

DEVELOPMENT OF INTERACTIVE WEB-BASED MEDIA FOR DC CIRCUIT SIMULATIONS WITH CER (CLAIM, EVIDENCE AND RATIONALE) FOR THE SKILL OF EXPLAINING SCIENTIFICALLY

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ABSTRACT

Because many high school students find abstract physics content hard to grasp, teaching such material calls for media that render it in a more concrete, visual form. This study set out to build an interactive learning tool for direct current (DC) electrical circuits, aimed at strengthening senior high school students' scientific explanation skills through a Claim-Evidence-Reasoning (CER) framework. The media combines text, images, animation, simulation, and interactive exercises so that instruction becomes more engaging, active, and centered on the learner. Its development followed the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) within a broader Research and Development (R&D) framework, moving through needs analysis, design, product construction, expert validation, limited testing, revision, and full implementation. A one-group pretest-posttest design was applied to 36 grade XII Physics students at SMAN 8 Pontianak, with a four-item essay test built around the CER framework serving as the measure of conceptual understanding. Three validators assessed the media's validity, and the same 36 students provided data on its practicality, while an additional effectiveness test (pretest-posttest) established the classical completion rate after use. The resulting media proved valid, practical, and effective for building scientific explanation skills, earning a very valid rating overall, and the practicality test likewise placed it in the very practical category. One limitation is that the media currently covers only DC circuit material and, since it runs through Google Sites, requires an internet connection—leaving other physics topics and offline use for future development. Even so, the media in its present form is ready for teachers to adopt in day-to-day instruction.

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1. INTRODUCTION

At the senior-secondary level, physics instruction plays a central role in building students' grasp of foundational science concepts, and direct current (DC) circuits are a good example of the challenge: ideas such as Ohm's law ($V = IR$), series and parallel wiring, and equivalent resistance stay abstract unless learners can actually visualize them. Indonesia's standing on international assessments underscores the problem on the 2022 PISA cycle the country's science-literacy score

reached only 383, well under the OECD average of 485, with particular weakness in applying dynamic-electricity concepts because of underdeveloped science-process skills, scientific explanation among them. Nationally, the 2019 TIMSS results told a similar story, with 40% of Indonesian secondary students falling the competency threshold for analyzing electrical circuits (Teresia et al., 2022). Part of the urgency stems from a digital divide still running through Indonesian physics classrooms. Although the 2024 Independent Curriculum foregrounds the Pancasila Student Profile and its emphasis on critical and creative thinking, roughly 80% of physics teachers continue to rely on conventional media, and only about 35% of high schools in West Kalimantan are equipped for interactive, blended instruction—despite the pandemic having pushed blended learning forward generally. Left unaddressed, this gap threatens Indonesia's global competitiveness in STEM, where the country currently sits at 68th of 141 economies on the 2024 Global Innovation Index (Matsun et al., 2018). Against this backdrop, the present study contributes: (1) a prototype open-source, web-based media tool for physics teachers and senior-secondary students; (2) an ADDIE-based validation model for scientific-explanation instruments; and (3) empirical evidence of skill gains from the local context of Pontianak specifically SMAN 8 Pontianak that speaks directly to the Independent Curriculum's goals.

Everyday classroom experience with DC circuits also reveals persistent trouble spots: up to 66% of students hold onto misconceptions about current, resistance, and the combined Ohm–Kirchhoff laws, a pattern traceable to the shortage of interactive media capable of making these abstractions visible. Scientific explanation built on claims, evidence, and reasoning matters for twenty-first-century critical thinking, yet national TKA physics data still put student performance at a modest 37.65% (Kemendikdasmen, 2025). Multimedia tools such as PhET simulations offer one way to close that gap through active, hands-on science. Three guiding questions shaped the study: what do high school students actually need from interactive media that supports scientific-explanation skills in DC circuit material; how should such media be developed through the ADDIE model so that it turns out valid, practical, and effective; and how effective, once developed, is that media at strengthening students' scientific explanation skills for DC circuits? These questions translate into research objectives that are deliberately concrete and measurable: to map what physics students and teachers in Pontianak City need from CER-oriented interactive media aligned with the Independent Curriculum and built through the ADDIE model, and to test how effectively the resulting media improves students' scientific explanation skills.

Rather than positioning students as passive recipients, interactive learning draws them actively into participating, collaborating, and engaging directly with the material being taught. (Jonassen, 1999) argues that this kind of learning strengthens conceptual understanding precisely because students are not simply absorbing information but are actively exploring and discovering it for themselves. Tools such as simulations and computer-based applications extend this by offering a richer, more immersive learning experience: students interact not only with content but with teachers and peers as well. Viewed this way, interactive media simulations, applications, educational software alike become practical tools for sharpening how clearly and logically students explain scientific ideas.

(McNeill & Krajcik, 2008) developed an assessment instrument for evaluating students' scientific explanation skills, giving teachers a way to pinpoint particular strengths and weaknesses in how students explain scientific concepts. Good science teaching, in this view, means helping students grasp both the purpose and the structure of an explanation, with teacher modeling and

classroom dialogue central to building scientific reasoning. Constructing a sound scientific explanation is itself one of the clearest markers of scientific thinking, since it draws together several sub-skills at once: stating a claim, weighing evidence for or against it, and judging whether that evidence actually supports the claim being made (Zimmerman, 2000). Assessing this ability therefore requires a measurement approach, and the instruments most widely used for the purpose are still those built around the three familiar components claim, evidence, and reasoning.

The novelty of this work lies in building web-based interactive media for DC-circuit simulation that explicitly trains scientific explanation through the CER (Claim-Evidence-Reasoning) framework, an approach that a review of the available literature did not turn up in earlier studies on this topic. Two prior projects come closest: (Nashrullah et al., 2023) developed 4D multimedia for analyzing electrical circuits at the junior-high level and reported it as valid and effective, while (Matsun et al., 2018) built an Android application covering electricity and magnetism (also 4D) with similarly positive validity and effectiveness results. Both, however, targeted general electricity and magnetism content for junior-high learners, and neither wove a Claim-Evidence-Reasoning framework into the design to train scientific explanation specifically. Where those two studies leaned on app-based navigation and drill-style practice, the media built for this study embeds CER scaffolding directly inside each learning activity, so that claims, evidence, and reasoning are constructed as part of instruction rather than bolted on afterward. The assessment approach differs too: instead of the multiple-choice or closed-ended validity checks used previously, this study scores open-ended, descriptive test items against a CER rubric, giving a more direct read on the quality of students' explanations. This design choice is not merely procedural: embedding CER scaffolding into every activity reflects a constructivist view of learning, in which understanding is built through active reasoning about evidence rather than through drill and recall alone, and it operationalizes the same claim-evidence-reasoning structure used to assess scientific explanation in prior instrument-development work. Together, these differences mark out the present study's position: an installation-free, web-based medium delivered through Google Sites, purpose-built for senior-high DC circuit material, that folds the CER framework into its instructional design, delivery mechanism, and assessment all at once.

2. METHOD

This research and development work took place at SMAN 8 Pontianak, in Pontianak City, West Kalimantan. Participants were grade XII Physics students, chosen through purposive sampling on the basis that they had already covered direct current circuit material. Across the formative stages of development, a single student took part in the individual trial, ten different students took part in the limited trial, and thirty-seven further students took part in the broad trial—each of these groups being separate both from one another and from the 36 students who subsequently took part in the main implementation/effectiveness test [to be confirmed by the author]. Data collection ran from February to March 2026.

This study follows a research and development (R&D) approach aimed at producing interactive media for direct current electrical circuits that strengthens high school students' scientific explanation skills. Development was guided by the ADDIE model Analysis, Design, Development, Implementation, and Evaluation chosen for its systematic stages and its fit with building technology-based learning media (Wijaya, 2015).

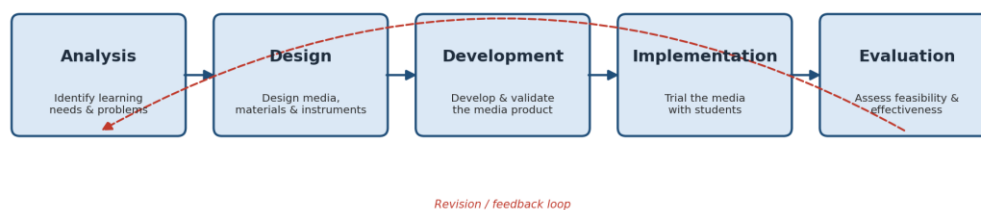


Figure 1. Flowchart of the ADDIE Development Procedure

As Figure 1 illustrates, the five ADDIE stages run in a linear sequence, each feeding into the next, with formative evaluation and revision built into every stage before the product moves on to implementation and final evaluation. The analysis stage focused on mapping the physics learning needs of high school students, with particular attention to direct current circuits. It examined the curriculum, students' characteristics, the difficulties they faced, and the kind of learning media that could support scientific-explanation skills, drawing on classroom observation, teacher interviews, and a review of literature on interactive media-based learning.

During the design stage, the interactive media took shape: learning outcomes were defined, materials were drafted, displays were laid out, assessment instruments were built, and scenarios for classroom use were planned. Text, images, animation, simulation, and interactive exercises were all woven in to support students' scientific exploration of the concepts. In the development stage, the media itself was built according to the design already worked out, then handed to subject-matter experts, media experts, and education practitioners for validation covering content, language, presentation, interactivity, and ease of use. Their feedback fed directly into revisions made before trial testing began.

The implementation stage centered on a limited trial with high school students who had already studied direct current circuits, run to gauge both their responses to the media and how feasible it was to use within actual classroom learning. Evaluation, finally, assessed how appropriate the media was and whether it improved students' scientific-explanation skills, drawing on expert validation results, student-response questionnaires, and scores from the scientific-explanation skills test. The instruments supporting this stage included expert validation sheets, student-response questionnaires, observation sheets for learning implementation, and descriptive tests built around the Claim, Evidence, and Reasoning approach.

Both quantitative and qualitative techniques were used for analysis. Expert-validation and student-response data were converted into feasibility percentages and then read against the media feasibility categories, while qualitative input validators' suggestions and comments guided revisions to the media itself. Gains in scientific-explanation skills, meanwhile, were tracked through the pre- and post-test results using a Shapiro-Wilk normality test, followed by the Wilcoxon Signed Rank Test, Cohen's *d*, and Hake's normalized gain (*N-Gain*), each described in full in Section 3.4.

The study adopted a pre-experimental, one-group pretest-posttest design. As (Sugiyono, 2013) describes it, this design records an initial score before treatment and a final score afterward, relying on a single experimental class rather than a comparison or control group; because the same group is measured twice, the effect of the treatment can still be read fairly clearly against the

students' own baseline. The design is shown schematically in the Figure that follows.

O1 X O2

Figure 2. Research Design

Where O1 is Initial test before treatment is given (Pretest), O2 is Final test after treatment (Posttest), and X is Treatment given.

The population and sample consisted of 36 grade XII students taking physics as a single class, which also served as the sole experimental class for the pretest–posttest comparison used to gauge the validity and effectiveness of the interactive media for building CER skills. Data-collection instruments included a CER rubric (a 0–1 scale for claims and a 0–2 scale for evidence and reasoning), the pretest and posttest themselves, a student-response questionnaire, and an expert-validation sheet. Analysis combined descriptive statistics (with a validity threshold above 80%), a normality test, and Hake's normalized gain.

Interviews with students and physics teachers in Pontianak City, together with classroom observation, supplied the qualitative data, while the scientific-explanation skills test drew on three CER indicators claim, evidence, and reasoning across four descriptive items. A three-person panel of material and media experts validated the developed media. Because the dataset held fewer than 50 cases, the skills-test results were checked for normality in SPSS 22 using the Shapiro-Wilk test. Given that the data turned out not to be normally distributed, a non-parametric Wilcoxon test was used instead, and a normalized gain for CER skills was then computed from that non-parametric analysis to judge how effective the interactive media had been. On the product-validation side, the content-validity check applied to the interactive media follows the criteria set out, used to judge whether the media was fit for classroom use.

Table 1. Validation Criteria

Criteria	Category	Conclusion
86% - 100%	Very Worthy	Can be used without revision
76% - 85%	Worthy	Can be used with Revision
60% - 75%	Not worthy	Can be used with major revisions
55% - 59%	Not feasible	Unable to use and further consultation
0% - 54%	Totally Unworthy	Unusable and no further consultation is necessary

Source: (Lestari et al., 2024)

The scientific-explanation rubric used here rests on three core components claim, evidence, and reasoning drawn from (Chaimala, 2009), supplemented by a fourth criterion, presentation skills, so that how clearly a student communicates the answer is also captured. All four criteria share the same three-level scale (2 = Good, 1 = Enough, 0 = Not enough); classifying a student's response starts by reading it against this scientific-reasoning content, and each test item was scored across all four criteria using the scale set out in Table 2.

Table 2. Indicators of scientific explanation skills instruments for students

Criteria	Score		
	2 (Good)	1 (Enough)	0 (Not enough)
<i>CLAIM</i> (Statement or conclusion that answers the initial question/problem)		Claims are clear, specific, and answer the question/problem precisely.	The claim is unclear, does not answer the question, or does not fit the context of the problem.
<i>EVIDENCE</i> (Scientific data that supports the claim)	The evidence provided is relevant, accurate, and strongly supports the claim (e.g., experimental data, physical laws, or theoretical references).	Evidence exists but is incomplete or of weak relevance to the claim.	Evidence is not provided, is irrelevant, or does not support the claim at all.
<i>REASONING</i> (Scientific reasoning or justification that connects claims and evidence)	Logical reasoning, connecting evidence to claims using scientific principles (e.g., Ohm's Law, Kirchhoff's Laws).	Reasoning is present but lacks depth or does not connect the evidence to the claim strongly enough.	Reasoning is absent, illogical, or does not use scientific principles.
<i>PRESENTATION SKILLS</i>	The CER delivery is systematic, the language is clear, and easy to understand.	The presentation is quite clear but there are some parts that are less structured.	Delivery is unstructured, difficult to understand, or incomplete.

Each test item was written in essay form so students could answer freely, drawing on their own knowledge and experience, and every item was framed around a phenomenon tied to direct current electrical circuits that students then had to explain. The instrument's validity and reliability Figures appear in Section 3.4.1. The underlying explanation rubric built around three core components was adapted into task-specific rubrics for this content, and students were scored from 1 to 3 on each of the three scientific-explanation categories to capture how they framed their explanations. Table 3.4 sets out how the development items are distributed across these three components. Item validity was checked using product-moment correlation, and instrument reliability using Cronbach's Alpha, both run through SPSS; the resulting validity and reliability Figures are reported in Section 3.4.1.

3. RESULTS AND DISCUSSION

3.1. Analyze

The analysis stage covered three areas. First, an analysis of learning problems drew on classroom experience: ten interviewed students reported difficulty grasping current, voltage, and resistance conceptually, compounded by limited practicum opportunities due to insufficient laboratory equipment, while 14 physics teachers across Pontianak City reported similar difficulty explaining DC circuit concepts precisely because the material is abstract pointing to a clear need for media that can make these concepts explainable. Second, a curriculum analysis mapped the material onto CP Phase F of the Independent Curriculum for high school physics: the relationship between current, voltage, and resistance (Ohm's Law), series and parallel circuits, and Kirchhoff's law. Third, a media-needs analysis established that the required media should offer interactive simulation, give direct feedback, and build scientific-explanation skills.

3.2. Design

Google Sites was chosen as the platform for the interactive media's design stage because of how easily it supports the learning process. Design work began with the site's external appearance, then moved to building out pages for learning activities activity sheets, teaching materials, practice questions along with quizzes, evaluations, and closing sections tied to direct current circuits, while settling on background design, imagery, and animation appropriate to the media. The final step was refining how the media would actually be produced so that its presentation, layout, and animation came together attractively. The stages of production were as follows:

3.2.1 Web structure design consisting of main media pages (home, learning outcomes, learning activities, evaluation, and closing).

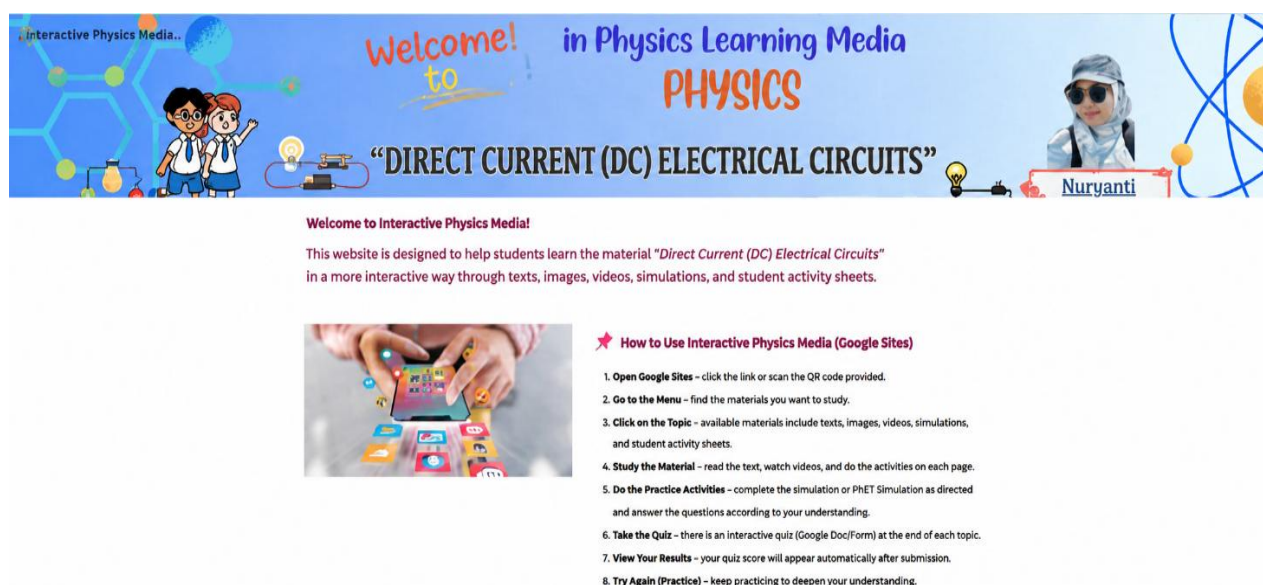


Figure 3. Initial view and Main Menu Page



Figure 4. Sample CER-Based Quiz Item

Figure 3 shows the media's welcome screen, which orients students with numbered instructions opening the Google Sites link, navigating the menu, working through the material, running the practice and quiz activities, and reviewing their results while Figure 4 shows a sample CER-based quiz item on Ohm's Law, presenting two series circuit diagrams that students must compare and explain using the Claim, Evidence, and Reasoning structure rather than simply selecting an answer. Together, the two screens illustrate how the media pairs straightforward navigation with instruction that asks students to reason scientifically, not just recall facts.

Interactive media brings a clear advantage to physics instruction on Direct Current Electric Circuits: students can grasp the underlying concepts while running experiments directly through the PhET Colorado simulations. Its drawback lies in scope rather than function the media built for this study covers only Direct Current Electric Circuit material and does not extend to other physics topics.

3.3 Development

Development work then moved into building the interactive media product, followed by assessment from subject-matter expert validators and product testing. Once validated and revised, the draft was piloted with 12th-grade Physics students at SMAN 8 Pontianak in a limited trial, with the results feeding directly into the final product.

3.3.1 Results of Validation by Material Experts

Three validators one school principal and two physics teachers carried out the material-expert validation, working from a 15-item questionnaire scored on a 1–4 scale that assessed the interactive media's content. Their assessment results are shown in Figure 5.

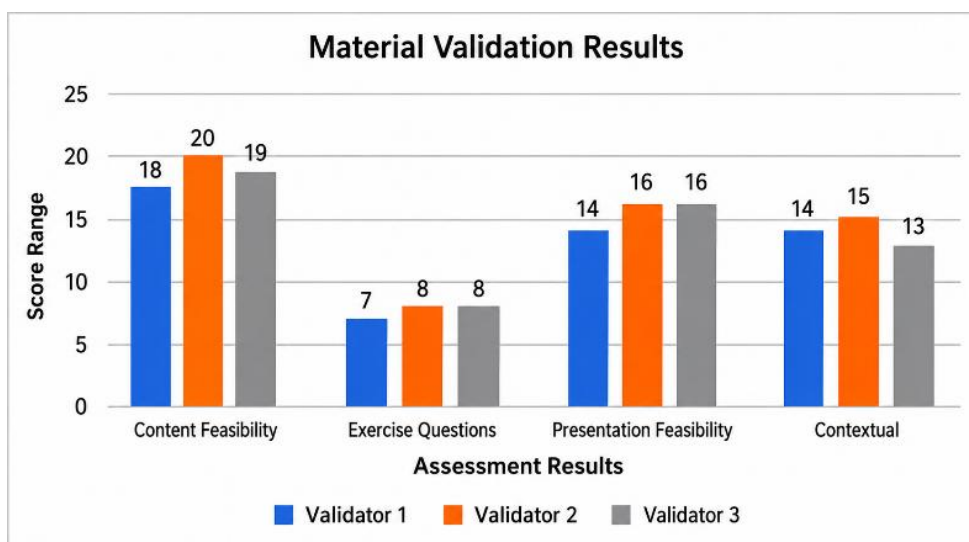


Figure 5. Bar Chart of Material Expert Validation Results

Figure 5 shows that Validator 1 scored the media 53 out of a possible total (88.33%), Validator 2 scored it 59 (98.33%), and Validator 3 scored it 56 (93.33%), for an average of 56.00, or 93.33% overall placing it in the very feasible category. On the materia l-content dimension, then, the developed media can be considered suiTable for classroom use.

3.3.2 Media Expert Validation Results

Media-expert validation covered usability, effectiveness, and visual communication, with the resulting suitability scores presented in the bar chart in Figure 6.

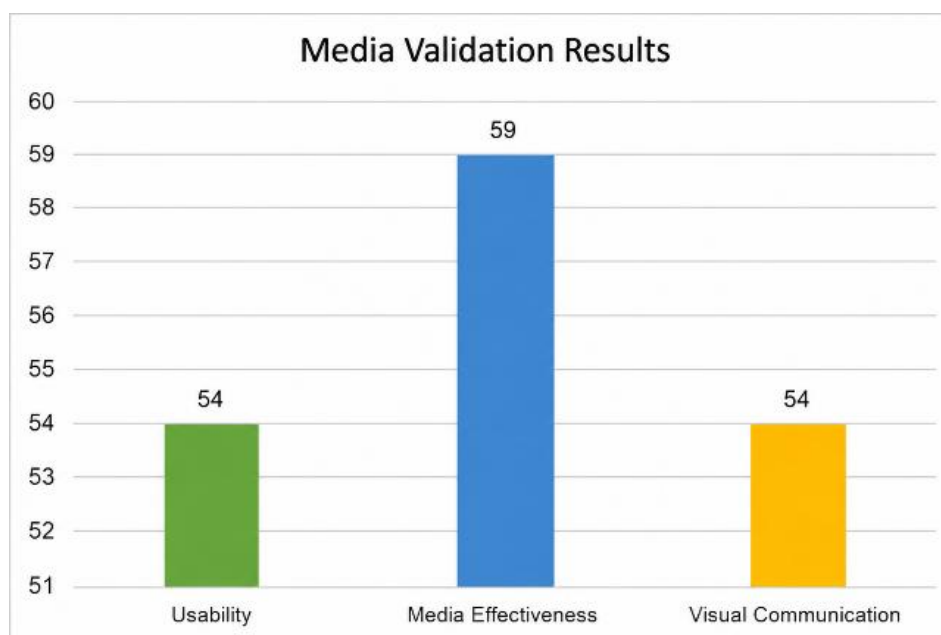


Figure 6. Average Bar Chart of Media Expert Validation Results

As Figure 6, the three validators together scored usability at 54 (90%), media effectiveness at 59 (98.33%), and visual communication at 54 (90%), for an average of 55.67, or 92.78% again

within the very feasible category, indicating a strongly positive assessment from the media experts.

3.4 Implementation

3.4.1 Instrument Validation Data

Data collection relied on pretests and posttests measuring students' scientific-explanation skills through essay-style questions, with test items mapped onto three explanation indicators from (Ennis, 2018) giving simple explanations, building basic skills, and drawing conclusions. Before the CER-based skills test was administered, its validity and reliability were checked empirically: item validity coefficients (product-moment r) ranged from 0.387 to 0.782, all clearing the critical r -Table value of 0.361 at the 5% significance level, so all 20 items counted as valid, while reliability came out to a Cronbach's Alpha of 0.873 high by the interpretation criteria used here. Together these Figures point to an instrument with acceptable validity and reliability, suitable for assessing scientific-explanation skills through the CER approach. This validity and reliability check was run before the main study, on 15 respondents drawn from outside the research sample specifically grade XII Physics students at SMAN 8 Pontianak to confirm each item's validity and reliability ahead of actual use. (Trie Rossy Handayani, Ismet, 2021) likewise report direct current electrical circuit validation as strongly valid for classroom use.

3.4.2 Data on Learning Outcomes Achievement

Learning-outcome data compare student achievement before and after treatment that is, before and after learning with the interactive media on direct current electrical circuits. From the data obtained, a normality test will be carried out with results as in the Table.

Table 3. Pretest and Posttest Normality Test Scores

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
Total_Pre	.164	36	.015	.960	36	.217
Total_Pro	.218	36	.000	.861	36	.000

Based on the Lilliefors Significance Correction results, the Shapiro-Wilk test yielded a pretest significance value of 0.217 (above the 0.05 threshold), indicating that the data were normally distributed. Conversely, the posttest value was 0.000 (below 0.05), indicating a non-normal distribution. Due to this asymmetry, hypothesis testing proceeded using the Wilcoxon Signed Rank Test. Since the data proved not to be normally distributed, the next step was hypothesis testing using the Wilcoxon Signed Rank Test, with the results shown in the Table 4.

Table 4. Pretest and Posttest Hypothesis Testing

		N	Mean Rank	Sum of Ranks
Total_Pro - Total_Pre	Negative Ranks	0a	.00	.00
	Positive Ranks	36b	18.50	666.00
	Ties	0c		
	Total	36		

a. Total_Pro < Total_Pre

b. Total_Pro > Total_Pre

c. Total_Pro = Total_Pre

The Ranks Table from the Wilcoxon Signed Rank Test returned 36 positive ranks and zero negative ranks, meaning every student's score rose from pretest to posttest, with no student remaining unchanged (ties = 0). Students' CER abilities, in other words, improved after using the learning media.

With the Wilcoxon test complete, the next step was an effect-size test to gauge how much influence the interactive media actually had on learning.

Table 5. Z-value in the Wilcoxon Test

	Total_Pro - Total_Pre
Z	-5.241b
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

The Wilcoxon Signed Rank Test returned an Asymp. Sig. (2-tailed) value of 0.000, the 0.05 threshold, confirming a significant difference between students' pretest and posttest scores. Applying the rank-based effect-size formula ($r = Z/\sqrt{N} = -5.241/\sqrt{36}$) to this result gives an effect size of $r = 0.8735$, which falls in the large-effect range evidence that the interactive media had a substantial influence on students' CER gains. A further significance check, using Cohen's d, was carried out to gauge how much influence the treatment had on learning outcomes, drawing on the data.

Table 6. Mean & Standard Deviation

Data	Mean	Standard Deviation
Pretest	12.0278	2.41999
Posttest	18.1944	1.61810

Table 6 shows the posttest mean (18.1944) exceeding the pretest mean (12.0278), while the standard deviation fell from 2.41999 to 1.61810 together pointing to both a rise in average CER ability after using the interactive media and less variation among students' scores post-treatment. These mean and standard-deviation Figures underpin the Cohen's d calculation that follows. Pooling the pretest and posttest standard deviations gave a combined value (SDpooled) of 2.058, which was then used to calculate Cohen's d. Cohen's d came out to 0.5127, placing it in the moderate-influence range suggesting the learning media had a moderate rather than large effect on students' CER abilities. The N-gain results can be seen in Table 6.

Table 6. N-Gain Learning Outcomes using CER

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Standard Deviation
N_Gain	36	.33	1.00	.7692	.21532

As Table 5 shows, all 36 grade XII Physics students completed both the pretest and posttest during the trial phase, and the N-Gain analysis returned an average of 0.7692 falling in the high category with individual scores ranging from a minimum of 0.33 to a maximum of 1.00. Students' CER abilities, in short, rose substantially after using the media. The N-Gain category is determined based on the following criteria:

Table 7. N-Gain category

N-Gain Value	Category
> 0.7	Tall
0.3 – 0.7	Currently
< 0.3	Low

3.4.3 Student Response Questionnaire Data

Student-response data came from a questionnaire completed by grade XII Physics students after they had worked through the learning activities in the Google Sites-based interactive media. Figure 7 summarizes those responses in bar-chart form.

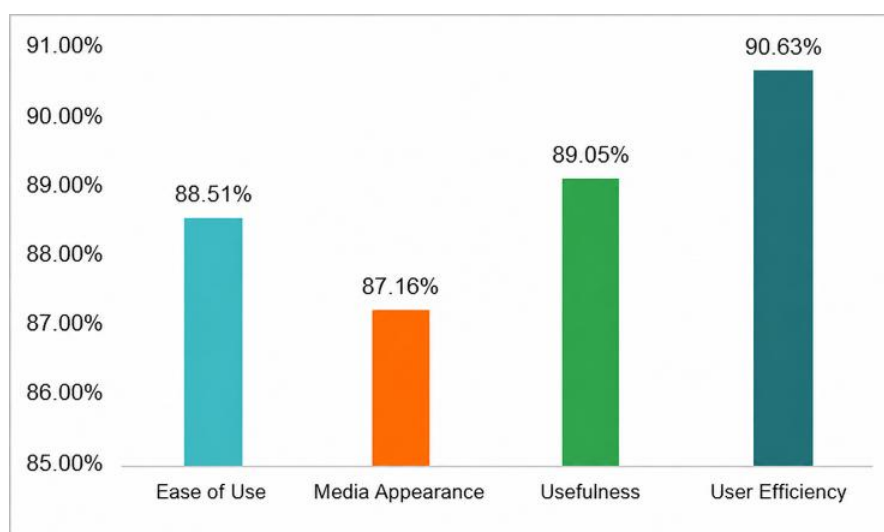


Figure 7. Bar Chart of Student Response Results

Figure 5 breaks the questionnaire results into four aspects: ease of use scored 88.51%, media appearance scored 87.16%, usefulness scored 89.05%, and user efficiency scored 90.63%, for an overall average of 88.72% placing the media in the very practical category.

3.5 Evaluation

The evaluation stage gathered feedback on the interactive media and found that it met the eligibility criteria for content, appearance, interactivity, and ease of use, while also proving capable of supporting more active, contextual physics instruction. Students' scientific-explanation skills visibly sharpened: their claims, evidence, and reasoning became more systematic after using the interactive media. Where their answers had previously been brief and short on scientific backing, they went on to produce explanations that were fuller, more logically connected, and more consistent conceptually.

This pattern echoes other research linking interactive media to greater student engagement and deeper conceptual understanding (Sari et al., 2023; Mahmud et al., 2021), and it sits comfortably within constructivist learning theory, which treats active learning experiences as central to building both conceptual understanding and scientific thinking. Read cautiously, then, the findings point to interactive media as a likely contributor to stronger scientific-explanation skills among high school students working with DC circuits though, absent a control group in this study, factors such as familiarity with the test, maturation, or the pretest itself cannot be fully ruled out as alternative explanations for the improvement observed (Husniyah & Ramli, 2023).

Taken together, the validation results point to a strongly feasible interactive medium for direct current electrical circuits: media experts rated it 92.78% and material experts 93.33%, both in the very valid category, indicating that the media meets the standards expected for content, appearance, language, interactivity, and fit with the learning objectives. As (Ananda & Sugiyono, 2022) note, expert validation of this kind is a critical checkpoint in development research, confirming a product's readiness for classroom use. Combining visual elements, simulation, and learning activities also helps students grasp abstract concepts more concretely, supporting the kind of independent knowledge-construction process described by (Mayer, 2021). Other work similarly finds that virtual, simulation-based media help students grasp physics concepts because it lets them explore ideas directly and in context (Finkelstein et al., 2005; Hake, 1998).

The study's results also show that the interactive media improved high school students' scientific-explanation skills for direct current circuits: the Wilcoxon Signed Rank Test's positive rank of 36 against a negative rank of 0 indicates every student gained ability after using the media. Frank Wilcoxon's test, designed to compare paired nonparametric data, captures exactly this kind of before-and-after change following treatment. The gain likely stems from the media giving students a direct, hands-on way to observe electrical phenomena through simulations and CER-based exercises an approach that, per (McNeill & Krajcik, 2008), builds students' capacity to state claims, marshal evidence, and connect scientific concepts logically when explaining a phenomenon.

The strength of that impact shows up in the effect size itself: 0.8735, which counts as high and points to a strong influence of the interactive media on students' abilities. It is worth noting that this rank-based Wilcoxon effect size and the Cohen's *d* reported in Section 3.4.2 (0.5127, moderate) are two different metrics rather than conflicting readings of the same result: the Wilcoxon *r* is computed from the standardized test statistic and sample size, while Cohen's *d* is computed from the pre-post mean difference relative to the pooled standard deviation, which here was inflated somewhat by the wider spread of pretest scores. Both point in the same direction a real, positive shift in students' CER ability but the size labels attached to each should not be read

as describing a single, unified effect. (Cohen, 2013) notes that an effect size this high reflects a treatment with a genuinely significant impact on learning outcomes consistent, here, with media that helps students both grasp DC circuit concepts and reason more systematically about the relationships among current, voltage, and resistance.

The N-Gain analysis tells a similar story, averaging 0.7692 a high value indicating a marked improvement in scientific-explanation skills after using the interactive media. (Hake, 1999) reads a high N-Gain of this kind as evidence of an effective gain in conceptual understanding, and here it likely reflects how the interactive simulations and visualizations let students grasp the relationships among DC-circuit variables more concretely and in context.

Practicality tells the same story: the student-response questionnaire averaged 88.72%, in the very practical category, meaning students responded positively to the media overall, finding it easy to use, engaging, and genuinely helpful for understanding the material. Richard E. Mayer's account of multimedia learning offers one explanation combining text, images, animation, and visual interaction, as this media does, tends to sharpen students' attention and motivation by supporting their cognitive processing and the positive responses recorded here likewise suggest a more active, enjoyable learning atmosphere that keeps students engaged throughout. This lines up with other research linking interactive media to greater motivation, interest, and active participation in science learning (Prensky, 2010; R Kustijono et al., 2019; Rahmawati et al., 2021), as well as work suggesting that interactive digital media make learning more student-centered and improve the overall learning experience (Hobri et al., 2020).

Taken as a whole, the study's results indicate that the interactive media developed for direct current electrical circuits is valid, practical, and effective at strengthening high school students' scientific-explanation skills, offering a more meaningful learning experience through concept exploration, virtual simulation, and scientifically grounded problem-solving. This aligns with earlier work showing that interactive media in physics instruction can improve conceptual understanding, scientific thinking, and active student participation alike (Hastuti, Giatman, Mukhlidi Muskhir, Hansi Effendi, 2023).

4. CONCLUSION

Drawing on the results and discussion above, the developed learning media meets the required validity criteria, earning an overall score of 93.06% across three expert validators and landing in the very suitable category for classroom use. It also meets the practicality bar, with a score of 88.72% ("very practical") on the student-response test. Because the posttest data did not follow a normal distribution, hypothesis testing relied on the Wilcoxon Signed Rank Test, which returned an Asymp. Sig. (2-tailed) value of 0.000 below 0.05 confirming a significant difference between students' pretest and posttest CER scores. The Ranks Table reinforces this: 36 positive ranks against zero negative ranks means every student improved after treatment. The N-Gain analysis averaged 0.7692, in the high category, pointing to a substantial rise in CER ability, while Cohen's *d* came out to 0.5127 a moderate rather than large effect. Taken together, these results support the conclusion that the learning media developed here effectively improves students' Claim, Evidence, and Reasoning abilities. Based on the results of the research, several key recommendations are proposed: teachers are encouraged to adopt the learning media used in this study as an alternative instruction method to enhance students' Claim, Evidence, Reasoning (CER) abilities, while students are expected to engage more actively in the learning process and develop

critical thinking skills through CER-based activities. Furthermore, schools should support the implementation of innovative learning media to elevate overall classroom quality, and future researchers are advised to expand upon this study by utilizing broader sample sizes, exploring different subject materials, incorporating a control group for deeper comparative insights, and developing more interactive learning media to achieve a greater impact on students' CER competencies.

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