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VALIDITY AND PRACTICALITY OF A GUIDED INQUIRY-BASED E-SWS USING LIVEWORKSHEETS TO FACILITATE GRADE XI STUDENTS' SCIENCE PROCESS SKILLS IN TEMPERATURE AND HEAT

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ABSTRACT

21st-century learning requires students to develop science process skills through student-centered learning. However, the results of observations showed that physics learning is still teacher-centered, dominated by conventional teaching methods, and students continue to experience difficulties in understanding temperature and heat. This study aims to develop a guided inquiry-based Electronic Student Worksheet (E-SWS) to facilitate the science process skills of Grade XI students on the topic of temperature and heat. This research employed a Research and Development *(R&D) approach using the 4-D development model, consisting of the* define, design, development, *and* disseminate *stages. The study involved 30 Grade XI students, one physics teacher from SMAN 1 Sungai Geringging, and three physics lecturers from the Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang (FMIPA UNP). The analysis of the validation instrument results showed that the developed Electronic Student Worksheet obtained a validation score of 0.95, which was categorized as "very valid." The practicality test results showed scores of 0.94 from the teacher and 0.85 from the students, both of which were categorized as "very practical." Based on these results, the developed guided inquiry-based Electronic Student Worksheet was considered valid and practical for use in physics learning. The Electronic Student Worksheet integrates guided inquiry-based learning with interactive activities through Liveworksheets and science process skill indicators, enabling students not only to understand the concepts of temperature and heat but also to actively engage in observing, measuring, classifying, communicating, predicting, and drawing conclusions from the investigation process.*

Keywords : E-SWS, guided inquiry, science process skills, temperature and heat.

I. INTRODUCTION

Physics learning is a learning process that not only emphasizes conceptual understanding but also actively engages students in acquiring knowledge through scientific activities. Science Process Skills are an important aspect of physics learning because they involve students in activities such as observing phenomena, processing information, conducting measurements, making predictions, communicating findings, and drawing conclusions. Science Process Skills in physics learning can be effectively assessed when teachers implement learning activities that are designed to be engaging and innovative[1]. Based on interviews conducted with physics teachers at SMAN 1 Sungai Geringging, teachers tend to emphasize teacher-centered learning. Teachers tend to focus on mathematical equations in solving physics problems and do not adequately train students in Science Process Skills [2]. A similar finding was reported by[3], who stated that classroom learning is still dominated by teachers, resulting in students having limited opportunities to develop their perceptions, interests, and attitudes in a positive manner. Students tend to memorize formulas and terms without understanding their uses and applications in everyday life, causing physics to be perceived primarily as a subject dominated by formulas. In line with this, a study by [4] identified Science Process Skills as one of the indicators of achieving physics learning objectives and demonstrated that learning involving investigative activities can contribute to the development of students' Science Process Skills.

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The development of science process skills requires learning that provides students with opportunities to engage directly in investigative activities while receiving appropriate guidance throughout the learning process. The guided inquiry model is one approach that can create such conditions because students are actively involved in the investigation process, while teachers provide guidance to ensure that the activities are carried out in a structured manner. In this model, teachers play an active role in guiding students to find answers to the problems presented. The advantages of the guided inquiry learning model include increasing students' motivation and enthusiasm for learning so that they become more actively engaged in the learning process, providing opportunities for students to develop their abilities according to their respective potential and interests, and helping students develop readiness and mastery of skills in cognitive processes [5]. Thus, students can arrive at conclusions more quickly and develop a deeper understanding of the learning material [6].

To ensure that guided inquiry-based learning can be implemented optimally, engaging teaching materials that are aligned with current technological developments are needed. Teaching materials used in learning should be designed in such a way that they can improve students' critical thinking skills. Students need teaching materials that are relevant to their needs and the development of the times. Teachers' ability to design and develop effective teaching materials is an important factor in optimizing the learning process [7]. Various types of teaching materials are used in the learning process, including printed materials such as books, modules, and Student Worksheets, as well as non-printed materials such as films, PowerPoint presentations, and Electronic Student Worksheets [8]. Electronic Student Worksheets offer several advantages over printed Student Worksheets. They are easy and practical to use. In addition, teachers can incorporate audio, video, links, and various types of questions, such as short-answer and multiple-choice questions, as well as other forms of assessment.

One of the platforms that provides services for creating Electronic Student Worksheets is Liveworksheets. Liveworksheets is a website that allows worksheets to be transformed into interactive worksheets that can be accessed online [9]. Liveworksheets is easy for students to use. Students can directly complete the worksheets without having to download or register beforehand to access the Electronic Student Worksheet uploaded to Liveworksheets. The platform also provides various types of questions and activities, including multiple-choice questions, matching, line drawing, drag-and-drop, and essay questions, which can be adapted to learning needs [10]. Liveworksheets also provides an automatic feedback feature that allows students to determine whether their answers or data interpretations are correct, thereby encouraging metacognitive processes. Liveworksheets supports the integration of videos and illustrative images that can be used as stimuli for scientific phenomena during the inquiry orientation stage. The platform can be accessed through a web browser without requiring the installation of additional applications, making it practical for use in schools with limited access to devices.

Research on the development of teaching materials and the implementation of learning models to facilitate science process skills in the topics of temperature and heat has been conducted using various approaches. A study by [11] developed a Student Worksheet on temperature and heat oriented toward science process skills and obtained validity and practicality results indicating that the product could be used in learning. A study by [12] also developed temperature and heat learning materials oriented toward science process skills using a guided inquiry discovery learning model and obtained a product that was valid and practical. Another study conducted by [13] developed learning materials using a guided inquiry model on temperature and heat for Grade 11 students and evaluated the product in terms of validity, practicality, and effectiveness. However, these studies have not specifically integrated a guided inquiry-based Electronic Student Worksheet with the Liveworksheets platform to facilitate the six science process skill indicators that are the focus of this study, namely observing, classifying, measuring, predicting, communicating, and concluding, in the context of Grade 11 physics learning on temperature and heat.

The use of digital technology in the development of worksheets provides opportunities to present more interactive learning activities. A study by [14] developed electronic student worksheets based on guided inquiry using Liveworksheets on the topics of temperature and heat, but the primary skill targeted in the study was critical thinking skills. Therefore, the present study has a distinct focus by utilizing Liveworksheets as a platform for a guided inquiry-based Electronic Student Worksheet specifically oriented toward science process skills. The novelty of this study lies in mapping the activities in the Electronic Student Worksheet to six science process skill indicators, namely observing, classifying, measuring, predicting, communicating, and concluding, within the context of Grade 11 physics learning on temperature and heat, as well as evaluating the product in terms of validity and practicality.

II. METHOD

This study employed a Research and Development (R&D) design aimed at developing a Guided Inquiry-Based Electronic Student Worksheet using Liveworksheets to facilitate students' science process skills in Grade 11 on the topic of temperature and heat, meeting the criteria of validity and practicality. The development model used was the 4D model, which consists of four stages: define, design, develop, and disseminate. This study was limited to the develop stage because the research focused on product development and the initial testing of the validity and practicality of the Electronic Student Worksheet. The disseminate stage was not conducted because the study was not intended to implement the product across a broader range of schools and students. Therefore, the omission of the disseminate stage constitutes one of the limitations of the study. Consequently, the findings only provide an initial description of the validity and practicality of the Electronic Student Worksheet within the research context and cannot yet be used to determine its effectiveness or generalizability to a broader population.

At the define stage, front-end analysis, learner analysis, task analysis, concept analysis, and learning objective analysis were conducted. Front-end analysis was conducted to identify problems in physics learning and the teaching materials used. Learner analysis was conducted to determine the characteristics of Grade 11 students as users of the Electronic Student Worksheet. Task analysis was conducted to identify the competencies and learning activities that students were expected to master. Concept analysis was conducted to determine the concepts related to temperature and heat that would be presented in the Electronic Student Worksheet. Furthermore, learning objective analysis was conducted to determine the learning objectives that served as the basis for developing the materials, activities, and exercises in the Electronic Student Worksheet.

The design stage was conducted by designing the Electronic Student Worksheet based on the results of the define stage. The Electronic Student Worksheet was designed by integrating the guided inquiry learning model and six indicators of science process skills, namely observing, classifying, measuring, predicting, communicating, and concluding. The learning activities in the Electronic Student Worksheet were arranged based on the stages of guided inquiry, which included observing phenomena and identifying problems, formulating questions, developing hypotheses and planning investigations, conducting investigations and collecting data, analyzing data and drawing conclusions, and communicating the results of the investigation. The designed product was then implemented in the form of an Electronic Student Worksheet using the Liveworksheets platform.

The develop stage aimed to produce an Electronic Student Worksheet that had undergone validation and practicality testing. Validation was conducted to determine the feasibility of the Electronic Student Worksheet based on the validators' assessments of the aspects of material substance, visual communication, instructional design, software utilization, guided inquiry learning model, and science process skills. After the validation process, the Electronic Student Worksheet was revised based on the comments and suggestions provided by the validators. Subsequently, practicality testing was conducted to determine the practicality of the Electronic Student Worksheet based on assessments from teachers and students as product users. The teacher practicality test covered the aspects of ease of use, attractiveness, time efficiency, usefulness, guided inquiry learning model, and science process skills, whereas the student practicality test covered the aspects of ease of use, attractiveness, time efficiency, and usefulness.

The research participants in the validation stage consisted of three validators, namely two physics experts from the Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, and one physics teacher from SMAN 1 Sungai Geringging. The validators were selected purposively by considering the relevance of their competencies and expertise to the developed product. The selection criteria included having an educational background and competencies relevant to physics or physics education, as well as experience in teaching or developing instructional materials. The practicality test was conducted with one physics teacher and 30 Grade 11 students from class XI F1 of SMAN 1 Sungai Geringging. Class XI F1 was selected purposively by considering the characteristics of the students relevant to the objectives of the study. The class was selected because the students had already studied the topic of temperature and heat and therefore possessed the prerequisite knowledge required to use and assess the developed Electronic Student Worksheet. In addition, class XI F1 was an academically advanced class at the school. All 30 students in class XI F1 participated in the practicality test. Thus, the results of the practicality test were used to describe the practicality of the Electronic Student Worksheet within the context of the participating students and were not intended to be generalized to all Grade 11 students.

The research instruments consisted of an Electronic Student Worksheet validation sheet, a teacher practicality questionnaire, and a student practicality questionnaire. The Electronic Student Worksheet validation sheet consisted of 47 statements grouped into six aspects, namely material substance, visual communication, instructional design, software utilization, guided inquiry learning model, and science process skills. The material substance aspect covered the consistency of scientific concepts and principles, the relevance of temperature and heat materials to everyday facts, conceptual accuracy, alignment with learning outcomes, the depth and breadth of the material, relevance to real-world problems, systematic presentation, the connection between the material and everyday life, and language use. The visual communication aspect covered navigation, consistency of colors and themes, visual comfort, the appropriateness of images and videos, font readability, design proportions, and the layout of the Electronic Student Worksheet. The instructional design aspect covered the title, learning outcomes, learning objectives, learning achievement indicators, learning materials, learning instructions, learning steps, student activities, exercises, and references. The software utilization aspect covered the use of features and the ease of using the Liveworksheets-based Electronic Student Worksheet. The guided inquiry learning model aspect assessed the ability of the Electronic Student Worksheet to guide students in observing and identifying problems, formulating questions, developing hypotheses and planning investigations, conducting investigations and collecting data, analyzing data and drawing conclusions, and communicating the results of investigations. The science process skills aspect consisted of six indicators, namely observing, classifying, measuring, predicting, communicating, and concluding.

The teacher practicality questionnaire consisted of 42 statements grouped into six aspects, namely ease of use consisting of 10 items, attractiveness consisting of 7 items, time efficiency consisting of 6 items, usefulness consisting of 6 items, guided inquiry learning model consisting of 7 items, and science process skills consisting of 6 items. The ease-of-use aspect covered the clarity of instructions, organization of the Electronic Student Worksheet, language use, explanations of the material, readability, activity steps, independent use, use at school and at home, reuse, and navigation. The attractiveness aspect covered the appearance, design, colors, visual elements, problems presented, interest in the temperature and heat material, and interactive features. The time-efficiency aspect assessed the efficiency of time use during learning activities, while the usefulness aspect assessed the benefits of the Electronic Student Worksheet in supporting the learning process. The guided inquiry learning model aspect assessed the ability of the Electronic Student Worksheet to assist teachers in guiding students through the inquiry process, while the science process skills aspect assessed the extent to which the six science process skill indicators were facilitated through the use of the Electronic Student Worksheet.

The student practicality questionnaire consisted of 29 statements covering four aspects, namely ease of use consisting of 10 items, attractiveness consisting of 7 items, time efficiency consisting of 6 items, and usefulness consisting of 6 items. The ease-of-use aspect assessed the ease of understanding the instructions, materials, language, text, activity steps, independent use, use at school and at home, reuse as a learning resource, and navigation. The attractiveness aspect assessed the appearance, design, colors, visual elements, problems presented, interest in the temperature and heat material, and interactive features. The time-efficiency aspect assessed the time used to study and complete the activities, while the usefulness aspect assessed the contribution of the Electronic Student Worksheet to students' understanding of the material, motivation, enjoyment of learning, and connection between the material and everyday life.

The three instruments used a four-point response scale, namely a score of 1 for strongly disagree, a score of 2 for disagree, a score of 3 for agree, and a score of 4 for strongly agree. In addition to providing scores for each statement, the validators and teacher were also given the opportunity to provide comments and suggestions, which were used as a basis for improving the Electronic Student Worksheet. The assessment procedure was carried out by assigning a score to each item according to the level of agreement with the statement provided. The assessment results were then used to determine the level of validity and practicality of the Electronic Student Worksheet.

The validity and practicality data were analyzed using a categorical assessment modified from Boslaugh and Watters [15]. The assessments provided by validators and practitioners for each statement were subsequently analyzed using Cohen's Kappa formula. The data processing resulted in a Kappa coefficient representing the level of validity and practicality of the developed Electronic Student Worksheet (E-SWS). The Kappa coefficient was calculated using the formula presented in Equation 1.

$$moment\ kappa\ (k) = \frac{P_0 - P_e}{1 - P_e} \tag{1}$$

Explanation:

K : Moment Kappa coefficient indicating the validity of the product.

P0 : The observed proportion, calculated by dividing the total score given by the validator by the maximum possible score.

Pe : The expected proportion, calculated by subtracting the total score given by the validator from the maximum possible score and then dividing the result by the maximum possible score.

The results of the analysis using the Moment Kappa formula were then categorized based on the criteria ranges presented in Table 1 and 2.

Tabel 1. Moment Kappa (k) Categories

Interval	Category
0,81-1,00	Highly Valid
0,61-0,80	Valid
0,41-0,60	Fairly Valid
0,21-0,40	Less Valid
0,01-0,20	Highly Invalid
0,00	Invalid

(Souce: Ref [15])

Tabel 2. Summary of Research Methodology

Component	Description
Participants	3 validators (2 physics experts and 1 physics teacher), 1 physics teacher for the practicality test, and 30 Grade 11 students of class XI F1
Instruments	Electronic Student Worksheet validation sheet (47 items), teacher practicality questionnaire (42 items), and student practicality questionnaire (29 items)
Indicators	Validation: material substance, visual communication, instructional design, software utilization, guided inquiry learning model, and science process skills; Teacher practicality: ease of use, attractiveness, time efficiency, usefulness, guided inquiry learning model, and science process skills; Student practicality: ease of use, attractiveness, time efficiency, and usefulness
Assessment	Four-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree
Data analysis	Moment Kappa (κ)

III. RESULTS AND DISCUSSION

1. Research Results

a. Results of the Define Stage

The define stage was conducted to identify the needs and problems in physics learning as the basis for developing a guided inquiry-based E-SWS. The results of the front-end analysis showed that the teaching materials used at SMAN 1 Sungai Geringging were still limited to the textbook by Ni Ketut Lasmi. Based on document analysis, the textbook contains learning objectives, learning materials, and practice questions; however, it does not include a learning objective flow, the number of practice questions is limited, and it does not provide activities that optimally engage students in discovering and constructing physics concepts. The teaching materials used also do not systematically facilitate the stages of guided inquiry and science process skills. The results of the teacher interview showed that the school has implemented the Merdeka Curriculum; however, temperature and heat are still considered difficult topics for students, particularly in distinguishing between the concepts of temperature and heat. The school has adequate facilities and infrastructure, including three computer rooms and internet access. However, the school has not previously used E-SWS, and the teacher needs electronic teaching materials that are easy to use and more interactive. In addition, the learning process has not yet implemented an interactive learning model, such as guided inquiry.

Student analysis was conducted through observations of science process skills and the distribution of a student needs questionnaire. The observation results showed that students' science process skills were 58.06% for observing, 41.1% for classifying, 46.77% for predicting, 45.2% for measuring, 46% for concluding, and 51.6% for communicating. These results indicate that students' science process skills still need to be facilitated through appropriate teaching materials. The results of the student needs questionnaire showed that 99% of students found it easier to remember learning materials through images, animations, or videos; 98% of students were more enthusiastic about learning using digital media; 96% of students found it easier to understand lessons when presented with attractive visual displays; 98% of students found it easier to master physics after conducting hands-on practices or experiments; and 95% of students found it easier to understand and analyze physics through real-life experiences. These results indicate that the developed E-SWS needs to be presented in an interactive and attractive manner and include investigative activities that provide students with direct learning experiences.

Task analysis was conducted based on the Learning Outcomes (CP), Learning Objectives (TP), and Learning Objective Flow (ATP) by integrating seven stages of guided inquiry: identifying problems and making observations, asking questions, planning investigations, collecting data and conducting investigations, analyzing data, drawing conclusions, and communicating the results. The material analysis covered temperature and temperature scales, heat and changes of state, thermal expansion, and heat transfer. Meanwhile, the learning objectives were directed toward enabling students to analyze the concepts of temperature and heat through scientific investigation activities by applying science process skills, communicating the results of investigations, and applying the concepts to everyday life.

b. Results of the Design Stage

The design stage was conducted to develop a guided inquiry-based E-SWS using Liveworksheets on the topic of temperature and heat. The design process began with the preparation of assessment instruments based on the indicators of learning objective achievement (IKTP) and science process skills indicators. The instrument developed was an observation sheet for assessing students' science process skills through simple experimental activities. Liveworksheets was selected as the main platform because it provides various interactive features that allow students to complete the E-SWS online, such as multiple-choice questions, fill-in-the-blank questions, matching activities, as well as the integration of images, videos, and learning links. Canva was used as a supporting tool to design the E-SWS layout to make it more attractive, systematic, and easy to understand. The E-SWS was designed in a digital format consisting of introductory, main content, and closing sections. The introductory section includes student identity, instructions for use, and competencies; the main content section contains learning materials, contextual problems, images, videos, and activities based on the guided inquiry syntax; while the closing section contains evaluation, reflection, and references. The initial design of the E-SWS consisted of a cover, main menu, developer identity, preface, product description, instructions for use, learning instructions, competencies, supporting information, work procedures, evaluation, and references. The instructions for use also included symbols representing the science process skills indicators to indicate the skills developed in each learning activity.

c. Results of the Develop Stage

The develop stage resulted in product validation and practicality testing conducted by teachers and students.

1) Product Validation Results

The product validity analysis obtained an average Moment Kappa coefficient of 0.95. The assessed components included content substance, visual communication, instructional design, software utilization, guided inquiry model, and science process skills. The content substance aspect obtained a score of 0.90, visual communication obtained 0.95, instructional design obtained 0.97, software utilization obtained 0.95, the guided inquiry model obtained 0.97, and science process skills obtained 0.94. These scores ranged from 0.90 to 0.97 and were categorized as very high or very valid.

Results of the Content Substance Validation

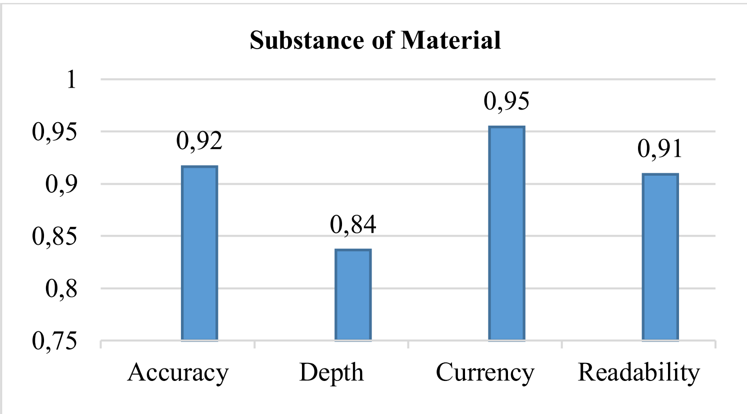

Figure 1. Content Substance Validity Results

Based on Figure 1, the content substance validation results show that all indicators obtained very high scores, ranging from 0.84 to 0.95. This indicates that the content substance of the developed product meets the criteria for very high validity.

Results of Visual Communication Validation

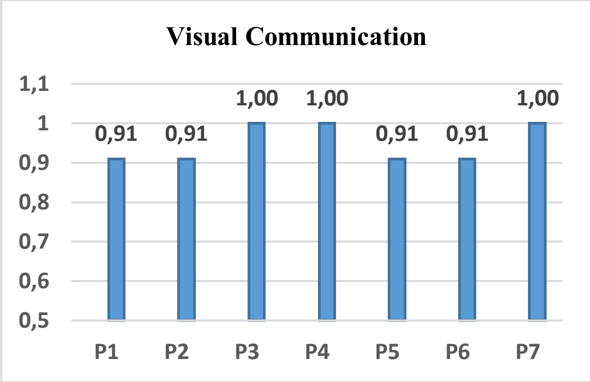

Figure 2. Plot Results of Visual Communication Validity

The validation results showed that the visual communication aspect obtained very high scores, ranging from 0.91 to 1.00. Overall, all indicators were categorized as very valid.

Results of Instructional Learning Design Validation

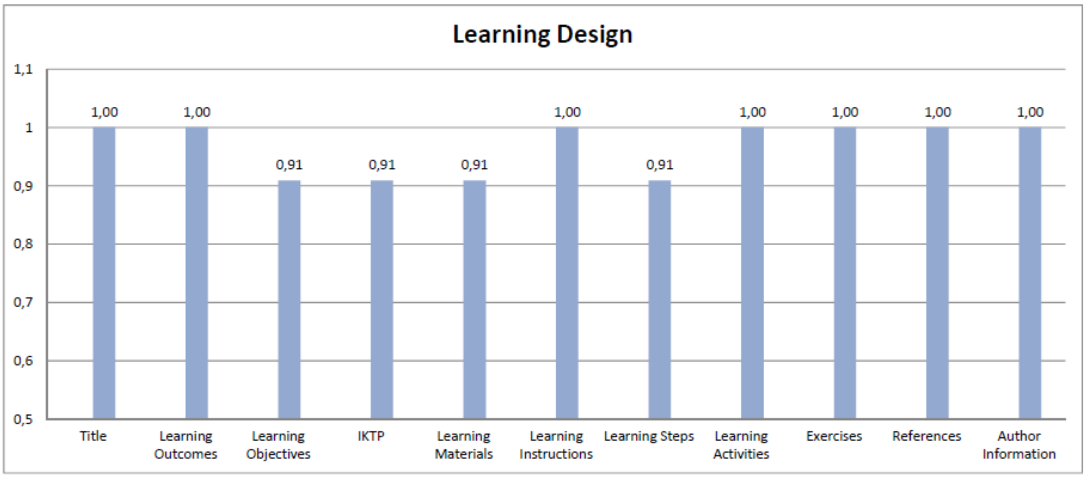

Figure 3. Plot Results of Instructional Design Validation

The validation results showed that all components of the instructional design obtained very high scores, ranging from 0.91 to 1.00. These results indicate that the developed instructional design meets the criteria for very high validity.

Results of Software Utilization Validation

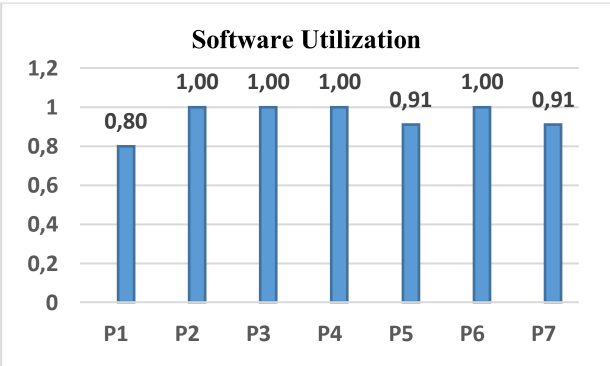

Figure 4. Plot of Software Utilization Validation

The validation results showed that all indicators obtained very high scores, ranging from 0.80 to 1.00. These results indicate that the software used in the development of the E-SWS was utilized optimally, effectively supporting the presentation of learning materials and user interaction.

Results of Guided Inquiry Model Validation

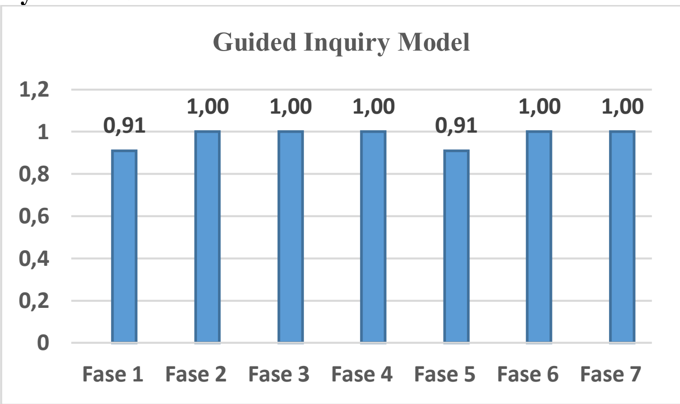

Figure 5. Plot Results of Guided Inquiry Model Validation

The validation results showed that all phases of the guided inquiry model obtained scores ranging from 0.80 to 1.00, which were categorized as high to very high. Fase (Phases) 2, 3, 4, 6, and 7 obtained the highest score of 1.00.

Results of Science Process Skills Validation

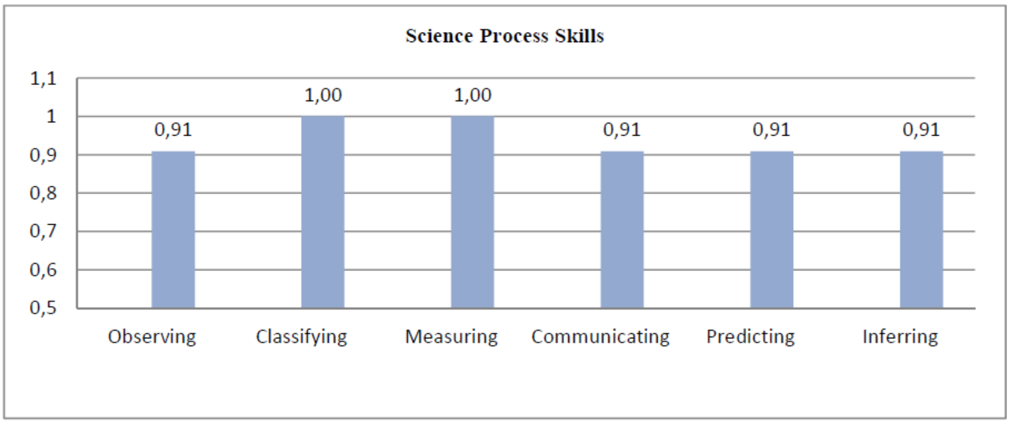

Figure 6. Plot Results of Science Process Skills Validation

Based on Figure 6, the validation results showed that the science process skills indicators obtained scores ranging from 0.91 to 1.00, indicating that all indicators were categorized as very high. During the validation process, the validators provided constructive comments regarding both the strengths and weaknesses of the guided inquiry-based E-SWS. The validators also provided suggestions that served as a basis for revising the product. The E-SWS was subsequently revised based on the suggestions provided by the validators. After the revision process was completed, a practicality test was conducted to determine the practicality of the guided inquiry-based E-SWS.

2) Product Practicality Results

Product Practicality Analysis Results

After the validation and revision processes were completed, resulting in a valid E-SWS product, the practicality test was conducted as the next stage of the study. The practicality test consisted of two stages, namely a practicality assessment by the teacher and a practicality assessment by the students. The results of the practicality analysis based on the teacher response questionnaire obtained a Moment Kappa coefficient of 0.94, which was categorized as very high. The practicality of the product was assessed based on six aspects: ease of use, attractiveness, time efficiency, benefits, guided inquiry model, and science process skills. The respective scores for each aspect were 0.90, 0.95, 0.89, 1.00, 1.00, and 0.94. A summary of the teacher practicality analysis results is presented in Figure 7.

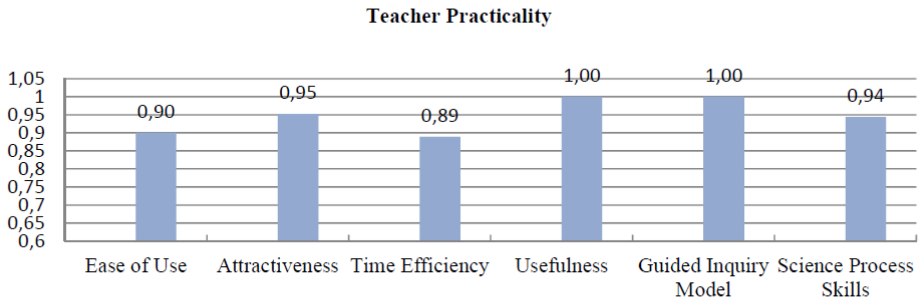

Figure 7. E-SWS Practicality Scores Based on Teacher Assessment

In addition to the practicality assessment conducted by the teacher, students were also involved in determining the practicality of the product. The analysis of practicality data obtained from 30 Grade XI F1 students at SMAN 1 Sungai Geringging resulted in an average Moment Kappa coefficient of 0.85, which was categorized as very high and very practical. The results of the student practicality analysis are presented in Figure 8.

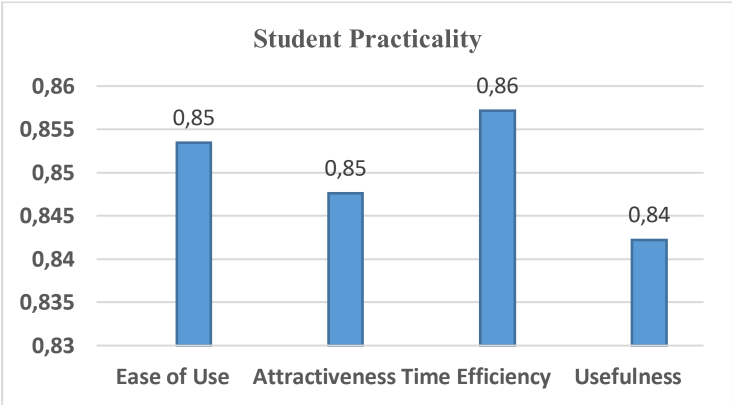

Figure 8. E-SWS Practicality Scores Based on Student Assessment

2. Discussion

Based on the results of the initial observation, the analysis of student and teacher needs, and the observation of students' science process skills at SMAN 1 Sungai Geringging, it was found that the teaching materials used in physics learning were still limited and predominantly conventional. The teaching materials did not fully support students' active involvement in the learning process and had not specifically facilitated students' science process skills. In addition, learning the topic of temperature and heat still presented challenges because the topic was considered relatively difficult for students to understand. Therefore, teaching materials are needed to support students' active involvement and provide more structured learning experiences through investigative activities. One alternative is a guided inquiry-based E-SWS presented interactively using Liveworksheets. The use of E-SWS is expected to help students follow the learning stages systematically while facilitating science process skills in physics learning.

The results of the define stage indicated that physics learning at SMAN 1 Sungai Geringging still faced several problems that became the basis for developing the E-SWS. The results of the front-end analysis through teacher interviews showed that the teaching materials used were still limited, and document analysis indicated that these materials still needed further development. This finding was also consistent with the results of the student analysis, which showed that students' science process skills still needed to be developed. The student questionnaire results showed that 99% of students found it easier to remember learning materials presented through images, animations, or videos; 98% of students were more enthusiastic about using digital media; 96% of students found it easier to understand learning materials when presented with attractive visual displays; 98% of students found it easier to master physics after conducting hands-on activities; and 95% of students found it easier to understand physics through real-life experiences. These findings indicate that students need teaching materials that are not limited to text but also provide interactive features and support independent learning. This finding is consistent with research conducted by Kurniawati, which reported that learning assisted by E-SWS involving students in learning activities can support the science process skills of Grade XI senior high school students through more active and meaningful learning experiences [16].

Furthermore, in the design stage, the guided inquiry-based E-SWS was designed using an appropriate writing process and structure. The components of the E-SWS included the title, learning instructions, competencies, supporting information, tasks or work procedures, and assessment [17]. The structure of the guided inquiry-based E-SWS was then adapted to the following stages: (1) identifying problems and conducting observations, (2) asking questions, (3) planning an investigation, (4) collecting data and conducting the investigation, (5) analyzing data, (6) drawing conclusions, and (7) communicating the results. In addition, each activity in the E-SWS was directed toward strengthening six science process skills indicators proposed by Rezba, namely observing, classifying, measuring, communicating, predicting, and concluding [18]. After the guided inquiry-based E-SWS was developed, product evaluation was conducted before implementation, consisting of: (1) an expert validity test to assess the suitability of the E-SWS with the learning objectives, temperature and heat materials, and science process skills indicators; and (2) a practicality test to assess the ease of use of the E-SWS by teachers and students. The practicality test was conducted during the development stage and involved a physics teacher and students as respondents.

The develop stage was conducted to ensure the quality of the guided inquiry-based E-SWS on the topic of temperature and heat. Two activities were carried out at this stage: validity testing and practicality testing. The validity test involved three physics expert lecturers from the Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang (FMIPA UNP), and one physics teacher from SMAN 1 Sungai Geringging to assess the feasibility of the product. The validation consisted of six aspects: content substance, visual communication, instructional design, software utilization, guided inquiry model, and science process skills. The validation results obtained an average validity coefficient of 0.95, categorized as very high. All assessed components showed very high validity. These results indicate that the developed product meets the criteria of content feasibility, presentation, language, visual design, and alignment with the guided inquiry syntax and science process skills indicators, making it suitable for use in the learning process. This finding is consistent with research conducted by Wulandari, which reported that a guided inquiry-based E-SWS on temperature and heat obtained a validity score of 0.95, categorized as very valid, and was therefore considered suitable as an innovative teaching material for physics learning.

Furthermore, a practicality test was conducted to assess the practicality of the product at SMAN 1 Sungai Geringging, involving 30 students who had studied the topic of temperature and heat. The practicality assessment of the guided inquiry-based E-SWS by the teacher covered ease of use, attractiveness, time efficiency, benefits, guided inquiry model, and science process skills. Meanwhile, the student practicality assessment covered ease of use, attractiveness, time efficiency, and benefits. The practicality test conducted with the teacher obtained an average score of 0.94, categorized as very high, while the practicality assessment by students obtained an average score of 0.85, also categorized as very high. These results indicate that the developed product meets the predetermined practicality criteria. This finding is consistent with research conducted by Ulfa, which reported that a guided inquiry-based physics E-SWS obtained a practicality score of 91%, categorized as very practical, and was therefore considered practical for use in physics learning at the senior high school level [19].

IV. CONCLUSION

Based on the results of the study, the guided inquiry-based Electronic Student Worksheet using Liveworksheets to facilitate Grade 11 students' science process skills on the topic of temperature and heat obtained a validity score of 0.95, which was categorized as very valid. The practicality test obtained scores of 0.94 based on the teacher's assessment and 0.85 based on the students' assessment, both of which were categorized as very practical. These results indicate that the developed Electronic Student Worksheet meets the criteria of very valid and very practical. The developed Electronic Student Worksheet integrates the guided inquiry learning model with six indicators of science process skills, namely observing, classifying, measuring, predicting, communicating, and concluding, on the topic of temperature and heat.

This study employed the 4D development model, consisting of the define, design, develop, and disseminate stages; however, its implementation was limited to the develop stage. The disseminate stage was not conducted because the study focused on product development and the initial assessment of the validity and practicality of the Electronic Student Worksheet. Based on the validation and practicality results, the developed guided inquiry-based Electronic Student Worksheet using Liveworksheets meets the criteria of very valid and very practical for use in Grade 11 physics learning on the topic of temperature and heat.

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