PILLAR OF PHYSICS EDUCATION
Vol. 19 (1), 2026, page.216-230
ISSN (Print) : 2337-9618
ISSN (Online) : 2684-8880

NEEDS ANALYSIS TO DEVELOP E-STUDENT WORKSHEET INTEGRATED JOYFUL LEARNING AND LOCAL WISDOM TO PROMOTE STUDENTS' CREATIVE THINKING AND COMMUNICATION SKILLS

Fadillah Reza Agustin[1], Asrizal[1*], Harman Amir[1], Emiliannur[1]

[1] *Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia*
Corresponding author. Email: asrizal@fmipa.unp.ac.id

ABSTRACT

Creative thinking and communication skills are 21st century competencies that need to be facilitated through contextual and technology-based teaching materials, but the student worksheets used in schools may not fully support them. This study analyzes the need for developing an E-Student Worksheet on measurement that integrates joyful learning with local wisdom, and it is limited to the define stage of Thiagarajan's 4D model. Data were collected from 30 class X students and one physics teacher at SMA Negeri 1 Padang Sago at the beginning of the odd semester of 2026, using four instruments validated by expert supervising lecturers, namely a creative thinking essay test, a written communication essay test, a questionnaire on perceived mastery of measurement, and a context analysis instrument, and were analyzed descriptively. According to the teacher's rating, the suitability of the school worksheet to the ideal E-Student Worksheet was 42.5%, with the flexible and interactive indicators as the lowest. Students' creative thinking and written communication reached values of 57.5 and 58.0, and their perceived mastery of measurement reached 56.0%, all in the poor category, with 18 of the 30 students in the very poor category on all three measurements. The findings are limited to one school and do not test the effectiveness of the product, but they provide a basis for designing an interactive and mobile-accessible E-Student Worksheet that uses Minangkabau local wisdom.

Keywords :*needs analysis, E-Student Worksheet, measurement, joyful learning, local wisdom, creative thinking and communication.*

Pillar of Physics Education is licensed under a Creative Commons Attribution ShareAlike 4.0 International License.

I. INTRODUCTION

Global developments require students to master 21st century skills known as the 4C skills, namely critical thinking, creativity, communication, and collaboration [1]. Science teaching materials that are designed to develop these skills have been reported to improve students' 21st-century skills [2]. Creativity, critical thinking, communication, and collaboration are also regarded as core competencies that need to be assessed and promoted systematically for the future of work and education [3]. Among the four, creative thinking skills and communication skills have a strategic role in physics learning. Creative thinking skills include the ability to generate many ideas, think flexibly, originally, and elaborate ideas, so that students are able to analyze natural phenomena and relate them to scientific concepts. The development of appropriate teaching materials is reported to improve students' creative thinking skills [4]. Meanwhile, communication skills are the ability to convey thoughts, ideas, and information to others through oral, writing, symbols, images, graphs, or numbers [5]. In physics, both skills can be trained through observing phenomena, measuring, analyzing data, and reporting results scientifically. For this reason, creative thinking and communication skills were selected as the target skills of this study, because both can be observed directly in measurement tasks, namely in designing measuring instruments and in reporting measurement results.

The 21st century learning is associated with a shift from teacher-centered learning to student-centered learning, as in ICT-integrated contextual learning that involves students actively and aims to improve their learning outcomes [6]. UNESCO emphasizes that education needs to focus on competencies relevant to global challenges, including adaptability, critical thinking, creativity, communication, and collaboration [7]. In Indonesia, the Independent Curriculum provides flexibility for schools and teachers to design learning that suits the needs and characteristics of students [8]. In line with that, the deep learning approach was introduced as a strategy to increase students' thinking capacity holistically through three pillars, namely mindful learning, meaningful learning, and joyful learning [9].

Information and communication technology, abbreviated as ICT, allows for the creation of an interactive, flexible, and adaptive learning environment because learning resources can be accessed anytime and anywhere [10]. Fahlevi and Asrizal report that ICT-based e-modules are effective in improving students' science process skills in online learning [11]. One form of ICT-based teaching material is the electronic student worksheet, which is referred to as the E-Student Worksheet in this article. Teaching materials are all forms of materials, both written and unwritten, that teachers use in carrying out learning [12], while the E-Student Worksheet is designed to facilitate students' learning activities in an interactive and independent manner [13]. Liveworksheet-assisted E-Student Worksheets are reported to improve science learning outcomes [14] and to support students' interest in learning [15].

Physics learning will be more meaningful if abstract concepts are associated with the context that students know. Joyful learning creates a conducive and fun learning atmosphere so that students can learn optimally without feeling pressured [16]. Local wisdom, on the other hand, bridges the concept of physics with the phenomena and culture around students so that learning becomes more contextual [17], [18]. In measurement material, the context is relevant because traditional units and measuring tools are known in Minangkabau culture, namely the depa for arm span, the hasta for forearm length, and the jengkal for hand span in length measurement, the kati and pikul for mass, and the dacin as a traditional balance. The hasta, for example, is reported as a unit used in building the Rumah Gadang [19]. This study does not measure whether students already know these units, and they are proposed only as a context for the product. Measurement is also the basis of scientific work in physics because all physical quantities are expressed through measurement results, so that mastery of this material supports future physics learning.

However, the learning conditions in the field have not been fully in line with these expectations. Analysis of high school physics teaching media and materials in West Sumatra shows that teachers have not made much use of ICT-based media, even though 21st century learning requires them so that students can practice 4C skills [20]. This limited use of ICT-based media means that students have few opportunities to explore physics concepts interactively and to communicate their ideas through digital learning activities. An earlier study in North Sumatra also reported that the creative thinking skills of high school students were relatively low [21], so current data from the research school are needed. Therefore, teaching materials that integrate technology and encourage students to generate ideas and communicate them are needed to close the gap between the expectation and the condition in the field.

Research on the development of E-Student Worksheets in physics learning has actually been conducted. Rahma and Asrizal developed an Ethno-PBL integrated fluid E-Student Worksheet using the 4D model and reported a product that is valid and practical for encouraging knowledge and creative thinking skills [22], but it has not integrated joyful learning and has not measured communication skills. Hayati et al. developed a measurement E-Student Worksheet for class X based on a scientific approach with a validity of 89.7%, which is categorized as very valid [23], but it does not contain joyful learning and local wisdom. Hizbi et al. developed an E-Student Worksheet based on the local wisdom of woven bamboo [24] and Shalsabilla et al. developed a student worksheet based on the local wisdom of Javanese gamelan to facilitate student involvement [25], but both have not specifically targeted creative thinking and communication skills. Meanwhile, Putri et al. analyzed the need for an E-Student Worksheet on temperature and heat based on problem-based learning and integrated with local wisdom to improve students' problem-solving skills, but that study has not reached product development [26]. Several international studies also report that teaching materials and learning models integrated with local wisdom or ethnoscience can support students' creative thinking, critical thinking, and character, for example Ethno-STEM project-based learning [27], physics teaching materials based on local wisdom [28], a local wisdom-based interactive digital module [29], and an ethnoecological STEM project-based learning model [30]. Thus, among the studies reviewed in this article, studies that combine joyful learning and local wisdom in E-Student Worksheets on measurement material to facilitate both skills are still limited.

The research gap addressed in this study lies in the combination of three elements in one E-Student Worksheet on measurement material, namely first, joyful learning that presents a fun learning atmosphere through interactive activities; second, Minangkabau local wisdom in the form of traditional units and measuring tools, such as depa, hasta, jengkal, kati, and dacin; and third, dual goals in the form of creative thinking skills and communication skills. In contrast to previous research which generally focused on one or two of these elements [26], this study began the development of a needs analysis that captures the gap in teaching materials as well as students' initial abilities in both skills. The results of this analysis are expected to be an empirical basis for the design of an E-Student Worksheet that connects abstract measurement concepts with students' cultural experiences.

The development of a product that is right on target begins with a comprehensive needs analysis. Thiagarajan's 4D model places the analysis at the define stage [31]. The research problem is formulated as how to develop an E-Student Worksheet on measurement that integrates joyful learning with local wisdom to facilitate students' creative thinking skills and communication skills. This study aims to analyze five aspects: the gap between the ideal E-Student Worksheet and the student worksheet used in schools, students' creative thinking skills, students' written communication skills, students' understanding of measurement materials, and the concept of measurement materials, including the relevant Minangkabau local wisdom context and the learning objectives that need to be achieved. The results of the analysis became the basis for the design of the E-Student Worksheet at the design and development stages. The need for joyful learning and local wisdom is adopted from the literature as design principles and is not tested by this needs analysis.

II. METHOD

This research is part of Research and Development, abbreviated as R&D, which is a method used to research, design, produce, and test the validity of a product [32]. The development model used is the Thiagarajan 4D model which consists of four stages, namely define, design, develop, and disseminate [31]. The overall research is limited to the define, design, and develop stages with validity and practicality tests, while the disseminate stage is not carried out due to time constraints. This article reports only the define stage, which is the analysis of needs before the product is designed. This restriction is based on the consideration that mistakes in identifying needs will affect the entire subsequent development process, so the needs analysis needs to be reported separately and completely. The planned product is an E-Student Worksheet on measurement that integrates joyful learning with local wisdom for high school students in grade X.

The research was carried out at SMA Negeri 1 Padang Sago at the beginning of the odd semester of 2026, which is the semester in which measurement material is taught in class X. The object of the research is the need for developing an E-Student Worksheet on measurement that integrates joyful learning with local wisdom. The needs analysis subjects consisted of 30 students in class X coded S1 to S30, who took the tests and questionnaires, and one physics teacher, coded G1, who was the respondent of the E-Student Worksheet context analysis instrument. The school was chosen purposively based on the consideration of ease of access because the researcher had carried out field teaching practice at SMA Negeri 1 Padang Sago, so this is a convenience choice and the results are not intended to be generalized. The student subjects were determined by a saturated sampling technique, namely all 30 students of one intact class X, while the teacher respondent was the one physics teacher who taught the class. The research was carried out after obtaining permission from the school. The identity of the respondents was kept confidential using codes, and the results obtained were only used for research purposes. According to the information from the teacher, the students' devices are generally adequate, the internet access at school is fairly good, and the school laboratory has Wi-Fi that can be used when the E-Student Worksheet is applied.

The define stage was carried out through five activities, namely front-end analysis, learner analysis, task analysis, concept analysis, and specifying instructional objectives [31]. Each activity has a different focus of analysis and is supported by specific instruments and data sources. Front-end analysis examines the gap between the ideal and the actual E-Student Worksheet, learner analysis examines students' creative thinking and written communication skills, and task analysis examines the tasks that students must master, while concept analysis and specifying instructional objectives examine the measurement concepts and the learning objectives to be achieved. The relationship of each activity to its focus of analysis and the data collected is presented in Table 1.

Table 1. Stage Activities Define and Data Collected

No	Define Activities	Focus Of Analysis	Data and Instruments
1	Front-end analysis	The gap between the ideal E-Student Worksheet and the student worksheet used by teachers in schools	E-Student Worksheet context analysis instrument with 32 items grouped into 5 ideal indicators, filled out by one physics teacher

No	Define Activities	Focus Of Analysis	Data and Instruments
2	Learner analysis	Creative thinking skills and written communication skills of class X students	Creative thinking essay test with 4 questions and written communication essay test with 3 questions, administered to 30 students
3	Task analysis	The ideal and actual conditions of the tasks that students must master in measurement material	Questionnaire on perceived mastery with 35 statements across 7 subtopics, administered to 30 students
4	Concept analysis	Physics concepts of measurement assessed with five criteria of a good concept and the relevant context of Minangkabau local wisdom	Literature review and task analysis results
5	Specifying instructional objectives	Learning objectives formulated with four components, namely audience, behavior, condition, and degree, and compared with the objectives in the teacher module	Analysis of the teacher module and synthesis of the results of activities 1 to 4

Source: [31]

Four instruments were used in this study, as presented in Table **2**. The creative thinking test was arranged based on four components according to Cummings and Blatherwick [33] with the discourse "Minangkabau Traditional Measurement System in Daily Life", which contained depa, hasta, jengkal, kati, pikul, and dacin. The written communication test was arranged based on three components according to Medriati and Risdianto [34] with the discourse "Tabuik Festival and Measurement in the Minangkabau Cultural Tradition". Each answer was assessed using rubrics on a scale of 1 to 5. The context analysis instrument compared the characteristics of the ideal E-Student Worksheet with the student worksheet used in schools on a scale from 1, which means very inappropriate, to 5, which means very appropriate. The questionnaire used a Likert scale from 1, which means strongly disagree, to 5, which means strongly agree.

Table 2. Data Collection Instruments

Instruments	Respondents	Number of Items	Components or Indicators	Scale
Creative thinking test	30 students	4 Essay Questions	Fluency, flexibility, originality, and elaboration [33]	Scores from 1 to 5
Written communication test	30 students	3 Essay Questions	Systematics/format, use of language, and completeness of content [34]	Scores from 1 to 5
E-Student Worksheet context analysis	1 physics teacher	32 items	Five ideal indicators formed from eight aspects of four items each: self-contained; stand-alone; interactive; multimedia; and flexible	Scores from 1, very inappropriate, to 5, very appropriate
Questionnaire on perceived mastery of measurement	30 students	35 Statements	Seven subtopics with five statements each: the nature of measurement; quantities and units; dimensions of quantities; measuring instruments; measurement uncertainty; significant figures; and scientific notation	Likert scale from 1, strongly disagree, to 5, strongly agree

Source: Research instruments

The E-Student Worksheet context analysis instrument was filled out by the physics teacher, while the creative thinking test, written communication test, and measurement questionnaire were completed by the students. All four instruments were arranged by the authors and validated by expert judgment of the supervising lecturers in physics education, who examined the suitability of the content, the construct, and the language and gave suggestions that were used to revise the instruments before data collection. The context analysis instrument was arranged from five ideal characteristics of the E-Student Worksheet, namely self-contained, stand-alone, interactive, multimedia, and flexible, which were set based on the advice of the supervising lecturers and elaborated into eight aspects of four items each, giving 32 items. The self-contained indicator merges the aspects of suitability with student characteristics, materials, and objectives and of continuous learning, while the stand-alone indicator corresponds to clear language and narrative. The interactive indicator merges interactive presentation and accommodation of learning styles, the multimedia indicator corresponds to attractive appearance, and the flexible indicator merges suitability with supporting facilities and support for the virtual learning environment. The two

essay tests were scored with analytic rubrics that have descriptors for each score from 1 to 5, and the questionnaire statements were arranged from the seven subtopics of measurement material. Reliability coefficients and inter-rater agreement were not calculated in this study. The five criteria of a good physics concept used in the concept analysis, namely meaningful and clear, supported by facts, consistent and logical, interrelated, and formal and analytical, were adapted by the authors from the principles of meaningful learning and concept organization, in which concepts are clarified with examples and linked through propositions and cross-links [35], and they were checked by the supervising lecturers. The learning objectives in the teacher module were analyzed by scoring the four components of an objective, namely audience, behavior, condition, and degree, on a scale from 0, which means not stated, to 4, which means stated completely and measurably.

The data were analyzed in a quantitative descriptive manner and presented in the form of tables, percentages, and values. The scores obtained were converted to percentages using Equation 1, and the overall percentage of each instrument was calculated from the total scores in the same way. For the creative thinking test and the written communication test, the percentage was reported as a value on a scale of 0 to 100. The ideal maximum score was calculated from the number of respondents, the number of items, and the maximum score per item, which is 5, and it is used as a reference point for describing the gap, not as a realistic level of attainment. Therefore, the ideal maximum score was 150 for each test question, 20 for each indicator formed from one aspect of four items and 40 for each indicator formed from two aspects of eight items in the context analysis, and 750 for each subtopic of the questionnaire, calculated as 30 students multiplied by 5 statements multiplied by 5. The percentages were rounded to the nearest integer before being interpreted by category in Table 3 [36]. These categories refer to achievement scores and are applied here descriptively to the Likert-based results, whose minimum possible percentage is 20%, so they should be read as a general guide. For the learning objectives, the ideal value was set at 76, the lower limit of the good category, because the objectives state the level of achievement that students are expected to reach.

$$P = \frac{\Sigma \text{ obtained score}}{\Sigma \text{ maximum score}} \times 100\% \quad (1)$$

Where P is the percentage of the score, Σ obtained score is the sum of the scores obtained by the respondents, and Σ maximum score is the highest total score that can be achieved.

Table 3. Category Interpretation Score Percentage

Interval in percent	Category
86–100	Excellent
76–85	Good
60–75	Fair
55–59	Poor
≤ 54	Very poor

Source: [36]

III. RESULTS AND DISCUSSION

Results

Table 4 presents the results of the front-end analysis, which compares the ideal E-Student Worksheet with the student worksheet used in schools. The comparison reflects the view of one physics teacher, who rated the printed, non-digital student worksheet used in class X through 32 items that cover eight aspects. Because the eight aspects overlap in meaning, they were merged into five ideal indicators, namely self-contained, stand-alone, interactive, multimedia, and flexible. The table reports the number of items, the actual score, the ideal score, the percentage, and the category of each indicator.

Overall, the suitability of the student worksheet used in schools to the ideal E-Student Worksheet reached only 42.5%, which was calculated from an actual score of 68 out of an ideal score of 160 and falls in the very poor category. Only the self-contained indicator reached the fair category at 60.0%, while the stand-alone indicator was poor at 55.0%, and the multimedia, interactive, and flexible indicators were very poor at 50.0%, 35.0%, and 22.5%. The flexible indicator, which covers suitability with supporting facilities and support for the virtual learning environment, was the weakest, and its actual score of 9 out of 40 shows that the worksheet can hardly be accessed anytime and anywhere. At the item level, 9 of the 32 items, or 28.1%, received a score of 1, no item received a score of 5, and only one item received a score of 4, and all nine items with a score of 1 belong to the interactive and flexible indicators. These findings answer the first research objective by showing a gap of 57.5 percentage

points between the ideal condition and the teacher's rating of the worksheet used in schools. Because the worksheet is not digital, low scores on the interactive, multimedia, and flexible indicators are partly expected, so the result confirms the need for a digital worksheet and is not a judgment of the teacher's worksheet.

Table 4. Results of the Front-End Analysis of the Ideal E-Student Worksheet and the Student Worksheet Used in Schools

Ideal Indicator	Items	Actual Score	Ideal Score	Percentage	Category
Self-contained	8	24	40	60.0%	Fair
Stand-alone	4	11	20	55.0%	Poor
Interactive	8	14	40	35.0%	Very poor
Multimedia	4	10	20	50.0%	Very poor
Flexible	8	9	40	22.5%	Very poor
Overall	**32**	**68**	**160**	**42.5%**	**Very poor**

Source: Research data from respondent G1

Figure 1 presents the percentage of suitability of the five ideal indicators in a bar chart so that the indicators can be compared directly. In the chart, SC stands for self-contained, SA for stand-alone, IN for interactive, MM for multimedia, and FL for flexible. The gray bar shows the overall average of 42.5%, which serves as the reference for judging whether an indicator is above or below the average. The chart is based on the same data as Table 4 and therefore visualizes the pattern of suitability across the five indicators.

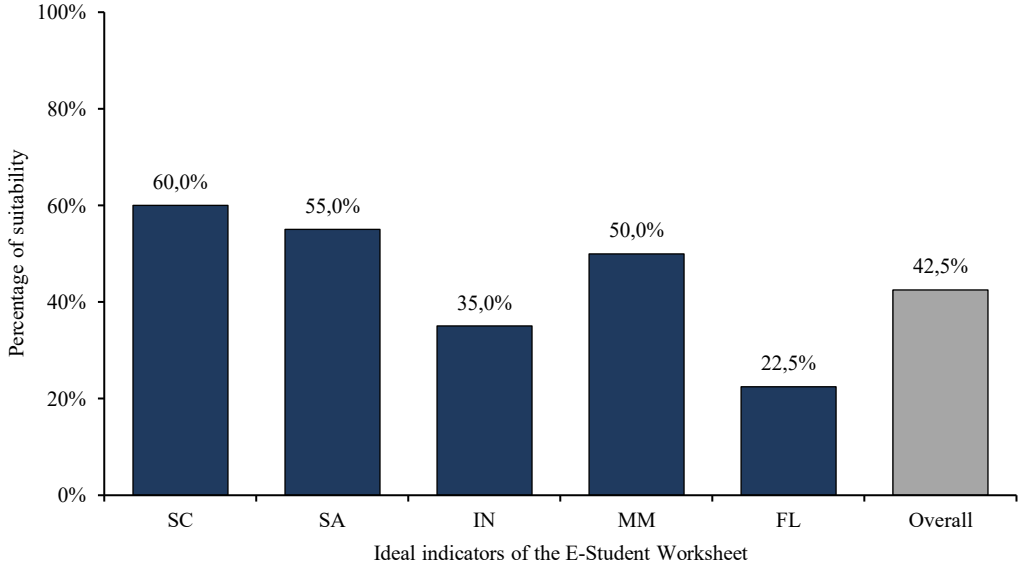


Figure 1. Percentage of suitability of the student worksheet used in schools to the ideal E-Student Worksheet on five ideal indicators. The gray bar shows the overall average.

Two indicators, namely interactive and flexible, fall below the overall average of 42.5%, while the other three indicators are above it. The highest bar belongs to the self-contained indicator at 60.0%, and the lowest bar belongs to the flexible indicator at 22.5%, so the spread between them is 37.5 percentage points. The mean of the two technology-dependent indicators, interactive and flexible, is 28.8%, which is 27.5 percentage points lower than the mean of 56.3% for the other three indicators. This pattern confirms that the largest gap lies in the features that depend on digital technology, whereas the indicators related to content and appearance are closer to the poor and fair categories. Therefore, the transformation from a conventional worksheet into a digital, interactive, and flexible E-Student Worksheet is the most urgent need identified in the front-end analysis.

Table 5 presents the results of the creative thinking test taken by 30 students on four indicators according to Cummings and Blatherwick [33]. The test consisted of four essay questions, and each question represents one indicator, namely fluency, flexibility, originality, and elaboration. Each answer was scored from 1 to 5 using a rubric, so the maximum score for each indicator was 150. The table reports the total score, the value on a scale of 0 to 100, and the category of each indicator.

Table 5. Results of the Student Creative Thinking Skills Test

Indicator	Questions	Total Score	Max.Score	Value	Category
Fluency	1	88	150	58.7	Poor
Flexibility	2	88	150	58.7	Poor
Originality	3	85	150	56.7	Poor
Elaboration	4	84	150	56.0	Poor
Overall	**1–4**	**345**	**600**	**57.5**	**Poor**

Source: Research data from 30 students

The average creative thinking value of the students was 57.5, calculated from 345 out of 600 possible scores, which falls in the poor category. Fluency and flexibility obtained the highest value at 58.7, followed by originality at 56.7 and elaboration at 56.0, so the difference between the highest and the lowest indicator was only 2.7 points. The indicators that concern the quantity and variety of ideas, namely fluency and flexibility, were slightly higher than those that concern the quality and depth of ideas, namely originality and elaboration, although the difference is small and was not tested statistically. However, the class average does not represent most students, because 18 students, or 60.0%, obtained a value of 40, with a score of 2 on all four questions, while the other 12 students, or 40.0%, obtained values from 80 to 90. Specifically, six students obtained 80, three students obtained 85, and three students obtained 90, and no student obtained a value between 41 and 79. This bimodal distribution produced a standard deviation of 22.0, so the class average of 57.5 does not represent most students, and the identical values of the 18 students arise because the rubric uses discrete descriptors, so answers that meet the same descriptor receive the same score. Therefore, the result answers the second research objective by showing one large group with very poor creative thinking and one smaller group with good to excellent creative thinking.

Table 6 presents the results of the written communication test taken by 30 students on three components according to Medriati and Risdianto [34]. The test consisted of three essay questions, and each question represents one component, namely systematics or format, language use, and completeness of content. Each answer was scored from 1 to 5 using a rubric, so the maximum score for each component was 150. The table reports the total score, the value on a scale of 0 to 100, and the category of each component.

Table 6. Student Written Communication Skills Test Results

Components	Questions	Total Score	Max. Score	Value	Category
Systematic/format	1	90	150	60.0	Fair
Language use	2	87	150	58.0	Poor
Completeness of content	3	84	150	56.0	Poor
Overall	**1–3**	**261**	**450**	**58.0**	**Poor**

Source: Research data from 30 students

The average written communication value of the students was 58.0, calculated from 261 out of 450 possible scores, which falls in the poor category. Systematics or format obtained the highest value at 60.0, which falls in the fair category, followed by language use at 58.0 and completeness of content at 56.0. The gap of 4.0 points between the highest and the lowest component is larger than the gap of 2.7 points among the creative thinking indicators, and it suggests, with caution because the difference is small and was not tested statistically, that students organize ideas slightly more easily than they express them completely. A score of 1 appeared only on question 2, for two students, and on question 3, for four students, which is consistent with completeness of content having the lowest value. In terms of the total score, 18 students, or 60.0%, obtained a total of 5 or 6 out of 15, while 12 students, or 40.0%, obtained a total of 12 to 15. The 12 students in the high group were the same students as in the creative thinking test, with a Pearson correlation coefficient of 0.99 between the two sets of scores, and this result answers the third research objective by showing that the same group of 18 students is very poor in both creative thinking and written communication.

Table 7 presents the results of the task analysis. In the define stage, the task analysis identifies the main skills and subskills that students must master [31], which in this study were the seven subtopics of measurement material. Students' perceived mastery of each subtopic was measured by a questionnaire of 35 statements, with five statements for each subtopic, completed by 30 students. The table reports the actual score, the ideal score, the percentage, and the category of each subtopic, with the ideal set at the maximum score.

Table 7. Task Analysis: Perceived Mastery of the Measurement Subtopics

Task Subtopic	Statement No.	Actual Score	Ideal Score	Percentage	Category
The essence of measurement	1–5	398	750	53.1%	Very poor
Quantities and units	6–10	431	750	57.5%	Poor
Dimensions of quantities	11–15	431	750	57.5%	Poor
Measuring instruments	16–20	432	750	57.6%	Poor
Measurement uncertainty	21–25	430	750	57.3%	Poor
Significant figures	26–30	426	750	56.8%	Poor
Scientific notation	31–35	390	750	52.0%	Very poor
Overall	**1–35**	**2,938**	**5,250**	**56.0%**	**Poor**

Source: Research data from 30 students

The overall actual score was 2,938 out of an ideal score of 5,250, which gives a percentage of 56.0% and falls in the poor category. No task reached the fair category, and the percentages ranged narrowly from 52.0% to 57.6%, so every subtopic was far below the ideal reference score. Scientific notation at 52.0% and the essence of measurement at 53.1% were the two lowest subtopics and both fall in the very poor category, although five of the seven subtopics lie between 56.8% and 57.6%, so the differences among most subtopics are small. At the statement level, 4 of the 35 statements fell in the fair category, 20 in the poor category, and 11 in the very poor category. The highest statements, at 60.0% to 61.3%, concerned measurement procedures, unit conversion, dimensional reduction, and the use of calipers, whereas the lowest statements, at 48.0% to 51.3%, concerned calculations with scientific notation, awareness of uncertainty, combining significant figures with scientific notation, and distinguishing direct from indirect measurements. This contrast suggests that students perceived themselves as more capable in procedural statements than in conceptual ones, which answers the fourth research objective in terms of perceived mastery and not of tested mastery.

Table 8 presents the distribution of the 30 students across the five categories on the creative thinking test, the written communication test, and the measurement questionnaire. The categories follow the interval criteria in Table 3, and each cell reports the number of students and the corresponding percentage. This distribution is presented because the class averages in the previous tables may hide differences among individual students. The table therefore shows how many students fall into each performance category on every instrument.

Table 8. Distribution of Students by Category on Three Measurements

Category	Interval in percent	Creative Thinking		Written Communication		Measurement Questionnaire	
		n	%	n	%	n	%
Excellent	86–100	3	10.0	11	36.7	0	0.0
Good	76–85	9	30.0	1	3.3	8	26.7
Fair	60–75	0	0.0	0	0.0	4	13.3
Poor	55–59	0	0.0	0	0.0	0	0.0
Very poor	≤ 54	18	60.0	18	60.0	18	60.0
Total		**30**	**100.0**	**30**	**100.0**	**30**	**100.0**

Source: Research data from 30 students, where n is the number of students

A total of 18 students, or 60.0%, were in the very poor category on all three measurements, and they were the same students on the creative thinking test, the written communication test, and the measurement questionnaire. The remaining 12 students were distributed in the upper categories, namely 3 excellent and 9 good students on the creative thinking test, 11 excellent and 1 good student on the written communication test, and 8 good and 4 fair students on the questionnaire. No student fell in the fair or poor category on either test, which shows that the class is divided into two clearly separated groups rather than spread evenly across the categories. The questionnaire is the only instrument in which students appeared in the fair category, and none of the students reached the excellent category, which may indicate that students rated their own mastery of the material more cautiously than their performance on the essay tests. The identical composition of the lowest group across the three instruments indicates that difficulties in creative thinking, written communication, and measurement material may be related to each other. Therefore, the learning design needs to provide differentiated support so that students in the lowest group are helped without holding back students who are already capable.

Figure 2 presents the results of the concept analysis of the measurement material in physics in a bar chart, with the indicators on the horizontal axis and the values on the vertical axis. The analysis used five criteria of a good physics concept, which were checked by the supervising lecturers and abbreviated as MC for meaningful and clear, SB for supported by facts, CL for consistent and logical, IR for interrelated, and FA for formal and analytical. The value of each criterion is the mean of the percentages of the related subtopics in Table 7, namely quantities and units together with the essence of measurement for MC, measuring instruments for SB, dimensions

of quantities for CL, measurement uncertainty for IR, and significant figures together with scientific notation for FA. The mapping of subtopics to criteria was proposed by the authors, so the chart regroups the data of Table 7 and should be read as an illustration of how far each criterion is reflected in the school condition.

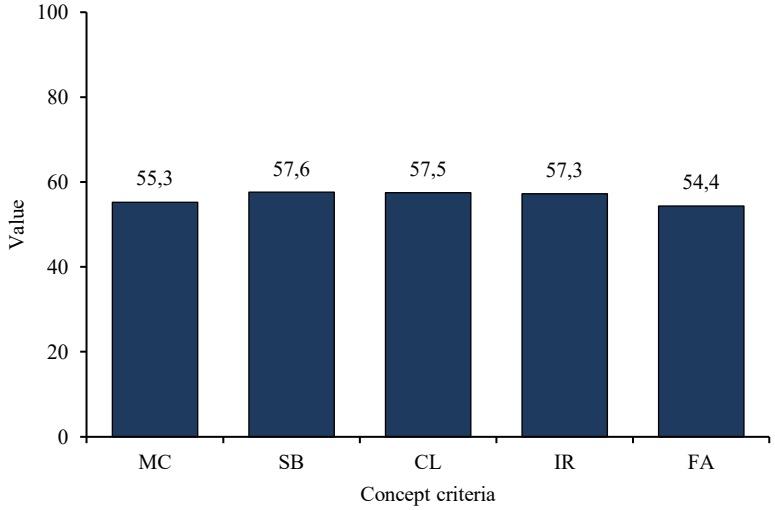


Figure 2. Values of the five concept criteria of the measurement material. Each value is the mean of the percentages of the related subtopics in Table 7.

Figure 2 shows that the five criteria of a good physics concept are not yet fulfilled at the school, because the values range only from 54.4 to 57.6, which fall in the poor and very poor categories. The lowest value belongs to the criterion of formal and analytical at 54.4, followed by meaningful and clear at 55.3, which are pulled down by scientific notation at 52.0% and the essence of measurement at 53.1%. The criteria of supported by facts, consistent and logical, and interrelated have slightly higher values at 57.6, 57.5, and 57.3, but the strongest statements of students concern procedures rather than the reasons behind them. The criterion of interrelated concepts is also reflected in the low statements on awareness of uncertainty and on distinguishing direct from indirect measurements, which indicates that students do not yet connect uncertainty, types of measurement, and significant figures into one structure. Each criterion could be linked to a Minangkabau local wisdom context proposed by the authors, namely depa, hasta, and jengkal for meaning, the dacin for facts, rice fields and traditional measures for derived quantities, body-based units for uncertainty, and tabuik size data for formal reporting. These links are proposals that still need to be validated by cultural experts, and they address the concept part of the fifth research objective as a basis for formulating the learning objectives.

The authors proposed six learning objectives based on the results of the front-end, learner, task, and concept analyses for students of class X. Each objective is formulated with four components, namely audience, behavior, condition, and degree. First, through activities with depa, hasta, jengkal, kati, and pikul in the E-Student Worksheet, students are able to distinguish base and derived quantities, determine their dimensions, and convert traditional units into SI units with a value of at least 76. Second, using the dacin for mass and simple calipers, measuring tapes, and protractors for length and angle, students are able to select and use measuring instruments according to the required accuracy with a value of at least 76. Third, by comparing body-based units that differ between users, students are able to explain the sources of measurement uncertainty and to distinguish direct from indirect measurement with a value of at least 76. Fourth, in a short report based on tabuik size data, students are able to report measurement results with significant figures and scientific notation with a value of at least 76. Fifth, through an open-ended design challenge inspired by the dacin, students are able to generate, vary, and elaborate ideas for a simple measuring instrument with a creative thinking value of at least 76. Sixth, using a report framework and scientific vocabulary, students are able to communicate measurement results in writing with complete systematics, language, and content with a written communication value of at least 76. The minimum value of 76 is an assumed target based on the lower limit of the good category, and the objectives are presented as a proposed design.

Figure 3 presents the actual value of each of the four components of a well-formulated learning objective in the teacher module used at the school, with the components on the horizontal axis and the values on the vertical axis. The components are abbreviated as AU for audience, BE for behavior, CO for condition, and DE for degree. The actual value was obtained by scoring each component in the module on a scale from 0 to 4 and converting the score to a value on a scale of 0 to 100, and it is read against the ideal value of 76, which is the lower limit of the good category in Table 3. The module analyzed was the physics module on work and energy for class XI used by

the teacher, which is a different topic and grade level and is therefore used only as an illustration of how learning objectives are written in a teacher module.

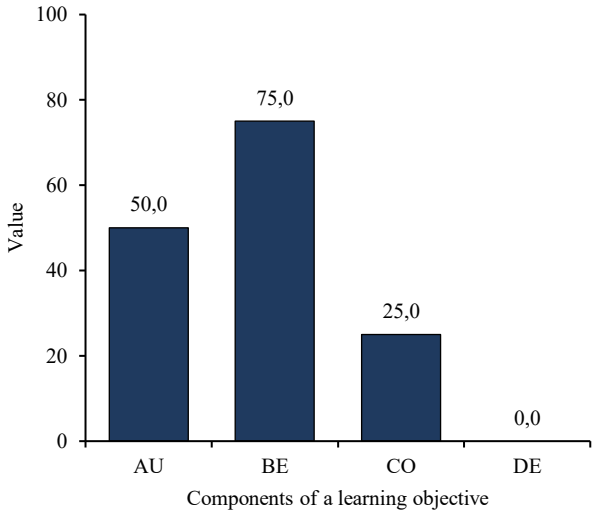


Figure 3. Actual values of the four components of the learning objectives in the teacher module.

The actual values of the four components range from 0 to 75, with a mean of 37.5, and all of them are below the ideal value of 76, so none of the components fulfills the ideal condition in this sample module. The audience component reaches 50, because the class level is written on the cover of the module but the objective does not state what students are expected to do. The behavior component is the highest at 75, because the competence statement uses the operational verb analyze with a clear content, namely the concepts of energy and work, so it is only one point below the ideal value. The condition component reaches only 25, because the application to everyday motion problems is mentioned but the learning situation, media, and activities that students use are not specified. The degree component is 0, because the module contains no standard of achievement for the objective, although it provides multiple-choice and essay questions for evaluation. This pattern shows that the sample module contains a statement of competence but not yet a complete learning objective, which illustrates why the E-Student Worksheet needs objectives that specify the audience, behavior, condition, and degree, as proposed in the six objectives above, although a conclusion about teachers' objectives in general requires analyzing the measurement module or several modules.

Discussion

The low suitability of the student worksheet used in schools to the ideal E-Student Worksheet indicates that the teaching materials used still function as conventional worksheets, not as ICT-based teaching materials. This condition is in line with Marsa and Desnita's findings that physics teachers in West Sumatra have not made much use of ICT-based media, even though 21st century learning requires these media so that students can practice 4C skills [20]. The teaching materials themselves should contain components that support learning activities, such as learning instructions, supporting information, assignments and work steps, and assessments [12]. The self-contained indicator obtained the highest percentage possibly because the preparation of the material does not depend on technology, so it can be fulfilled by the conventional student worksheet format, which is a hypothesis that needs confirmation. On the other hand, the flexible indicator, which depends on technology such as support for the virtual learning environment and access via mobile devices, is almost not met, which may be because the student worksheet is not yet in a digital format. At the same time, the school conditions appear to support the transition to a digital worksheet, because according to the teacher the students' devices are generally adequate, the internet access is fairly good, and the laboratory with Wi-Fi can be used when the E-Student Worksheet is applied.

The digital format addresses this gap because the E-Student Worksheet can display interactive multimedia, provide live feedback, and be accessed through various devices [37]. Online learning that allows learning resources to be accessed anytime and anywhere also requires teaching materials that can be accessed without space and time limitations [10]. Ghaisani and Setyasto report that Liveworksheet-assisted E-Student Worksheets can improve science learning outcomes, making the application worthy of consideration as a development platform [14]. In addition, the E-Student Worksheet makes it easier for teachers to quickly distribute and update learning content [14], [37]. Thus, the transformation of the conventional student worksheet into a web-based E-Student Worksheet is a fundamental need that needs to be met before other pedagogical aspects are

designed. However, the limitations of students' devices and internet connections still need to be anticipated with a lightweight access design and an alternative print version.

The gap in teaching materials goes hand in hand with the low skills of students, which is first seen in creative thinking because all indicators are categorized as poor. This condition is in line with Mawarni and Sani who reported that the creative thinking skills of high school students are relatively low [21]. This condition is also relevant to the international emphasis on promoting creativity as a core competency of future-oriented education [3], and to evidence that project-based learning integrated with a local context can improve students' creativity [30]. Creative thinking requires students to produce fluent, flexible, original, and detailed ideas, so this ability only develops if students are often faced with tasks that make room for various answers. The values of originality at 56.7 and elaboration at 56.0 are indeed slightly lower than those of fluency and flexibility at 58.7, but the difference of 2.0 to 2.7 points cannot be interpreted as a significant difference. The assumption that these two indicators demand novelty and detailed descriptions, which are difficult to achieve without gradual practice, still needs to be tested further. Therefore, the limitations of students' creative thinking are more appropriately seen as comprehensive. Learning that has not encouraged students to come up with alternative solutions can be one of the causes of this condition.

This comprehensive nature becomes more apparent when the score distribution is considered, because students are divided into two groups, so the class average is not representative of the abilities of most students. Students who score 2 on all questions give answers that according to the rubric contain few ideas, one approach, and tend to follow existing examples. This cross-indicator uniformity indicates that the main obstacle may lie in the habit of facing open-ended tasks, rather than in one particular skill aspect, although this conjecture needs to be confirmed through interviews or learning observations. Cummings and Blatherwick emphasize that creative thinking is stimulated through imagination, emotional connectedness, and real-life experiences that can be explored directly[33]. These principles support the need for E-Student Worksheet that presents a real and fun context and gradual tasks from guided to open. The development of appropriate teaching materials is reported to improve creative thinking skills [4], so that the designed E-Student Worksheet has the opportunity to answer this need.

A similar pattern appears in written communication skills, when systematics or format, at a value of 60.0, is only slightly higher than language use, at 58.0, and completeness of content, at 56.0. This small difference only shows the tendency that students are more able to compile sequences rather than pour scientific content precisely and completely, because systematics questions only require students to retell the process of making tabuik, while the other two questions require the use of physics terms and the presentation of complete reports. Written communication includes systematics, language use, and completeness of content [34], so all three need to be trained in stages. Zubaidah defines communication as the conveyance of ideas through oral, writing, symbols, images, graphs, or numbers [5], so the E-Student Worksheet can train them through various forms of representation. Thus, the report framework, scientific vocabulary, and gradual writing exercises are important components of the E-Student Worksheet.

The relationship between the two skills can be seen from the similarity of twelve students in the high group in both tests, which shows that creative thinking and written communication skills move together in the study subjects. Both tests require students to write down ideas in the form of essays, so the ability to write ideas is likely to affect scores on both. The very high correlation coefficient cannot be interpreted as a cause-and-effect relationship because it is based on only 30 students in two clearly separated groups. However, this pattern supports the idea that one learning device can facilitate both skills at once. This view is in line with joyful learning which according to Widyawulandari et al. can develop communication and cooperation and increase learning motivation [38].

In addition to these two skills, the understanding of measurement material as a student's learning task also shows a pattern that needs to be observed, as students tend to assess themselves more capable of procedural statements than conceptual ones. This tendency suggests that measurement learning may have emphasized work steps, which needs to be confirmed through interviews with teachers or classroom observation. However, conceptual understanding of uncertainty is equally important because each measurement is always accompanied by uncertainty that estimates how far the measurement results can differ from the actual value. The low percentage of awareness of uncertainty and the distinction between direct and indirect measurements indicates that the conceptual foundation of this material is not yet strong. Direct and indirect measurements themselves are the basis for grouping measurement types in physics [39].

Such conceptual weaknesses are most evident in scientific notation as the lowest subtopic, as this subtopic demands mastery of significant figures and operations with exponents simultaneously. Significant figures include all certain digits plus one digit that still contains uncertainty [40], so that the understanding of uncertainty and significant figures are interrelated. This linkage explains why statements that combine significant figures and scientific notation are among the lowest. Since questionnaires measure perception, low scores can also reflect a

lack of self-confidence and not just a lack of mastery. Therefore, the results of the questionnaire need to be reinforced with a test of mastery of concepts at a later stage of development.

In addition to the differences between subtopics, the group of 18 students who were consistently in the very poor category on all three measurements showed a sharp gap in ability within one class. This condition requires teaching materials that provide different learning paths so that students who are still struggling are helped without hindering students who are already capable. The E-Student Worksheet allows students to learn at their own pace and needs and get direct feedback [37]. With this feature, tiered activities can be designed from guided assignments to open-ended assignments.

The concept analysis and the learning objectives show how the findings can be translated into the content of the E-Student Worksheet. Each of the five criteria of a good physics concept is connected with a measurement concept, the condition of students at the school, and a Minangkabau local wisdom context, so the design does not stand on assumptions alone. The comparison of the learning objectives in one sample teacher module with the four components of a well-formulated objective shows a mean value of 37.5 against the ideal value of 76, with the degree component absent and the condition component weak. This suggests that, at least in this sample, the objectives rely on the statement of competence and do not yet specify the learning situation and the level of achievement, but the module covers a different topic and grade level, so the comparison is only illustrative. The learning objectives of the E-Student Worksheet therefore state all four components and set a minimum value of 76 as the level of achievement, while closing the gap in the concepts requires tasks that move from guided to open-ended activities and are supported by feedback.

All findings from the front-end analysis, learner analysis, task analysis, concept analysis, and learning objectives lead to the draft of the E-Student Worksheet that is discussed below. Table **9** summarizes the relationship between the needs analysis findings, the identified needs, and the characteristics of the designed E-Student Worksheet. The table describes six main findings together with the proposed design that answers each finding. This synthesis serves as a bridge between the define stage and the design stage of the 4D model, and each design is associated with an element of joyful learning or relevant local wisdom.

Table 9. Synthesis of Needs Analysis Findings and Characteristics of the Designed E-Student Worksheet

No	Analysis Findings	Requirements	Characteristics of the Designed E-Student Worksheet
1	The suitability of the school's student worksheet to the ideal E-Student Worksheet is 42.5%, and the flexible indicator is the lowest at 22.5%	Digital teaching materials that are easily accessible and integrated with the online learning environment	Web-based E-Student Worksheets that can be opened via mobile phone, compiled with the Canva application and Liveworksheets, and shared via a link or Google Classroom
2	The interactive indicator is 35.0% and the multimedia indicator is 50.0%	Multimedia, interaction, and feedback features	Images, videos, animations, simulations, quizzes, and interactive questions with live feedback as enjoyable elements
3	Creative thinking at a value of 57.5, which is poor, with all indicators ranging from 56.0 to 58.7	Open-ended assignments that train a wide range of ideas, approaches, novelties, and details	A challenge to design measuring instruments from the context of the dacin and traditional units, with stages from guided to independent, representing the real world and student centered elements
4	Written communication at a value of 58.0, which is poor, with completeness of content at 56.0 as the relatively lowest component	Structured scientific writing exercises	Report framework, scientific vocabulary, and group discussions to prepare explanations and reports on measurement results, representing the collaboration element
5	Perceived mastery of measurement subtopics at 56.0%, with scientific notation at 52.0% and the essence of measurement at 53.1% as the lowest subtopics	Strengthening the concepts of uncertainty, types of measurements, significant figures, and scientific notation	Sequential material with contextual examples and repetitive exercises, representing the relevant element
6	18 out of 30 students, or 60.0%, were in the very poor category on all three measurements	Differentiation of difficulty	Tiered activities with automated prompts and feedback

Source: The author's analysis

The design in Table 9 places joyful learning as an approach that creates a conducive and fun learning atmosphere so that students learn without feeling pressured [16]. The low interactive indicator in the school student worksheet shows a wide space for the application of this principle through quizzes, videos, and group activities. The indicators of enjoyable, real world, relevant, collaboration, and student centered [41] can be used as a reference so that the fun element does not reduce academic weight. The risk of learning that is too relaxed to the point that cognitive goals are not achieved needs to be controlled with a systematic activity design. Thus, the fun element is placed as a means of achieving learning goals, not as goals themselves. The need for joyful learning is not tested

by this needs analysis and is supported only by the literature. Among the design features in Table 9, the digital and interactive format follows directly from the findings on the interactive and flexible indicators, while the choice of Canva, Liveworksheets, Google Classroom, videos, simulations, and tiered activities represents the authors' preferences that can be replaced by equivalent tools.

In addition to the fun element, local wisdom helps students relate the material to the social and cultural environment so that learning is more contextual and meaningful [17]. Traditional Minangkabau units and measuring tools, such as depa, hasta, kati, and dacin, provide concrete examples of non-standard units, non-uniformity, and the need for standards. This context is relevant to the low subtopic, namely the nature of measurement and uncertainty, because anthropometric units that depend on the wearer's body reveal a concrete source of uncertainty. Safitri et al. report that learning based on local wisdom helps students connect abstract physics material with daily life and increases learning motivation [18]. This finding is consistent with international studies reporting that teaching materials and digital modules based on local wisdom or ethnoscience support students' creative thinking, critical thinking, and character [27]–[30]. The limitation that not all materials are easily associated with local wisdom [18] may not constitute a significant obstacle to measurement because this material appears close to traditional trade and agricultural activities, although this assumption needs to be examined. Likewise, the need for local wisdom in this study is based on the literature and was not tested with the students and the teacher.

The combination of joyful learning and local wisdom has practical implications for the design of the E-Student Worksheet and physics learning. For developers, the results of the analysis show the need for a platform that can be accessed via mobile phones, activities that are arranged in stages from guided to open, and a framework for writing reports to train written communication. For teachers, the E-Student Worksheet can be an alternative teaching material that connects the concept of measurement with the cultural context of students, while strengthening the concepts of uncertainty, significant figures, and scientific notation needs to be given a special portion. This implication is an initial design and has not proven that the developed E-Student Worksheet will improve students' skills. These implications also clarify the research gap of this study compared to previous research. Hizbi et al. [24] and Shalsabilla et al. [25] have utilized local wisdom, but have not specifically targeted creative thinking and communication skills. This difference shows that, among the studies referenced in this article, there is no E-Student Worksheet that combines these four elements.

However, the results of the study need to be interpreted by considering some limitations. The study involved only one school, one teacher, and 30 students, so the results were contextual and could not be generalized. The small number of test items and descriptive analysis limited the depth of psychometric analysis, whereas the material questionnaire measured students' perception and not the actual mastery of concepts. The front-end analysis data were sourced from a single teacher without triangulation through interviews or observations, and both tests were in the form of essays so that the scores of the two skills were interrelated. The four instruments were validated by expert judgment of the supervising lecturers, but empirical validity and reliability coefficients and inter-rater agreement were not reported. Each indicator in the two essay tests was measured by only one question, so differences among indicators cannot be separated from the difficulty of the questions, and the Minangkabau contexts used in the tests may have lowered the scores of students who are unfamiliar with them. The front-end analysis compared a printed worksheet with digital criteria and relied on one rater, the sample module for the learning objectives came from a different topic and grade level, and the information about students' devices, internet access, and school facilities came only from the teacher's report and not from a survey of the students. The scores of the 18 students in the lowest group are identical because they follow the discrete rubric descriptors, so they show the level of the descriptor and not the variation within the group, and the cultural links were not validated by cultural experts. The next design and develop stages will test the validity and practicality of the E-Student Worksheet, while its effectiveness can be examined in follow-up research.

IV. CONCLUSION

The needs analysis at the define stage, based on one school, one teacher, and 30 class X students, indicates a need for an E-Student Worksheet on measurement that facilitates creative thinking and communication skills. According to the teacher's rating, the school worksheet reached only 42.5% of the ideal E-Student Worksheet, with the flexible indicator at 22.5% and the interactive indicator at 35.0% as the lowest. Students' creative thinking and written communication reached values of 57.5 and 58.0, their perceived mastery of measurement reached 56.0%, and 18 of the 30 students were in the very poor category on all three measurements, which shows one large group of students who need priority support. The concept analysis and the sample module analysis suggest that measurement concepts can be linked to Minangkabau units and measuring tools and that learning objectives need to state the audience, behavior, condition, and degree. Based on these findings, a digital, interactive, and mobile-accessible E-Student Worksheet, which is feasible because the students' devices are adequate and the laboratory

has Wi-Fi, with open-ended tasks, a report framework, and reinforcement of uncertainty, significant figures, and scientific notation is proposed as a design, whose validity, practicality, and effectiveness remain to be tested in further research with more schools and teachers.

REFERENCES

[1] B. Trilling And C. Fadel, "21st Century Skills: Learning For Life In Our Times," 2009.

[2] A. Asrizal, Y. Yurnetti, And E. A. Usman, "Ict Thematic Science Teaching Material With 5e Learning Cycle Model To Develop Students' 21st-Century Skills," J. Pendidik. Ipa Indones., Vol. 11, No. 1, Pp. 61–72, 2022.

[3] B. Thornhill-Miller Et Al., "Creativity, Critical Thinking, Communication, And Collaboration: Assessment, Certification, And Promotion Of 21st Century Skills For The Future Of Work And Education," J. Intell., Vol. 11, No. 3, P. 54, 2023.

[4] R. Yuliska, S. Syafriani, And R. Ramli, "Efektivitas Pengembangan Lkpd Fisika Sma/Ma Berbasis Inquiry Training Untuk Meningkatkan Kemampuan Berpikir Kreatif Peserta Didik," J. Eksakta Pendidik., Vol. 4, No. 1, Pp. 89–96, 2020.

[5] S. Zubaidah, "Mengenal 4c: Learning And Innovation Skills Untuk Menghadapi Era Revolusi Industri 4.0," In 2nd Science Education National Conference, 2018, Pp. 1–18.

[6] A. Asrizal And A. W. Utami, "Effectiveness Of Mechanical Wave Learning Material Based On Ict Integrated Ctl To Improve Students Learning Outcomes," J. Penelit. Pendidik. Ipa, Vol. 7, No. 4, Pp. 632–641, 2021.

[7] R. Education, "Towards A Global Common Good," Unesco Retrieved June, Vol. 6, P. 2015, 2015.

[8] I. Kemdikbud, "Buku Saku Kurikulum Merdeka; Tanya Jawab," Kementeri. Pendidik. Dan Kebud., Vol. 150, 2022.

[9] T. P. P. Mendalam, "Pembelajaran Mendalam Menuju Pendidikan Bermutu Untuk Semua," 2024.

[10] Y. Bilfaqih And M. N. Qomarudin, Esensi Penyusunan Materi Pembelajaran Daring: Panduan Berstandar Penyusunan Materi Pembelajaran Daring Untuk Pendidikan Dan Pelatihan. Deepublish, 2015.

[11] A. Fahlevi And A. Asrizal, "Efektivitas E-Modul Getaran Dalam Kehidupan Sehari-Hari Pada Pembelajaran Daring Untuk Meningkatkan Keterampilan Proses Sains Siswa," J. Pendidik. Fis. Dan Teknol., Vol. 7, No. 2, Pp. 111–118, 2021.

[12] D. P. Nasional, "Panduan Pengembangan Bahan Ajar," 2008, Jakarta: Depdiknas.

[13] A. Prastowo, "Panduan Kreatif Membuat Bahan Ajar Inovatif Menciptakan Metode Pembelajaran Yang Menarik Dan Menyenangkan," 2019.

[14] N. R. T. Ghaisani And N. Setyasto, "The Development Of Liveworksheets-Based Electronic Student Worksheets (E-Lkpd) To Improve Science Learning Outcomes," J. Penelit. Pendidik. Ipa, Vol. 9, No. 8, Pp. 6147–6156, 2023.

[15] Z. Zhalila And G. H. Medika, "Pengembangan Elektronik Lembar Kerja Peserta Didik (E-Lkpd) Berbantuan Liveworksheets Untuk Memfasilitasi Pencapaian Minat Belajar Matematika Peserta Didik Di Kelas Vii Smpn 3 Ampek Angkek," J. Cendekia J. Pendidik. Mat., Vol. 8, No. 3, Pp. 2424–2437, 2024.

[16] M. Enco, "Menjadi Guru Profesional Menciptakan Pembelajaran Kreatif Dan Menyenangkan," Pt. Remaja Rosdakarya, 2006.

[17] H. Darmadi, "Educational Management Based On Local Wisdom (Descriptive Analytical Studies Of Culture Of Local Wisdom In West Kalimantan)," J. Educ. Teach. Learn., Vol. 3, No. 1, Pp. 135–145, 2018.

[18] A. N. Safitri, S. Sarwanto, And D. Harjunowibowo, "Pengembangan Modul Pembelajaran Fisika Berbasis Kearifan Lokal Pada Materi Suhu Dan Kalor," J. Mater. Dan Pembelajaran Fis., Vol. 13, No. 1, P. 32, 2023, Doi: 10.20961/Jmpf.V13i1.60093.

[19] F. Irianti, M. A. D. Alexandra, and C. S. S. Aji, "Kajian Etnomatematika Rumah Adat Gadang Suku Minangkabau," in PRISMA, Prosiding Seminar Nasional Matematika, vol. 5, 2022, pp. 222–226.

[20] P. B. Marsa And D. Desnita, "Analisis Media, Sumber Belajar, Dan Bahan Ajar Yang Digunakan Guru Fisika Sma Materi Gelombang Di Sumatera Barat Ditinjau Dari Kebutuhan Belajar Abad 21," J. Eksakta Pendidik., Vol. 4, No. 1, Pp. 81–88, 2020.

[21] R. Mawarni And R. A. Sani, "Pengaruh Model Project Based Learning Berbasis Stem Terhadap Kemampuan Berfikir Kreatif Siswa Pada Materi Pokok Fluida Statis Di Kelas Xi Sma Negeri 4 Tebing Tinggi Tp 2019/2020," J. Inov. Pembelajaran Fis., Vol. 8, No. 2, Pp. 8–15, 2020.

[22] D. R. Desfi and A. Asrizal, "Pengembangan E-LKPD Fluida Terintegrasi Etno-PBL untuk Mendorong Kemampuan Pengetahuan dan Keterampilan Berpikir Kreatif Siswa," J. Pendidik. Tambusai, vol. 9, no. 1, 2025, doi: 10.31004/jptam.v9i1.26418.

[23] S. Hayati, Y. Yurnetti, D. Desnita, and D. S. Suherman, "Pembuatan E-LKPD Berbasis Pendekatan

Saintifik pada Materi Pengukuran dalam Kerja Ilmiah Fase E SMA/MA," J. MIPA dan Pembelajarannya, vol. 5, no. 2, 2025.
[24] T. Hizbi, B. Novianti, B. Wajdi, And E. Yuliani, "Pengembangan E-Lkpd Berbasis Kearifan Lokal Kerajinan Anyaman Bambu Model Project Based Learning Untuk," Vol. 7, No. 3, Pp. 524–530, 2023.
[25] Y. L. Shalsabilla, Y. Utomo, And D. Fatmawati, "Pengembangan Lkpd Dengan Pendekatan Culturally Responsive Teaching Kearifan Lokal Gamelan Jawa Materi Gelombang Bunyi Untuk Memfasilitasi Keterlibatan Siswa," Vol. 15, Pp. 715–723, 2025.
[26] R. W. Putri, S. Riyasni, A. Fauzi, And F. U. Jhora, "Need Analysis For The Development Of E-Lkpd On Temperature And Heat Based On Pbl Using Google Sites Integrated With Local Wisdom To Improve Students ' Problem -Solving Skills," Vol. 19, No. 1, Pp. 205–215, 2026.
[27] W. Sumarni And S. Kadarwati, "Ethno-Stem Project-Based Learning: Its Impact To Critical And Creative Thinking Skills," J. Pendidik. Ipa Indones., Vol. 9, No. 1, Pp. 11–21, 2020.
[28] S. Hartini, "The Development Of Physics Teaching Materials Based On Local Wisdom To Train Saraba Kawa Character," J. Pendidik. Ipa Indones., 2018.
[29] J. Syahfitri And M. Muntahanah, "The Effectiveness Of Local Wisdom-Based Interactive Digital Module On Students' Critical Thinking Disposition," Int. J. Eval. Res. Educ., Vol. 13, No. 4, P. 2170, 2024.
[30] M. H. Rohman, P. Marwoto, S. E. Nugroho, And S. Supriyadi, "Effectiveness Of Ethnoecological-Stem Project-Based Learning Model To Improve Critical Thinking Skills, Creativity, And Science Concept Mastery," Int. J. Cogn. Res. Sci. Eng. Educ., Vol. 12, No. 3, Pp. 521–534, 2024.
[31] S. Thiagarajan, D. Semmel, And M. Semmel, "Thiagarajan, Sivasailam; And Others Instructional Development For Training Teachers Of Exceptional Children: A Sourcebook. Indiana Univ., Bloomington. Center For Innovation In," No. Mc.
[32] Sugiyono, Metode Penelitian Dan Pengembangan. Bandung: Alfabeta,Bandung, 2019.
[33] J. B. Cummings And M. L. Blatherwick, Creative Dimensions Of Teaching And Learning In The 21st Century. Springer, 2017.
[34] R. Medriati And E. Risdianto, "Penerapan Pendekatan Student Centered Learning (Scl) Untuk Meningkatkan Keterampilan Berpikir Kreatif Dan Komunikatif Mahasiswa Pendidikan Fisika Semester Iii Universitas Bengkulu," J. Kumparan Fis., Vol. 3, No. 1 April, Pp. 67–74, 2020.
[35] J. D. Novak and A. J. Cañas, "The Theory Underlying Concept Maps and How to Construct and Use Them," Technical Report IHMC CmapTools 2006-01 Rev 01-2008, Florida Institute for Human and Machine Cognition, 2008.
[36] M. N. Purwanto, "Prinsip-Prinsip Dan Teknik Evaluasi Pengajaran," 2019.
[37] S. Suryaningsih And R. Nurlita, "Pentingnya Lembar Kerja Peserta Didik Elektronik (E-Lkpd) Inovatif Dalam Proses Pembelajaran Abad 21," J. Pendidik. Indones., Vol. 2, No. 7, Pp. 1256–1268, 2021.
[38] R. Widyawulandari And M. Indriayu, "Implementation Of Joyful Learning Approach In Providing Learning Motivation For Elementary School Student," In International Conference On Science, Technology, Education, Arts, Culture And Humanity-" Interdisciplinary Challenges For Humanity Education In Digital Era"(Steach 2018), Atlantis Press, 2019, Pp. 54–58.
[39] A. Mikrajuddin, Fisika Dasar 1. Kamppus Ganesa, 2016.
[40] R. A. Serway, J. W. Jewett, And V. Peroomian, Physics For Scientists And Engineers, Vol. 2. Saunders College Publishing Philadelphia, 2000.
[41] G. R. Affandi, C. Hadi, F. Megawati, N. Laili, And N. M. Rohmah, "Joyful Learning & Media Pembelajaran: Teori Dan Penerapannya Pada Konteks Pendidikan," Umsida Press, Pp. 1–76, 2024.