed with as many as ten essay items. Each question measures wave energy concepts and creative thinking skills according to the indicators in the Guilford framework [30] and predetermined learning outcomes. The questions developed have passed expert validators and were tested on 17 students who have taken environmental physics lectures.

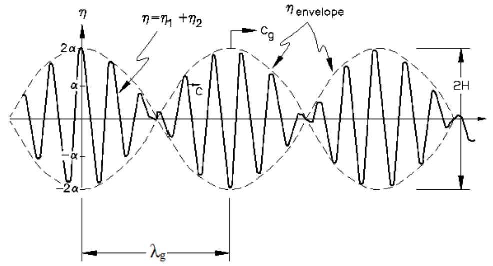
Table 8. Results of Item Analysis

Problem	Item Discrimination		Item Difficulty		Validity (r_{table}= 0.482)		Reliability
	Value	Interpretation	Value	Interpretation	Person Correlation	Interpretation	
item_1	0.325	Good	0.632	Middle	0.822	Valid	0.923 (Very Reliable)
item_2	0.45	Good	0.647	Middle	0.914	Valid	
item_3	0.475	Good	0.662	Middle	0.754	Valid	
item_4	0.1	Very Bad	0.282	Difficult	0.308	Invalid	
item_5	0.325	Good	0.603	Middle	0.814	Valid	
item_6	0.475	Good	0.632	Middle	0.895	Valid	
item_7	0.55	Good	0.647	Middle	0.926	Valid	
item_8	0.4	Good	0.618	Middle	0.875	Valid	
item_9	0.05	Very Bad	0.253	Difficult	0.119	Invalid	
item_10	0.525	Good	0.662	Middle	0.907	Valid	

Based on Table 8, eight other questions are valid and reliable out of the ten items developed. They are appropriate to measure students' creative thinking skills in lectures on environmental physics regarding wave energy as a renewable energy source. In contrast, two questions were declared invalid, namely questions number 4 and 9. Based on the analysis of the difficulty level of the two questions, it is quite challenging to do, so almost all students get very low scores.

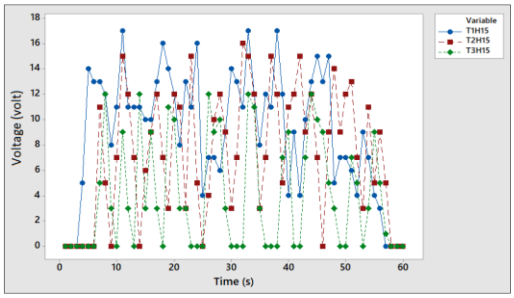
Figure 4 shows two creative thinking skills tests in which problem number 4 measures the elaboration indicators, namely the ability to add or detail an idea to improve the quality of the concept. From the answers of 17 students who worked on the problem, students needed help finding a mathematical relationship between group velocity and the velocity of the ocean waves in the deep sea and shallow seas, so most students did not complete the answer to the question. However, even though declared invalid, other questions are still declared valid for measuring elaboration skills. In addition, from Figure 4, there is also item 9, which is declared invalid, and based on an analysis of the difficulty level, the problem is declared difficult. Problem number 9 is used to measure the originality indicator, which is the ability to come up with ideas in ways that are original, new, unique, and rarely given by most people [25,31]. Still, it is not a problem because there are other questions that are valid for measuring these skills. Therefore 2 questions that are declared invalid and they are not reduce the measurement of creative thinking skills for all indicators based on the Guilford framework. However, both of questions were revised because they represented each indicator of learning outcomes. The revision of question number 4 was carried out in the question redaction where it did not ask students to explain the mathematical relationship between phase velocity and group velocity. Meanwhile, question number 9 is revised in the graphic image section where the graph displayed is simpler, only displaying data on the maximum voltage, average voltage, and minimum voltage generated by the converter.

4



The ocean wave flux can be determined from the product of wave energy and wave velocity. This means that the sea wave flux is directly proportional to the group velocity (C_g) rather than the phase speed of wave (C). Based on the picture above, explain the difference in wave-particle group velocity and wave phase velocity! And describe the relationship mathematically in the deep sea and shallow sea!

9



The graph above is the result of a prototype wave energy converter testing that utilizes the motion of a buoy tumble as a driving system on ocean waves with different periods (T = 1 s, 2 s, and 3s) with the same wave height (H = 15 cm) for 1 minute. Describe why the voltage generated by the converter is unstable (up and down) for 1 minute! And explain how to make the output voltage stable?

Figure 4. Invalid Questions

Implementation and evaluation stage

The lecture program implementation plan that was developed makes it easier for lecturers to design how the lecture process is oriented to improving students' creative thinking skills one semester ahead.

Table 9. Implementation Results of The Lecture Program

	Concept	Creative Thinking Skills				
	Mastery	Sensitivity	Fluency	Flexibility	Originality	Elaboration
N-gain	0.725	0.787	0.711	0.787	0.698	0.744
Criteria	High	High	High	High	Middle	High

Based on the implementation data analysis results, the lecture program developed shows that the N-gain of students' mastery of concepts and creative thinking skills is above 0.7, which is in the high category. This shows that the developed course program positively impacts increasing students' mastery of concepts and creative thinking skills in environmental physics lectures. This is consistent with what has been revealed by several studies, namely, that project-based learning can improve students 'mastery of concepts [32,33] and can also enhance students' thinking skills [34,35].

Based on evaluation results, the developed program is very suitable for application in learning locations near the coast. This is evidenced by increased students' mastery of concepts and creative thinking skills. The development of an assessment is not only done to measure the mastery of concepts but also to measure students' creative thinking skills. Each question developed can measure one or two indicators of creative thinking skills. In addition, the lecture program developed can also direct lecturers to create media or teaching aids that can equip students with certain skills [36,37]. Therefore, various instruments are developed so that the specified learning outcomes are fully achieved [38]. In addition, lectures conducted are more directed and measurable and train lecturers to be more creative with various lecture instrument developments.

All of the products produced from this study, namely project-based lecture implementation plans, creative thinking test instruments, and wave energy converter prototypes, are related to each other in that they have an orientation to enhance students' creative thinking skills. With precise lecture planning, lecture activities are directed and effective, but the developed project-based lecture plans will positively impact students' development of creative thinking skills [39,40]. Likewise, when there are no creative thinking test instruments, the creative thinking skills that have been equipped for students are not measurable [41], in other words, it will not be known that the success in equipping creative thinking skills students fail. Meanwhile, with the developed prototype, it will be easier for students to work on projects related to the development of OWC converters. In addition, the existence of a media in the form of a converter from used materials that were developed indirectly motivated students [42], to develop wave energy converters from used materials without reducing the function of the converter.

The limitations of this research were that the evaluation of the program could have been carried out more thoroughly at every stage of development. The program's success was only assessed from the data on the increase in pre-service physics teachers' mastery of concepts and creative thinking skills. In addition, the designed lecture program is more suitable for universities close to the coast or with a marine laboratory. The lecture program developed only focuses on developing creative thinking skills. For further research, it is necessary to design lectures on ocean waves that seek to increase creative skills and other 21st-century skills simultaneously.
The research has positively impacted the development of renewable energy technology, especially regarding using OWC as a renewable energy source. Project-based lectures that are not only oriented towards student cognitive abilities but also emphasize the development of 21st-century skills can produce resources with skills and expertise in renewable energy, especially OWC. In addition, the resulting prototype will pave the way for researching and developing theories in physics and OWC converter technology.

IV. CONCLUSION

The design of an environmental physics lecture on OWC produced a project-based lecture program oriented to develop students' creative thinking skills through a combination of classroom, laboratory, and marine environment lectures. It also produced a prototype OWC converter made from secondhand materials that can be used to explain the use of ocean waves as a renewable energy source. In addition, a set of test instruments was also produced in the essay form items to measure students' creative thinking skills regarding the concept of ocean waves and their use as a renewable energy source. All products that were produced have passed the validation stage and are properly implemented. For further research, it is necessary to develop multimedia, which is like a virtual lab, to describe the concepts that are very difficult to observe directly on shore students so that students can more quickly understand and master the ocean wave concepts.

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