PhET-assisted electronic student worksheets of physics (eSWoP) on heat for inquiry learning during covid

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Abstract. Now, this is referred to as the industrial era 4.0, which is present simultaneously as the era of disruption. Therefore, this study aims to produce Electronic Student Worksheets of Physics (eSWoP) with the help of Sway to use PhET Simulations on physics learning about temperature and heat. This research was conducted using ADDIE (Analyze, Design, Development, Implementation, and Evaluation) research methods. The sample for the application of eSWoP used in the study was 86 students aged 16-18 years from a province in Indonesia. The result of this study is a PhET-assisted eSWoP teaching material that can be used through various electronic devices, using PhET simulations that can help students understand physics subjects at temperature and heat. In the questionnaire given to students, information was obtained that eSWoP media is useful, easy to use and can increase students' learning motivation. It was suggested that eSWoP technology could be a powerful and effective tool to enable students from the physics lesson into the inquiry process. Moreover, the implications of using eSWoP for teaching physics and recommendations for further studies are also discussed in this study.

1. Introduction

In the era that has entered industry 4.0 today, everything cannot be separated from the influence of technology [1]. Industrial era 4.0 coincided with the age of disruption [2]. This technology exists because of the emergence of many innovations and scientific developments [3]. The advancement of this technology provides many conveniences and benefits for human life, especially in education. One of the benefits of this technological development in education is the emergence of learning media and teaching materials, making it easier for students and teachers in the learning process [4]. By using the existing ones, it is hoped that students can better understand and assist in following the learning process to improve the quality of education.

Physics is one of the branches of natural sciences, which studies various natural phenomena in everyday life [5]. To investigate this nature, students will face natural wonders, laws, and formulations for solving problems faced. Physics does not only rely on books, but experiments need to be carried out to support the theories, laws, and concepts of physics contained in books [6]. The results of observations
made at 1st Public Islamic High School (MAN) Kerinci are known that 87% of students have difficulty studying physics. Students reasoned that physics is a subject that is difficult to reach and difficult. Other results show that 68% of students find it difficult to learn physics on temperature and heat materials so that more innovative teaching materials are needed [7]. Based on data from observations and interviews with students and physics teachers at 12th Public High School of Banda Aceh, information was obtained that the average value of students' daily tests, especially on the topic of temperature and heat, was still below the Minimum Completion Criteria (KKM). This is shown from the KKM set by the school, which is 75 only 70% of students who pass the KKM [8].

By taking advantage of technological developments to carry out experiments besides being carried out directly in the laboratory, these experiments can be conducted virtually. This virtual experiment uses a virtual laboratory. A virtual laboratory provides laboratory tools and materials through computer programs so that students can do experiments or practicum [9]. Virtual laboratories have several advantages, such as this laboratory can be used anytime and anywhere, does not require equipment and chemicals, and this virtual laboratory can see even small and abstract things [10]. One example of a virtual laboratory is Physic Education and Technology Simulation (PhET).

The research results conducted by a Rwandan secondary school stated that using PhET simulation in learning could improve students' understanding of studying physics [11]. PhET simulation in education can make learning more effective because, with PhET simulation, teachers can use PhET as a demonstration material, and students can play while learning by using PhET simulation [12]. In addition to research conducted at At-Taqwa Islamic Secondary School at Maumere, PhET simulation can improve students' understanding of physics concepts. This study showed that there were differences in the learning outcomes of students who were taught using PhET simulation media and those who were not taught using PhET simulation media. The result is learning using PhET simulation is better than control class learning [9]. Thus, it can be concluded that using PhET simulation media in learning can improve students' understanding of physics concepts.

In conducting practicals both virtual and directly in the laboratory, students need a Student Worksheet. Student Worksheet is one of the teaching materials that can help students to be able to develop thinking skills and encourage them to do a practicum to concrete the concept [13]. Based on the observations made at 95th Public High School of Jakarta, the Student Worksheet used did not increase the motivation of students to do a practicum. It is also supported by another research conducted at 8th Public High School of Bengkulu City in which 61.36% of students agree that the use of The Student Worksheet provided by the teacher still did not help students to understand the material in terms of students' concepts and process skills [14]. The implementation of practical activities requires Student Worksheet, which can make students design their investigations independently so that participants can understand and find concepts [15]. So, in this case, it is necessary to develop a Student Worksheet in accordance with the responses of students at 7th Public High School of Jambi City as much as 90% of students agree that the development of an electronic Student Worksheet of Physics (eSWoP) will be made [16]. One alternative to making eSWoP can be made using Microsoft Sway software.

Microsoft Sway is one of the online media that is practical and easy to use. Sway can be accessed from various devices such as smartphones, tablets, laptops, or computers when connected to the internet; thus, the use of Sway can be done without being limited by space and time [17]. Sway can also create and display interesting content [18]. Because of these advantages, Sway can be used to develop an e-Student Worksheet. Another advantage obtained is that an eSWoP with Sway will make it easier for students to learn in this era of disruption or online learning.

Regarding the explanation, it is necessary to develop teaching materials in the form of eSWoP assisted by Microsoft Sway to use PhET in physics learning about temperature and heat material. It is expected that this media can positively impact students and help students understand the learning material. Therefore, the author aims to develop an eSWoP assisted by Microsoft Sway for the use of PhET in physics learning on temperature and heat materials. The eSWoP is intended for students who are in the upper secondary education level. In addition, this eSWoP will be used as teaching materials that can be applied in the learning process by teachers.
2. Method
This research was conducted using the Analyze, Design, Development, Implementation, and Evaluation (ADDIE) research method. The ADDIE model was developed by Dick and Caray to design a learning system. The ADDIE development model consists of five stages of development, namely Analysis, Design, Development, Implementation, and Evaluation. Schematic of the steps in the ADDIE development model as shown in Figure 1 [19]. The sample for the application of eSWoP used in the study was 86 students aged 16-18 years from a province in Indonesia. In the questionnaire given to students, information was obtained that eSWoP media is functional, easy to use and can increase students' learning motivation.

![Figure 1. ADDIE Development Model Scheme](image)

3. Result
The Student Worksheet resulting from this development is called Electronic Student Worksheet of Physics (eSWoP). This eSWoP discusses temperature and heat material for the use of PhET simulations made with the help of Microsoft Sway to make this teaching material more contemporary and make it easier for students to learn physics. This eSWoP will be published to students by sharing this eSWoP link to be accessed from all types of devices connected to the internet network. The display of this eSWoP is responsive, meaning that the resulting eSWoP display will adjust to the user's screen. This eSWoP can make it easier for students to do practicum because this eSWoP contains the title of the experiment, the purpose of the experiment, the theoretical basis, tools and materials, experimental procedures, tables of observational data, questions, and conclusions so that students can work independently. In addition, this Student Worksheet is equipped with a PhET simulation so that students no longer need to access the PhET simulation at a different website address. In addition, it is also equipped with an observation table that can be filled in directly by students via Microsoft Form. This will make it easier for students to work on eSWoP on Heat. After accessing the shared link, students will see the eSWoP on Heat display in Figure 2.

![Figure 2. eSWoP on Heat Cover Display](image)
After that, students will find instructions using eSWoP on Heat, shown in Figure 3.

Figure 3. Display of eSWoP on Heat Instructions for Use

After students understand the instructions for using eSWoP, then students will see the Basic Competence display, shown in Figure 4.

Figure 4. Basic Competency Display

Because this eSWoP has been integrated with the PhET simulation, students don't need to access the PhET simulation at a different tab browser or website address, as shown in Figure 5.

Figure 5. PhET Simulation Display on eSWoP on Heat
eSWoP on Heat Questionary to Students

The results showed that eSWoP on Heat contributed to students' concepts in physics subjects, with 86 students as respondents. In the questionnaire given to students, information was obtained that this eSWoP on Heat was useful and interesting for their learning. This is in line with the research results conducted in 2017, which showed that the application of LKPD can increase student motivation and learning outcomes at State Senior High School 4 Singaraja [20]. It has been suggested that eSWoP on Heat can be a powerful and effective teaching material for students studying physics subjects. The full results are shown in Figure 6.

Based on Figure 6, it can be seen that eSWoP on Heat is implemented according to the needs of students in grade 2.80 with good categories on a scale of 1-3. While eSWoP media is easy to use and can increase learning motivation by 2.85 with a good category on a scale of 1-3, and the application of eSWoP on Heat to support investigations is 2.80 with a good category on a scale of 1-3. The eSWoP on Heat material that was delivered was facilitated for learning during the COVID-19 (Corona Virus) pandemic of 2.82 with a good category on a scale of 1-3. Students feel the benefits of implementing eSWoP media are 2.84, with good categories on a scale of 1-3. Research in 2021 also results that electronic student worksheets can be used for distance learning which is helpful for the current COVID pandemic conditions [21].

4. Conclusion

eSWoP on Heat learning media with the help of Microsoft Sway for the use of PhET Simulation in physics learning about temperature and heat using the ADDIE research method. This eSWoP on Heat can be used by sharing a link to be accessed from all devices, mobile phones, laptops, and tablets connected to the internet network. This research still needs further research related to the validation of eSWoP on Heat assisted by Microsoft Sway for the use of PhET simulation in physics learning about temperature and heat until finally, the media is suitable for use by teachers in the learning process. Researchers' suggestions are to be followed up in further research, namely the need to develop eSWoP on other physics materials so that eSWoP can support physics learning as a whole at the senior high school level.

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