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Validity and Readability of E-Worksheet Based on Education Sustainable Development Assisted by Digital Climate Map on Global Warming Subject

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Abstract

Global warming has a significant impact on the environment, with the earth's temperature continuing to rise due to human activities that produce carbon emissions, such as burning fossil fuels and deforestation. Sustainable education (ESD) is key in addressing this issue, through the implementation of curriculum and learning methods based on sustainability values. This research aims to develop physics learning tools in the form of E-Worksheet digital map-based to support students' understanding of the issue of global warming. The utilization of technology in E-Worksheet allows flexible access, real-time, and environmentally friendly, in line with ESD principles. This research uses the ADDIE model R&D design which is focused until the Develop stage to develop ESD-based Physics E-Worksheet learning media on global warming and climate change material. Qualitative data was obtained from the responses of validators and students, while quantitative data came from the Likert scale results in the validation and readability tests. The product validity results showed an average of 85% (valid with minor revisions), while the readability test obtained an average of 88.98% (very good). This media is declared suitable for use in learning because it is practical, supports sustainability education, and increases students' knowledge and awareness of environmental issues. The limitation of the research lies in the focus on the development stage, so further research is needed to test the effectiveness and implementation of the product.

Keywords: ESD, Global Warming, Electronic Worksheet, Digital Climate Map

INTRODUCTION

Global Warming is a global challenge faced by the whole world. The phenomenon of global warming has a huge impact on environmental conditions (Pinontoan et al., 2021; Wahyuni & Suranto, 2021) According to the results of research by the National Centers for Environmental Information, there is an increase in the earth's surface temperature every year with the hottest earth temperature record occurring in 2024 since 175 years ago. The temperature increase in 2024 experienced a higher temperature increase of 0.10°C (0.18°F) than the previous year. According to the Intergovernmental Panel on Climate Change (IPCC), most of the global warming since the mid-20th century has been caused by increasing concentrations of greenhouse gases due to human activity. The greenhouse effect causes sunlight to be trapped in the Earth's atmosphere. The radiation received will continue to increase, causing an increase in the Earth's temperature. The increase in greenhouse gas concentrations is caused by several human activities that produce carbon emissions (Irma, 2024). These activities include burning fossil fuels, deforestation, industry and so on (Evseeva et al., 2021; Irma, 2024). Therefore, the importance of overcoming this problem is a common goal of all nations.

The United Nations (UN) in 2015 agreed on 17 points of sustainable development goals or the so-called Sustainable Development Goals (SDGS). In the agreement, one of them includes the point of Climate Change (climate change) at point 13. Meanwhile, Indonesia became the 6th largest greenhouse gas emitter in the world throughout 2023 with a total of 701.4 million tons of carbon dioxide (kompas.com. 2024).

Education is the key to overcoming these problems in order to realize sustainable development (Uralovich et al., 2023). According to Rismawati et al. (2023) there are three main concepts in the foundation of sustainable education, namely curriculum, teaching methods and learning objectives that refer to sustainability values. This concept emerged based on international recognition called Education Sustainable Development (ESD). According to UNESCO, the

purpose of the ESD concept is to be able to foster humans in considering various actions in local and global perspectives based on current and future environmental, social and economic aspects.

The concept of ESD in physics learning can be applied in global warming material in phase E. To implement a lesson, a learning tool is needed that is in accordance with the teaching method carried out (Fitri et al., 2020). One of the tools that can be used in learning is the Learner Worksheet (LKPD). There are two types of Worksheet currently that are often developed, namely electronic worksheet (E-Worksheet) and conventional worksheet. The advantage of E-Worksheet over conventional worksheet is its ease of use which is not limited by time and place (Kautsar et al., 2025). E-Worksheet utilizes technology to facilitate storage and organization of learning and can reduce the risk of data loss.

This advantage can be optimized with the use of devices that are able to illustrate a physics concept with relevance. One of the media that can be used to illustrate global warming material is a digital climate map. Digital climate map is one of the media that provides interactive and dynamic data visualization, allowing students to understand the material. Digital climate maps have the potential to explain geospatial data, graphics, information and illustrations of a condition of the earth's surface clearly (Dewi et al., 2024). Digital climate maps also allow learners to conduct independent exploration of information related to global warming and climate change. Learners can access information in real time with actual data related to global warming conditions. This provides an opportunity for learners to broaden their horizons and understanding of current environmental issues. Based on the literature review, there is no physics e-learning tool integrated with digital climate map.

Therefore, in this research the author aims to develop a learning tool, electronic student worksheet digital climate map with ESD (Education Sustainable Development) orientation. E-Worksheet will facilitate the access of students to the digital climate map website provided as a simulation. The utilization of technology in the worksheet will provide easy access in the process (Mulyati, 2023). Learners can work on worksheets anywhere and anytime so that it helps the flexibility of learning (Daryanes et al., 2023; Mulyati, 2023). Moreover, the use of E-Worksheet can help reduce the use of paper. This is in line with the implementation of sustainable education (ESD) which contributes to the sustainability of the environment.

METHODS

This study uses an R&D research and development design with the *Analysis, Design, Develop, Implement, and Evaluate* (ADDIE) model. The model is complete, relevant and rational with this type of development research to produce or develop a learning media product (Sugiyono, 2020). The research flow used in this study is as shown in Figure 1.

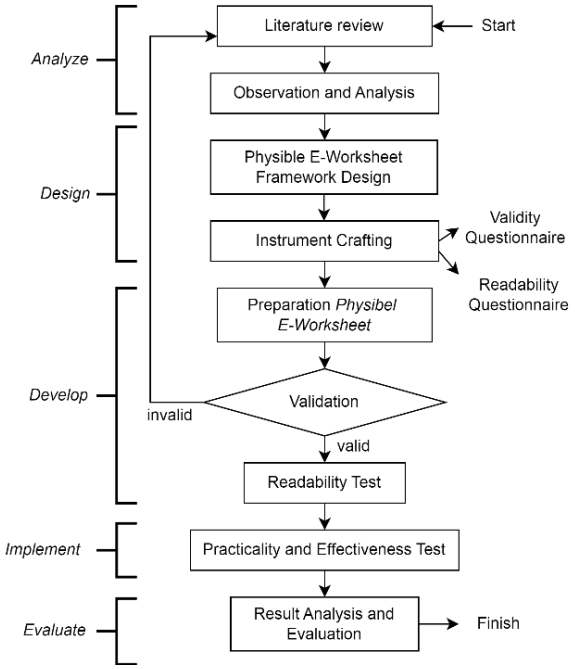

Figure 1. Research flow diagram

In this study, the development model carried out only until the Develop stage which is used as a benchmark in the implementation of further research. The data obtained from this study are qualitative and quantitative data. Qualitative data in the form of responses from validators and students. Quantitative data is obtained through the results of the Likert scale percentage of the validation test questionnaire and the readability of E-Worksheet. The data analysis technique carried out in the form of descriptive analysis to determine the validity and readability of the E-Worksheet that has been developed. In the first stage, Analyze, researchers conducted a literature study and analyzed learning needs to determine the limits and objectives of the study. At the Design stage, researchers conducted an initial design of the global warming electronic Worksheet based on the results of the needs analysis at the previous stage. In addition, at

the design stage, the research instrument was also compiled. The instruments used were validity questionnaire and readability questionnaire.

The next stage is Develop. At this stage the researcher begins to make electronic worksheet according to the initial design design worksheet is made based on syntax and indicators that have been adjusted to the needs. At this stage the researchers also tested the validity of the product by providing validity as well as conducting interviews with 3 experts as validators. The validators include experts in digital learning, and experts in ESD-oriented physics learning. Product validity is known by calculating the total validity score of the experts.

$$V = \frac{TSe}{TSh} \times 100\% \quad \text{..... (1)}$$

Description:

V = Validity
TSe = Total score validator
TSh = Total maximum score (expectation)

The results of the validation calculation in percentage form are then matched according to the criteria according to Akbar (2013) as in Table 1 below.

Table 1. Validity Test Criteria

No.	Figures	Validity Category	Description
1	85.01-100.00%	Very Valid	Very good to use
2	70.01-85.00%	Fairly Valid	Usable with minor revisions
3	50.01-70.00%	Less Valid	Can be used with major revisions
4	50.00-01.00%	Invalid	Not to be used

(Akbar, 2013)

After the worksheet product is declared valid, a readability test is carried out to high school students who have received climate change and global warming material. The readability test was carried out by distributing a questionnaire of 18 questions with a Likert scale. The calculation on the readability test assessment is calculated through the equation 2.

$$PK = \frac{total\ score}{Criteria\ score} \times 100\% \quad \text{.....(2)}$$

Keterangan:

PK = Readability percentage (%)
Kriteria = Total maximum score

The total score on the readability test was then matched with the criteria according to Sarip et al. (2022) in Table 2 below.

Table 2. Readability Test Criteria

Percentage	Criteria
80.1%-100%	Very good
60.1%-80%	Good
40.1%-60%	Medium
20.1%-40%	Not good
0.0%-20%	Not very good

RESULT AND DISCUSSION

The electronic LKPD media based on climate maps is designed with Problem Based Learning syntax integrated with sustainability-oriented climate maps called Physible E-Worksheet (Physics Sustainable Electronic Worksheet). The PBL learning model was chosen because it has been empirically proven to be effective in improving students' problem solving ability, which is one of the 21st century skills and is very relevant to sustainable education (Ramandani et al., 2023; Yulanda et al., 2023). So that the development of problem solving skills in Physible E-Worksheet is not only focused on cognitive aspects, but also directed to foster active participation in solving real problems by considering aspects of environmental, social, and economic sustainability (Qiroah & Lestari, 2024) This reinforces the idea that physics learning is not only about formulas, but must also be contextualized and touch the reality faced by students (Kim, 2018).

The platform used in developing Physible E-Worksheet is an edform website that can be accessed and done directly anywhere and anytime by each learner. In the platform, Physible E-Worksheet can be synchronized with each learner's email account to avoid cheating in the process. The use of Edform is also in line with the results of Nurkhasanah & Rohaeti's research (2024) which states that digital platforms like this are effective in increasing learning flexibility and learner motivation, especially in learning based on environmental issues.

Physible E-Worksheet can display problem-oriented YouTube videos that are in accordance with the concept of problem-based learning. So that students can explore from contextual problems that occur around them. The video can be played directly on one edform website platform. Physible E-Worksheet based on sustainable education (ESD) which is reflected in questions that stimulate learners to think deeply related to the context of problems in economic, social and environmental aspects. Previous research by Nursofa & Hamdu (2021) showed that ESD in learning can increase students' sensitivity to sustainability issues and foster ecological responsibility early on. Thus, Physible E-Worksheet not only facilitates understanding of physics concepts, but also directs students to become agents of change in facing global challenges. In addition, Physible E-

Worksheet also integrates exploration using climate maps. This climate map is used as an additional visualization equipped with concrete data on global warming that we often do not feel. Climate maps are intended to help learners have a real understanding of the problems that occur. Figure 2 and 3 shows the integration of climate maps and the inclusion of sustainability aspects in the Physible E-Worksheet.

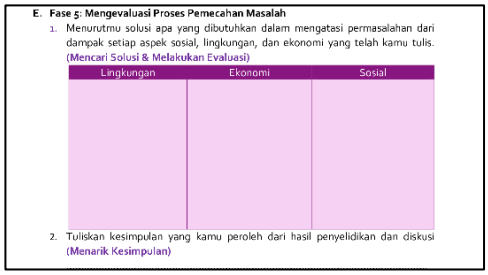

Figure 2. environmental, social, economic aspect questions

Figure 3. climate map

Furthermore, the validity test was conducted to 2 expert validators. The validity test was carried out based on 2 categories of aspects, namely content and construct. The content aspect includes the validity of the material/content in accordance with the purpose of developing the Physible E worksheet. Validation of the content aspect resulted in a score of 87.50% which is classified as very valid.

Table 3. Validity Test Results

Assessment Aspect	**Validator**		**Average**
Content	V1	V2	**Value**
Alignment of content with learning outcomes	3	3	3
Aligned with Sustainable Learning (ESD)	4	4	4
Accuracy concepts according to facts, theories, and procedures in the field	4	3	3.5
Orderliness of the materials	4	3	3.5
Suitability with *problem-based learning* model	4	4	4
Assessment Aspect	**Validator**		**Average**
Content	V1	V2	**Value**
Ability to improve students' problem solving skills	3	3	3
Total			21
Validation Score			87.50%
Validation Criteria			**Very valid**
Construct			
Ease of use	4	4	4
Clarity of instructions	2	4	3
Conformity with language rules	3	3	3
Sentences are easy for students to understand	4	3	3,5
Effectiveness of Physible E-Worksheet in learning	4	3	3,5
Total			17
Validation Score			**85.00%**
Validation Criteria			**Valid**

The validity test was carried out based on 2 categories of aspects, namely content and construct. The content aspect includes the validity of the material/content in accordance with the objectives of the Physible E worksheet development. Validation of the content aspect resulted in a score of 87.50% which is classified as very valid. The highest score in the content category is in the aspect of the connection of the material in supporting Education Sustainable Development (ESD) learning. This is in line with the form of Physible E-Worksheet activities that connect with the main aspects of SDGS, namely the environment, social economy. This confirms that the Physible E-Worksheet has been able to accommodate sustainability values as recommended by UNESCO (2017) which emphasizes that ESD learning media should encourage students to think systemically and connect science knowledge with global issues.

Then in the construct category, a validity percentage of 85.00% was obtained in the valid category. The highest score obtained in this category is in the aspect of ease of use. E-Worksheet can be used in real time through the same platform without requiring downloading files or other software. Students' work will be recorded automatically and can be accessed by teachers on the same platform, making it easier for teachers to conduct assessments. In line with this, digital learning tools have accessibility anywhere and anytime, which makes it easier for users, both teachers and students (Afifah & Desstya, 2024).

However, the clarity aspect of the instructions still received a score of 2 from the first validator. The

validator stated that the instructions provided were still not specific, especially on the technical use of the edform platform, which can be seen in Figure 4. The importance of explicit and tiered instructions in digital learning media is used so as not to confuse learners, especially when using new technology (Haspen et al., 2021; Sudirman et al., 2024).

The next action, it is necessary to make minor revisions to the instructions for use section as shown in Figure 5. The revised instructions for use have included coherent steps for working on the Physible E-Worksheet through the edform website and its features. Starting from how to continue the slide to the next page, using the video feature, links, filling in questions to how to submit the work done. This revision not only clarifies the flow of work, but also supports the user-friendly principle which is very important in digital technology-based learning (Widiawati et al., 2022; Wulandari et al., 2021).

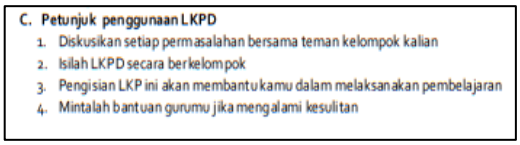
C. Petunjuk penggunaan LKPD
1. Diskusikan setiap permasalahan bersama teman kelompok kalian
2. Isilah LKPD secara berkelompok
3. Pengisian LKP ini akan membantu kamu dalam melaksanakan pembelajaran
4. Mintalah bantuan gurumu jika mengalami kesulitan

Figure 4. Before revision

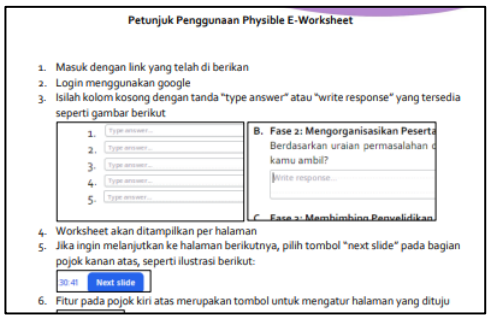

Figure 5. After Revision

The Physible E-Worksheet product developed was only carried out once validation test, because the validation results stated that the Physible E-Worksheet was valid and could be used in the next stage with minor improvements. After making improvements according to the expert validator's suggestions, the Physible E-Worksheet product entered the next stage, namely the student readability test. The readability test was conducted on 28 high school students. The readability test aims to help researchers determine the parts that still need to be revised so as to obtain clarity of information from the point of view of students as potential users (Sarip et al., 2022). Of the 19 aspects measured, the resulting readability test assessment is shown in Table 4.

Table 4. Readability test result data

No.	Aspects	Percentage
1	Material content is easy to understand	86.43 %
2	Material content adds new knowledge	92.14 %
3	Media can help visualize the issue of global warming well	89.29 %
4	Raise awareness of global warming	92.14 %
5	Help my thinking skills in solving problems	87.86 %
6	Assist continuous learning	89.29 %
7	Support SDGS values in the principle of (reduce) paper use	89.29 %
8	Use of informative language	85.71 %
9	Use of language that is easy to understand	87.86 %
10	Appropriateness of images and videos in supporting material understanding	91.43 %
11	Appropriateness of font selection	87.14 %
12	Can improve the effectiveness of learning	89.29 %
13	Attractive display of the E-Worksheet	90.71 %
14	Clarity of the images presented	88.57 %
15	Easy access anywhere and anytime	90.71 %
16	Easy access through various devices	88.57 %
17	Can be used practically	91.43 %
18	Does not require expensive costs	86.43 %
Response percentage		**88.98%**
Category		**Very good**

Based on the results of the student readability test, the overall assessment was 88.98% which was classified as very good. These results show that the Physible E-Worksheet language is very good in meeting the aspects of design, language, material. It can be concluded that Physible E-Worksheet can be implemented as a good teaching media, can add new knowledge to students, provide awareness of global warming issues, and support sustainable learning.

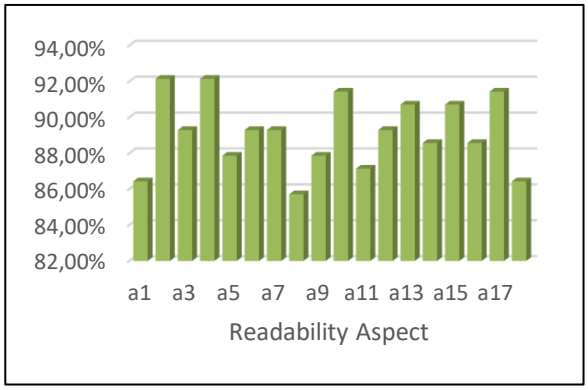

Figure 5. Readability results

The highest assessment of readability test results lies in the content/material aspect of the Physible E-Worksheet that can provide new knowledge and increase awareness of the issue of global warming and climate change by 92.14%. This is because the Physible E-Worksheet displays the concept of albedo which is rarely conveyed in school learning. In addition, Physible E-Worksheet also provides a visualization display through climate maps. This feature provides more information and data about global warming. In the practicality aspect, the use of Physible E-Worksheet received a score of 91.43% which is classified as a high score compared to other aspects. This is in accordance with the purpose of using Physible E-Worksheet which is electronically based and can be accessed and done directly anywhere and anytime.

In the language aspect, Physible E-Worksheet gets an average rating of 86.79% which is classified as good. The assessment shows that the Physible E-Worksheet has language that is easy to understand and quite informative. In addition, in the aspect of display design, the Physible E-Worksheet obtained a readability score of 90.71% which is classified as very good. This shows that the Physible E-Worksheet has an attractive design that fits the theme of global warming. In addition, there are pictures and videos that can provide visualization and explanation of the material discussed, as evidenced by the readability assessment on the aspect of presenting pictures and videos obtaining a percentage of 91.43%. Furthermore, in the aspect of ease of understanding the material, the percentage value is 86.43%. This percentage is classified in the good category, but this aspect is classified as the aspect with the lowest assessment when compared to the assessment of other aspects. This is because the Physible E-Worksheet utilizes climate map media that has never been used before for learning. So that in a limited readability test, students still feel unfamiliar with the use of climate maps in the investigation process. So that this becomes one of the things that need to be considered in implementing Physible E-Worksheet with the delivery of simpler practices so that students can easily understand the system of using climate maps in learning.

CLONCUSION

The validity of the ESD-based Physible E-Worksheet (Physiscs Sustaiable E-Worksheet) teaching media on global warming and climate change material received an average score of 85.00% classified as valid with minor revisions. So that Physible E-Worksheet can be declared feasible to use as teaching media. Meanwhile, the readability test of Physible E-Worksheet received an overall average score of 88.98% which is classified as very good. From this assessment, it can be stated that the *Physible E-Worksheet* can be used in the learning process on climate change and global warming material. *Physible E-Worksheet* is known to add new knowledge, increase students' awareness of the problems of global warming and climate change, can help support sustainable education (Education Sustainable Development), and its use is considered practical because it can be done directly anywhere and anytime. The limitations in this research were only carried out until the development stage, because this research focused on the validity and readability of the product. The product still needs to be researched at the next stage, namely the Implement and Evaluate stages. So that from further research the *Physible E-Worksheet* product can be tested practically and effectively for use in learning.

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