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# Needs Analysis to Develop Linear Motion E-Student Worksheet Based on Inquiry Learning Model and Local Wisdom to Improve Student's Critical Thinking Skills

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## ABSTRACT

Twenty-first-century physics learning requires innovative teaching materials to improve students' critical thinking skills. Currently, physics instruction still relies on conventional printed textbooks that lack variation. This study aims to analyze the need for developing an E-Student Worksheet based on Inquiry learning and oriented to local wisdom in linear motion kinematics material to enhance high school students' critical thinking skills. The study used a descriptive approach with a preliminary study research type. The subjects consisted of one physics teacher and 34 tenth-grade students at SMA Negeri 9 Padang. Data was obtained and triangulated through a structured combination of observations, interviews, questionnaires, and critical thinking skills tests. The results showed that students' critical thinking skills were still relatively low, with an average score of 38.4%, especially in the analysis indicator. In addition, students strongly need interactive digital teaching materials that systematically support contextual, inquiry-based learning. Therefore, developing an E-Student Worksheet based on Inquiry learning oriented to local wisdom is highly important to support more active and meaningful physics learning.



## INTRODUCTION

The development of science and technology in the 21st century has had a big impact on many aspects of life, including education. Digital transformation has led to a shift in learning from conventional methods to more innovative, interactive, and student-centered approaches. The 21st-century education demands a learning process that not only focuses on mastering concepts but also helps students develop the ability to understand information, analyze problems, and solve various real-life issues (Wulandahri et al., 2025). These demands require teachers to design learning experiences that actively involve students rather than positioning them as passive recipients of information. Consequently, the availability of innovative and contextual teaching materials becomes a key factor in achieving these twenty-first century learning goals.

In line with these demands, the implementation of the Independent Curriculum emphasizes student-centered learning, encourages curiosity, and develops higher-order thinking skills through meaningful learning experiences. The Independent Curriculum also gives teachers the opportunity to create flexible, innovative learning that matches the characteristics of their students. In this context, using technology in learning becomes an important need to create interactive and adaptive learning that keeps up with the times (Antika et al., 2024). Realizing this vision, however, requires more than curriculum policy alone; it also requires teaching materials that are specifically designed to support independent, inquiry-based, and technology-integrated learning activities in the classroom.

The development of digital technology is also driving changes in the use of media and learning materials in schools. Using digital-based learning materials has become a necessity in modern education because it can provide a more interactive and flexible learning experience. One form of digital learning material that can be used in teaching is the E-Student Worksheet. E-Student Worksheet is designed not only as a tool for delivering content but also as a medium that can help students actively engage in the learning process through various structured learning activities. By utilizing digital features such as images, videos, animations, simulations, and interactive exercises, E-Student Worksheet can help students understand concepts more deeply at their own learning pace (Riadhi et al., 2025).

The state of physics learning in schools still shows various deep-seated problems, limitations, and conceptual challenges that hinder student development. Physics learning tends to focus heavily on the mechanical delivery of material and dry formulaic solving of math problems, so students end up memorizing abstract equations more than deeply understanding the underlying physics concepts. The learning process is also still heavily dominated by teacher-centered lectures and teacher-led board illustrations, which makes students less active, highly passive, and unengaged in active learning. As a result, students experience severe difficulties when analyzing complex physical phenomena, connecting abstract kinematics concepts to everyday life experiences, and solving problems scientifically using evidence-based reasoning. This alarming situation shows that physics learning in secondary educational institutes has not fully supported or nurtured the development of students' higher-order thinking skills (HOTS), particularly critical thinking. This conventional reliance on pure mathematical drill exercises without qualitative conceptual grounding creates an educational environment where physics is feared rather than understood, causing long-term misconceptions regarding fundamental laws of nature such as velocity, vector direction, and acceleration.

One important skill to develop in learning physics is critical thinking. Critical thinking is the ability to analyze information, evaluate arguments, make interpretations, draw conclusions, and make decisions logically and systematically. According to Facione (2020), Critical thinking skills include interpretation, analysis, evaluation, inference, explanation, and self-regulation. These skills are really important in learning physics because students are expected to understand concepts, analyze natural phenomena, and solve various scientific problems in a structured and evidence-based manner. In the context of kinematics, critical thinking acts as an essential framework that enables a student to distinguish between scalar quantities like speed and vector quantities like velocity, enabling them to evaluate experimental data discrepancies, interpret complex motion graphs accurately, and self-regulate their own understanding when facing counter-intuitive physical motion behaviors.

Various studies show that students' critical thinking skills in Indonesia are still quite low. Ananta et al. (2025), stated that students still have difficulty analyzing physics problems and drawing conclusions based on the observations they made. The analysis indicator is consistently the weakest aspect of students' critical thinking across various levels of basic education. These difficulties tend to appear when physics learning emphasizes routine calculation over investigative, evidence-based reasoning. Putri et al. (2025) stated that students still have trouble processing information systematically and evaluating problems on their own. This situation shows that learning innovations are needed to support the development of students' critical thinking skills in physics lessons.

Aside from learning models that are less supportive, the use of teaching materials that are not yet varied is also one of the reasons for students' low critical thinking skills. Teaching materials used in schools are generally still in the form of printed books and simple student worksheets that are unable to facilitate interactive learning. In fact, using electronic teaching materials can help students learn more independently. One digital teaching material that can be used is the Electronic Student Worksheet. E-Student Worksheet is an electronic-based student worksheet that includes text, images, videos, animations, as well as interactive activities that can help students understand concepts in a more concrete and systematic way (Gaurisankar et al., 2022). Developing this kind of digital teaching material is therefore considered a strategic step to address the limitations of conventional worksheets.

The use of E-Student Worksheet in physics learning is considered able to increase student engagement in the learning process. Miliniawati & Isnaeni (2023), stated that E-Student Worksheet can help students develop critical thinking skills through activities like analysis, problem-solving, and scientific investigations. In addition, E-Student Worksheet allows students to access learning materials more flexibly through their digital devices, so the learning process isn't limited to the classroom in terms of time and space. Presenting materials with a mix of images, videos, animations, and interactive exercises can also boost interest in learning and help students understand concepts independently. Therefore, E-Student Worksheet not only serves as a learning resource but also as a tool that can create a more active, engaging, and student-centered learning experience in line with 21st-century learning demands (Utami & Emiliannur, 2025).

To make the use of the E-Student Worksheet effective in training students' critical thinking skills, a learning model that matches twenty-first century learning characteristics is needed. One learning model that can be applied is inquiry learning. Inquiry learning is a model that emphasizes the process of scientific investigation to discover concepts independently. In inquiry learning, students are trained to observe phenomena, formulate problems, develop hypotheses, collect data, test hypotheses, and draw conclusions. Through these stages, students can develop critical thinking skills and understand concepts more meaningfully, rather than simply memorizing formulas handed down by the teacher.

Some studies show that inquiry learning is effective in improving students' critical thinking skills. Panuluh (2022), stated that inquiry learning can improve students' science process skills and analytical abilities through scientific investigation activities. In Addition, Samadun et al. (2023) further emphasized that a preliminary needs analysis is a crucial first step before developing an inquiry-based worksheet, since it ensures that the resulting product truly addresses students' actual learning problems. Through this model, students are directly involved in discovering concepts rather than merely receiving information passively from the teacher. Therefore, inquiry learning becomes a relevant learning model to be integrated into the development of a physics E-Student Worksheet.

Besides using the right learning model, physics learning also needs to be contextually connected to students' real-life experiences and cultural environments to make learning more meaningful and less abstract. One pedagogical approach that can be applied is integrating local wisdom into learning. Local wisdom consists of noble values, culture, indigenous knowledge, and daily practices that develop organically in the community and are passed down through generations. This socio-cultural integration bridges the deep gap between theoretical equations found in academic textbooks and the actual environmental applications that students encounter daily within their local communities. Integrating local wisdom into physics learning can help students understand abstract concepts through physical phenomena that are close to everyday life, making learning highly contextual, tangible, and easier to relate to.

Pardede et al. (2024) stated that integrating local wisdom into physics teaching materials can improve students' understanding of concepts and their engagement in learning. In Addition, Tressyalina et al. (2023) explained that teaching materials based on local wisdom can help students connect scientific concepts with real-life experiences in their surroundings. In the topic of straight-line motion kinematics, motion concepts can be linked to various community activities, such as traditional boat movements, traditional games, local transportation, or local cultural activities. This integration is expected to help students understand motion concepts in a more concrete and meaningful way, while at the same time preserving local cultural values through the learning process.

Based on previous research, the development of digital teaching materials generally still focuses on using certain learning models without contextually integrating local wisdom. In addition, research related to the needs analysis for developing a local-wisdom-oriented, inquiry-based E-Student Worksheet on linear motion kinematics material has not been conducted extensively. Therefore, this study offers novelty in the form of a needs analysis for developing an E-SWS that integrates inquiry learning and local wisdom as an effort to improve students' critical thinking skills in physics learning. This needs analysis is essential because it identifies the actual gap between students' current condition and the desired learning outcome, which subsequently forms the basis for the design of the teaching material to be developed.

This study aims to analyze the need for developing an E-Student Worksheet based on inquiry learning and oriented towards local wisdom to improve high school students' critical thinking skills on straight-line motion kinematics material. The results of this study are expected to contribute to the development of innovative, interactive, and contextual physics teaching materials in line with the demands of 21st-century learning. In addition, this study is expected to serve as a reference for teachers in developing physics learning that can enhance students' critical thinking skills through the integration of technology, inquiry learning, and local wisdom. More broadly, the findings of this needs analysis are also expected to enrich the growing body of research on E-Student Worksheet in Indonesian physics education.

## METHODS

This study uses a descriptive approach with a preliminary study research type aimed at obtaining an overview of the initial conditions of physics learning and identifying the development needs for teaching materials in the form of a Student Worksheet based on inquiry learning and oriented toward local wisdom to improve students' critical thinking skills on the topic of linear motion kinematics. The data analysis technique used is descriptive statistics, which is used to describe or explain the collected data as it is, without intending to draw generalized conclusions. Descriptive statistics were presented in the form of tables and percentages, as well as measures of central tendency such as the mean. A descriptive approach was chosen because this study focuses on systematically collecting information about learning conditions, student characteristics, and teaching material needs required in the physics learning process, rather than testing a hypothesis or measuring a treatment effect.

The research subjects consisted of one physics teacher and 34 tenth-grade students at SMA Negeri 9 Padang who had studied linear motion kinematics in the even semester of the 2025/2026 school year. The selection of research subjects was carried out using purposive sampling, with the consideration that students in this class had already studied material relevant to the research focus, so they could provide accurate information regarding the learning conditions and teaching material needs. The physics teacher was included as a subject because of her direct experience in delivering the linear motion kinematics topic and her first-hand knowledge of the difficulties students commonly face. Involving both students and the teacher was intended to provide a completer and more triangulated picture of the learning needs from two complementary perspectives.

The research was carried out at SMA Negeri 9 Padang during the even semester of the 2025/2026 academic year. The preliminary study was implemented in three main stages: preparation, data collection, and data analysis. In the preparation stage, the researchers developed and validated the research instruments, namely the interview guide, the needs analysis questionnaire, and the critical thinking skills test. In the data collection stage, the critical thinking test and questionnaire were administered to the 34 students, followed by a semi-structured interview with the physics teacher. Finally, in the data analysis stage, the collected data were tabulated, scored, and analyzed descriptively to determine the initial condition of students' critical thinking skills and the teaching material needs required for developing the E-Student Worksheet.

The data collection technique was carried out through interviews, questionnaires, a critical thinking skills test, and document analysis of the curriculum's official learning objectives for the linear motion kinematics topic. The critical thinking skills test was given to students to obtain an initial picture of their critical thinking ability on the topic of linear motion kinematics. The test consisted of essay questions referring to the critical thinking indicators proposed by Facione (2020), namely interpretation, analysis, evaluation, inference, explanation, and self-regulation. The needs analysis questionnaire was designed using a four-point Likert scale covering five aspects: learning conditions, students' perception of their own critical thinking skills, the use of digital learning media, the implementation of inquiry learning, and the integration of local wisdom. Meanwhile, the interview with the physics teacher was conducted in a semi-structured manner to obtain more in-depth information regarding learning conditions, students' difficulties, the teaching materials currently used, and the need for developing digital-based teaching materials.

Data from the critical thinking skills test and the needs analysis questionnaire were analyzed using descriptive statistics in the form of percentages. The percentage score for each student and each indicator was calculated by dividing the obtained score by the maximum possible score, then multiplying by 100%. The resulting percentages were subsequently classified into five categories

**Table 1**. Needs Analysis Category

| Percentage (%) | Category |
|---|---|
| 0-20 | Very Low |
| 21-40 | Low |
| 41-60 | Moderate |
| 61-80 | High |
| 81-100 | Very High |

(Sahlan, 2015)

This categorization was applied both to the overall average score and to each indicator, so that the strengths and weaknesses of students' critical thinking skills and learning needs could be identified in more detail. Data from the teacher interview were analyzed qualitatively through data reduction, categorization of key themes, and descriptive interpretation to complement and confirm the quantitative findings from the test and questionnaire.

## RESULTS AND DISCUSSION

## Results

The results of these preliminary needs analysis were systematically gathered, tabulated, and cross-referenced through a structured combination of quantitative measurements and qualitative diagnostic workflows to map out the current baseline of physics instruction. These field data collection strategies were purposefully implemented during the initial "Define" phase of the 4D development model (Define, Design, Develop, and Disseminate) to establish a comprehensive empirical and pedagogical foundation before entering the technical prototyping and digital programming phases of the E-Student Worksheet. By addressing the instructional environment from multiple angles, these preliminary assessments ensure that the resulting digital learning media will directly target the documented learning obstacles, structural deficiencies, and unique cultural characteristics of the specific student cohort in high school physics classrooms.

*Front-End Analysis*

The front-end analysis was conducted to diagnose the baseline quality, teacher habits, and the front-end analysis was conducted as an essential diagnostic step to comprehensively evaluate the baseline quality, structural layout, teacher pedagogical habits, and operational limitations of the physics instructional materials currently deployed in the classroom environment. This critical evaluation aimed to identify the deep practical and pedagogical gap between the existing static, print-based school resources and the dynamic, multi-sensory interactive media platforms required by modern 21st-century physics education. To ensure data validity, the researchers measured the operational landscape by administering an extensive needs analysis questionnaire to the student cohort, tracking their technical readiness, learning preferences, and practical obstacles when utilizing traditional physics textbooks during individual and collaborative assignments.

The empirical data collected from the student needs questionnaire provided concrete evidence of a severe pedagogical mismatch in the current instructional ecosystem. The baseline data compiled from the field documents a substantial student demand for the transition to interactive digital platforms, as reflected by the high average need score of 75.00% across the critical parameters evaluated, which is systematically visualized in Figure 1. While the physics teacher still relies heavily on conventional printed books and simple worksheets that focus on procedural formula-memorization, students actively perceive that static text formats fail to illustrate the abstract principles of motion.

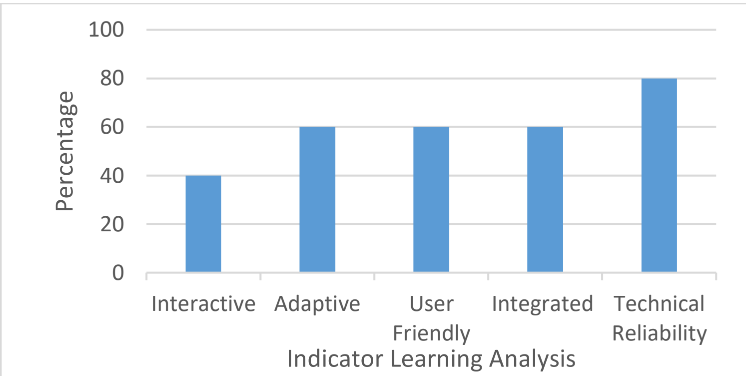


**Figure 1**. Analysis of Teaching Material

To examine these patterns from a broader perspective, a comprehensive analysis of student learner needs covering five essential aspects was mapped out to gauge technological readiness and instructional expectations. The resulting questionnaire metrics structurally confirmed that 88.97% of the cohort possesses a very high interest toward the integration of digital learning media in physics lessons. Furthermore, the students recorded a substantial score of 77.21% regarding the limitations of current learning conditions, indicating that they strongly perceive major shortcomings in the conventional printouts currently distributed during physics class. The complete visual breakdown of these five interconnected learner parameters is organized systematically in Figure 2.

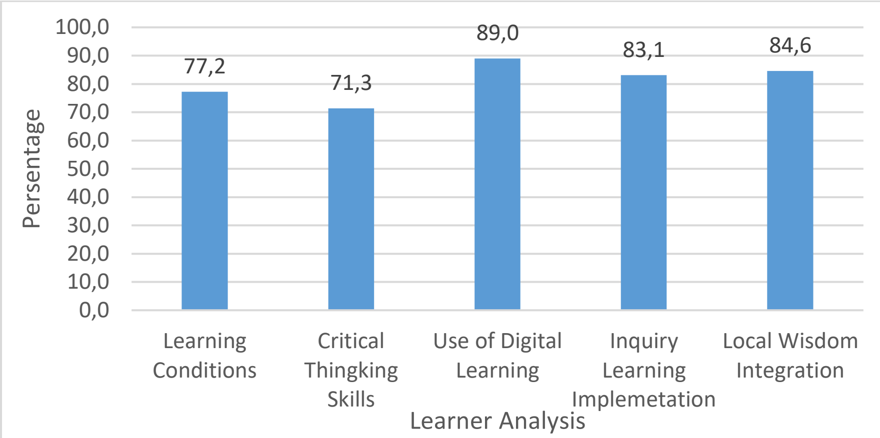


**Figure 2**. Learner Needs Analysis

The distribution of these percentages visualized in Figure 2 establishes a definitive justification for immediate pedagogical change. The high rate for the use of digital learning paired with the high score for local wisdom integration (84.56%) provides clear empirical evidence that high school learners strongly reject purely theoretical, disconnected mechanical tasks. Instead, they express an overwhelming preference for an educational platform that anchors abstract kinematics properties onto familiar cultural practices within their immediate West Sumatran environment. Consequently, integrating these regional cultural phenomena into the core physics curriculum is expected to help students understand velocity and acceleration concepts in a more concrete, localized, and meaningful way.

Looking closer at the structural components required within the teaching materials, the results of the inquiry learning integration analysis indicate a high student expectation level with a cumulative percentage of 83.09%. Students strongly express that their current classroom worksheets contain no scientific investigation phases, leading to passive formula absorption. The specific student responses regarding their explicit requirements for inquiry-based scaffolding are presented systematically in Table 2.

**Table 2**. Analysis of Inquiry Needs

| Inquiry Structural Requirement | Percentage |
|---|---|
| Presence of a clear problem orientation stage | 83.09% |
| Opportunities to formulate hypotheses independently | 80.88% |
| Embedded digital guidance for virtual data collection | 85.29% |

The high percentage for incorporating a digital guidance block for virtual data collection (85.29%) presented in Table 2 implies that integrating explicit inquiry sequences within the digital tool is considered an essential requirement to structurally guide students away from rote memorization. By providing digital spaces for variable manipulation, the worksheet will naturally support the development of self-directed scientific reasoning. Transitioning to a unified, mobile-responsive electronic workspace is a verified necessity to resolve these tech-pedagogical deficits and foster student autonomy. Transforming these conventional printouts into an interactive Electronic Student Worksheet based on inquiry and cultural context is therefore an urgent empirical necessity to foster self-directed learning and enhance critical thinking.

*Learner Analysis*

A targeted learner analysis was systematically executed by administering a comprehensive critical thinking skills diagnostic test to the 34 tenth-grade students at SMA Negeri 9 Padang to accurately map out their baseline cognitive abilities, specific learning blocks, and operational challenges within the topic of linear motion kinematics. This diagnostic instrument was structurally designed around Facione's validated higher-order thinking framework, ensuring that each open-ended essay question rigorously measured the specific operational sub-skills of interpretation, analysis, evaluation, inference, explanation, and self-regulation. The quantitative results obtained from this test provided an objective, empirical snapshot of the students' actual ability to process abstract physics variables, dismantle complex mechanical word problems, and mathematically reconstruct vector relationships on an electronic or physical canvas. It was found that students' critical thinking skills were in the low category, with an average score of 38.4%. The results of the students' critical thinking skills test are presented in Table 3.

**Table 3**. Percentage of Critical Thinking Skills

| Indicator | Percentage | Category |
|---|---|---|
| Interpretation | 41.18% | Moderate |
| Analysis | 32.35% | Low |
| Evaluation | 41.91% | Moderate |
| Inference | 39.71% | Low |
| Explanation | 38.24% | Low |
| Self-Regulation | 36.76% | Low |

Based on Table 3, it can be seen that each indicator of critical thinking skills has different values. The lowest critical thinking skill indicator is analysis. The low score in this indicator shows that students still have difficulty analyzing problems, connecting various concepts, and finding logical relationships between existing information and the solutions needed. In linear motion kinematics, analytical skills are very important because students need to understand the relationships between various physical quantities such as distance, displacement, speed, velocity, and acceleration. This low achievement indicates that there needs to be innovation in learning that can help students develop their analytical skills in a more structured way. This numerical breakdown reveals that students cannot break down complex mechanical word problems into simplified individual vector components. The exceptionally low percentage in the analysis phase (32.35%) implies that current classroom routines treat equations as rigid algebraic recipes rather than dynamic physical relationships. Consequently, when students are presented with non-routine physics problems, they fail to reconstruct the kinematic framework, indicating a critical need for an instructional device that targets multi-variable processing.

*Task Analysis*

The task analysis was rigorously executed to mathematically isolate, categorize, and interpret the exact statistical patterns governing student assignment workflows, homework performance limits, and standardized evaluation results derived from the critical thinking diagnostic test. By applying a parametric descriptive statistical analysis across the entire evaluated cohort, this step aimed to uncover how students navigate multi-variable mechanics questions and where the structural boundaries of their operational understanding currently lie. Tracking these descriptive parameters is vital for identifying whether current classroom tasks successfully accommodate individual learning paces or if they inadvertently exacerbate performance disparities among students due to a lack of structural scaffolding within traditional homework assignments. The quantitative metrics tracking the absolute cohort distribution, data dispersion, and performance limits based on a maximum total score of 100 are presented systematically in Table 4.

**Table 4**. Analysis of Student Task Performance

| No | Descriptive Parameter | Value | Note |
|---|---|---|---|
| 1. | Total Score | 100 | Maximum Possible Test Score |
| 2. | Minimum Score | 25 | Baseline Performance Floor |
| 3. | Maximum Score | 78 | Peak Achievement Ceiling |
| 4. | Standard Deviation | 12.45 | Data Dispersion & Variance |

The parametric metrics compiled in Table 4 reveal a wide distribution in student task performance across the evaluated cohort. This quantitative variance highlights a massive competency gap between high-performing individuals and struggling students when working through mechanical physics tasks. Because the current homework assignments and student tasks focus primarily on routine procedural computation, students are unable to establish a high standardized baseline floor, leaving the minimum score at a low value of 25. The maximum score of 78 indicates that even the top-performing students struggle to achieve perfect scores or reach the maximum value of 100 when faced with complex, non-routine task demands. Therefore, instructional tasks must be systematically reconstructed into structured inquiry stages to provide multi-tier scaffolding that helps close this wide standard deviation gap

*Concept Analysis*

The concept analysis was systematically carried out to critically evaluate the curriculum alignment, abstract structural properties, cognitive hierarchies, and contextual suitability of the linear motion kinematics sub-topics as outlined under the Independent Curriculum framework. This rigorous conceptual mapping was vital to identify which specific physical quantities and mathematical definitions could be explicitly and seamlessly integrated with West Sumatran local wisdom without compromising scientific accuracy. This step was vital to ensure the physical concepts could be explicitly integrated with West Sumatran local wisdom, as outlined in Table 5.

**Table 5**. Local Wisdom Integrated and Linear Motion Concept Analysis

| No | Kinematics Concepts | Integrated Local Wisdom | Suitability with Inquiry and Local Wisdom |
|---|---|---|---|
| 1. | Basic Concepts of Motion | *Pacu Jawi* (Traditional Bull Racing): Analyzing the total tracking path vs the absolute change in initial-to-final position | High suitability; provides excellent visual problem scenarios to trigger contextual inquiry processes. |
| 2. | Uniform Linear Motion | *Bendi* (Traditional Carriage): Investigating the steady-state motion profile over flat, straight regional roadways. | All sub-topics require visualization; connecting to *Bendi* provides clear velocity profiles over time. |
| 3. | Uniformly Accelerated Linear Motion | *Kincia Aia* (Traditional Waterwheel): Measuring the dynamic rate of change in linear velocity at the wheel's edge during water transitions. | Rich real-world cultural contexts fully support independent observation and field data collection. |

| | | | |
|---|---|---|---|
| 4. | Free Fall Motion | Harvesting *Kelapa Muda* (Young Coconuts): Observing the natural drop of coconuts from regional plantation trees. | Ideal context to model vertical trajectories and analyze acceleration values under gravity. |
| 5. | Vertical Upward Motion | *Simak Tuba* / Traditional Stone Throwing Games: Observing the vertical flight path of a stone thrown directly upward. | High conceptual value; directly helps students visualize the dynamic balance between initial velocity and deceleration. |

The structural concept check compiled in Table 5 uncovers significant potential for cultural integration across all five fundamental physics concepts. While students display adequate fluency when calculating isolated numerical variables, they experience severe conceptual failures when interpreting absolute vector parameters. Grounding abstract kinematics concepts in familiar cultural activities, such as *Pacu Jawi*, *Bendi*, and regional environmental phenomena, transforms abstract formulas into tangible, observable real-world operations. Presenting these regional practices within a digital workspace helps high school students visualize velocity-time variables as dynamic physical relationships rather than isolated mathematical formulas. To dismantle these persistent student misconceptions effectively, it is essential to build an instructional device that bridges curriculum objectives directly with local cultural realities.

*Specifying Instructional Objectives*

The concept analysis was systematically carried out to critically evaluate the curriculum alignment, abstract structural properties, cognitive hierarchies, and contextual suitability of the linear motion kinematics sub-topics as outlined under the Independent Curriculum framework. This rigorous conceptual mapping was vital to identify which specific physical quantities and mathematical definitions could be explicitly and seamlessly integrated with West Sumatran local wisdom without compromising scientific accuracy. The students' structural readiness and pedagogical expectations for Inquiry Learning were measured across 6 distinct indicators using the standard ABCD parameters, as detailed in Figure 3.

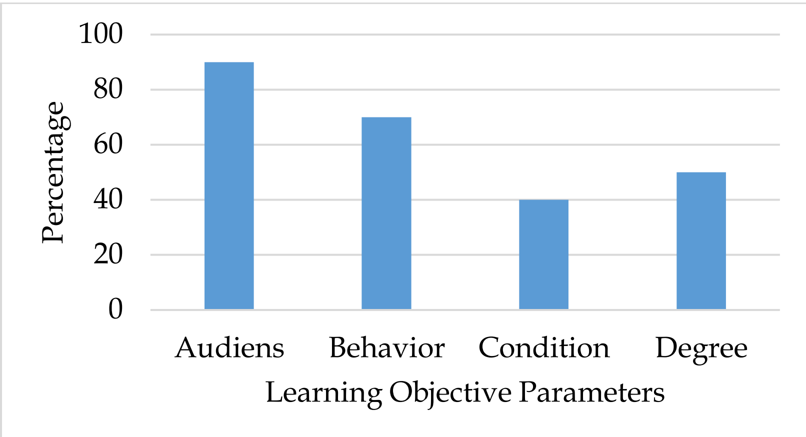


**Figure 3**. Analysis of Learning Objectives

The parameters structured in Figure 3 demonstrate that while the curricular framework is fundamentally solid, significant areas require immediate pedagogical refinement. The high score in the Audience parameter (90%) confirms that the educational targets consistently position students as the active core group within the classroom environment. However, the lower values obtained in the Condition (40%) and Degree (50%) domains show that the current learning goals fail to integrate specific digital interaction verbs or measurable validation benchmarks. Students are expected to complete physics tasks like analyzing one-dimensional motion and drawing vector slopes, yet the text instructions do not clearly specify the interactive electronic tools or cultural context to be used. Therefore, rewriting these learning objectives to incorporate the ABCD model completely is an empirical requirement to establish a highly responsive, inquiry-driven learning media environment.

## Discussion

The comprehensive needs analysis conducted during the Define stage reveals a profound, statistically backed gap between current physics instruction at SMAN 9 Padang and the rigorous cognitive competencies demanded by 21st-century education. The front-end analysis findings, now reinforced by multi-parameter data, indicate that students possess a stark and overwhelming preference for interactive digital learning materials over the conventional printed resources currently dominating the classroom. This critical structural deficiency is highly consistent with Riadhi et al. (2025), who documented a major instructional paradigm shift across Indonesian physics education demanding the development of Electronic Student Worksheets to overcome the severe text-density and lack of variation found in static textbook.

Furthermore, the exceptionally high student readiness and interest in digital tools (88.97%) recorded in the expanded learner analysis emphasizes that modern high schoolers are digital natives who require dynamic hypermedia scaffolding. As argued by Wulandahri et al. (2025), digital modules are not merely delivery systems but core pedagogical instruments capable of hosting interactive animations, virtual labs, and automated feedback loops that traditional paper media cannot replicate. The fact that students rated the current shortcomings of their learning conditions at 77.21% demonstrates a widespread, conscious dissatisfaction with passive lectures, proving that the transition toward an interactive electronic workspace represents a crucial evolutionary step to rescue student autonomy.

This media limitation directly underpins the low cognitive profiles documented in the learner analysis, where students' critical thinking skills failed to reach the minimum competency threshold across all dimensions. The absolute collapse of the analysis indicator to the lowest position (32.35%) exposes a profound cognitive bottleneck in students' operational logic. According to Facione (2020), analytical proficiency is a foundational cornerstone of critical thinking that requires students to identify intentional inferential relationships among statements, concepts, and physical quantities. The field evidence suggests that because students are continuously subjected to routine formula-memorization drills, they remain entirely incapable of breaking down complex kinematics word problems into isolated components. This widespread failure aligns with the baseline evidence reported by Juliyantika & Batubara (2022) and Ananta et al. (2025), confirming that conventional worksheets treat physics as an abstract mathematical exercise rather than an investigative science. Consequently, without a targeted structural intervention, students will continue to experience a severe limitation in constructing independent scientific reasoning.

The parametric distribution tracked during the task analysis further corroborates this pedagogical crisis, highlighting a substantial performance variance among the student cohort. The wide standard deviation (12.45) combined with a low minimum score of 25 mathematically proves that conventional textbooks fail to accommodate the diverse learning speeds present within a single classroom. Samadun et al. (2023) argued that when physics tasks are presented without a highly structured inquiry pathway, low-achieving students are quickly left behind while high-achieving students fail to reach absolute concept mastery. Differentiated learning tasks, as noted by Elviana et al. (2024), require real-time scaffolding prompts that can adapt to individual problem-solving workflows. The complete absence of analytical check balances in traditional workflows prevents students from verifying the mathematical precision of their kinematic models. Thus, restructuring student tasks into explicit inquiry cycles is a key requirement to close this wide standard deviation gap and ensure equitable cognitive development.

To address these cognitive gaps effectively, the concept analysis establishes that integrating West Sumatran local wisdom offers a powerful, contextually responsive remedy for abstract conceptual blocks. Embedding familiar regional cultural activities—such as *Pacu Jawi*, *Bendi*, and *Kincia Aia*—into the core physics curriculum bridges the gap between scientific laws and concrete physical experiences. Pardede et al. (2024), demonstrated that when abstract formulas are anchored to phenomena that students encounter daily, conceptual understanding increases significantly because cognitive resistance is reduced. Tressyalina et al. (2023) and Khotimah et al. (2023) further excelled that culturally integrated science modules promote deep cultural preservation while enhancing student engagement. In the context of linear motion kinematics, analyzing the velocity profiles of a *Bendi* or the vector displacement of *Pacu Jawi* transforms dry algebraic variables into meaningful investigations. This contextual integration ensures that the resulting E-Student Worksheet satisfies the demands of the Independent Curriculum by anchoring scientific literacy within the students' local environment.

Finally, the sharp mismatch exposed in the analysis of instructional objectives underscores the urgent necessity of reformulating the current physics curriculum frramework. While the target audience is clearly established, the critical lack of explicit interaction conditions and observable success criteria within the existing goals directly limits independent exploration. Samudra & Yulkifli (2019) stressed that an inquiry-driven worksheet can only succeed if the underlying objectives explicitly layout the hypermedia conditions and investigation parameters provided to the learners. Yuzan & Jahro (2022) and Utami & Emiliannur (2025) einforced this by proving that technology-supported objectives are crucial for guiding students systematically through data collection and critical reasoning. The high average student readiness score (76.47%) recorded in the survey confirms that the student body is fully prepared to engage with an interactive learning environment. Therefore, rewriting the instructional objectives using the complete ABCD framework is a prerequisite to ensure that the subsequent stages are systematically aligned with the students' cognitive needs.

## CONCLUSION

Based on the empirical findings and systematic diagnostic data gathered throughout the preliminary needs analysis stage, it can be concluded that tenth-grade high school students' critical thinking skills in linear motion kinematics are still poorly developed, as evidenced by a low test average of 38.4% and an absolute lowest achievement in the analysis indicator at 32.35% due to a continuous reliance on conventional, print-based textbooks that prioritize routine calculations over conceptual investigation. Furthermore, the sharp contrast between their low objective performance and their high self-reported perception (71.32%) exposes a distinct illusion of competence, which highlights an urgent necessity to replace passive teaching routines with structured metacognitive scaffolding. Conversely, the survey documents an exceptionally high technological readiness and enthusiasm among the student body, with 88.97% of the cohort demanding interactive digital media and 84.56% explicitly seeking the integration of local wisdom to make abstract physics laws more tangible. Therefore, the development of a unified, mobile-responsive Electronic Student Worksheet (E-SWS) based on Inquiry Learning and explicitly oriented toward West Sumatran cultural practices (such as *Pacu Jawi*, *Bendi*, and *Kincia Aia*) is highly urgent and empirically justified to dismantle persistent cognitive blocks, foster self-directed scientific reasoning, and fully satisfy the modern contextual mandates of the Independent Curriculum.

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