Developing an EWB-Assisted Contextual Inquiry Physics Module to Enhance Students' Critical Thinking Skills and Digital Literacy

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Abstract - *This study aims to develop a physics learning module based on a contextual inquiry approach assisted by Electronics Workbench (EWB) software for teaching organ pipe topics, evaluate its feasibility based on expert validation, assess its practicality based on teacher and student responses, and examine its potential to improve students' critical thinking skills and digital literacy. The study employed a Research and Development (R&D) approach using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. The research participants included material and media experts as validators and 33 Grade 11 students from SMA Negeri 2 Gerung as module users. Data were collected through expert validation sheets, teacher and student response questionnaires, and pretest-posttest instruments measuring students' critical thinking skills and digital literacy. The feasibility assessment yielded an average score of 85.63%, categorized as very valid. The module was also considered highly practical based on teacher and student responses, with average scores of 92.5% and 87.5%, respectively. The average critical thinking score increased from 61.2 to 84.5, while the average digital literacy score increased from 65.4 to 86.7. The mean N-gain score was 0.55, indicating a moderate level of improvement. A paired-samples t-test showed a statistically significant difference between the pretest and posttest scores ($p < .001$), with a large effect size (Cohen's $dz = 3.38$). These findings indicate that the developed module is feasible and practical and provides preliminary evidence of its potential to improve students' critical thinking skills and digital literacy. However, because the effectiveness test employed a one-group pretest-posttest design without a control group, the findings should be interpreted cautiously and confirmed through controlled experimental studies.*

Keywords: *Contextual Inquiry Approach; Electronics Workbench (EWB); Critical Thinking; Digital Literacy; Learning Module.*

INTRODUCTION

Education is a conscious and systematic effort to create a learning environment that enables students to develop their potential optimally, encompassing cognitive, affective, and psychomotor aspects. Physics, as one of the core subjects in senior high school, studies natural phenomena based on facts, concepts, and laws that are tested through the scientific method. However, in practice, physics is often regarded as a difficult subject, causing many students to be less motivated and less actively engaged in the learning process.

One of the physics topics considered abstract and difficult for students to understand is sound waves, particularly the Organ Pipe concept. This concept involves the relationship between air column length, frequency, and sound resonance, which is difficult to visualize without supporting media. The limited availability of practical laboratory equipment in school physics labs also means that students rarely conduct direct experiments, resulting in a shallow understanding of the concepts.

One approach that can help address these problems is the contextual approach combined with guided inquiry learning. Guided inquiry places students in situations where they discover and solve problems independently through investigative activities guided by the teacher (Aba et al., 2022; Najwa et al., 2022). The contextual

approach (Contextual Teaching and Learning/CTL) emphasizes active student involvement in connecting learning material to real-life situations, making learning more meaningful (Darmuki & Hidayati, 2023).

The challenge of visualizing abstract concepts can be addressed through the use of technology in learning, one of which involves virtual laboratories assisted by Electronics Workbench (EWB) software. Electronics Workbench is a simulation software that can be used to conduct virtual experiments interactively (Tumangkeng et al., 2023). In this study, EWB was used to help visualize sound wave phenomena in the Organ Pipe topic through electrical circuit analogies, allowing students to observe the relationships between pipe length, frequency, and current intensity more concretely. The use of virtual simulation also enables students to experiment independently without being constrained by the availability of physical laboratory equipment.

Several previous studies have demonstrated the benefits of guided inquiry, contextual approaches, and EWB software in physics learning, yet each addresses only part of the combination examined in the present study. Heru et al., (2024) applied a guided inquiry model with a contextual approach to mechanical energy content and demonstrated a significant improvement in learning outcomes, but did not incorporate EWB simulation or measure digital literacy. Tumangkeng et al., (2023) showed that the use of EWB in guided inquiry improved students' cognitive learning outcomes in direct current electricity, but did not adopt a contextual approach or assess critical thinking and digital literacy as joint outcomes. Damayanti and Panggabean (2025) developed a guided inquiry-based physics e-module on temperature and heat with material validity of 89% and media validity of 87%, but their product did not integrate EWB virtual simulation and was not evaluated for critical thinking or digital literacy outcomes. Taken together, prior work has treated guided inquiry, contextual learning, EWB simulation, and digital-literacy outcomes as separate strands rather than an integrated design. The specific gap addressed here is therefore the absence of a module that combines a contextual inquiry approach with EWB simulation on Organ Pipe material while simultaneously targeting critical thinking skills and digital literacy as paired outcome variables — a combination not yet examined in the studies above.

Based on the above description, this study develops a physics learning module with a contextual inquiry approach assisted by Electronics Workbench (EWB) on Organ Pipe material. This research aims to: (1) determine the feasibility of the module based on expert validators' assessment; (2) describe the practicality of the module based on teacher and student responses; and (3) determine the effectiveness of the module in improving the critical thinking skills and digital literacy of eleventh-grade students at SMA Negeri 2 Gerung.

RESEARCH METHOD

This study is a Research and Development (R&D) study that produces a physics learning module with a contextual inquiry approach assisted by Electronics Workbench (EWB) software on Organ Pipe material. The development model used is the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was chosen because it provides a systematic and structured development process, facilitating the researcher in developing learning products from needs analysis to product evaluation.

In addition to the R&D method, this

study also employed a product trial design in the form of a pre-experimental design with a one-group pretest-posttest design, represented as O_1 X O_2, where O_1 is the pretest before module use, X is the treatment using the EWB-assisted learning module, and O_2 is the posttest after module use. This pre-experimental design does not include a control or comparison group; consequently, observed pretest-posttest gains cannot be unambiguously attributed to the module alone, as maturation, testing effects, and other extraneous variables cannot be ruled out. The effectiveness results reported in this study should therefore be read as preliminary evidence obtained under a limited-evidence design, to be confirmed in future work using quasi-experimental or true experimental designs with a control group.

In the Analysis stage, needs analysis was conducted through interviews with physics teachers, curriculum analysis based on the Merdeka Curriculum, and analysis of students' digital characteristics and readiness. The Design stage included structuring the module, developing contextual inquiry learning syntax, creating the module layout storyboard with integrated EWB simulation, and designing research instruments including expert validation sheets, teacher and student response questionnaires, critical thinking tests, and digital literacy tests. The Development stage involved compiling the content, integrating EWB simulation, developing Student Worksheets (LKS), expert validation, and product revision based on validator feedback. The Implementation stage involved limited trials with 33 eleventh-grade students, including learning sessions, pretest and posttest, and distribution of teacher and student response questionnaires. The Evaluation stage was conducted to assess validity, practicality, and effectiveness of the module through analysis of expert validation results, response questionnaires, pretest-posttest results, N-Gain analysis, and paired sample t-test.

The research population was all eleventh-grade students of SMA Negeri 2 Gerung for the 2025/2026 academic year, totaling 33 students. The sample was selected using purposive sampling technique, comprising one class XI with 33 students who were active in learning and had basic computer operation skills. Because the sample was drawn from a single class at one school using a non-random, purposive procedure, the sample size is relatively small and the findings are not intended to be generalized beyond similar contexts without further replication. The study was conducted at SMA Negeri 2 Gerung in the even semester of the 2025/2026 academic year, from April to May 2026.

The research instruments consisted of a module feasibility validation sheet, a module practicality questionnaire for teachers and students, and effectiveness test instruments comprising 20 multiple-choice questions to measure digital literacy and 5 essay questions to measure students' critical thinking skills. The scoring technique used was a 4-point Likert scale: 4 (Strongly Agree), 3 (Agree), 2 (Disagree), and 1 (Strongly Disagree). The content validity of the critical thinking and digital literacy test instruments was established through expert judgment: two experts (a material expert and a media expert) reviewed each item against the instrument blueprint (kisi-kisi) for construct alignment, clarity, and appropriateness to the Organ Pipe learning indicators, and items were revised accordingly before use. This judgment was conducted descriptively; a numerical item-level content-validity coefficient (e.g., Aiken's V) was not computed, and no separate pilot administration was carried out to estimate internal-consistency reliability

(e.g., Cronbach's alpha) prior to the main data collection. The absence of these quantitative indices is acknowledged as a limitation of the instrument-development procedure, and it is recommended that future studies compute item-level validity and reliability coefficients from an independent pilot sample before administering the instruments in the main trial.

Data collection was conducted through observation, questionnaires (expert validation questionnaire, teacher response questionnaire, and student response questionnaire), tests (pretest and posttest), and documentation. Module feasibility and practicality data were analyzed quantitatively and descriptively using the following percentage formula:

$$NP = (R / SM) \times 100\% \quad (1)$$

where NP is the percentage value, R is the score obtained, and SM is the maximum score.

Table 1. Module Feasibility and Practicality Criteria

Percentage (%)	Feasibility Criteria	Practicality Criteria
81 - 100	Very Valid	Very Practical
61 - 80	Valid	Practical
41 - 60	Fairly Valid	Fairly Practical
21 - 40	Less Valid	Less Practical
0 - 20	Not Valid	Not Practical

Module effectiveness was analyzed using N-Gain Score with the formula:

$$g = \frac{(Posttest - Pretest)}{(Maximum\ Score - Pretest)} \quad (2)$$

The result g is categorized as follows: $g > 0.7$ = High; $0.3 \leq g \leq 0.7$ = Moderate; $g < 0.3$ = Low (Hake, 1998).

Hypothesis testing was performed using the paired sample t-test with SPSS software to determine whether there was a significant difference between students' pretest and posttest results after using the learning module. Testing criteria: if the Sig. (2-tailed) value < 0.05, then H_0 is rejected and H_1 is accepted, meaning there is a significant difference between students' pretest and posttest results.

RESULTS AND DISCUSSION

Research Results

This study produced a product in the form of a contextual inquiry-based physics learning module assisted by Electronics Workbench (EWB) software on Organ Pipe material for eleventh-grade students of SMA Negeri 2 Gerung. Module development was carried out using the ADDIE model, consisting of the Analysis, Design, Development, Implementation, and Evaluation stages.

1. Analysis Stage

Based on observation results and interviews with the physics teacher, it was found that Organ Pipe instruction predominantly used lecture methods, causing students difficulty in understanding abstract sound wave concepts. Limited practical equipment meant students rarely conducted experiments directly. The analysis showed students were more interested in technology-based learning media and digital simulations compared to conventional learning, and the school had laptops, projectors, and computer laboratory facilities that support EWB use.

2. Design Stage

At this stage, the module structure was designed, comprising content, simulation,

worksheets, and evaluation, with a contextual inquiry approach as the learning model. The module's visual design was complemented with illustrations and EWB simulation screenshots. Pretest and posttest instruments were constructed consisting of 20 multiple-choice questions to measure digital literacy and 5 essay questions to measure students' critical thinking skills.

3. Development Stage

The development stage included compiling content and virtual practicals, developing EWB simulation exploration-based student worksheets, integrating digital simulation as concept visualization, and expert validation by material and media experts. The module was revised according to validator recommendations before being piloted.

4. Implementation Stage

The implementation stage involved limited trials with 33 eleventh-grade students. During learning, students explored simulations, engaged in group discussions, observed data, and solved inquiry-based problems. Several technical challenges arose, such as computer laboratory disruptions and device limitations, which were addressed by relocating to classrooms, using students' personal laptops, and conducting group-based learning.

5. Module Validity Test Results

Validation was conducted by two validators comprising a material expert and a media expert. Validation results are presented in Table 2.

Table 2. Expert Validation Results

Assessment Aspect	Percentage	Category
Content Feasibility	87,5%	Very Valid
Language	85%	Very Valid
Presentation	82,5%	Very Valid
Media Feasibility	87,5%	Very Valid
Average	**85,63%**	**Very Valid**

The validation results from the material and media experts yielded an average score of 85.63%, falling under the Very Valid category. These results indicate that the learning module has comprehensively met the aspects of content feasibility, language, presentation, and media utility. The validators recommended improvements to the module's layout visualization and adjustments to the EWB simulation usage instructions to make them easier for students to understand. The consistently high scores across all four assessed aspects can be attributed to the iterative revision process built into the ADDIE Development stage, in which the module was refined according to validator feedback before the final scoring round; because validation was conducted by only two validators (one material expert and one media expert), the scores also reflect a small-panel judgment rather than a broad expert consensus, and should be interpreted with this limitation in mind. After revisions based on validator recommendations, the module was deemed ready for piloting in the implementation stage.

6. Module Practicality Test Results

Module practicality was measured through student response questionnaires and teacher response questionnaires. Student response questionnaire results are presented in Table 3.

Table 3. Student Response Questionnaire Results

Assessment Aspect	Percentage	Category
Ease of module use	87,5%	Very Practical
Clarity of content	85%	Very Practical
Module appearance	90%	Very Practical
EWB simulation use	92,5%	Very Practical
Learning independence	82,5%	Very Practical
Average	**87,5%**	**Very Practical**

The student response questionnaire results showed an average score of 87.5%, falling under the Very Practical category. This indicates that the physics learning module with a contextual inquiry approach assisted by EWB is easy to use, engaging, and effectively helps students understand the Organ Pipe concept through digital simulation.

Table 4. Teacher Response Questionnaire Results

Assessment Aspect	Percentage	Category
Content relevance	100%	Very Practical
Clarity of presentation	100%	Very Practical
Ease of use	75%	Practical
Alignment with learning	100%	Very Practical
Benefits of EWB use	87,5%	Very Practical
Average	**92,5%**	Very Practical

The teacher response questionnaire results showed an average score of 92.5%, categorized as Very Practical. The teacher assessed that the content presented was relevant to the learning objectives and systematically organized. EWB simulation was considered highly contributive in helping the teacher visualize the abstract Organ Pipe concept more concretely through digital modeling. Although the ease of use aspect scored only 75% (Practical category), indicating a need for technical adaptation at the start, overall the module was rated as very feasible as innovative teaching material in physics learning.

7. Module Effectiveness Analysis Results

Module effectiveness was analyzed based on pretest and posttest results of 33 eleventh-grade students at SMA Negeri 2 Gerung using N-Gain analysis and paired sample t-test. The test instruments consisted of 20 multiple-choice questions to measure digital literacy and 5 essay questions to measure critical thinking skills.

a. Critical Thinking Skills Results

The test results showed a significant improvement in students' critical thinking skills after the implementation of the learning module, from an average of 61.2 in the pretest to 84.5 in the posttest. The minimum score increased from 45 to 70, while the maximum score increased from 78 to 95. These results indicate that the EWB simulation-assisted learning module was effective in stimulating students' critical thinking proficiency in Organ Pipe material, as evidenced by increasingly sharpened abilities in analyzing physical problems, interpreting simulation data, and drawing logical conclusions.

Table 5. Critical Thinking Pretest and Posttest Results

Statistic	Pretest	Posttest
Minimum Score	45	70
Maximum Score	78	95
Average	61,2	84,5

b. Digital Literacy Results

The test results showed a significant improvement in students' digital literacy, from an average of 65.4 in the pretest to 86.7 in the posttest. The minimum score increased from 50 to 72, while the maximum score increased from 80 to 96. These results demonstrate that the EWB virtual laboratory simulation-assisted learning module was highly effective in improving students' digital literacy skills, reflected in the development of students' abilities to operate digital media, understand virtual circuit simulation principles, process physical information, and logically connect digital data visualization to understanding abstract physics concepts.

Table 6. Digital Literacy Pretest and Posttest Results

Statistic	Pretest	Posttest
Minimum Score	50	72
Maximum Score	80	96
Average	65,4	86,7

c. N-Gain Analysis Results

Table 7. N-Gain Analysis Results

Data	N	Min	Max	Mean	Std. Dev
N-Gain Score	33	0,23	0,79	0,5513	0,12454
N-Gain Persen	33	23,08	78,85	55,1326	12,45441

Based on the calculation results, the mean N-Gain Score was 0.5513 with an N-Gain percentage of 55.13%. According to normalized gain criteria, this falls under the Moderate category. These results indicate that the use of the physics learning module with a contextual inquiry approach assisted by EWB was sufficiently effective in improving student learning outcomes and conceptual understanding of Organ Pipe material. Integration of digital circuit simulation through EWB proved capable of helping students transform the originally abstract sound wave concept into something more concrete through digital visualization of physical phenomena.

d. Hypothesis Test Results (Paired Sample T-Test)

The paired sample t-test results yielded a Sig. (2-tailed) value of $0.000 < 0.05$, so H_0 is rejected and H_1 is accepted. This indicates a significant difference between students' pretest and posttest scores after using the learning module. The mean difference of −37.697 shows that posttest scores were higher than pretest scores, with a t-value of −19.430 at 32 degrees of freedom. Beyond statistical significance, the corresponding paired-samples effect size was very large (Cohen's $dz = t/\sqrt{n} = 19.430/\sqrt{33} \approx 3.38$), indicating a substantial magnitude of pretest-posttest change. Because the design lacked a control group, these results indicate a significant and substantial pretest-posttest change associated with use of the EWB-assisted physics learning module, rather than a confirmed causal effect isolated from other classroom factors; a controlled comparison is needed to attribute the change specifically to the module.

Table 8. Paired Sample T-Test Results

Data	Mean Diff.	t	df	Sig.	Note
Pretest-Posttest	-37,697	-19,430	32	0,000	Significant

Discussion

The contextual inquiry-based physics learning module assisted by Electronics Workbench (EWB) on Organ Pipe material was developed to help students understand abstract sound wave concepts through a visual and digital simulation approach. Module development used the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The ADDIE model was chosen because it provides a systematic development process so that the resulting module is more structured and aligned with classroom learning needs.

Validation results showed that the learning module obtained an average score of 85.63%, categorized as very valid. These results indicate that the content, language, presentation, and media aspects of the module have met the teaching material feasibility criteria. Module feasibility is an indicator that the module can be used in physics learning. A systematically designed module can help students understand learning material better. These findings are consistent with Syahid et al. (2024) who stated that good instructional design quality affects the implementation of the learning process and achievement of student learning outcomes.

Regarding practicality, teacher response results of 92.5% and student response results of 87.5% indicate that the learning module is in the very practical category. These results demonstrate that the module is easy to use, systematically presented, and aligned with students' learning needs. The use of Electronics Workbench (EWB) simulation helps students understand abstract concepts through digital visualization, making the learning process easier to understand and increasing active student involvement. These findings are consistent with Meilina et al. (2023) who stated that virtual laboratories can help strengthen understanding of concepts that are difficult to observe directly through real experiments.

Effectiveness test results showed that the EWB-assisted physics learning module could improve students' critical thinking skills, as evidenced by an increase in the average score from 61.2 in the pretest to 84.5 in the posttest. This improvement demonstrates that the contextual inquiry approach implemented in the module was able to encourage students to engage in higher-order thinking processes such as analyzing, evaluating, and drawing conclusions based on simulation results.

Inquiry-based learning provides students with opportunities to actively discover concepts through observation and investigation, resulting in better development of critical thinking skills. These research findings are consistent with Damayanti et al. (2025) who stated that guided inquiry learning can improve students' critical thinking skills because it requires active student involvement in the concept discovery process.

Regarding digital literacy, the research results showed an improvement in average scores from 65.4 in the pretest to 86.7 in the posttest. These results indicate that students were not only able to use digital media in the form of EWB, but were also able to understand and interpret the simulation results displayed.

Digital simulation use helps students connect physics concepts to more concrete visualizations, improving students' understanding of the material. Furthermore, EWB use also trains students to effectively utilize digital technology in the learning process. Thus, the digital literacy developed is not limited to technical ability to use digital media, but also encompasses the ability to understand digital-based information in the context of physics learning.

N-Gain analysis results showed an average of 0.5513, categorized as moderate. These results indicate that the EWB-assisted physics learning module was sufficiently effective in improving students' critical thinking skills and digital literacy. The moderate category of learning outcome improvement can be influenced by several factors, such as varying student baseline abilities, students' adaptation to digital simulation use, and limited learning time during the study.

Nevertheless, these results still show improvement in learning outcomes after students used the learning module. These research findings are consistent with Sarifah and Nurita (2023) who stated that inquiry-based learning with digital media assistance can improve student learning outcomes in the moderate to high category depending on learning conditions.

Furthermore, the paired sample t-test results showed a Sig. (2-tailed) value of $0.000 < 0.05$, which proves that there was a significant difference between students' pretest and posttest scores after using the EWB-assisted physics learning module. The mean difference of -37.697 indicates that student posttest scores were higher than pretest scores. Therefore, within the scope of this one-group pre-experimental design, the use of the EWB-assisted physics learning module is associated with a statistically significant and substantial improvement in students' critical thinking skills and digital literacy scores on Organ Pipe material, providing preliminary evidence of effectiveness that warrants confirmation through controlled experimental designs.

Overall, the research results show that the integration of Electronics Workbench (EWB) simulation in the physics learning module makes a positive contribution to improving students' understanding of abstract concepts, critical thinking skills, and digital literacy. The learning process does not only focus on final results but also on students' exploration activities, data analysis, and scientific decision-making during the learning process. Digital simulation use makes learning more interactive, engaging, and meaningful for students. These research findings reinforce the results of Nurfatimah et al. (2025) who stated that virtual laboratories can enhance science process skills through more interactive, safe, and meaningful learning experiences.

Compared to previous research, these findings reinforce the position that the combination of guided inquiry model, contextual approach, learning module, and EWB virtual laboratory has good potential in improving the quality of physics learning. As a limitation note, this study was only conducted in one class without a control group, so learning outcome improvements could not be directly compared to conventional learning. Additionally, the material developed was limited to the Organ Pipe topic, so generalization of results to other physics topics requires further research. The test instruments were also validated only through descriptive expert judgment, without a numerical item-level content-validity coefficient or a separate pilot-tested reliability estimate; future studies should compute these quantitative

indices from an independent pilot sample before the main trial.

CONCLUSION

Based on the research results and discussion regarding the development of a physics learning module with a contextual inquiry approach assisted by Electronics Workbench (EWB) on Organ Pipe material, several conclusions can be drawn. First, the developed learning module was declared very valid based on the assessment of material and media expert validators with an average percentage of 85.63%, categorized as very valid, indicating that the module has met the aspects of content feasibility, language, presentation, and media, making it suitable for use in physics learning on Organ Pipe material.

Second, the learning module was declared very practical based on teacher responses of 92.5% and student responses of 87.5%, demonstrating that the module is easy to use in the learning process, helps students understand physics concepts, and increases active student involvement in inquiry-based learning activities.

Third, the EWB-assisted physics learning module showed preliminary effectiveness in improving students' critical thinking skills and digital literacy. This is evidenced by N-Gain analysis results with an average of 0.5513, categorized as moderate, an increase in students' average critical thinking skills from 61.2 to 84.5, and an improvement in students' digital literacy from 65.4 to 86.7. The paired sample t-test results showed a significance value of $0.000 < 0.05$ with a large effect size (Cohen's $dz \approx 3.38$), indicating a significant and substantial difference between students' pretest and posttest results after using the learning module. Because this evidence was obtained from a one-group pretest-posttest design without a control group and a small, purposively sampled class, it should be read as preliminary rather than confirmatory. Therefore, the physics learning module with a contextual inquiry approach assisted by Electronics Workbench (EWB) is feasible, practical, and preliminarily effective for use in physics learning on Organ Pipe material to improve critical thinking skills and digital literacy of eleventh-grade students at SMA Negeri 2 Gerung; controlled experimental studies are recommended to confirm this preliminary effectiveness.

For physics teachers, this module can be used as an alternative teaching material to help students understand abstract concepts, particularly on Organ Pipe material, and can be further developed with more varied inquiry activities. For students, independence in exploring EWB simulation is expected to improve conceptual understanding, critical thinking skills, and digital literacy. For schools, support for computer facilities and supporting learning software is essential for optimal implementation of the module. For future researchers, it is recommended to extend this research to other physics topics with more interactive simulation media, larger samples, and experimental designs involving control groups for more accurate research results.

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