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Development of Electronic Portfolio Assessments to Optimize Students' Critical Thinking Skills in Measurement Materials

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ABSTRACT

Critical thinking skills are an important competency in 21st century physics learning. Ideally, assessments not only measure conceptual understanding but also facilitate the development of critical thinking through sustainable and transparent assessment instruments. The novelty of this study lies in the integration of electronic portfolio assessment with the Liveworksheet platform, a combination that has not previously been directed specifically at optimizing students' critical thinking skills in physics measurement materials, and which offers a practical contribution as an alternative formative assessment tool that embeds critical thinking indicators, transparent rubrics, and continuous feedback directly within the assessment medium. Preliminary findings at SMAN 1 Sungai Tarab show that students' critical thinking skills are still low, teacher assessment questions are still procedural and not in line with critical thinking indicators, feedback has not been given optimally, and assessment rubrics have not been communicated to students. Based on these findings, this study aims to analyze the need for the development of a Liveworksheet-assisted electronic portfolio assessment to optimize critical thinking skills in measurement materials. The research uses the Research and Development (R&D) method of the 4D model, limited to the define (needs analysis) stage, with a quantitative descriptive approach involving 30 students of class X Phase E1. Data were collected through Facione (2011) indicator-based critical thinking tests, questionnaires, and teacher interviews. The results showed that the average critical thinking skills were in the low category (39%), with the highest achievement in self-regulation (43%) and the lowest in evaluation (36%). Teachers' instruments do not reflect indicators of critical thinking, feedback is minimal, and rubrics are only used internally. These findings establish the empirical basis for the subsequent design of a Liveworksheet-assisted electronic portfolio assessment that integrates critical thinking indicators, transparent rubrics, and continuous feedback; the effectiveness of this assessment in improving students' critical thinking skills has not yet been evaluated and remains a direction for further research.

Keywords : Electronic Portfolio Assessment, Liveworksheet, Critical Thinking Skills, Measurement , and Research and Development

I. INTRODUCTION

In the 21st century, the Indonesian nation is faced with challenges that demand to improve the quality of human resources in order to be able to compete globally. To answer these challenges, students need to develop various thinking skills, ranging from simple to high-level thinking skills [1]. High-level thinking includes four main categories, namely problem-solving, creative thinking, critical thinking, and decision-making [2]. In this study, the researcher only focused on critical thinking skills, because one of the life skills that needs to be developed and acquired through education is critical thinking.

The imperative to enhance critical thinking competencies is additionally substantiated by the outcomes derived from international evaluative instruments. Specifically, the PISA 2022 findings indicate that the scientific literacy proficiencies exhibited by Indonesian students remain below the established mean of

Organisation for Economic Co-operation and Development (OECD) member nations. This observation suggests that the capacity for deductive reasoning, the analytical deconstruction of phenomena, and evidence-based decision-making utilizing scientific data are not reaching their full potential among Indonesian learners [3]. This condition reinforces the importance of learning interventions, including through assessment design, which systematically trains students' critical thinking skills from the secondary education level.

The capacity for reflective contemplation, which is directed toward discerning appropriate courses of action or justifiable tenets, is characterized as critical thinking. The cultivation of these analytical proficiencies is of paramount importance, as individuals adept in their application exhibit enhanced logical reasoning, superior problem-solving capabilities, and the facility to arrive at judicious conclusions regarding both belief and conduct [4]. Furthermore, these essential analytical faculties encompass the capacity to discern verity from fallacy, objective reality from subjective viewpoint, or imaginative fabrication from factual accounts. The cultivation of critical thinking proficiencies can be effectively achieved within an educational framework by presenting learners with situated dilemmas drawn from quotidian existence [5].

Student academic achievement during the educational progression is gauged via multifaceted evaluative procedures. Assessment is an overview of learning outcomes that include how assessments are carried out, assessment techniques, data processing, grade determination, and reporting carried out by teachers and known by all stakeholders, including parents, schools, and students themselves [6]. According to their function, assessments are divided into three types, namely*: assessment as learning*, *assessment for learning*, and *assessment of learning.* Assessment *as learning* used to reflect on the learning process. This assessment functions as a formative assessment. The *assessment for learning* is an assessment used for learning improvement. This assessment also functions as a formative assessment [7]. From the results of the formative assessment, educators get information about the need to improve learning the next day by designing positive, supportive and meaningful learning. The last assessment is *assessment of learning*, This assessment is used for learning evaluation. Its implementation is usually at the end of learning [8]. Specifically in this study, the researcher will focus on *assessment as learning* and *assessment for learning*, because This assessment functions as a formative assessment.

Formative assessment serves several crucial functions: 1) It facilitates the diagnosis of students' foundational competencies and identifies their specific learning requirements. 2) It provides educators with valuable insights to refine pedagogical approaches, thereby enhancing the learning experience's relevance. 3) It offers students constructive feedback, enabling them to optimize their learning methodologies. 4) It ascertains the extent to which students have assimilated course content during instructional activities. 5) It catalyzes a transformation in the classroom environment, fostering increased student engagement and motivation through the implementation of positive, supportive, and purposeful educational initiatives [8]. A prime illustration of an assessment strategy that educators can leverage as a feedback mechanism is the portfolio assessment. To date, however, portfolio assessments that explicitly integrate critical thinking indicators, a digital platform, transparent rubrics, and continuous feedback in a single instrument remain rare, particularly in the context of physics measurement materials; this combination is the specific gap that the present study addresses through the integration of electronic portfolio assessment with the Liveworksheet platform.

Portfolio assessments can be used to improve critical thinking skills and determine students' progress in the learning process because portfolio assessments have the potential to determine students' competencies comprehensively. Portfolios can also provide relevant feedback for learning that impacts students' views on assessments [9]. Comprised of assembled works, portfolios serve as a valuable instrument for educators to meticulously observe and appraise the trajectory of a learner's development throughout a specified period. In contrast, standardized assessments such as tests and quizzes furnish educators with a snapshot of a student's knowledge acquisition at discrete temporal junctures [10]. The application of traditional portfolio assessments causes a lack of efficiency in the time used during the teaching and learning process, resulting in less than optimal achievement of the objectives in the learning.

One of the important materials in learning physics is *measurement.* Measurements are the basis of all experimental and observational activities in the physical sciences. A good understanding of measurement concepts helps learners develop critical thinking skills, particularly in terms of accuracy, accuracy, and data analysis [11]. This material provides an opportunity to practice logic, reasoning, and understanding of the importance of uncertainty in measurement results. Therefore, the topic of measurement has a strategic role in shaping the scientific mindset of students from an early age.

A number of previous studies on physics learning have also confirmed that students' critical thinking skills on various topics tend to be in the low to medium category. In a 2021 study, Sundari and Sarkity ascertained that secondary school students exhibited suboptimal critical thinking proficiencies concerning concepts of temperature and heat. This deficiency was particularly pronounced in their ability to formulate straightforward explanations and derive conclusions derived from empirical measurement data. Similar findings were reported by Hidayati, Makhrus, and Sutrio (2022) on harmonic vibration materials, which showed that students' critical

thinking skills improved significantly when facilitated with the right approach and assessment. Both of these findings reinforce the argument that measurement materials, as a methodological foundation in physics, require assessment designs that explicitly train rigor, accuracy, and data-driven reasoning—not just measure the final outcome of learners' answers.

However, conditions in the field show that students' critical thinking skills are still relatively low. Observations and interviews conducted at SMAN 1 Sungai Tarab revealed that the assessment process used by teachers still focused on the ability to memorize concepts and the final learning outcomes. The assessment used is still in the form of multiple-choice questions and simple written assignments so that it is not able to measure students' critical thinking skills optimally. In addition, students have not received feedback that helps them improve the learning process in a sustainable manner.

The results of the preliminary study showed that the average critical thinking skills of students in class X Phase E1 were in the low category with a percentage of 39%. Low critical thinking skills can be seen in the ability of students to analyze problems, evaluate information, and draw conclusions based on the data obtained. This condition shows the need to develop assessments that can help students develop critical thinking skills more optimally.

One of the assessment alternatives that can be used is the electronic portfolio assessment. Electronic portfolio assessment is a form of digital assessment used to collect students' work in a systematic and sustainable manner [12]. The use of electronic portfolio assessments allows students to document the learning process, reflect on the results of their work, and get feedback from teachers. According to Masluhah and Rizkiatul, electronic portfolio assessments can increase student involvement in learning because the assessment process not only assesses the final results, but also the learning development of students[13].

In this study, an electronic portfolio assessment was developed using the Liveworksheet platform. Liveworksheet is a digital platform that can be used to create online-based interactive worksheets to facilitate the assessment process and collection of student assignments. The use of Liveworksheets in learning can help teachers provide more effective, engaging, and interactive assessments [14]. In addition, the platform allows for direct feedback so that learners can find out their shortcomings in the learning process.

The effectiveness of Liveworksheet in training students' critical thinking skills has been proven at various levels and learning materials. Developed a contextual E-LKPD assisted by Liveworksheet and found the product to be feasible and effective for training the critical thinking skills of high school students [15]. Reported that interactive problem-based learning-based E-LKPD assisted by Liveworksheets was able to improve students' critical thinking skills as well as physics learning outcomes [16]. In line with that, on the concept of cell division[17], as well on thermodynamics material, show that Liveworksheet consistently has a positive influence on students' critical thinking skills across science and physics subjects [18]. These findings became the empirical basis for the selection of Liveworksheet as an assessment development platform in this study.

A corpus of prior investigations indicates that the implementation of electronic portfolio evaluations is instrumental in augmenting students' capacity for critical discernment. Specifically, research undertaken by Siswaningsih et al. posits that the design of assessments grounded in electronic portfolios facilitates enhanced student engagement within the pedagogical process and fosters improvements in critical thinking competencies [19]. Complementing these findings, a separate study by Bella and Kristin demonstrates that the integration of Liveworksheets into instructional methodologies yields positive effects on both learning engagement and the cultivation of students' critical thinking prowess [20].

Although various previous studies have proven the benefits of Liveworksheets in improving critical thinking skills, most still focus on the development of student worksheets (E-LKPD) as a learning medium, not as a sustainable portfolio assessment instrument. More relevant research was conducted by Evriliani, Nahadi, and Fatimah, who developed an electronic portfolio assessment based on STEM creative content to assess students' mastery of concepts and creative thinking on acid-base materials; However, the research focused on chemistry subjects and creative thinking skills, not critical thinking in physics learning [21]. On the other hand, a systematic literature review by Astagisa and Malik confirms that the development of formative assessments in physics learning within the framework of the Independent Curriculum is still limited and requires further innovation, especially assessments that are able to document the learning process of students comprehensively and sustainably [22]. This mapping revealed a research *gap was identified* in the form of the unavailability of an electronic portfolio assessment assisted by Liveworksheet which is specifically designed to optimize students' critical thinking skills in measurement materials in physics learning.

Based on this description, it is necessary to develop an electronic portfolio assessment assisted by Liveworksheet which can be used to optimize students' critical thinking skills in measurement materials. Therefore, this study aims to produce a valid and practical electronic portfolio assessment so that it can be used as an alternative assessment in learning physics on measurement materials.

II. METHOD

This scholarly inquiry employs the Research and Development (R&D) methodology, characterized by a structured, systematic sequence of operations designed for the origination of novel commodities or the enhancement of pre-existing ones [24]. In this study, the development of electronic portfolio assessments is directed to produce an assessment instrument that not only measures aspects of knowledge, but also students' critical thinking skills that are integrated with the principles of sustainable development.

The development model applied is the 4D model, which includes four main stages, namely *Define* (definition), *Design* (planning), *Develop* (development), and *Disseminate* (dissemination). This model was first introduced by Sivasailam Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel in 1974 [25]. The 4D model was chosen in this study because the stages are systematic and relatively simpler than other development models such as ADDIE or Borg and Gall, making it suitable for the development of classroom-scale assessment instruments with limited time and researcher resources. In addition, the stage *develop* on 4D models explicitly accommodates expert validation processes and limited trials, which are the main needs in producing valid and practical assessment products. However, in this study, product development was only carried out up to the stage *develop*, considering the limitations in terms of cost, time, and capabilities owned by researchers.

The subjects in this study are students of class X Phase E1 at SMAN 1 Sungai Tarab. The research population is all students of class X Phase E1, with the sample determined using *purposive sampling* techniques based on the consideration that the class has studied the measurement material and is recommended by the physics subject teacher as a representative class. The research sample amounted to 30 people consisting of one study group. The product developed is in the form of an electronic portfolio assessment in the form of an essay assignment equipped with *a Liveworksheet-assisted* assessment rubric on the measurement material.

Data collection in this study was carried out through three techniques, namely questionnaires, tests, and interviews. The questionnaire is used to find complete information about problems that occur to students by filling in factual answers when filling out statements. The test is used to measure students' critical thinking skills, while interviews are conducted with Physics teachers to obtain information about the assessment system that has been applied in the learning process. All instruments (questionnaires, tests, and validation sheets) are arranged based on a grid that contains aspects, indicators, and number of items, so that the instrument development process can be accounted for systematically.

The assessment tool designed to measure critical thinking proficiencies was meticulously developed in alignment with Facione's 2011 conceptualization of critical thinking indicators. This framework enumerates six distinct sub-constructs: *Interpretation, Analysis, Evaluation, Inference, Explanation*, and *Self-regulation*. The test instrument is in the form of a description question (essay) developed by adapting instruments from previous research, which also refers to the Facione 2011 indicator. Before use, the test instrument is validated by experts and tested for reliability using Cronbach's Alpha coefficient to ensure the internal consistency of the question item [26]. The data obtained was then analyzed using descriptive statistics, which is an analysis technique that aims to process, summarize, and present data systematically to facilitate understanding. Thus, the results of the analysis are expected to provide accurate information as a basis for the development of more effective learning assessment instruments.

The results of the needs analysis are calculated using the percentage formula, which is by comparing the score obtained to the maximum score, then multiplied by 100%. This calculation aims to determine the level of achievement in each aspect measured in the research. The percentage value obtained is then used as the basis for interpreting the category of needs and the level of critical thinking skills of students.

$$score\ obtained = \frac{Total\ score\ obtained}{Maximum\ total\ score} \times 100\% \qquad (1)$$

Data analysis to evaluate the needs of each indicator through the use of the conditions in the Table

Table 1. Student Ability Category

Total score range (%)	Categories
81-100	Very high
61-80	Height
41-60	Medium

21-40	Low
0-20	Very low

(Source: Ref[27])

III. RESULTS AND DISCUSSION

Results

The real conditions related to critical thinking skills in the field show that the critical thinking skills obtained by students are still not optimal. This condition can be seen from the results of the essay test that has been carried out at SMAN 1 Sungai Tarab. A preliminary study conducted at SMAN 1 Sungai Tarab showed that critical thinking skills are still relatively low. The results of the analysis of test scores for each level of indicators were obtained as follows:

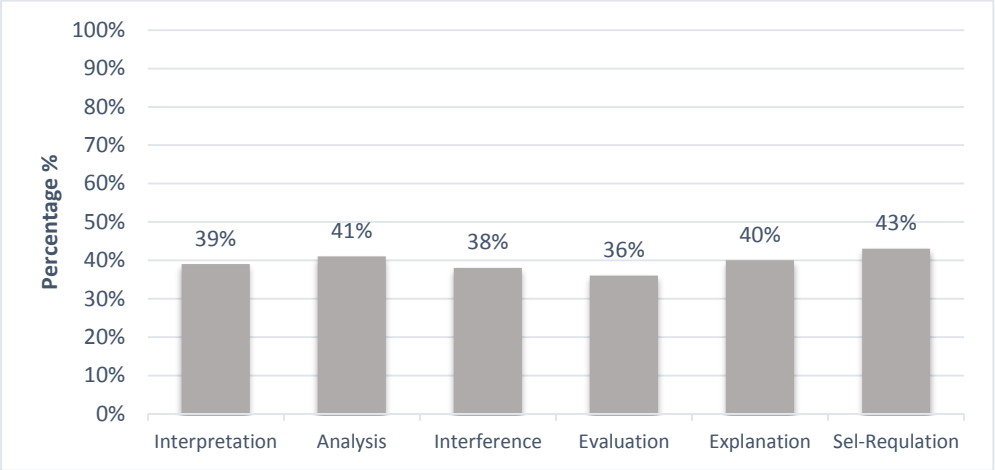


Fig. 1. Critical Thinking Skills Test Results

According to the findings from the evaluation of the examination results concerning various levels of critical thinkng skill indicators among the 30 students in class X phase E1 at SMAN 1 Sungai Tarab, the data was collected using descriptive questions (essays) created by [28], which align with the indicators established by facione (2011). The outcomes from the analysis of the test scores for each indicator canbe viewed in table 3 below.

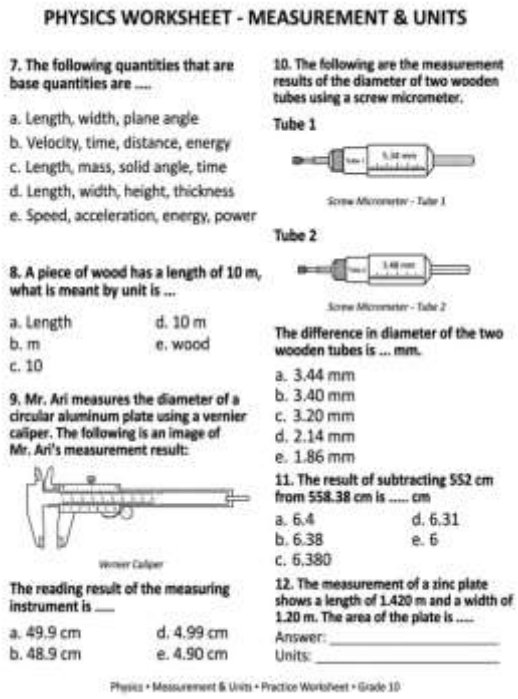
Table 2. Results of Students' Critical Thinking Skills Test by Indicator

Yes	Indicator	Average Score (%)	Categories
1	*Interpretation*	39%	Low
2	*Analysis*	**41%**	Medium
3	Inference	38%	Low
4	Evaluation	**36%**	Low
5	Explanation	**40%**	Low
6	Self-regulation	43%	Medium
	Overall average	**39%**	**Low**

The data in Table 2 shows that students' abilities vary in each indicator of critical thinking skills. The indicator with the highest achievement was obtained in **self-regulation** with an average of 43%, while the lowest achievement was obtained in the **evaluation** indicator with an average of 36%. Overall, the average critical thinking skills of students are in the low category, which is 39%.

Several previous research results also confirmed that the level of critical thinking skills of students in Indonesia in general is still in the low category. Concluded that the critical thinking skills of students at the primary and secondary education levels are classified as poor[29], in line with the findings of Setianingsih et al. and Sirmayeni 2023 in different learning contexts. The low critical thinking skills of students are caused by various factors, including students who are not trained to involve the critical thinking process in answering questions [30]

The second real condition based on observations made at SMAN 1 Sungai Tarab found that teachers were still using questions or questions that were not in accordance with the indicators of critical thinking skills. This is clearly seen in the example of the questions shown in Figures 2 and 3 below, which show that there is no relationship between the questions and the critical thinking skills indicator.



PHYSICS WORKSHEET - MEASUREMENT & UNITS

7. The following quantities that are base quantities are ....

a. Length, width, plane angle
b. Velocity, time, distance, energy
c. Length, mass, solid angle, time
d. Length, width, height, thickness
e. Speed, acceleration, energy, power

8. A piece of wood has a length of 10 m, what is meant by unit is ...

a. Length
b. m
c. 10
d. 10 m
e. wood

9. Mr. Ari measures the diameter of a circular aluminum plate using a vernier caliper. The following is an image of Mr. Ari's measurement result:

Vernier Caliper

The reading result of the measuring instrument is .....

a. 49.9 cm
b. 48.9 cm
d. 4.99 cm
e. 4.90 cm

10. The following are the measurement results of the diameter of two wooden tubes using a screw micrometer.

Tube 1

Screw Micrometer - Tube 1

Tube 2

Screw Micrometer - Tube 2

The difference in diameter of the two wooden tubes is ... mm.

a. 3.44 mm
b. 3.40 mm
c. 3.20 mm
d. 2.14 mm
e. 1.86 mm

11. The result of subtracting 552 cm from 558.38 cm is ..... cm

a. 6.4
b. 6.38
c. 6.380
d. 6.31
e. 6

12. The measurement of a zinc plate shows a length of 1.420 m and a width of 1.20 m. The area of the plate is ....

Answer: _____
Units: _____

Physics • Measurement & Units • Practice Worksheet • Grade 10

Fig. 2. Examples of assessments used by teachers

The analysis of physics subject assessment questions in class X students, especially the examples of measurement material questions that have been studied, indicates that most of the questions are still procedural and tend to only measure low-level thinking skills. These questions generally ask students to memorize concepts, read the scale of measuring tools, or calculate averages, without encouraging students to analyze, evaluate data, or draw conclusions based on evidence. Each question was cross-checked against the six Facione (2011) indicators (Interpretation, Analysis, Evaluation, Inference, Explanation, and Self-regulation) to determine which cognitive demands it addressed, and the majority were found to require only recall or straightforward calculation rather than analysis, evaluation, or inference. In fact, critical thinking skills are one of the important competencies in 21st century learning. Critical thinking skills include the ability to evaluate information objectively, formulate arguments logically, and make decisions based on valid and relevant data [31]. Due to the significance of his ability in education, it is essential to create evaluation tools that serve to assess academic achievements while also motivating learners to enhance their critical thinking abilities.

Observations at SMAN 1 Sungai Tarab further indicate that the provision of feedback on student learning outcomes has not been carried out optimally. Teachers tend to only give scores or final grades, such as a numeric mark or a brief remark of "correct" or "incorrect," without an in-depth explanation of the location of the mistakes

or corrective strategies that can be done by students. In fact, effective feedback is one of the important aspects of formative assessment because it can help students understand their strengths and weaknesses and improve learning strategies in the future. Quality feedback can increase learning motivation, encourage self-reflection, and support the development of critical thinking skills in a sustainable manner [32].

One of the important tools that can support the provision of structured and objective feedback is the assessment rubric. The rubric is a guideline that contains assessment criteria and a clear description of the level of achievement for each indicator. The use of rubrics in portfolio assessments allows teachers to provide assessments in a transparent, fair, and consistent manner. In addition, rubrics also play a role in helping students understand learning expectations so that they can conduct self-evaluation and gradually improve the quality of work results [33]. In the context of assisted electronic portfolio assessment Liveworksheet, digital rubrics can also be inserted or attached as part of the worksheet, so that students can know directly the assessment benchmark of the assignment being done [34]. Here is an example of a rubric used by teachers in the learning process.

c. Skills Assessment
Test Rubric
Form: Non-Test (product presentation and product)

No	Aspect	Fulfilled Score	Points (fill with numbers 1, 2, 3, or 4)	Total points
1	Planning Process	• Collecting information sources, data, literature, interviews, and observations regarding the basic concepts of measurement, units, measuring instruments, and their application in daily life • Selection of communication media • Selection of communication media		
2	Implementation Process	• Analyzing information sources in the form of data, literature, interviews, and observations regarding how to use measuring instruments, important rules, standard units, and accuracy in measurement • Teamwork or group discussion • Work ethic in discussion groups		
3	Product Result - Communication Media	• Media appeal (having artistic value, creative, and interesting) • Suitability of media content with the topic • Ease of understanding the media		
4	Presentation	• Use of good and correct language • Delivery that is easy to understand • Attractiveness of the media used • Compactness		
Total Score = (total points of all aspects) / 48 × 100				

Fig. 3. Examples of Rubrics Used by Teachers

The observations also indicate that teachers have used the assessment rubric shown in Figure 3 below to assess the learning outcomes of students. However, the rubric is only used by teachers as an internal guideline in providing assessments, and is not conveyed or given to students. This condition causes students to not clearly know the assessment criteria used, so they lack a clear understanding of what aspects are being assessed and the expected achievement standards. In fact, openness to assessment rubrics is very important to help students reflect, improve their work, and encourage the creation of more transparent and accountable learning [35].

The three findings are the low achievement of students' critical thinking skills in all Facione indicators, teacher assessment questions that do not reflect critical thinking indicators, and the lack of openness of rubrics and feedback to students collectively show the need for alternative assessments that are able to integrate critical thinking indicators explicitly, provide a transparent and accessible rubric for students. as well as facilitating ongoing feedback. The findings at the ***Define*** stage are the empirical basis for the design of Liveworksheet-assisted electronic portfolio assessments at the ***next Design*** and ***Develop*** stage.

Discussion

According to the findings from a study conducted at SMAN 1 Sungai Tarab, a detailed understanding was achieved regarding the true state of physics education, particularly in connection with the critical thinking abilities of students and the effectiveness of the assessment tools employed. These results serve as the primary basis for creating electronic portfolio assessments supported by Liveworksheet on measurement topics.

The findings from the examination of the essay assessment performed on 30 pupils in class X Phase E1 indicated that the collective critical thinking abilities of the students remained in the below-average range, with an average score of 39%. Based on the analysis per indicator referring to the Facione 2011 framework, the highest achievement was obtained in the indicator *Self-regulation* with an average of 43%, while the lowest achievement is found in the indicator *Evaluation* with an average of 36%. This gap between the highest and lowest indicators can be explained by the different cognitive demands of each skill and by what students are routinely trained to do in the classroom. Self-regulation, in Facione's 2011 framework, largely involves monitoring and correcting one's own work, such as re-checking calculation steps or verifying the accuracy of measurement units; this is a procedural habit that physics instruction already reinforces repeatedly through numerical exercises, so it is relatively well developed even without explicit critical thinking instruction. Evaluation, in contrast, requires students to judge the adequacy, credibility, and validity of evidence or data, a higher-order judgment that must be explicitly modeled and practiced rather than acquired incidentally. Because, as the next findings show, teacher assessment questions in this school remain procedural and rarely ask students to judge the quality of data or evidence, students have limited opportunity to practice this specific skill, which plausibly explains why evaluation is the weakest indicator. This asymmetry is consistent with the characteristics of physics learning in schools which still emphasizes mastery of calculation procedures rather than evidence-based reasoning [31], as also reflected in the results of the analysis of teacher questions in the next findings. This situation corresponds with the results from Miftianah and colleagues, who noted that a significant number of students in Indonesia have not yet developed strong critical thinking abilities [28]. A contributing factor is that students often find it challenging to effectively use critical thinking processes when responding to questions [36]. Therefore, it is necessary to develop assessment instruments that can systematically train and encourage students' critical thinking skills in an ongoing manner. Especially in the aspect of evaluating evidence and data which is the weak point of students in this study.

In addition to low critical thinking skills, the results of observations on the assessment instruments used by teachers also show that physics problems in class X measurement materials are still dominated by procedural questions and only measure low-level thinking skills. These questions generally only ask students to memorize concepts, read the scale of measuring instruments, or make simple calculations, without encouraging students to analyze, evaluate data, or draw conclusions based on available evidence. In fact, critical thinking skills are one of the essential competencies in 21st century learning which includes the ability to evaluate information objectively, formulate arguments logically, and make decisions based on valid and relevant data [31]. This condition emphasizes the need for the development of assessment instruments that not only measure learning outcomes, but also are able to stimulate and develop students' critical thinking skills optimally. The findings also explain why the achievement of evaluation indicators on the essay test was the lowest among the six Facione indicators: students were rarely faced with questions that required them to assess the adequacy and quality of measurement data, so these skills were not adequately trained in the daily learning process.

In addition, the results of the observation also revealed that the provision of feedback on students' learning outcomes has not been carried out optimally. Teachers tend to only give scores or final grades without an adequate explanation of the location of the mistakes or corrective strategies that can be taken by students. This condition is less supportive of student learning development, considering that effective feedback is an important component of formative assessment that can help students understand their strengths and weaknesses, as well as encourage improvement of learning strategies in the future. As stated by Hernández Rivero, quality feedback has been proven to increase learning motivation, encourage self-reflection, and support the sustainable development of students' critical thinking skills [32]. This lack of descriptive feedback also reinforces the connection between the second and first findings: without feedback that explains the weaknesses in the evaluation aspect of evidence, students do not have the opportunity to improve the way they critically assess the data, so weaknesses in evaluation indicators tend to persist over time.

Another finding that also strengthens the urgency of this research is the use of assessment rubrics that are not optimal. Although teachers have used rubrics as assessment guidelines, they only function as internal references and are not communicated to students. As a result, students do not understand the assessment criteria used and the expected achievement standards, so they cannot reflect and improve their work results independently. In fact, the openness of the assessment rubric to students is very important to encourage the creation of transparent and accountable learning [35]. In the context of the development of Liveworksheet-assisted electronic portfolio assessments, digital rubrics can be embedded directly into the worksheet alongside

each task, and the platform's comment feature can be used to attach short, indicator-specific written feedback to individual student responses. In this way, Liveworksheet supports rubric transparency by making the assessment criteria visible to students before and after they complete an assignment, and supports formative feedback by allowing teachers to explain, rather than merely score, students' work [37]

Overall, the four findings are interrelated and lead to specific product design decisions. The low achievement of evaluation indicators is the basis for the preparation of an essay rubric that explicitly contains the criteria of "the ability to assess the adequacy and validity of measurement data", not just the criterion of "accuracy of final answers". The lack of descriptive feedback is the basis for designing the comment/written feedback feature for each task in Liveworksheet. Meanwhile, the closure of the assessment rubric is the basis for the decision to insert digital rubrics directly on the worksheet, so that students can access the assessment criteria in real-time before and after doing the assignment.

Taken together, these findings indicate that the condition of physics learning at SMAN 1 Sungai Tarab requires innovation in the assessment system. The development of a Liveworksheet-assisted electronic portfolio assessment on measurement materials is considered a relevant and targeted solution to the problems identified in the field. This product has the potential to improve the quality of assessment and to support the sustainable development of students' critical thinking skills in physics learning, although this potential has not yet been empirically confirmed through validation or implementation.

It should be noted that this study has limitations, namely that the preliminary study was only conducted in one class (30 students) in one school, so that the identified needs profile is specific in the context of SMAN 1 Sungai Tarab and cannot necessarily be generalized to the wider student population. In addition, because the development stage in this study was only carried out until the ***development stage*** on the 4D model, the findings regarding the effectiveness of the product in improving students' critical thinking skills in actual time cannot be concluded at this stage and require further research up to the stage of large-scale implementation ***(disseminate)***.

IV. CONCLUSION

This study shows that students' critical thinking skills at SMAN 1 Sungai Tarab remain low overall, that current teacher assessment questions do not reflect critical thinking indicators, and that feedback and assessment rubrics have not been made transparent to students. These findings, obtained through the needs analysis conducted at the *Define* stage of the 4D model, establish the empirical basis for developing a Liveworksheet-assisted electronic portfolio assessment that explicitly integrates critical thinking indicators, a transparent rubric, and continuous feedback on measurement materials. As the product has only been developed and has not yet been validated or implemented in the classroom, the primary contribution of this study at this stage lies in identifying and substantiating this need, rather than in demonstrating improved learning outcomes. Further research is recommended to validate the instrument with experts, trial it with students, and examine its effectiveness in supporting critical thinking skills through to the *Disseminate* stage.

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REFERENCES

[1] K. Shopia, I. Sudarmaji, and P. Purnawati, “Incorporating Thinking Skills and ICT-Competence to Optimize Teachers’ Professional Competence in the 21st Century,” *Indones. J. Community Serv.*, vol. 5, no. 2, p. 228, 2023, doi: 10.30659/ijocs.5.2.228-238.

[2] E. Emiliannur, I. Hamidah, A. Zainul, and A. R. Wulan, “Efektivitas Asesmen Kinerja Untuk Meningkatkan Disposisi Berpikir Kritis Fisika Siswa Sma,” *WaPFi (Wahana Pendidik. Fis.*, vol. 3, no. 1, p. 85, 2018, doi: 10.17509/wapfi.v3i1.10946.

[3] OECD, “PISA 2022 Results Factsheets: Indonesia,” 2023.

[4] R. Ennis, “Critical Thinking: Reflection and Perspective Part II,” *Inq. Crit. Think. Across Discip.*, vol. 26, no. 2, pp. 5–19, 2011.

[5] N. Mediartika and N. Aznam, “Pengembangan instrumen penilaian portofolio berbasis multiple

intelligence untuk mengukur kemampuan berpikir kritis dan sikap ilmiah," *J. Inov. Pendidik. IPA*, vol. 4, no. 1, pp. 52–63, 2018, doi: 10.21831/jipi.v4i1.9973.

[6] T. Permadi and M. Mustangin, "Pengembangan Attitude E-Assessment Pada Pembelajaran Matematika Sekolah Menengah Atas," *JPM J. Pendidik. Mat.*, vol. 1, no. 2, p. 118, 2015, doi: 10.33474/jpm.v1i2.719.

[7] P. Aliya, S. Nurbaeti, A. Firdaus, F. Suparman, and M. Pd, "Efektifitas Penilaian Portofolio dalam Meningkatkan Hasil Belajar Peserta Didik," vol. 11, no. April, pp. 156–165, 2025.

[8] A. Nur Budiono and M. Hatip, "Asesmen Pembelajaran Pada Kurikulum Merdeka," *J. Axioma J. Mat. dan Pembelajaran*, vol. 8, no. 1, pp. 109–123, 2023, doi: 10.56013/axi.v8i1.2044.

[9] A. Ulfa Mawaddah, W. Siswaningsih, and D. Lutvia, "Pengembangan Instrumen Asesmen untuk Meningkatkan Keterampilan Berpikir Kritis pada Materi Kelarutan dan Hasil Kali Kelarutan (Ksp) berbasis E-Portofolio," *J. Ris. dan Prakt. Pendidik. Kim.*, vol. 12, no. 2, pp. 124–136, 2024.

[10] Herwani, "Penilaian Keterampilan Portofolio Dalam," *Cross-border*, vol. 5, no. 1, pp. 12–25, 2022.

[11] N. Hal *et al.*, "Upaya Peningkatan Minat Belajar Sains Fisika di SDN 022 Samarinda Utara Melalui Pelatihan Pengukuran Dasar Samarinda Utara , Kota Samarinda namun listrik PLN telah tersedia 24," vol. 7, no. 4, 2023.

[12] H. C. Barrett, "Researching Electronic Portfolios and Learner Engagement: The REFLECT Initiative," *J. Adolesc. Adult Lit.*, vol. 50, no. 6, pp. 436–449, 2007, doi: 10.1598/JAAL.50.6.2.

[13] M. Masluhah and A. Kiki Rizkiatul, "Electronic Portofolio Sebagai Instrumen Penilaian Pembelajaran Siswa di Era Digital," *J. Basicedu*, vol. 5, no. 5, pp. 3(2), 524–532, 2020, [Online]. Available: https://journal.uii.ac.id/ajie/article/view/971

[14] S. Andriyani, Novi.; Hanafi, Yahya.; Safitri, Irma Y. B.; Hartini, "Penerapan Model Problem Based Learning Berbantuan LKPD Live Worksheet untuk Meningkatkan Keaktifan Mental Siswa pada Pembelajaran Tematik Kelas VA SD Negeri Nogopuro," in *Prosiding Pendidikan Profesi Guru*, 2020, pp. 122–130. [Online]. Available: http://eprints.uad.ac.id/21216/

[15] M. Pabri, R. Medriati, and E. Risdianto, "Uji Kelayakan E-LKPD Berbasis Kontekstual Berbantuan Liveworksheet untuk Melatih Kemampuan Berpikir Kritis di SMA," *J. Ilm. Pendidik. Fis.*, vol. 6, no. 3, p. 637, 2022, doi: 10.20527/jipf.v6i3.6812.

[16] E. Prihandono, T.; Supriyono, A.; Meilina, I. L.; Ernasari, "Penerapan E-LKPD interaktif berbasis problem based learning berbantuan Liveworksheets untuk meningkatkan kemampuan berpikir kritis dan hasil belajar fisika," *J. Pembelajaran Fis.*, vol. 12, no. 3, pp. 114–126, 2023, doi: 10.19184/jpf.v12i3.43462.

[17] M. Annida, S.F.; Putra, A.P.; Zaini, "Pengaruh penggunaan E-LKPD berbasis Liveworksheets terhadap hasil belajar dan keterampilan berpikir kritis peserta didik pada konsep pembelahan sel," *QUANTUM J. Inov. Pendidik. Sains*, vol. 13, no. 2, pp. 155–167, 2022, doi: 10.20527/quantum.v13i2.12111.

[18] N. Linggar Jati, P.; Emiliannur, E.; Winarno, "Pengembangan E-LKPD berbasis problem solving berbantuan Liveworksheet untuk berpikir kritis siswa pada materi termodinamika," *J. MIPA dan Pembelajarannya*, vol. 4, no. 11, pp. 1–10, 2024.

[19] W. Siswaningsih, D. D. Apriani, and L. Ilkmanun, *Development of Electronic Portfolio Assessment Within a Chibernetic Approach Framework to Build Z ' s Generation Critical Thinking Skills in Chemistry Learning*, vol. 2024, no. Ijcse. Atlantis Press International BV, 2024. doi: 10.2991/978-94-6463-626-0.

[20] V. Bella and F. Kristin, "Pengembangan E-LKPD Berbasis Liveworksheet Untuk Meningkatkan Kemampuan Berpikir Kritis dalam Pembelajaran IPAS Materi Letak Geografis Wilayah Indonesia Kelas V SD," *JIIP - J. Ilm. Ilmu Pendidik.*, vol. 7, no. 9, pp. 10677–10682, 2024, doi: 10.54371/jiip.v7i9.5473.

[21] S. S. Evriliani, A. S.; Nahadi; Fatimah, "Pengembangan asesmen portofolio elektronik berbasis konten kreatif STEM untuk menilai penguasaan konsep dan berpikir kreatif siswa pada materi asam basa," Universitas Pendidikan Indonesia, 2025.

[22] A. Astagisa, R.; Malik, "Systematic literature review (SLR): Pengembangan asesmen formatif untuk mendukung pembelajaran fisika dalam kerangka Kurikulum Merdeka," *J. Media Akad.*, 2025.

[23] Okpatrioka, "Research And Development (R&D) Penelitian Yang Inovatif Dalam Pendidikan," *Dharma Acariya Nusant. J. Pendidikan, Bhs. dan Budaya*, vol. 1, no. 1, pp. 86–100, 2023, doi: 10.47861/jdan.v1i1.154.

[24] A. O. W. Maut, "Pentingnya Asesmen Diagnostik dalam Implementasi Kurikulum Merdeka (IKM) di SD Negeri Tongkuno Kecamatan Tongkuno Kabupatem Muna Sulawesi Tenggara," *J. Pendidik. Masy. dan Pengabdi.*, vol. 02, no. 4, pp. 1305–1312, 2022, [Online]. Available: http://ejurnal.pps.ung.ac.id/index.php/dikmas%0AAsesmen

[25] M. I. Thiagarajan, S.; Semmel, Dorothy S.; Semmel, *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook*. Bloomington, Indiana: Leadership Training Institute/Special

Education, University of Minnesota, 1974.
[26] P. G. Subhaktiyasa, "Evaluasi Validitas dan Reliabilitas Instrumen Penelitian Kuantitatif: Sebuah Studi Pustaka," *J. Educ. Res.*, vol. 5, no. 4, pp. 5599–5609, 2024, doi: 10.37985/jer.v5i4.1747.
[27] Sugiyono, *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta, 2017.
[28] R. Putri Aruna, Emiliannur, and N. Winarno, "EFEKTIFITAS MODEL PEMBELAJARAN TEAM GAME TOURNAMENT (TGT) MENINGKATKAN BERPIKIR KRITIS SISWA Kata kunci Keywords," vol. 4, no. 12, p. 2024, 2024, doi: 10.17977/um067.v4.i12.2024.2.
[29] S. M. Sofi'atun, Supriyono, P., Suneki, H., & Sri, "Pemanfaatan Liveworksheet Sebagai Media Pembelajaran Berbasis Literasi Pada Mata Pelajaran Pendidikan Pancasila di SMK Negeri 7 Semarang," vol. 5, no. 3, pp. 1–23, 2022.
[30] P. Sarip, Nurazizah; Kaharuddin; Palloan, "Analisis Keterampilan Berpikir Kritis Peserta Didik Kelas X di SMAN 10 Makassar," *J. Sains dan Pendidik. Fis.*, vol. 18, no. 3, pp. 291–299, 2022, doi: 10.35580/jspf.v18i3.31668.
[31] P. A. Facione, "Critical Thinking for Life," *Inq. Crit. Think. Across Discip.*, vol. 28, no. 1, pp. 5–25, 2011, doi: 10.5840/inquiryct20132812.
[32] V. M. Hernández Rivero, P. J. S. Bonilla, and J. J. S. Alonso, "Feedback and self-regulated learning in higher education," *Rev. Investig. Educ.*, vol. 39, no. 1, pp. 227–248, 2021, doi: 10.6018/RIE.423341.
[33] I. Itaristanti, "Portofolio Sebagai Salah Satu Model Penilaian Otentik Di Sd/Mi," *Al Ibtida J. Pendidik. Guru MI*, vol. 3, no. 2, p. 212, 2016, doi: 10.24235/al.ibtida.snj.v3i2.904.
[34] J. M. Olson and R. Krysiak, "Rubrics as tools for effective assessment of student learning and program quality," *Curric. Dev. Online Instr. 21st Century*, no. January 2021, pp. 173–200, 2021, doi: 10.4018/978-1-7998-7653-3.ch010.
[35] O. Altintas, "The use of open-ended items for giving feedback during the formative assessment process," *Int. J. Assess. Tools Educ.*, vol. 9, no. Special Issue, pp. 109–125, 2022, doi: 10.21449/ijate.1132981.
[36] P. Sarip, Nurazizah, Kaharudin A., & Pariabti, "Analisis Keterampilan Berpikir Kritis Peserta Didik Kelas X," *J. Sains dan Pendidik. Fis.*, vol. 18, no. 3, pp. 291–299, 2022, [Online]. Available: http://ojs.unm.ac.id/jsdpf
[37] R. Olson, Jacqueline M.; Krysiak, "Rubrics as Tools for Effective Assessment of Student Learning and Program Quality," IGI Global, 2021, pp. 173–20. doi: 10.4018/978-1-7998-7653-3.ch010.