# Android-Integrated Physics Modules with Contextual Inquiry for Students' Critical Thinking and Digital Literacy

**Siti Nurjannah[1*], Syifaul Gummah[1], Lovy Herayanti[1], & Muhammad Fuaddunnazmi[1]**
[1]Physics Education Study Program, Universitas Pendidikan Mandalika, Indonesia
*Corresponding Author: sitinurjannah.physics@gmail.com

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***Abstract*** *- This study aimed to develop an Android-integrated physics learning module based on a contextual inquiry approach to support students' critical thinking skills and digital literacy at MAN 3 Mataram. The study employed a Research and Development (R&D) method using the ADDIE model, which consists of Analyze, Design, Development, Implementation, and Evaluation stages. The participants were 17 eleventh-grade students at MAN 3 Mataram. Data were collected through observations, questionnaires, and tests and analyzed using descriptive statistics, N-Gain analysis, and paired-samples t-test. The developed module integrated the Physics Formulas application as a supporting learning medium. Expert validation results showed an average validity score of 84.40%, categorized as very valid. The implementation results indicated a high N-Gain score of 75.48% and a statistically significant difference between pretest and posttest scores, $t(16) = 15.54$, $p < .001$. Students' critical thinking and digital literacy responses reached 92.50% and 87.50%, respectively. Therefore, the developed module was considered feasible and demonstrated potential to support technology-based physics learning.*

***Keywords***: *Critical Thinking Skills; Contextual Inquiry-Based Approach; Digital Literacy; Physics Learning Module.*

## INTRODUCTION

The development of 21st-century education requires students to possess various essential skills, such as critical thinking, problem-solving, creativity, collaboration, and digital literacy. Critical thinking is one of the key competencies that must be developed in the learning process because it helps students analyze information, evaluate problems, and make logical and rational decisions. The development of critical thinking skills has become a major focus in modern education and is implemented across various school subjects (Vieira et al., 2011).

In addition to critical thinking, digital literacy is also an essential skill in today's era of technological advancement. Digital literacy refers not only to the ability to use technology but also to the ability to search for, understand, evaluate, and utilize digital information effectively and responsibly. Therefore, modern learning should integrate digital technology so that students can adapt to current developments. Students with strong digital literacy skills tend to demonstrate better critical thinking abilities in the context of physics learning (Mufidah & Putranta, 2024).

In physics learning, critical thinking skills and digital literacy are highly important because physics involves not only theoretical concepts but also analytical skills, logical reasoning, and problem-solving based on natural phenomena. However, students often find physics difficult due to the abstract nature of the material and the dominance of teacher-centered learning approaches. Students tend to memorize formulas without deeply understanding the concepts and often struggle to relate physics concepts to everyday life. This finding is consistent with the research conducted by Pelawi & Sinulingga (2016), which revealed that students prioritize memorizing concepts and equations rather than understanding the contextual meaning of physics.

The low level of students' critical thinking skills and scientific literacy in Indonesia is also reflected in the results of the 2022 Programme for International Student Assessment (PISA), in which Indonesia scored 383 in science, below the OECD average of 476. These results indicate that students' ability to understand, analyze, and apply scientific concepts remains relatively low. One factor contributing to students' low critical thinking skills and digital literacy is the suboptimal use of technology-based media and teaching materials in the learning process. In fact, the development of digital technology, particularly Android-based smartphones, has great potential to support more interactive, flexible, and engaging learning experiences.

Critical thinking and digital literacy are two essential skills that students must possess in 21st-century learning. Critical thinking includes interpretation, analysis, evaluation, inference, explanation, and self-regulation, all of which are necessary for making logical and rational decisions (Facione, 2015). Meanwhile, digital literacy encompasses not only the ability to use technology but also the ability to access, understand, evaluate, and utilize digital information effectively and responsibly (UNESCO, 2018). These two skills are interconnected because digital literacy enables students to obtain information through technology, while critical thinking helps them analyze and evaluate the information objectively and logically.

Previous studies have found that mobile-enabled learning environments can significantly improve students' critical thinking performance and engagement in science learning contexts (Ismail et al., 2018). Therefore, physics learning should be designed by utilizing digital technology and learning activities that encourage students to think actively, analyze problems, and draw conclusions based on observations and investigations.

The use of Android-based learning media enables students to access learning materials anytime and anywhere through text, video, animation, simulations, and interactive practice exercises. Mobile learning has been shown to improve accessibility, engagement, and conceptual understanding in physics learning environments (Siswanto et al., 2025). Thus, the development of Android-based learning modules can serve as one solution to improve the quality of physics learning. Mobile learning platforms also provide flexible and interactive learning experiences that support inquiry and conceptual understanding in science education (Becker et al., 2020).

Previous research has demonstrated that the use of technology-based learning modules can enhance students' learning motivation and critical thinking skills (Perdana et al., 2017; Prastuti et al., 2018). Other studies have also revealed that smartphone-assisted inquiry-based learning environments significantly improve students' analytical reasoning and critical thinking skills in physics education (Lintangesukmanjaya et al., 2025). Furthermore, the use of Android-based interactive learning media has been shown to positively impact students' critical thinking skills compared to conventional learning methods (Rahmawati et al., 2025).

To make learning more meaningful, the use of learning modules should be supported by an appropriate learning approach, one of which is the contextual inquiry approach. The contextual inquiry approach encourages students to discover learning concepts independently through investigation and by connecting the material to real-life situations. This approach can create a more active, interactive, and student-centered learning environment, thereby fostering critical thinking skills and improving students' digital literacy.

Based on several previous studies, research integrating contextual approaches, inquiry strategies, and the Android platform into a unified physics learning module remains limited. Although previous studies have explored Android-based learning media and inquiry-based learning separately, only a few have integrated contextual inquiry, mobile-assisted learning, critical thinking, and digital literacy simultaneously in the context of physics education (Ismail et al., 2018; Becker et al., 2020; Kao et al., 2024). Previous studies have primarily focused on Android-based learning media (Prastuti et al., 2018), inquiry-based learning (Becker et al., 2020), or digital literacy enhancement separately. However, limited studies have simultaneously integrated Android-assisted learning modules, contextual inquiry activities, critical thinking development, and digital literacy enhancement within a single physics learning intervention.

Unlike previous studies that focused solely on Android-based learning media or inquiry approaches independently, this study integrates Android-assisted physics modules with contextual inquiry activities to simultaneously improve students' critical thinking skills and digital literacy in physics learning.

## RESEARCH METHODS

This study employed a Research and Development (R&D) method aimed at developing an Android-integrated physics module using a contextual inquiry approach to improve students' critical thinking skills and digital literacy. The learning module was developed by utilizing the *Physics Formulas* application available on the Android platform as a supporting learning medium. The development model used in this study was the ADDIE model, which consists of five stages: Analyze, Design, Development, Implementation, and Evaluation. The research was conducted at MAN 3 Mataram

**Table 1.** Stages of the ADDIE Development Model

| ADDIE Stage | Research Activities |
|---|---|
| **Analyze** | Conducting an analysis of learning needs, students' characteristics, the condition of students' critical thinking skills and digital literacy, and analysis of physics material on the topic of Newton's Law of Gravitation. |
| **Design** | Designing an Android-integrated physics module using the *Physics Formulas* application, preparing learning materials, student worksheets (LKPD), contextual inquiry-based learning activities, and research instruments |
| **Development** | Developing the learning module and conducting expert validation on aspects of content, language, graphic design, inquiry approach, critical thinking skills, and digital literacy |
| **Implementation** | Implementing the module with 17 eleventh-grade students at MAN 3 Mataram to determine the practicality and effectiveness of the module in physics learning |
| **Evaluation** | Conducting evaluation and revision of the module based on validation results, teacher and student responses, and the results of pretests and posttests on students' critical thinking skills and digital literacy |

Data collection in this study was conducted through observation, questionnaires, and tests. Observation was used to identify the condition of physics learning at the school. Questionnaires were used to obtain data regarding the validity and practicality of the module based on evaluations from validators, teachers, and students. Tests were used to measure the improvement of students' critical thinking skills and digital literacy through pretest and posttest activities. The research instruments used in this study included learning observation sheets, expert validation sheets, teacher and student response questionnaires, as well as pretest and posttest questions to assess students' critical thinking skills and digital literacy.

The critical thinking instrument consisted of 30 multiple-choice items and 5 essay items. Digital literacy was assessed using a separate questionnaire adapted from UNESCO (2018), while critical thinking skills were measured through 30 multiple-choice items and 5 essay questions. Reliability analysis was conducted using Cronbach's Alpha prior to implementation to evaluate the internal consistency of the instruments.

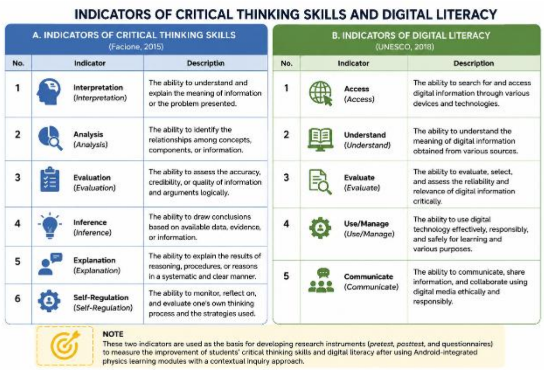


**Figure 1.** Indicators of Critical Thinking Skills and Digital Literacy

**Table 2**. Blueprint of the Critical Thinking Instrument

| Indicator | Description | Item Numbers |
|---|---|---|
| Analysis | Analyzing the effects of changes in mass and distance variables on gravitational force | 1, 2, 4, 6, 7, 10, 11, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 |
| Evaluation | Evaluating extreme conditions, dominant variables, and experimental results | 5, 12, 14, 18 |
| Interpretation | Interpreting simulation results and identifying patterns | 13, 19 |
| Inference | Drawing conclusions from simulation outcomes | 3, 8, 15, 30 |

The instrument blueprint was developed based on Facione's (2015) critical thinking framework. The multiple-choice items and essay questions were designed to assess students' abilities in analyzing, interpreting, evaluating, and drawing conclusions from simulation-based investigations using the Physics Formulas Android application. Digital literacy indicators were measured separately through a questionnaire adapted from UNESCO (2018).

The indicators used in this study were based on the critical thinking indicators proposed by Facione (2015) and the digital literacy indicators proposed by UNESCO (2018). These indicators served as the basis for developing the research instruments, including the pretest, posttest, and questionnaires, to measure the improvement of students' critical thinking skills and digital literacy after using the Android-integrated physics learning module with a contextual inquiry approach. The data analysis techniques consisted of descriptive and inferential statistics. Descriptive statistics were used to analyze validity and practicality data. The effectiveness of the developed module was examined using N-Gain analysis and paired-samples t-test. Cohen's d effect size was also calculated to determine the magnitude of learning improvement.

Data obtained from expert validation and response questionnaires were analyzed using percentage techniques to determine the feasibility and practicality of the module. The percentage was calculated using the following formula:

$$Percentage = \frac{\text{Obtained Score}}{\text{Maximum Score}} \times 100\% \qquad (1)$$

The percentage results were then categorized into five categories: very feasible, feasible, fairly feasible, less feasible, and not feasible. Meanwhile, to determine the effectiveness of the module in improving students' critical thinking skills and digital literacy, a Normalized Gain (N-Gain) analysis was employed. The data were obtained from students' pretest and posttest results. The N-Gain score was calculated using the following formula:

$$N - Gain = \frac{Posttest\ Score - Pretest\ Score}{\text{Maximum Score} - Pretest\ Score} \qquad (2)$$

With the following criteria:

**Table 3**. Validity Criteria

| Percentage Range | Validity Criteria |
|---|---|
| 81-100% | Very Valid |
| 61-80% | Valid |
| 41-60% | Moderately Valid |
| 0-20% | Invalid |

The N-Gain results were then categorized into three levels: high, medium, and low, to determine the level of improvement in students' abilities after using the Android-integrated physics module.

## RESULTS AND DISCUSSION

### Results

This study produced an Android-integrated physics module using a contextual inquiry approach on the topic of Newton's Law of Gravitation for eleventh-grade students at MAN 3 Mataram. The module was developed by utilizing the *Physics Formulas* application as a supporting learning medium that can be accessed through students' Android smartphones.

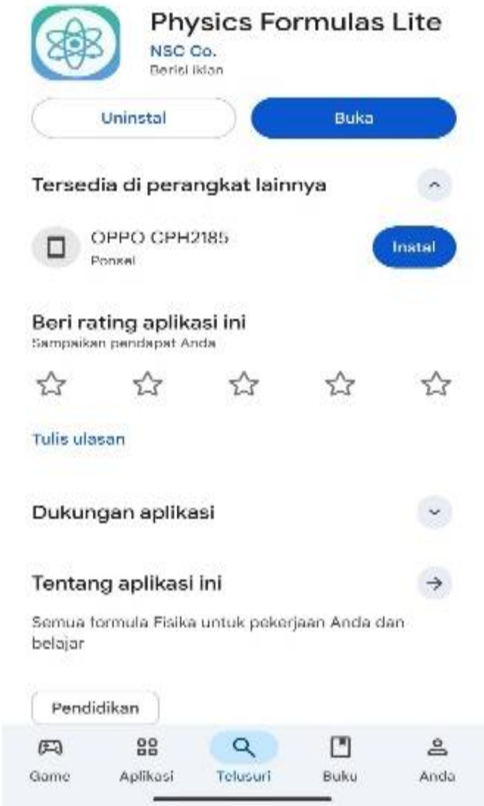


**Figure 2.** Physics Formulas Application

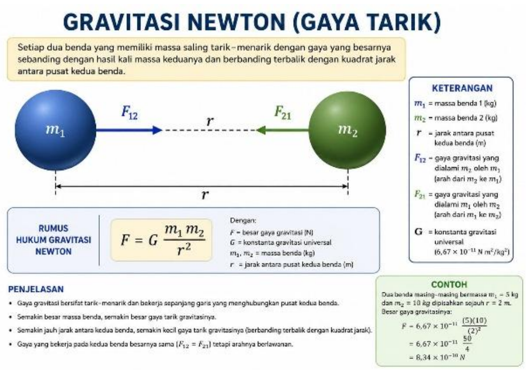


**Figure 3.** Learning Materials in the Physics Formulas Application

The module was developed using the ADDIE model, which consists of the Analyze, Design, Development, Implementation, and Evaluation stages.

**Table 4**. Validation Results from Three Experts

| Validator | Percentage | Category |
|---|---|---|
| **Validator I** | 84,10% | Very Valid |
| **Validator II** | 91,50% | Very Valid |
| **Validator III** | 72,20% | Valid |
| **Mean Score** | 84,40% | Very Valid |

After the learning module had been developed, it was validated by three expert validators. The validation covered aspects of content feasibility, language use, presentation, graphic design, suitability of the contextual inquiry approach, development of critical thinking skills, digital literacy, and the appropriateness of the student worksheets (LKPD). The validation results showed that Validator I obtained a percentage of 84.10% in the "very valid" category, Validator II obtained 91.50% in the "very valid" category, and Validator III obtained 72.20% in the "valid" category. Overall, the average percentage score was 84.40%, which falls into the "very valid" category. These results indicate that the developed module is feasible for use in physics learning.

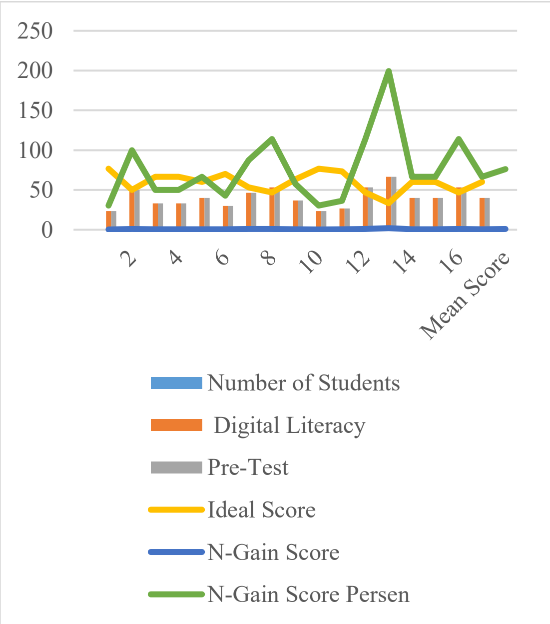


**Figure 4.** Digital Literacy Pretest

The findings revealed that students experienced difficulties in understanding the concept of Newton's Law of Gravitation because previous learning activities were still teacher-centered and focused more on the use of formulas rather than contextual conceptual understanding. In addition, the use of technology-based learning media in physics instruction was still limited, resulting in students' critical thinking skills and digital literacy not being optimally developed.

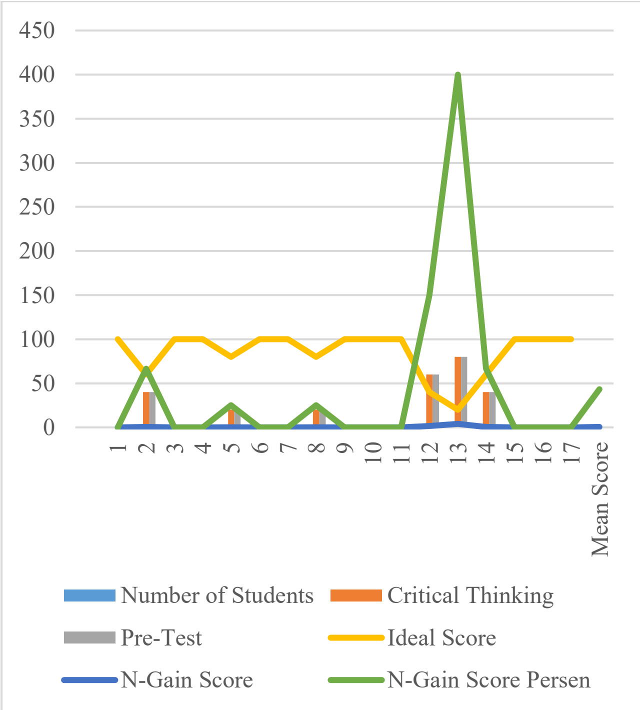


**Figure 5.** Critical Thinking Pretest

The module in this study was designed by integrating a contextual inquiry approach with the *Physics Formulas* application in learning activities. The module contains learning materials, inquiry activity procedures, student worksheets (LKPD), practice exercises, application usage guidelines, and simulation-based exploration activities to help students understand the relationship between mass, distance, and gravitational force more concretely.

During the implementation stage, the module was tested on 17 eleventh-grade students at MAN 3 Mataram. The implementation results showed that the use of the module improved students' critical thinking skills and digital literacy. This improvement was identified through pretest and posttest results analyzed using the N-Gain test.

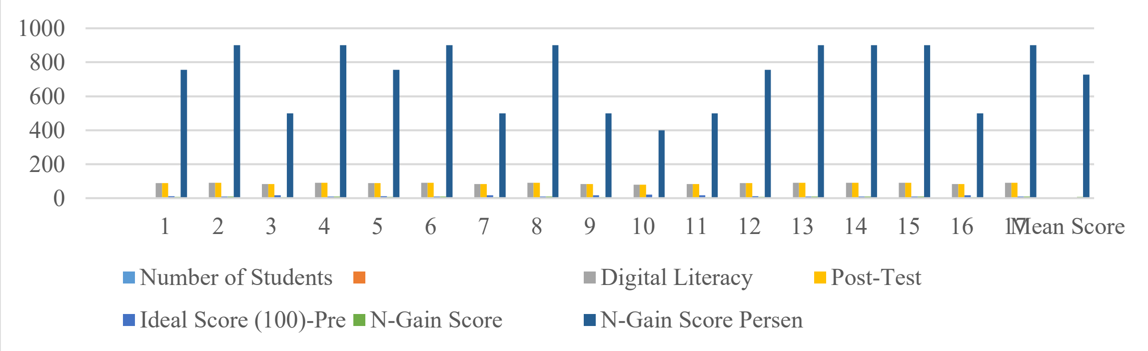


**Figure 6**. Digital Literacy Post-test

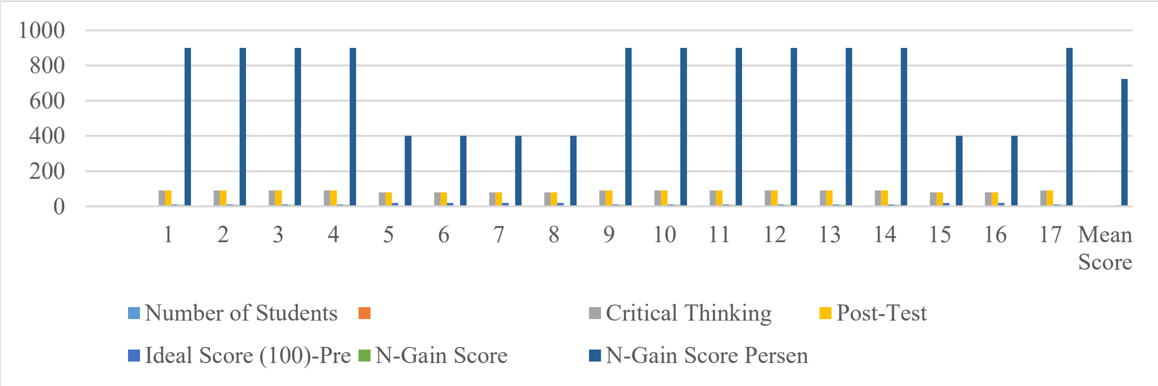


**Figure 7**. Critical Thinking Post-test

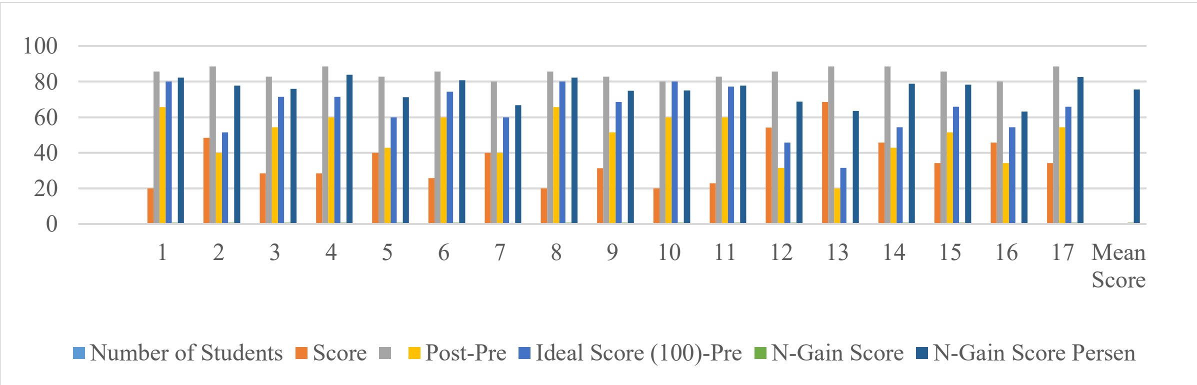


**Figure 8**. N-Gain Score Results of the Pre-Test and Post-Test

**Table 5**. Effectiveness of the Android-Integrated Physics Learning Module

| Statistic | N-Gain Score | N-Gain Persen (%) |
|---|---|---|
| **Number of Students** | 17 | 17 |
| **Minimum Value** | 0,63 | 63,17% |
| **Maximum Value** | 0,84 | 83,92% |
| **Mean** | 0,7548 | 75,48% |
| **Standard Deviation** | 0,06621 | 0,62144 |

Based on the effectiveness analysis results, the implementation of the Android-integrated physics learning module produced highly positive outcomes. The lowest N-Gain score recorded was 0.63, while the highest score was 0.84, indicating that all students experienced improvement after using the module. The average N-Gain score of 0.7548 or 75.48% falls into the high category, demonstrating that the module was highly effective in improving students' understanding. The relatively small standard deviation value of 0.06621 also indicates that the improvement among students was relatively consistent.

**Table 6.** Paired-Samples t-Test Results

| Variable | Pretest Mean | Posttest Mean | T | df | p |
|---|---|---|---|---|---|
| Learning Outcomes | 35.76 | 84.84 | 15.54 | 16 | <0.001 |

A paired-samples t-test revealed a statistically significant difference between pretest and posttest scores, $t(16) = 15.54$, $p < .001$. Students' average score increased from 35.76 to 84.84 after the implementation of the Android-integrated physics module.

**Table 7**. Effect Size Results

| Variable | Cohen's d | Interpretation |
|---|---|---|
| Learning Outcomes | 3.77 | Very large |

The calculated Cohen's d value of 3.77 indicates a very large effect size, suggesting substantial learning improvement following the implementation of the module.

In addition, students appeared more active during the learning process through simulation exploration activities, data analysis, discussions, and independent conclusion-making. The results of the critical thinking questionnaire showed a percentage of 92.50% in the "very good" category. These results indicate that students were able to identify problems, formulate hypotheses, analyze simulation data, evaluate information, and draw conclusions based on the physics concepts studied.

Meanwhile, the digital literacy questionnaire results obtained a percentage of 87.50%, which also falls into the "very good" category. These findings indicate that students were able to independently use Android-based learning applications, understand digital information, explore application features, and utilize technology responsibly during the learning process.

The practicality of the module also received positive responses from both students and teachers. The student response questionnaire obtained a percentage of 83% in the "very practical" category, while the teacher response questionnaire obtained 80% in the "practical" category. These results indicate that the module was easy to use, attractive, systematic, and helpful in making physics learning more interactive and flexible.

During the evaluation stage, revisions and improvements were made based on suggestions from validators and implementation results in the classroom. Several improvements included adjusting the learning materials to the features of the *Physics Formulas* application, adding illustrations to practice questions, and improving the module design to make it more attractive and easier for students to understand. Overall, the Android-integrated physics module was declared feasible and showed promising potential for supporting physics learning.

**Discussion**

The development of the Android-integrated physics module with a contextual inquiry approach in this study aimed to create physics learning that is more interactive, contextual, and student-centered. The module was developed by utilizing the *Physics Formulas* application as a supporting learning medium to help students understand the concept of Newton's Law of Gravitation through independent exploration and investigation activities.

The results showed that the developed module had a very high level of validity, with an average percentage of 84.40%. These findings indicate that the module fulfilled aspects of content feasibility, language, presentation, graphic design, suitability of the contextual inquiry approach, development of critical thinking skills, and digital literacy. The high validity level indicates that the developed module was aligned with the needs of physics learning in schools and was appropriate for use in the learning process.

The success of the module in improving students' critical thinking skills can be seen from the questionnaire results, which obtained a percentage of 92.50% in the "very good" category. The significant pretest–posttest difference and very large effect size further support the effectiveness of the developed module. The very large effect size suggests that the observed improvement was not only statistically significant but also educationally meaningful. This finding indicates that the integration of contextual inquiry activities with Android-assisted learning resources may provide a learning environment that promotes deeper conceptual understanding and active student engagement.

This finding is consistent with previous studies showing that inquiry-oriented mobile learning environments facilitate students' analytical reasoning and reflective thinking processes (Ismail et al., 2018). Other findings also indicate that smartphone-assisted inquiry-based learning can improve students' critical thinking skills in physics learning (Lintangesukmanjaya et al., 2025).

This improvement occurred because the contextual inquiry approach provided students with opportunities to actively engage in the learning process through observing, analyzing, formulating hypotheses, evaluating data, and drawing conclusions. These activities indirectly trained students' critical thinking skills in understanding physics concepts more deeply.

In addition, the use of the *Physics Formulas* application helped students visualize the relationship between mass, distance, and gravitational force more concretely. Learning that previously focused on memorizing formulas shifted into a more exploratory and contextual learning process. This finding is in line with constructivist theory, which states that knowledge is actively constructed by students through learning experiences and interactions with the learning environment.

The results also showed that the module improved students' digital literacy, with a percentage score of 87.50% in the "very good" category. The improvement in digital literacy was reflected in students' ability to use Android-based learning applications, independently explore digital features, understand digital information, and utilize technology responsibly during the learning process. Digital physics teaching materials have been reported to simultaneously foster critical thinking and digital literacy in physics learning environments (Abdillah & Nugroho, 2025).

The use of digital technology in physics learning provides more flexible and engaging learning experiences, making students more active in the learning process. Interactive digital learning environments encourage students to independently access, evaluate, and utilize digital information, thereby strengthening digital literacy competencies (Kao et al., 2025).

The findings of this study are consistent with previous research indicating that the use of Android-integrated learning media and digital simulations can improve student engagement, critical thinking skills, and the effectiveness of physics learning. Research conducted by Rahmat et al. (2023) examined Phys-cast as a physics learning medium to facilitate independent physics learning through Android applications. The results showed that the Phys-cast media had good compatibility and was considered valid, practical, and effective for use in physics learning.

Dayu et al. (2025) also demonstrated that the use of digital simulation media can increase student participation in physics learning. In addition, Solehayati et al. (2025) stated that inquiry-based learning supported by digital simulations received positive responses from both students and teachers because it was easier to understand and improved learning effectiveness.

The integration of learning media and digital technology combines instructional tools (visual and audio media) with modern platforms such as applications and the internet. This collaboration creates a more interactive learning experience, eliminates spatial limitations, and is highly relevant to students' current needs. These findings are also supported by the research conducted by Rizki et al. (2025), which showed that the integration of pedagogy and learning technology can improve students' learning experiences, creativity, and motivation in physics learning. The practicality of the module also showed highly positive results based on student responses of 83% and teacher responses of 80%.

These findings indicate that the module was easy to use, attractive, systematic, and helpful for teachers in delivering physics learning materials more interactively. The integration of Android applications within the module also provided flexibility for students to study anytime and anywhere through their smartphones.

This study has advantages over previous studies because it not only developed an Android-integrated module but also simultaneously integrated a contextual inquiry approach with the development of critical thinking skills and digital literacy in physics learning.

The improvement in students' critical thinking skills can be associated with the contextual investigation activities embedded within the module, which encouraged students to formulate hypotheses, analyze evidence, and independently construct conceptual understanding. These findings are consistent with constructivist learning theory, which emphasizes active knowledge construction through authentic investigation (Becker et al., 2020). Therefore, the developed Android-integrated physics module can serve as an innovative alternative teaching material to support technology-based physics learning in the digital era.

This study was limited by the relatively small number of participants (n = 17) and the absence of a comparison group. Consequently, the findings should be interpreted as preliminary evidence obtained during the implementation stage of product development. Future studies involving larger samples and experimental designs are recommended.

## CONCLUSION

Based on the results of this research and development, the Android-integrated physics module employing a contextual inquiry approach was found to be feasible and demonstrated potential to support physics learning at MAN 3 Mataram. The module was developed using the ADDIE model and supported by the Physics Formulas application as a digital learning medium. Expert validation results indicated an average score of 84.40%, categorized as "very valid," demonstrating that the developed module met the criteria of content quality, presentation, language, graphical design, inquiry approach suitability, critical thinking development, digital literacy integration, and worksheet feasibility.

The implementation results indicated substantial improvement in students' learning outcomes, supported by a high N-Gain score and significant pretest–posttest differences. Students also demonstrated positive responses regarding critical thinking and digital literacy development. Therefore, the developed module shows potential as an innovative teaching material for technology-based physics learning. Nevertheless, further studies involving larger samples and comparison groups are recommended to strengthen the evidence regarding its effectiveness.

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