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Making of Digital Assessments Using WIZER.ME in The PBL Learning Model to Measure High School Student's Critical Thinking Abilities on Temperature and Heat Materials

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ABSTRACT

Through the use of the Wizer.me digital platform and the Problem Based Learning (PBL) learning model, this study attempts to develop a digital evaluation to gauge high school students' critical thinking abilities about temperature and heat. The Plomp development model, which comprises a development or prototype stage and a preliminary research stage, was used in the study's Research and Development (R&D) methodology. At SMA Negeri 1 Banuhampu, teacher interviews and the students' initial critical thinking ability tests were analyzed as part of the preliminary research stage. The findings of the investigation demonstrated that pupils' critical thinking abilities remained weak. Additionally, students' comprehension of temperature and heat concepts was also comparatively inadequate, and schools had not fully adopted digital evaluations. Based on these findings, a digital assessment prototype was developed that was made according to Ennis's critical Based on these results, a digital assessment prototype was created using the syntax of the PBL paradigm and Ennis' critical thinking markers. This digital evaluation makes use of five PBL model syntaxes. Using Aiken's V formula, three physics lecturers evaluated the assessment prototype. The results showed that the content, language, presentation, and graphics aspects of the assessment fell into the extremely valid category. The product revision incorporates the validators' suggestions and input. The study's findings show that the digital assessment with essay questions is appropriate for use as a tool to gauge students' critical thinking abilities about heat and temperature. In order to promote the development of 21st-century abilities, this study suggests using essay-based digital evaluations in physics education.

Keywords: Digital Assessment, Wizer.me, Critical Thinking Skills, PBL Model, Temperature and Heat

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I. INTRODUCTION

The Industrial Revolution 4.0, or 21st-century education, has been ushered in for Indonesian education. As science and technology get more advanced, this age is changing along with them. A paradigm shift in learning is being driven by 21st-century education, which includes changes in the curriculum, media, and technology employed [1]. Every person can grow his or her knowledge, abilities, and attitudes as well as all of his or her potential through education [2]. In addition to emphasizing knowledge, learning in this century also aims to cultivate skills [3]. The four Cs of this century are creativity, teamwork, communication, and critical thinking and problem solving [4,5].

Critical thinking is one of the skills that every learner needs in the twenty-first century [6]. Through the systematic process of critical thinking, students can assess the premises, reasoning, language, and supporting data of other people's claims [7,8]. The capacity to think critically in order to solve a problem logically is known as critical thinking ability [9,10]. People with this skill are able to assess arguments, examine data, and make conclusions based on reason, proof, and thorough thought [11]. Every student has the potential to think critically, but the problem is how to develop this ability in the learning process. To develop critical thinking skills, students must be directly involved in the learning process [12]. While every student has the potential for critical thinking, the primary challenge lies in developing these abilities effectively within the learning context. Therefore, a learning approach that actively engages students is needed so they can practice and hone their critical thinking skills through direct experience, discussion, and reflection on the information and arguments they encounter. Thus, the active involvement of students in the learning process is the main key in developing critical thinking

skills which are not only beneficial for academic success, but also serve as important provisions in facing the challenges of life in the future.

The Problem Based Learning (PBL) learning approach is one that has been shown to be successful in developing students' critical thinking abilities [13,14]. In order to help students grasp the fundamental ideas and concepts of a subject, the problem based learning model employs real world situations as a framework and a stimulus for their critical thinking and problem solving skills [15]. This approach encourages pupils to solve the teacher's difficulties [16]. The learning grammar of problem-based learning is intended to foster students' critical thinking abilities, particularly in the area of critical thinking itself [17]. Teachers can encourage students to participate more actively in learning and teaching activities under this paradigm, which will boost their confidence in voicing their thoughts [18]. In order to foster students' abilities and skills, particularly their critical thinking abilities, this model requires them to not only comprehend an issue but also collaborate to solve it [19]. Additionally, students are taught to accept others' viewpoints on the issues under discussion and to have the courage to voice their own [20]. According to the aforementioned remark, using the Problem Based Learning (PBL) approach has been successful in encouraging students to use critical thinking during their learning process.

Even if critical thinking abilities have been emphasized in the classroom, the actual situation does not match the expectations based on the facts. As a result, an initial investigation was carried out to look at the situation on the ground. Three real-world situations were found by this study: an examination of students' critical thinking abilities, an examination of heat and temperature, and an examination of technological challenges in the usage of learning assessments.

Students' critical thinking abilities are the subject of the first issue. At SMAN 1 Banuhampu, researchers assessed the critical thinking abilities of physics majors in grade XI Phase F. An early ability test instrument consisting of essay questions about heat and temperature was used to gauge this ability. Figure 1 below shows that the critical thinking abilities of the pupils at SMAN 1 Banuhampu are still comparatively low where researchers employed Ennis's (2011) critical thinking ability indications [21]. Of the five indicators used, there is one indicator that is still not mastered by students, namely the indicator in making conclusions. Where the average value obtained is 23%, which is in the very low category.

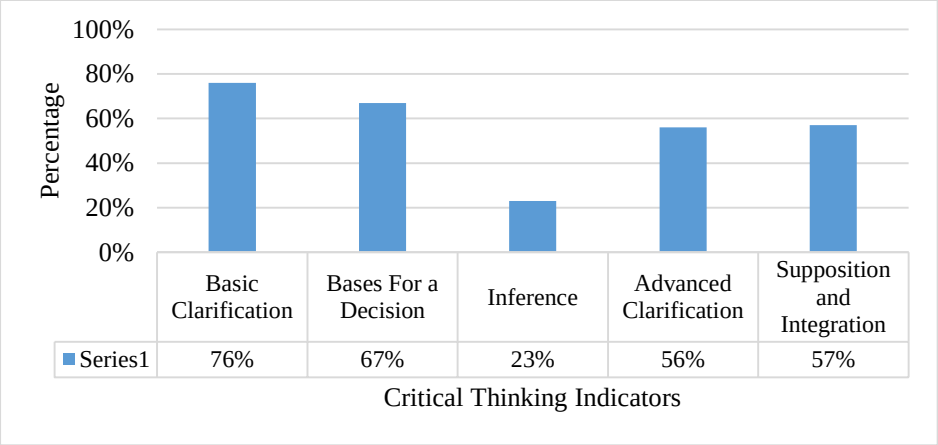

Fig 1. Graph of The Results of The Initial Critical Thinking Ability Test For Students

A number of other studies have demonstrated that pupils' critical thinking abilities remain inadequate, in addition to the findings of the first ability tests that were administered. According to research by Sundari & Sarkity (2021), 11th grade students at SMA Negeri 2 Kisaran had low critical thinking abilities on the subject of heat, with an average score of 50.72. In the meantime, the average score of 26.5 showed that the indication for making inferences was still categorized as extremely low [22]. Additionally, Permata & Suyana's (2019) study revealed that students' critical thinking abilities remain comparatively low, with an average proportion of 35.41%. The following represents the percentage breakdown for each component of critical thinking abilities: giving fundamental explanations (36.80%), developing fundamental abilities (40.80%), making inferences (32.00%), offering further explanations (30.67%), and developing plans and tactics (36.80%) [23].

The second problem relates to the topic of temperature and heat. Based on the results of the Daily Assessment on temperature and heat in grade XI Phase F, the average score obtained by students was 69, which is included in the low category. The results of the initial test instrument that has been conducted also indicate that many students still have difficulty understanding the concept of temperature and heat, as evidenced by the low success rate in answering questions related to the topic. Furthermore, several studies have shown that the material on temperature and heat is still poorly understood by students. Research conducted by Sadiah (2021) shows that students' understanding of temperature and heat material at SMA Negeri 2 Kota Jambi is still

relatively low. Of the 45 students who were the subjects of the study, the average score for students' conceptual understanding was 45.51%, with the lowest score being 4 and the highest being 80 [24]. In addition, research conducted by Hara, Astiti, & Lantik (2023) showed that mastery of physics concepts on temperature and heat material in class XI of SMA Negeri 12 Kota Kupang was in the moderate category with a percentage of 55% [25].

The third issue relates to technology in the use of assessments in the learning process. This third issue was measured through interviews with three physics teachers at SMAN 1 Banuhampu. The interviews revealed that the implementation of assessments focused on measuring students' critical thinking skills is still suboptimal. Although critical thinking assessments have begun to be implemented in certain materials, their implementation is uneven and remains limited. Teachers tend to focus more on conventional assessments that measure fundamental conceptual understanding rather than encouraging students to analyze, evaluate, and create solutions to physics problems in depth.

Additionally, interviews showed that while schools continue to employ printed tests, the use of technology in assessments which can offer a more dynamic and adaptable learning experience has not been widely adopted. However, by offering quicker feedback and encouraging the growth of students' critical thinking abilities, digital exams have the potential to improve the effectiveness of learning [26]. In addition, digital assessments can also increase student engagement, provide fast and personalized feedback, and increase learning motivation through interactive and creative elements [27]. One of the platforms that can be used for digital-based assessment is Wizer.me [28]. A service called Wizer.me provides extensive tools for finishing online tasks. With a vast array of question kinds, such as open-ended, multiple-choice, assignments, word search, drawing, gap-filling, and tables, Wizer.me promotes educators' creativity in producing electronic worksheets [29]. Using Wizer.me, students can automatically correct their answers and receive feedback from teachers, so they can repeat and relearn [30].

According to the aforementioned explanation, a digital assessment that uses the Wizer.me platform to gauge students' critical thinking abilities is required, particularly when it comes to the subject of temperature and heat in the Problem Based Learning (PBL) learning model. In order to gauge students' critical thinking abilities about temperature and heat, researchers are interested in developing a digital evaluation using Wizer.me inside the PBL learning model. The goal of this research is to create a reliable digital evaluation tool that can be used to gauge students' critical thinking abilities about heat and temperature.

II. METHOD

This study employs the Research and Development (R&D) research methodology, which is used to create a specific product and assess its efficacy [31]. The end result of this study is a digital test that uses the Wizer.me website to enhance high school students' critical thinking abilities using the Problem Based Learning (PBL) learning paradigm on temperature and heat content.

The Plomp model is the design model that was applied in this investigation. The steps in this strategy for doing development research are extremely sequential. There are three steps in this approach, specifically: 1) Preliminary Research, which includes requirements analysis and literature review; 2) Development or Prototyping Phase, which includes prototype design, formative evaluation, and prototype revision, is the step of creating answers to issues raised in preliminary research. 3) In practice, the assessment phase is the time for testing and evaluation. Only two phases were completed in this study, notably up until the validation test (expert review).

First, a needs analysis and literature assessment comprise the early research stage. In order to gather information on the challenges teachers and students face when learning physics, specifically with regard to temperature and heat, a preliminary study was carried out as part of the requirements analysis. Teachers and students participated in this pilot project. The purpose of this literature evaluation was to identify the best ways to enhance students' critical thinking abilities, particularly with regard to temperature and heat. A number of relevant books and scientific journals were used in this investigation.

Second, formative assessment, prototype design, and prototype revision comprise the development and prototyping phase. Following the completion of the preliminary research phase, prototype design is executed. At this stage, the prototype is designed and evaluated. The prototype is a product design that will be developed into the desired product and must first undergo a series of tests. In addition to designing the prototype, this stage also designs research instruments, namely a self-evaluation sheet and a product validity sheet. Formative evaluation in this design phase is key in conducting a research. After the prototype design is completed, the initial stage is a self-evaluation or self-assessment by the researcher himself, to check the completeness of the assessment design and language. The next stage is validity testing through expert review. This stage is a validation carried out by three expert physics lecturers who provide an assessment of the designed assessment.

The V-Aiken formula was used in the product validity data analysis technique. Four factors content compatibility, language use, presentation suitability, and assessment graphics were examined in order to determine the validity of the product. Based on the findings of n experts' evaluations of an item, the content validity coefficient was determined using Aiken's V formula [32].

The Aiken's V formula used is as follows.

$$V = \frac{\Sigma s}{[n(c-1)]}$$
$$S = r - I_O$$

Description :
I_O = lowest validity assessment score
c = highest validity assessment score
r = score given by the validator

The results of the Aiken's V formula can be interpreted as falling between 0 and 1. Table 1 below displays the Aiken's V validity index.

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Table 1. Validity Assessment Index

Interval	Assessment
V < 0,4	Less Valid
$0,4 \leq V \leq 0,8$	Valid
V > 0,8	Very Valid

III. RESULTS AND DISCUSSION

A. Research Result

1. Preliminary Research Phase

A literature study and needs analysis were carried out as part of the preliminary investigation. Teachers were interviewed and students were given a test on critical thinking abilities as part of the needs analysis. Table 2 below displays the students' critical thinking abilities test results.

Table 2. Data from the analysis of students' critical thinking skills

Critical Thinking Indicators	Percentage
Basic Clarification	76%
Bases For a Decision	67%
Inference	23%
Advanced Clarification	56%
Supposition and Integration	57%

The aforementioned table demonstrates that Grade XI Phase F pupils' critical thinking abilities remain comparatively low. The results of the tests that the pupils took make this clear. According to the measures of critical thinking skills, giving straightforward explanations received the greatest average score of 70%, while drawing conclusions received the lowest average score of 23%.

Three physics teachers were interviewed, and the results showed that: 1) teachers are aware of the skills that pupils need in the twenty-first century, 2) Teachers have digital assessments to gauge students' critical thinking abilities, but they are rarely used; 3) Teachers themselves have never created digital assessments to gauge students' critical thinking abilities, particularly when it comes to temperature and heat materials; and 4) Teachers face a number of challenges when creating and utilizing digital assessments.

The findings of the literature review suggest that the issue of students' critical thinking abilities in comprehending the concepts of heat and temperature need a solution. Essay evaluations may be the most effective way to gauge students' critical thinking abilities, according to the researchers' analysis of the literature.

2. Development or Prototyping Phase

The results obtained at this stage include a product prototype design, self-evaluation, and expert review. The product prototype design is a digital assessment in the form of an essay, complete with work instructions, student answer sheets, answer keys, and a scoring rubric. The prototype is designed based on the problem grid

and the temperature and heat material using the PBL model. An example of the cover developed can be seen in Figure 2, and an example of the problem can be seen in Figure 3 below.

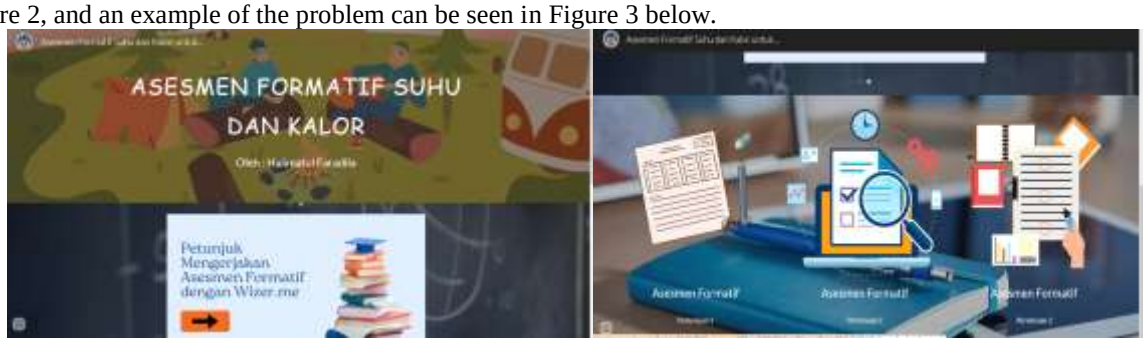

Fig 2. Cover Design

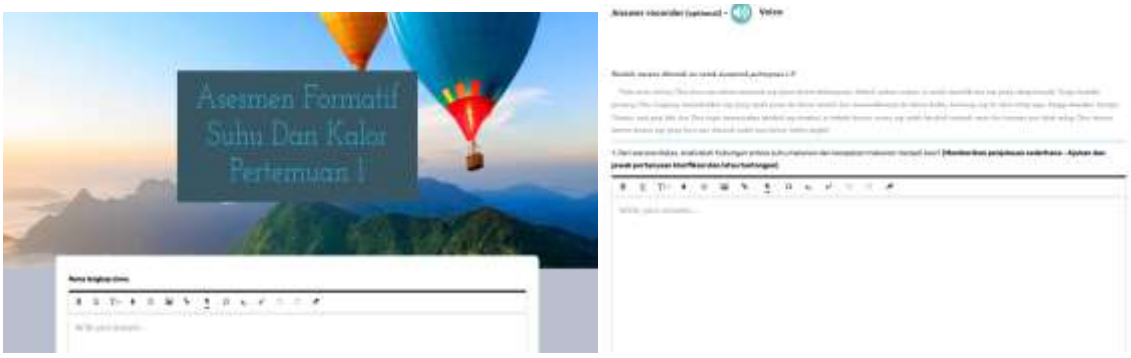

Fig 3. Assessment Question Design

After the assessment prototype was designed, a formative evaluation was conducted, consisting of two stages: self-evaluation and expert review. The self-evaluation results showed that the assessment met the test's completeness requirements. This was demonstrated by the completeness of the question outline, which included question indicators and questions tailored to the material students had learned at school. The completeness of the question instructions, student answer sheets, answer keys, and scoring rubrics were also included. The language used was based on Indonesian language rules.

The processes of product validation and revision were then completed. By evaluating the validation evaluation sheet, validity testing was carried out. Three physics professors from Universitas Negeri Padang's Faculty of Mathematics and Natural Sciences carried out the validation evaluation. Four factors were evaluated as part of the validation process: assessment graphics, language use, presentation adequacy, and content appropriateness. Table 3 below displays the findings of the validator 1 examination.

Table 3. Validator 1 Assessment Results

No	Aspect	Aikens'V Index	Criteria
1	Content Appropriateness	0,91	Very Valid
2	Language Use	0,88	Very Valid
3	Presentation Appropriateness	0,79	Valid
4	Assessment Graphics	0,80	Valid

From Table 3 above, we can see that for all aspects assessed by validator 1, they were categorized as valid. Furthermore, the results of the assessment by validator 2 can be seen in Table 4 below.

Table 4. Validator 2 Assessment Results

No	Aspect	Aikens'V Index	Criteria
1	Content Appropriateness	0,75	Valid
2	Language Use	0,75	Valid
3	Presentation Appropriateness	0,75	Valid
4	Assessment Graphics	0,75	Valid

Based on Figure 5, it can be seen that all aspects assessed received values in the valid category. Furthermore, the results of validator 3 research are as in Table 5 below.

Table 5. Validator 3 Assessment Results

No	Aspect	Aikens'V Index	Criteria
1	Content Appropriateness	0,75	Very Valid
2	Language Use	0,75	Very Valid
3	Presentation Appropriateness	0,75	Very Valid
4	Assessment Graphics	0,75	Very Valid

The third validator examined four different aspects of the instrument, just as the first two. The validators evaluated 32 items in all. The four characteristics were deemed very valid, and the content validation analysis's findings were comparable to those of the earlier validators. Figure 4 below shows all of the validation findings from the three validators.

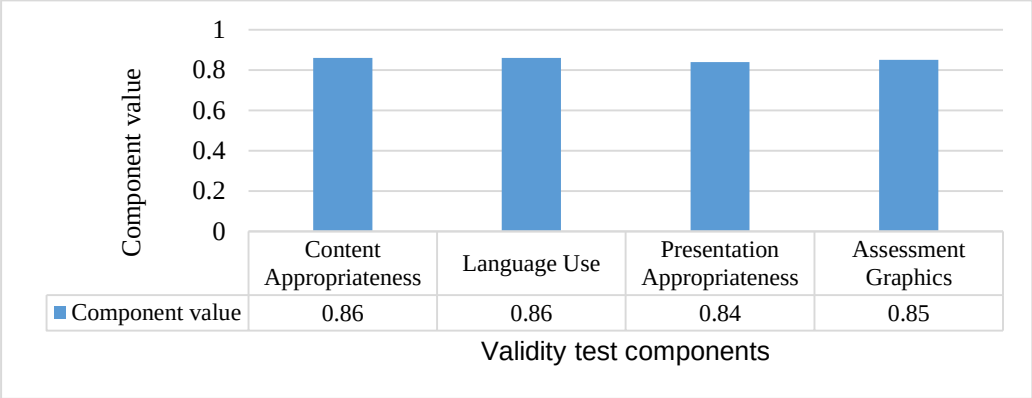

Fig 4. Product Validation Chart

Based on the validator's assessment, the assessment was found to be valid with several revisions. During the validation process, the validator provided suggestions that served as the basis for revising the assessment. These suggestions can be seen in Table 6 below.

Table 6. Validator's Suggestions

No	Response	Suggestion
1	Add expansion problems based on expansion coefficients and heat transfer rates.	Already repaired
2	Correct the incorrect words in the questions for meeting 1	Already repaired
3	Add critical thinking indicators to each PBL model syntax	Already repaired
4	Add images and videos that relate to the phenomenon or story.	Already repaired
5	In syntax 3, 4 and 5 it should consist of several questions according to the activities carried out by students.	Already repaired

Based on the validator's suggestions, the researchers revised the assessment prototype. The assessment before and after revisions can be seen in Figures 5 and 6 below.

Fig 5. Before revision

Fig 6. After revision

B. Discussion

The assessment used in this study was developed to determine students' critical thinking skills. The assessment used was a digital essay-based assessment. This discussion explores several aspects related to the research findings from each stage. The following is an explanation:

The researchers' needs analysis revealed that the current reason students have problems with critical thinking is due to the lecture method of learning. This is evident in student test results, which indicate that students' critical thinking skills are still low.

Based on the results of the product design, a self-evaluation is necessary as a form of personal evaluation regarding the suitability of the questions with the indicators of learning objective achievement, the completeness of the questions in the form of scoring guidelines, student answer sheets, and instructions for working on the questions. In the self-evaluation activity, the language and sentence structure of the questions are also checked, ensuring that the questions are free from the use of regional sentences and ambiguous sentences, as well as sentences that can give rise to multiple meanings for students.

The assessments resulting from the self-evaluation activities underwent expert review. At this stage, the assessments were tested for their feasibility in measuring students' critical thinking skills by three experts (validators). The assessment aspects were considered. The assessment aspects consisted of four aspects: content appropriateness, language use, presentation appropriateness, and assessment graphics.

Based on the findings of the validity test, which was conducted by the three validators using the learning objective achievement indicators. At 0.86, the average content feasibility score falls into the extremely valid range. With an average score of 0.86, the language use component falls into the very valid group. With an average score of 0.84, the presenting feasibility component is deemed highly genuine. With an average score of 0.85, the evaluation graphic component is deemed to be highly valid. The assessment findings are highly valid and may be used to gauge students' critical thinking abilities based on the feasibility, language use, presentation feasibility, and assessment visual features, according to the results of the validation tests conducted by three validators. This is because the assessment has met all the aspects required in creating questions.

IV. CONCLUSION

This development resulted in a digital formative assessment on temperature and heat. The assessment was validated by three validators. The assessment validation test results were categorized as highly valid. This indicates that the instrument is suitable for measuring students' critical thinking skills on temperature and heat.

V. ACKNOWLEDGMENT

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