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Diagnosing High School Students' Misconceptions in Dynamic Electricity Using a Web-Based Four-Tier Test

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Abstract

This study aimed to identify the conceptual understanding and types of misconceptions demonstrated by senior high school students in dynamic electricity using a web-based Four-Tier Diagnostic Test. The study employed a quantitative descriptive design involving 91 twelfth-grade students from a public senior high school in Jember, Indonesia, selected through purposive sampling. The validated instrument consisted of 30 items, each comprising a conceptual answer, answer-confidence rating, supporting reason, and reason-confidence rating. Expert validation yielded an overall feasibility score of 96%, indicating that the instrument was feasible for use. Students' responses were classified as understanding the concept, not understanding the concept, misconception, or error based on the combinations of answers, reasons, and confidence levels. Across the student-item responses, 18% were classified as understanding the concept, 27% as not understanding the concept, 42% as misconceptions, and 13% as errors. Among the misconception-classified responses, theoretical misconceptions accounted for the largest proportion at 19.3%, followed by correlational misconceptions at 17.8%, calculation misconceptions at 16.9%, basic misconceptions at 16.4%, language-interpretation misconceptions at 15.3%, and systematic misconceptions at 14.3%. These findings show that students experienced substantial difficulties in understanding fundamental principles and connecting related concepts in dynamic electricity. The instrument can provide teachers with diagnostic information for designing targeted instructional and remedial activities.

Keywords: Conceptual Understanding; Dynamic Electricity; Four-Tier Diagnostic Test; Misconceptions; Web-Based Assessment

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INTRODUCTION

Digital technologies have become integral to contemporary education by expanding access to learning materials, practice questions, and other instructional resources through the internet (Ediyanti et al., 2020; Parveen & Ramzan, 2024). Although this accessibility supports flexible learning, students must be able to evaluate the information they obtain and relate it to scientifically accepted concepts, particularly in physics (Gurcay & Gulbas, 2015). Without adequate conceptual understanding, exposure to information from different sources may reinforce ideas that are inconsistent with established scientific explanations.

Conceptual understanding enables students to explain physical phenomena, connect related principles, and solve problems meaningfully (Hindarto & Wiyanto, 2017). However, students often construct explanations that differ from scientifically accepted concepts. These explanations are commonly described as misconceptions (Pablico, 2010). Misconceptions are not merely accidental mistakes; rather, they are relatively stable patterns of reasoning based on incorrect or incomplete prior knowledge. Because students may repeatedly use these ideas to interpret new information, misconceptions can persist and interfere with subsequent learning (Scaife, 2002; Kurudirek et al., 2025).

Students and teachers may not immediately recognize misconceptions. Therefore, identifying them is an essential first step before teachers implement remedial instruction or conceptual-change strategies (Goris & Dyrenfurth, 2010). If misconceptions remain unaddressed, students may integrate new information into an inaccurate conceptual framework, thereby increasing the discrepancy between their understanding and accepted scientific explanations (Arsyad, 2025). This problem is particularly important in physics because many concepts are abstract and require students to coordinate verbal, visual, mathematical, and symbolic representations (Nuraeni, 2025). Effective physics instruction therefore requires teachers to identify and address misconceptions explicitly (Özkan & Selçuk, 2013).

Dynamic electricity is one of the physics topics in which students commonly experience conceptual difficulty because it involves abstract and interconnected ideas, including electric current, voltage, resistance, energy transfer, and circuit configuration (Hermawati, 2022). Inadequate understanding of one concept may affect students' interpretation of other concepts and limit their ability to solve more advanced problems (Winarso & Toheri, 2017). Previous studies have identified several misconceptions about electrical circuits, including the belief that electric current is consumed, that currents from different parts of a circuit collide, that current and voltage are interchangeable, and that a closed circuit can operate without a voltage source (Widodo et al., 2018). Students also frequently misunderstand the distribution of current and voltage in series and parallel circuits. These misconceptions are often interconnected rather than limited to a single isolated concept (Lee & Law, 2001).

Students' difficulties may also arise from their inability to connect multiple representations of a physical phenomenon. Physics instruction frequently uses diagrams, graphs, mathematical expressions, and models to make abstract concepts more accessible (Martini et al., 2021). However, students may struggle to coordinate these representations or transfer information from one representation to another when solving problems (Nguyen, Gire, & Rebello, 2010). Consequently, misconception diagnosis should identify not only whether a student's answer is correct but also the type of conceptual difficulty reflected in the answer and supporting reasoning.

This study used six misconception indicators adapted from the framework applied by Yuberti et al. (2020). These indicators distinguish difficulties in connecting concepts, explaining theoretical principles, applying conceptual procedures, completing problem-solving steps, performing calculations, and interpreting question language. The indicators are presented in Table 1.

Various diagnostic instruments have been developed to identify students' conceptual difficulties more accurately than conventional multiple-choice tests (Gurel et al., 2015). Conventional assessments generally indicate whether an answer is correct or incorrect but cannot determine whether an incorrect response results from a misconception, insufficient knowledge, low confidence, or guessing. The Four-Tier Diagnostic Test addresses this limitation by examining students' conceptual answers, supporting reasons, and confidence in both components. It therefore provides more detailed information about students' conceptual understanding and misconceptions (Fadhilatullathifi et al., 2020; Ozkaya, 2022).

Table 1. Misconception indicators

Type of misconception	Indicator
Correlational misconception	Students cannot identify or explain the relationship between the concept being assessed and other relevant concepts.
Theoretical misconception	Students cannot correctly explain the fundamental theory or principle underlying the concept.
Systematic misconception	Students recognize the required solution steps but apply them using an incorrect conceptual understanding.
Basic misconception	Students cannot determine or complete the appropriate procedure for solving the problem.
Calculation misconception	Students apply an appropriate solution procedure but make an error when determining the numerical result.
Language-interpretation misconception	Students cannot correctly interpret the meaning or intention of the question.

A Four-Tier Diagnostic Test consists of four related components. The first tier contains a multiple-choice conceptual question, while the second tier records the student's confidence in the selected answer. The third tier requires the student to select a reason supporting the answer, and the fourth-tier records confidence in the selected reason. The confidence measures in the second and fourth tiers apply the Certainty of Response Index developed by Hasan, Bagayoko, and Kelley (1999). This approach helps distinguish responses based on limited understanding from confidently held misconceptions (Mustari et al., 2020; Latif et al., 2021). By combining answer accuracy, reasoning accuracy, and confidence, the instrument can classify each student-item response as understanding the concept, not understanding the concept, misconception, or error.

The Four-Tier Diagnostic Test has been recognized as an effective instrument for assessing conceptual understanding in science and mathematics (Kirbulut & Geban, 2014; Fadhilatullathifi et al., 2020; Adimayuda et al., 2025). Its diagnostic value lies in its ability to distinguish misconceptions from other forms of incorrect responses. This distinction is important because students who hold misconceptions require different instructional support from students who simply lack knowledge or confidence.

Diagnostic testing is intended to identify specific learning difficulties so that teachers can design appropriate instructional or remedial actions (Ministry of National Education, 2007). Recent technological developments have encouraged the integration of diagnostic tests into digital and web-based platforms. Such platforms can improve accessibility, scoring efficiency, and data management while allowing researchers to collect student responses systematically (Brugliera, 2024; Alam et al., 2026). However, a web-based diagnostic instrument must still meet content, language, usability, and technical-feasibility requirements before it is implemented.

Previous research confirms that misconceptions in electricity remain common. Halim et al. (2019) reported considerable student difficulty in understanding dynamic electricity concepts. Nuraeni (2025) similarly identified students who understood the assessed concepts, students who lacked knowledge, and students who held misconceptions. Peşman and Eryılmaz (2010) developed a three-tier diagnostic test for simple electric circuits, demonstrating the value of combining conceptual answers with supporting reasoning. Nevertheless, limited research has integrated a Four-Tier Diagnostic Test into a web-based platform while also classifying misconception responses according to distinct indicators.

Accordingly, this study addresses two related needs: evaluating the feasibility of a web-based diagnostic instrument and identifying students' conceptual-status patterns and misconception types in dynamic electricity. The study was guided by the following research question: What conceptual-status categories and types of misconceptions are demonstrated by senior high school students in dynamic electricity, as identified using a web-based Four-Tier Diagnostic Test? Therefore, this study aimed to identify the distribution of conceptual understanding and misconception types among senior high school students and to evaluate the feasibility of the web-based instrument. The findings are expected to provide teachers with diagnostic information for designing targeted instructional and remedial activities in dynamic electricity.

METHOD

Research Design and Participants

This study employed a quantitative descriptive design to identify students' conceptual understanding and misconceptions in dynamic electricity without manipulating the study variables. Quantitative descriptive research uses numerical data to describe patterns observed within a defined group (Siregar, 2025). This design supports the statistical description and interpretation of an existing phenomenon based on empirical data (Ghanad, 2023; Slater & Hasson, 2025).

The participants were 91 twelfth-grade students enrolled in a public senior high school in Jember, Indonesia. Purposive sampling was used because the participants were required to meet three criteria: (1) they had completed instruction on dynamic electricity, (2) they had not previously participated in similar misconception-identification research, and (3) their school had not previously implemented a web-based diagnostic assessment system.

Research Procedure

The research procedure is summarized in Figure 1. The study began with a needs analysis, learner analysis, and analysis of the Four-Tier diagnostic framework. Classroom observations, interviews, and documentation were then used to identify learning difficulties and define the conceptual scope of the instrument.

A theoretical review was subsequently conducted to prepare the test blueprint for dynamic electricity. Based on the blueprint, 30 Four-Tier Diagnostic Test items were constructed and integrated into a website using HTML and Google Apps Script. The initial version underwent pretesting and functionality checks before being submitted for expert validation. The website and instrument were then revised according to the validators' comments. Following revision, the instrument was administered to the participants, and the responses were collected, classified, and analyzed. The final stages involved compiling the findings, discussing the results, and drawing conclusions.

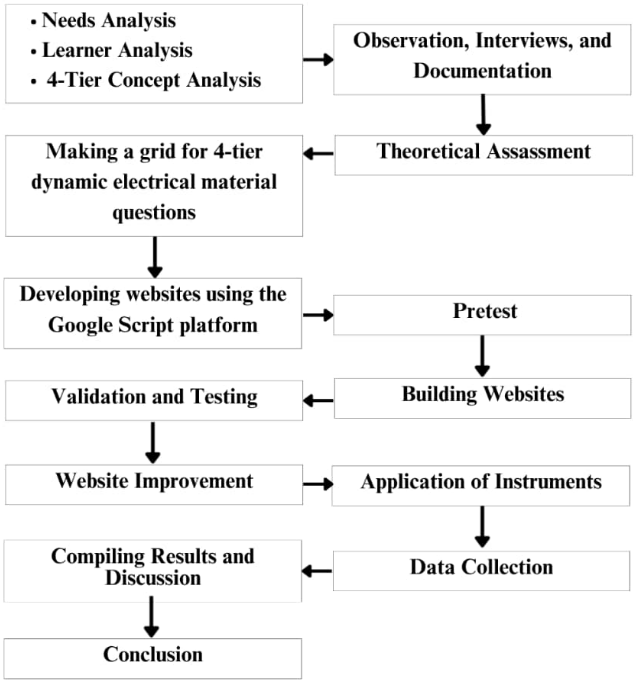


Figure 1. Research procedure for developing and implementing the web-based Four-Tier Diagnostic Test

Preliminary Data Collection

Classroom Observation

Preliminary classroom observations were conducted after the researchers obtained permission from the school. The observations aimed to identify students' learning needs, examine the instructional practices used by physics teachers, and understand the classroom learning environment. The findings informed the development of the diagnostic-test indicators and item contexts (Beringuel et al., 2025).

Interviews

Structured interviews containing open-ended questions were conducted with physics teachers and students. Although the main questions were prepared in advance, participants were allowed to elaborate on their responses. The interviews were used to obtain preliminary information about students' conceptual understanding, identify physics topics perceived as difficult, and explore possible sources of misconceptions (Pertiwi, 2025; Bigozzi et al., 2018). The interview findings supported instrument development and provided contextual information for interpreting the diagnostic-test results.

Development of the Web-Based Four-Tier Diagnostic Test

The primary research instrument was a web-based Four-Tier Diagnostic Test developed to identify students' conceptual understanding and misconceptions in dynamic electricity. A test provides structured stimuli that produce measurable responses for analysis (Kiray & Simsek, 2021). The instrument consisted of 30 multiple-choice items developed according to the six misconception indicators presented in Table 1. Each item consisted of four tiers: (1) Tier 1 contained a multiple-choice conceptual question; (2) Tier 2 measured the student's confidence in the selected answer; (3) Tier 3 contained alternative reasons supporting the answer; and (4) Tier 4 measured the student's confidence in the selected reason.

The confidence ratings in Tiers 2 and 4 followed the Certainty of Response Index framework developed by Hasan, Bagayoko, and Kelley (1999). The combination of answer accuracy, reasoning accuracy, and confidence was used to distinguish conceptual understanding, lack of understanding, misconceptions, and errors.

Response Classification and Scoring

Each student-item response was classified using the combinations presented in Table 2. The classification was applied separately to every response rather than assigning each student permanently to one conceptual-status category. Consequently, one student could demonstrate understanding on one item and a misconception, lack of understanding, or error on another item.

Table 2. Four-tier response combinations

No.	Category	Tier 1: Answer	Tier 2: Answer confidence	Tier 3: Reason	Tier 4: Reason confidence
1	Understanding the concept	Correct	Sure	Correct	Sure
2	Not understanding the concept	Correct	Sure	Correct	Not sure
3		Correct	Sure	Incorrect	Not sure
4		Correct	Not sure	Correct	Sure
5		Correct	Not sure	Correct	Not sure
6		Correct	Not sure	Incorrect	Not sure
7		Incorrect	Sure	Correct	Not sure
8		Incorrect	Sure	Incorrect	Not sure
9		Incorrect	Not sure	Correct	Not sure
10		Incorrect	Not sure	Incorrect	Not sure
11	Misconception	Correct	Sure	Incorrect	Sure
12		Correct	Not sure	Incorrect	Sure
13		Incorrect	Sure	Incorrect	Sure
14		Incorrect	Not sure	Incorrect	Sure
15	Error	Incorrect	Sure	Correct	Sure
16		Incorrect	Not sure	Correct	Sure

For data coding, the four conceptual-status categories were assigned numerical values, as shown in Table 3. These values were used to organize and summarize the classified responses; the main findings were reported as frequencies and percentages.

Table 3. Scoring criteria for four-tier response classifications

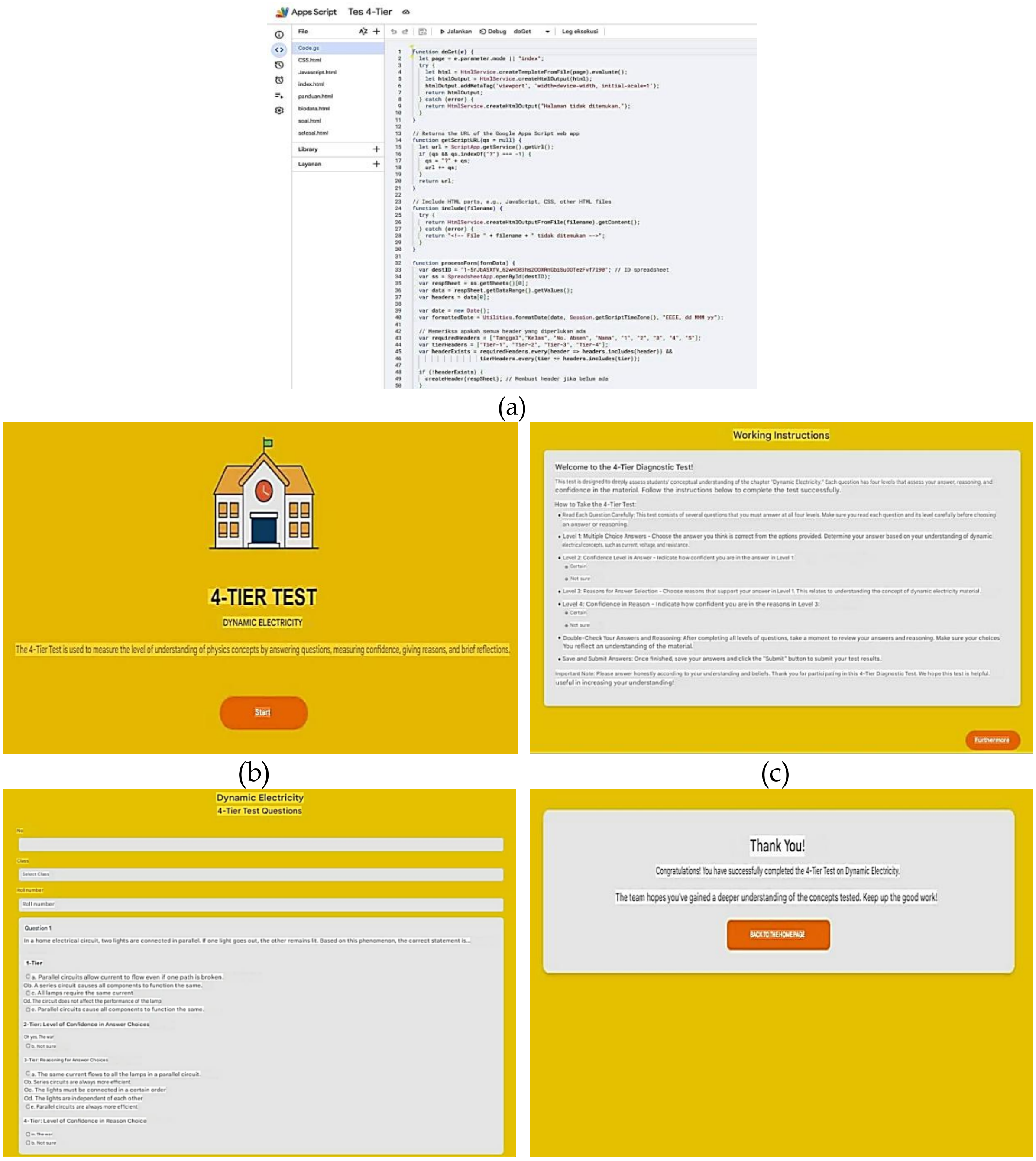
Category	Score
Understanding the concept	3
Misconception	2
Not understanding the concept	1
Error	0

Responses classified as misconceptions were further grouped according to the six indicators presented in Table 1: correlational, theoretical, systematic, basic, calculation, and language-interpretation misconceptions.

Web-Based Instrument Interface

The instrument was developed using HTML and Google Apps Script. Figure 2 presents the main components of the web-based system. Figure 2(a) shows the Google Apps Script development environment used to construct and manage the instrument.

Figure 2(b) presents the landing page through which students accessed the diagnostic test. Figure 2(c) shows the instructions page explaining how to complete the four tiers. Figure 2(d) presents the test interface containing the student-information fields and Four-Tier questions. Figure 2(e) shows the completion page displayed after students submitted their responses.



(a) (b) (c) (d) (e)

Figure 2. Web-based Four-Tier Diagnostic Test interface: (a) Google Apps Script development environment, (b) landing page, (c) test instructions, (d) diagnostic-test interface, and (e) completion page

Expert Validation and Instrument Feasibility

The feasibility of the web-based Four-Tier Diagnostic Test was evaluated by four validators: two physics education experts and two media experts. The validation process assessed six aspects: (1) content validity and appropriateness of the test items,

(2) construction and organization of the instrument, (3) language clarity and readability, (4) visual design and media quality, (5) attractiveness and functionality, and (6) suitability of the instructions and time allocation (Kania et al., 2024).

The validators completed evaluation questionnaires, and their scores were converted into percentages using Equation (1), where: P = feasibility percentage; n = total score assigned by the validators; and N = maximum possible validation score.

$$P = \frac{n}{N} \times 100\ \% \qquad (1)$$

The percentages were interpreted according to the criteria presented in Table 4.

Table 4. Instrument feasibility criteria

Percentage (%)	Feasibility category
76–100	Feasible
56–75	Moderately feasible
40–55	Less feasible
0–39	Not feasible

The validators' written comments were also reviewed. The researchers revised the wording, visual components, instructions, and interface before administering the instrument to the participants.

Test Administration

After the instrument had been validated and revised, it was administered to 91 twelfth-grade students during a classroom session lasting approximately 90 minutes, equivalent to two 45-minute lessons. Students accessed the instrument using Android smartphones or computers through a QR code or web link distributed by the researcher.

Before the test began, the researcher introduced the web application, explained the navigation procedures, and informed the students about possible technical problems. Students were instructed to complete all four tiers of every item independently. The researcher supervised the session to ensure that the administration procedures were followed consistently. After submission, the responses were stored for analysis of conceptual-status categories and misconception types.

Data Analysis

The data analysis consisted of two stages: instrument-feasibility analysis and conceptual-status and misconception analysis.

Instrument-Feasibility Analysis

Validation scores from the physics education and media experts were converted into percentages using Equation (1). The percentage for each assessment aspect and the overall feasibility percentage were then classified according to the criteria in Table 4 (Yuniar et al., 2024).

Conceptual-Status Analysis

Each student-item response was classified as understanding the concept, not understanding the concept, misconception, or error according to Table 2. The frequency of responses in each category was converted into a percentage using Equation (2) (Surmaini, Syafe'i, & Diani, 2021), where: P = percentage of responses in a category; f = frequency of responses classified in that category; and n = total number of responses included in the relevant calculation.

$$P = \frac{f}{n} \times 100\ \% \qquad (2)$$

For the item-level analysis, nnn was 91 because each item was answered by 91 students. For the overall conceptual-status analysis, nnn was 2,730 student-item responses, obtained from 91 students completing 30 items.

Misconception-Type Analysis

Responses classified as misconceptions were grouped into six predetermined types: correlational misconception, theoretical misconception, systematic misconception, basic misconception, calculation misconception, and language-interpretation misconception. The frequency of each misconception type was summed across the items assigned to the corresponding indicator. The percentage of each type was calculated using the total number of misconception-classified responses as the denominator. This procedure was used to determine the most frequent conceptual difficulties demonstrated by students in dynamic electricity.

RESULTS AND DISCUSSION

Result

Preliminary interview findings indicated several possible factors associated with students' misconceptions, including less engaging and less interactive instructional practices, low interest in physics, and reliance on information obtained from external sources, particularly the internet (see Supplementary Materials). These findings should be interpreted as contextual indications rather than direct causal relationships. They nevertheless suggest the importance of strengthening students' conceptual understanding and guiding them in evaluating information from different learning sources.

The expert validation scores were converted into percentages using Equation (1) and interpreted according to the feasibility criteria presented in Table 4. Table 5 presents the validation results from two media expert validators (VM1 and VM2) and two physics education expert validators (VP1 and VP2).

Table 5. Expert Validation Results for the Web-Based Four-Tier Diagnostic Test

Assessment indicator	VM1	VM2	VP1	VP2	Total score	Max. score	(%)	Category
Question content	34	34	35	35	138	144	96	Feasible
Language	16	15	16	15	62	64	97	Feasible
Media quality and appearance	8	8	8	8	32	32	100	Feasible
Attractiveness	7	7	8	7	29	32	91	Feasible
Total	**65**	**64**	**67**	**65**	**261**	**272**	**96**	**Feasible**

As shown in Table 5, the web-based Four-Tier Diagnostic Test obtained an overall feasibility score of 96%. All assessment indicators were categorized as feasible, with scores ranging from 91% for attractiveness to 100% for media quality and appearance. These results indicate that the instrument was considered appropriate for identifying students' conceptual understanding and misconceptions in dynamic electricity.

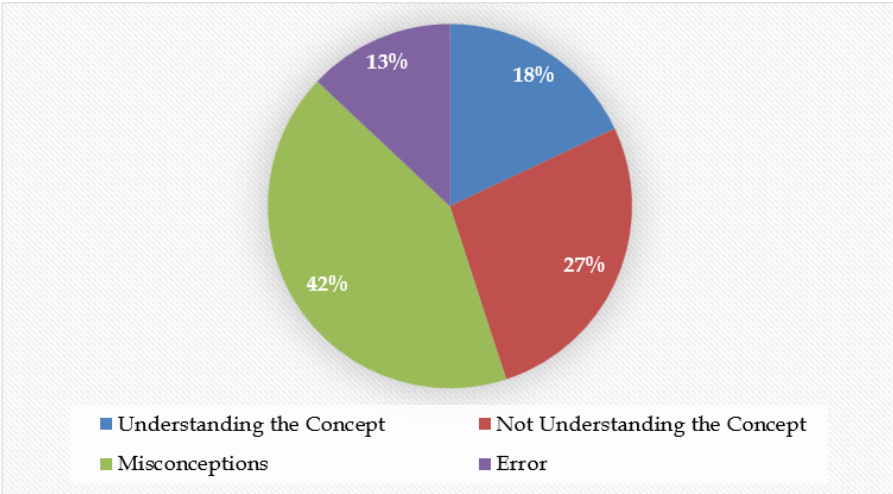


Figure 3. Distribution of Conceptual-Understanding Categories in Dynamic Electricity

Analysis of the responses to the 30 diagnostic items showed that 18% of the student-item responses were classified as understanding the concept, 27% as not understanding the concept, 42% as misconceptions, and 13% as errors, as presented in Figure 3. These percentages represent response classifications across the test items rather than the percentages of unique students assigned permanently to each category.

Responses from the 91 students were subsequently analyzed for each of the 30 test items. Figure 4 presents the number of responses classified as understanding the concept, not understanding the concept, misconception, and error for each item. The responses classified as misconceptions were then grouped according to the six misconception indicators presented in Table 6.

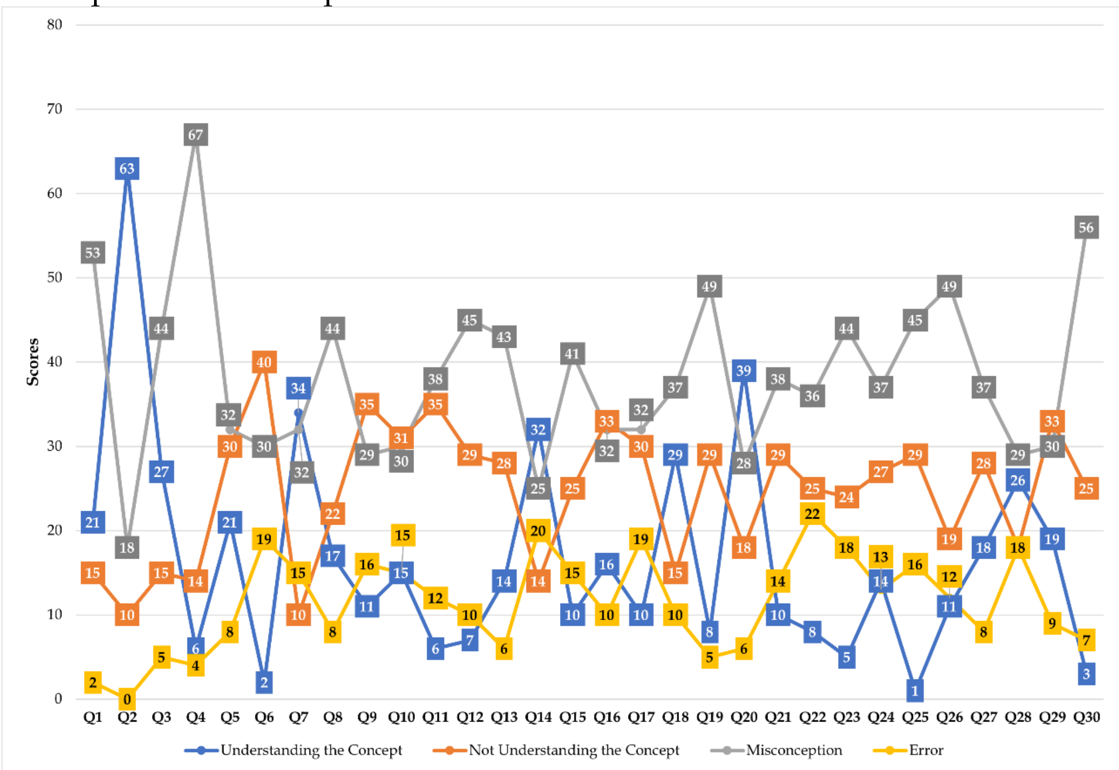


Figure 4. Distribution of Conceptual-Status Categories across the 30 Test Items

Table 6. Number of Misconception-Classified Responses for Each Test Item

Question No.	Number of responses	Type of misconception	Question No.	Number of responses	Type of misconception
1	53	Theoretical	16	32	Calculation
2	18	Systematic	17	32	Language interpretation
3	44	Basic	18	37	Correlational
4	67	Calculation	19	49	Theoretical
5	32	Language interpretation	20	28	Systematic
6	30	Correlational	21	38	Basic
7	32	Theoretical	22	36	Calculation
8	44	Systematic	23	44	Language interpretation
9	29	Basic	24	37	Correlational
10	30	Calculation	25	45	Theoretical
11	38	Language interpretation	26	49	Systematic
12	45	Correlational	27	37	Basic
13	43	Theoretical	28	29	Calculation
14	25	Systematic	29	30	Language interpretation
15	41	Basic	30	56	Correlational

Table 6 shows that misconception-classified responses occurred in every test item. Across the 30 items, 1,150 responses were classified as misconceptions. Of these responses, 17.8% were categorized as correlational misconceptions, 19.3% as theoretical misconceptions, 14.3% as systematic misconceptions, 16.4% as basic misconceptions, 16.9% as calculation misconceptions, and 15.3% as language-interpretation misconceptions. These percentages were calculated directly from the response frequencies presented in Table 6.

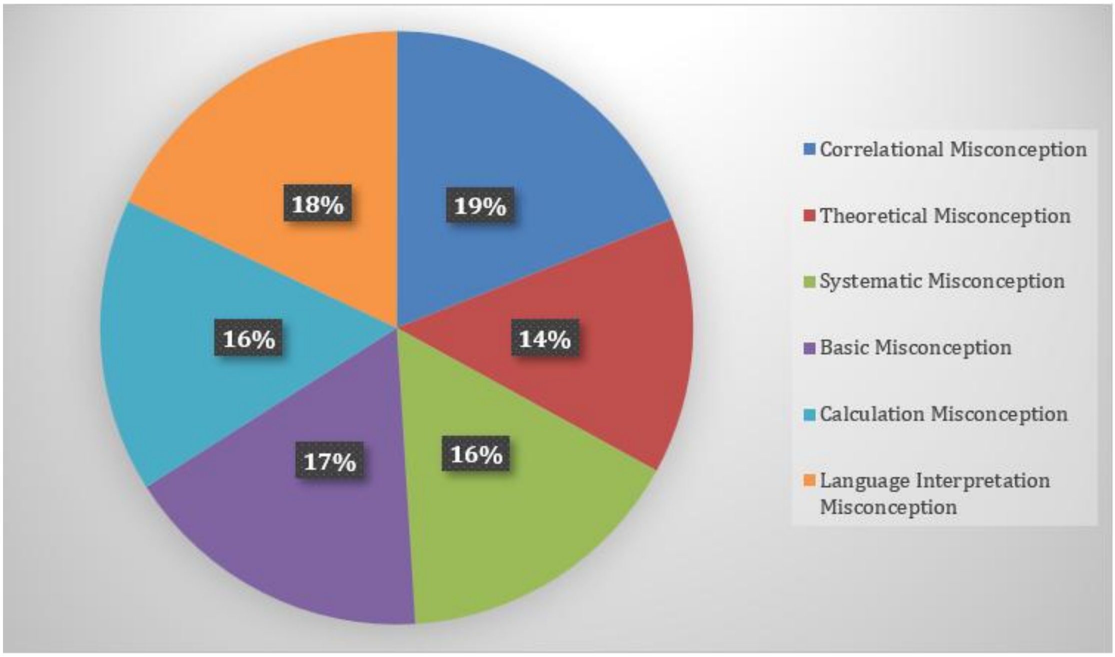


Figure 5. Distribution of Misconception Types in Dynamic Electricity

Theoretical misconceptions represented the largest proportion of misconception-classified responses at 19.3%, followed by correlational misconceptions at 17.8%. Systematic misconceptions constituted the smallest proportion at 14.3%. The complete distribution of misconception types is presented in Figure 5.

Discussion

Instrument Feasibility

The expert-validation process evaluated the feasibility of the web-based Four-Tier Diagnostic Test before its implementation. The assessment covered four main aspects: question content, language, media quality and appearance, and attractiveness. As presented in Table 5, the instrument obtained an overall feasibility score of 96%, placing it in the feasible category. This result indicates that the instrument was considered appropriate for identifying students' conceptual understanding and misconceptions in dynamic electricity.

A feasible diagnostic instrument should produce information that accurately represents students' knowledge, reasoning, and areas requiring instructional improvement. Reffiane and Saptono (2021) emphasized that assessment instruments must meet validity requirements to support accurate interpretation of students' abilities and learning needs. In the present study, all four assessed aspects exceeded the minimum feasibility criterion, although the validators identified several components that required minor revision before implementation.

Content Validity

The content-validation assessment included nine criteria: (1) alignment of the questions with the indicators, (2) consistency between the assessed concepts and the research framework, (3) clarity of the question components, (4) suitability of the instrument for dynamic electricity concepts, (5) alignment with the learning objectives, (6) alignment with the required competencies, (7) clarity of the subject matter, (8) clarity and function of images, graphs, tables, and diagrams, and (9) independence of each question from the answers to previous questions.

As shown in Table 5, the question-content aspect obtained a feasibility percentage of 96%. The detailed validation results in the Supplementary Materials indicate that the criterion concerning the clarity of images, graphs, tables, and diagrams received comparatively lower scores. The researchers therefore revised the size and visual clarity of these components before administering the instrument.

Clear visual information is important in physics assessment because diagrams and images often represent relationships that cannot be communicated efficiently through text alone. Puspitarini and Hanif (2019) reported that clear visual media can help explain learning content and increase students' motivation. Nuralim (2021) similarly stated that images and text should clarify information for readers. Zenki-Dalipi and Osmani (2022) further explained that appropriate visual representations help communicate information and make relationships among components more visible. Thus, improving the visual elements reduced the likelihood that students' responses would be influenced by unclear diagrams rather than by their conceptual understanding.

Language Structure

The language assessment covered four criteria: (1) conformity with standard Indonesian language conventions, (2) communicative and comprehensible wording,

(3) avoidance of local-language expressions, and (4) avoidance of uncertain terms such as "should," "usually," and "sometimes." The language aspect obtained a feasibility percentage of 97%.

The comparatively lower score for grammatical accuracy led to revisions in sentence structure and wording. This revision was necessary because ambiguous or grammatically inaccurate statements may affect how students interpret diagnostic questions. Setiyadi et al. (2025) stated that adherence to Indonesian language conventions can improve clarity and support students' understanding. Therefore, the language revision aimed to ensure that students' responses reflected their conceptual understanding rather than difficulties caused by unclear wording.

Media Quality and Appearance

The media-quality and appearance assessment focused on the appropriateness of the background design and the functionality and durability of the digital medium. This aspect received the maximum score of 32 out of 32, corresponding to a feasibility percentage of 100%. The result indicates that the web-based platform met the expected visual and functional criteria.

Website-based learning and assessment media should be visually aligned with the content and learning objectives so that students can maintain their attention while completing the activity. Isnaini et al. (2026) noted that website-based media can support conceptual understanding when their visual design is relevant to the learning content. Arisanti (2025) further explained that digital media can provide greater efficiency and flexibility than paper-based materials. In this study, the web-based format enabled the diagnostic test to be administered simultaneously to multiple students and facilitated systematic collection of their responses.

Attractiveness

The attractiveness assessment examined whether the platform's appearance could attract students' attention and support accurate interpretation of the questions. This aspect obtained a score of 29 out of 32, equivalent to 91%, and was therefore categorized as feasible. Although this was the lowest percentage among the four validation aspects, it remained above the required feasibility threshold.

Sofian and Anggraeni (2021) stated that visual presentation is important because students initially respond to the appearance of the learning medium. Tomita (2018) similarly found that the visual appeal of instructional media can influence learners' motivation. Thus, the instrument's appearance was considered sufficiently attractive for implementation, although further improvements in interface consistency, readability, and visual organization could strengthen students' engagement.

Conceptual-Status Analysis

The analysis showed that 42% of the 2,730 student-item responses were classified as misconceptions, as presented in Figure 3. This percentage does not mean that 42% of the 91 students were permanently categorized as having misconceptions. Instead, it represents the proportion of responses across the 30 diagnostic items that met the misconception-classification criteria. A student could demonstrate conceptual understanding on one item but show a misconception, lack of understanding, or error on another item.

Figure 4 presents the distribution of the four conceptual-status categories across the 30 questions. Misconception-classified responses occurred in every item, although their frequencies differed. This pattern indicates that students' conceptual difficulties were distributed across the dynamic electricity concepts assessed by the instrument rather than being concentrated in only one question.

Using the descriptive criteria reported by Sundari et al. (2022), in which misconception percentages of 31%–60% are classified as moderate, the overall misconception-response percentage of 42% falls within the moderate category. Nevertheless, this proportion remains educationally important because misconceptions may be held with confidence and can persist when they are not explicitly identified and addressed.

Desstya et al. (2025) stated that a Four-Tier Diagnostic Test is effective for identifying misconceptions because it combines students' answers, reasons, and confidence levels. This combination enables teachers to distinguish students who hold misconceptions from those who have insufficient knowledge or low confidence. The resulting diagnostic information can therefore support the selection of targeted instructional and remedial strategies.

The preliminary interviews indicated several possible contextual factors associated with the identified misconceptions, including limited use of engaging and interactive instructional strategies, low student interest in physics, and reliance on information obtained from external sources. These findings should not be interpreted as evidence of direct causation because the study employed a descriptive design. However, they suggest that classroom instruction and the quality of students' learning resources may influence the development or persistence of conceptual difficulties. Zeybek (2026) emphasized that addressing misconceptions requires instructional methods that are appropriate for the topic and supported by teachers' strong conceptual understanding.

Types of Misconceptions

Based on the frequencies reported in Table 6, theoretical misconceptions accounted for the largest proportion of misconception-classified responses, at 19.3%. They were followed by correlational misconceptions at 17.8%, calculation misconceptions at 16.9%, basic misconceptions at 16.4%, language-interpretation misconceptions at 15.3%, and systematic misconceptions at 14.3%. The distribution of these six categories is presented in Figure 5.

These findings indicate that students' most frequent difficulty involved understanding or explaining the fundamental principles underlying dynamic electricity. The relatively similar percentages across the six categories also show that the students' difficulties were multidimensional. Their misconceptions involved conceptual knowledge, relationships among concepts, problem-solving procedures, calculations, and interpretation of question language.

Theoretical Misconceptions

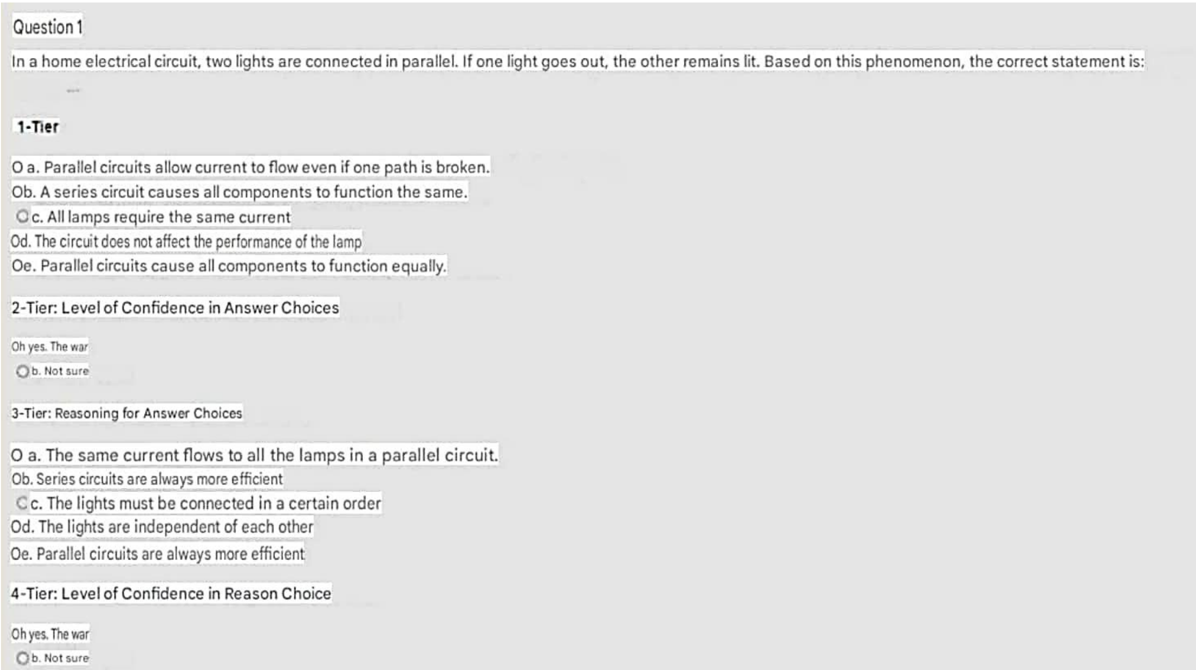
Theoretical misconceptions represented the largest category, accounting for 19.3% of all misconception-classified responses. This category indicates that students had difficulty understanding or explaining the fundamental theories and principles underlying dynamic electricity.

Figure 6 presents Question 1, which assessed students' understanding of a household parallel circuit. The item described two lamps connected in parallel and asked why one lamp remained lit when the other lamp went out. The scientifically correct explanation is that each lamp is connected through an independent branch.

Consequently, current can continue flowing through the intact branch even when another branch is disconnected.

According to Table 6, 53 responses to Question 1 were classified as theoretical misconceptions. This result suggests that many students had difficulty explaining the basic operating principle of a parallel circuit. Some students may have recognized the observable outcome—that one lamp remained lit—but may not have correctly explained the phenomenon in terms of independent current paths.

The four-tier structure was useful for analyzing this difficulty because it distinguished students who selected an incorrect answer with high confidence from those who selected the correct answer but provided an incorrect supporting reason. Therefore, Question 1 generated diagnostic information that could not be obtained from a conventional multiple-choice item alone.



Question 1

In a home electrical circuit, two lights are connected in parallel. If one light goes out, the other remains lit. Based on this phenomenon, the correct statement is:

1-Tier

O a. Parallel circuits allow current to flow even if one path is broken.
Ob. A series circuit causes all components to function the same.
Oc. All lamps require the same current
Od. The circuit does not affect the performance of the lamp
Oe. Parallel circuits cause all components to function equally.

2-Tier: Level of Confidence in Answer Choices

Oh yes. The war
Ob. Not sure

3-Tier: Reasoning for Answer Choices

O a. The same current flows to all the lamps in a parallel circuit.
Ob. Series circuits are always more efficient
Cc. The lights must be connected in a certain order
Od. The lights are independent of each other
Oe. Parallel circuits are always more efficient

4-Tier: Level of Confidence in Reason Choice

Oh yes. The war
Ob. Not sure

Figure 6. Example of a Four-Tier Diagnostic Test item assessing students' understanding of parallel electrical circuits

Abdila and Khairuna (2022) explained that theoretical misconceptions occur when students do not adequately understand the fundamental concepts underlying the material. In the context of dynamic electricity, this finding suggests that instruction should emphasize the physical meaning of current pathways and circuit configurations rather than relying only on the memorization of definitions or formulas.

Correlational Misconceptions

Correlational misconceptions accounted for 17.8% of the misconception-classified responses. This category reflects difficulty in identifying relationships among relevant concepts. In dynamic electricity, students must connect current, voltage, resistance, energy transfer, and circuit structure when interpreting a problem.

Bara et al. (2026) explained that correlational misconceptions occur when students fail to recognize the relationship between the concept presented in a question and other relevant concepts. Such difficulties may prevent students from transferring their understanding from one circuit representation to another or from connecting a familiar household phenomenon with its underlying electrical principles.

Calculation Misconceptions

Calculation misconceptions constituted 16.9% of the misconception-classified responses. These misconceptions occurred when students followed an appropriate general procedure but made an error in determining the final numerical result.

Mohyuddin and Khalil (2016) explained that calculation misconceptions may occur even when students appear to understand the required solution steps. In dynamic electricity, these errors may involve incorrect numerical substitution, arithmetic operations, unit conversion, or application of relationships among current, voltage, and resistance. Teachers should therefore examine both students' solution procedures and their final answers when diagnosing these difficulties.

Basic Misconceptions

Basic misconceptions accounted for 16.4% of the misconception-classified responses. This category indicates that students could not determine or complete the appropriate procedure for solving a problem.

Hayati and Setyaningrum (2019) described basic misconceptions as difficulties in selecting and applying the required problem-solving steps. The present findings suggest that some students require more structured guidance in identifying known and unknown quantities, selecting relevant physical principles, and organizing their solutions systematically.

Language-Interpretation Misconceptions

Language-interpretation misconceptions represented 15.3% of the misconception-classified responses. These misconceptions may occur when students do not correctly interpret the meaning of a question, particularly when the item presents a contextual situation or requires students to connect verbal information with a circuit diagram.

Exacta et al. (2024) stated that students who cannot interpret the intended meaning of a text may also experience difficulty initiating an appropriate reasoning process. Therefore, diagnostic questions should use concise, unambiguous language that is appropriate for students' reading levels. However, students should also receive opportunities to practice interpreting physics problems presented in different verbal, symbolic, and visual formats.

Systematic Misconceptions

Systematic misconceptions accounted for the smallest proportion, at 14.3%. This category reflects situations in which students recognize the steps required to solve a problem but apply those steps using an incorrect conceptual understanding.

Kurudirek et al. (2025) explained that systematic misconceptions occur when students follow a recognizable procedure while misunderstanding the concept underlying that procedure. Although this category had the lowest percentage, it remains important because the repeated use of an incorrect procedure can reinforce conceptual errors over time. Instruction should therefore emphasize the reasoning underlying each solution step rather than only the completion of a prescribed algorithm.

Study Contribution

This study extends previous diagnostic-test research by integrating a Four-Tier Diagnostic Test into a web-based platform and classifying misconception responses according to six predetermined indicators. Janah et al. (2021) developed a Four-Tier

Diagnostic Test to measure students' misconceptions, while Hesti (2022) demonstrated that such an instrument could identify students' conceptual profiles. Istiyono et al. (2023) also developed and validated a Four-Tier instrument for use in physics education.

The present study contributes by combining web-based administration, expert validation, response-confidence analysis, and classification of misconception types in dynamic electricity. This combination provides teachers with more detailed information than a conventional multiple-choice assessment because it identifies not only whether students' answers are correct but also whether their reasoning and confidence indicate conceptual understanding, insufficient knowledge, misconception, or error.

Study Limitations

Several limitations should be considered when interpreting the findings. First, the participants were 91 students from one public senior high school selected through purposive sampling. Therefore, the findings describe the participating group and should not be generalized to all senior high school students.

Second, the web-based instrument could be accessed through Android smartphones and computers but was not fully compatible with iOS devices. Third, responses could be lost when technical or network problems occurred because the platform did not include an automatic response-saving and recovery function. Finally, successful administration depended on a stable internet connection.

These technical limitations did not alter the original response data included in the analysis, but they should be addressed in future development to improve the platform's accessibility, reliability, and user experience.

CONCLUSION

The web-based Four-Tier Diagnostic Test was considered feasible for identifying students' conceptual understanding and misconceptions in dynamic electricity, obtaining an overall expert-validation score of 96%. Across the 2,730 student-item responses, 18% were classified as understanding the concept, 27% as not understanding the concept, 42% as misconceptions, and 13% as errors. These percentages represent response classifications across the 30 test items rather than fixed classifications of individual students.

Among the 1,150 misconception-classified responses, theoretical misconceptions accounted for the largest proportion at 19.3%, followed by correlational misconceptions at 17.8%, calculation misconceptions at 16.9%, basic misconceptions at 16.4%, language-interpretation misconceptions at 15.3%, and systematic misconceptions at 14.3%. These findings indicate that students experienced substantial difficulty understanding fundamental principles and connecting related concepts in dynamic electricity. The diagnostic information generated by the instrument can help teachers distinguish misconceptions from limited knowledge or low confidence and design more targeted instructional activities.

RECOMMENDATION

Physics teachers should use Four-Tier Diagnostic Tests to identify students' conceptual difficulties before selecting remedial or follow-up instructional strategies. Particular attention should be given to strengthening students' understanding of fundamental electrical principles and the relationships among current, voltage, resistance, and circuit configurations.

Future development of the web-based instrument should improve cross-platform compatibility so that it can be accessed through Android and iOS devices as well as computers. The platform should also include automatic response saving and recovery to prevent data loss during network interruptions. A stable internet connection should be prepared before test administration, and the instrument may be adapted to diagnose misconceptions in other physics topics.

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Data Availability
The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Ernasari	√	√		√	√				√	√		√		
M. D. F Hermansyah	√		√			√		√			√		√	
Rangga Alif Faresta		√		√			√				√			

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

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