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# *The Use of Light Labyrinth Media to Support Students' Conceptual Understanding of Light Reflection and Refraction*

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**Keywords:**

Light Labyrinth; conceptual understanding; light reflection; light refraction; learning media.

**ABSTRACT.** This study aimed to describe changes in students' conceptual-understanding scores on light reflection and refraction after learning with Light Labyrinth media. The study used a quantitative one-group pretest–posttest design involving 20 seventh-grade students at MTs Nur-Rahma, Bengkulu City, Indonesia. Data were collected through tests administered before and after the learning activity and were summarized descriptively using N-Gain and the statistical tests reported in the manuscript. The mean score increased from 55 on the pretest to 80 on the posttest, with an N-Gain of 0.56, categorized as moderate. The manuscript reports a paired-samples t-test result of $t = 8.25$, $df = 19$, $p < .001$; however, this result must be verified against the raw data and a normality check of the paired score differences. Descriptively, the findings indicate higher scores after learning with Light Labyrinth. Because the study did not include a control group, the increase cannot be attributed solely to the media.

## INTRODUCTION

Science learning requires students not only to remember facts but also to understand the relationships among concepts, phenomena, and their applications in everyday life. Conceptual understanding is important because students who understand a concept can explain phenomena in their own words, interpret information, and use knowledge to solve problems. In the topic of light, conceptual understanding is needed so that students do not merely memorize the laws of reflection and refraction, but can also predict the direction of light propagation and explain why its direction changes.

Light reflection and refraction can present conceptual difficulties because students need to understand the incident ray, reflected ray, refracted ray, and the relationship between rays and the normal line. Students must also connect observed phenomena with ray diagrams and scientific explanations. Research on understanding reflection and refraction highlights the importance of connecting multiple forms of representation in learning.

One way to support students' understanding is to use learning media that allow them to observe light phenomena. Learning media can provide concrete experiences and help connect theoretical explanations with observations. Previous studies have reported the use of interactive media to support conceptual understanding in physics and optics.

Previous research has also examined e-modules, multimedia, and Android-based media for reflection, refraction, and optical instruments. Inquiry and experimental activities are also relevant because they give students opportunities to observe phenomena and develop explanations based on evidence. However, further research is needed on teaching aids shaped as a light labyrinth that allow students to trace light paths and measure changes in conceptual understanding of reflection and refraction.

Light Labyrinth is a light-maze teaching aid that invites students to trace light paths and identify reflection and refraction. It is designed from simple materials and may serve as an alternative teaching aid when laboratory facilities are limited. Activities using the media should be accompanied by guiding questions so students do more than try different paths: they should predict, observe, record, and explain their findings.

The novelty of this study lies in using Light Labyrinth as a concrete teaching aid for learning about light reflection and refraction and measuring changes in conceptual-understanding scores before and after instruction. Since the study used a single group without a control group, the findings are interpreted as score changes after instruction rather than causal evidence that the changes were caused solely by the media.

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*Research Question And Objective*

This study aimed to identify differences in students' conceptual-understanding scores on light reflection and refraction before and after learning with Light Labyrinth media and to describe the magnitude of improvement using N-Gain.

*Significance Of The Study*

Theoretically, this study is expected to contribute to research on the use of concrete teaching aids in optics education. Practically, it may serve as a reference for teachers designing light-observation activities supported by guiding questions and scientific explanations.

*Related Studies*

Several previous studies relevant to this research are summarized in Table 1. The summary is organized according to the focus of each study, as indicated by its title, and illustrates the position of the present study in relation to existing research.

**Table 1.** Summary of Relevant Previous Studies.

| Study | Focus | Relevance to this study |
|---|---|---|
| Tadeo and Yoo [1] | Recognition of reflection and refraction concepts across representations | Highlights the importance of connecting phenomena, diagrams, and explanations |
| Sriyani et al. [2] | Effects of interactive learning media on conceptual understanding | Supports the use of media to develop conceptual understanding |
| Yanti et al. [3] | Interactive media for optical-instrument topics | Provides context for optics education |
| Aprianti et al. [4] | CTL-based physics e-module on light reflection and refraction | Addresses the same content using different media |
| Dolo et al. [5] | Interactive multimedia for light reflection | Addresses conceptual understanding of reflection |
| Rahayu et al. [6] | Guided inquiry and scientific argumentation in optics and light | Supports evidence-based explanation activities |
| Rahmati and Sari [7] | Laboratory-based inquiry on light reflection | Supports direct observation |
| Aini and Rusdiana [8] | Android-based interactive media with experiments on optical instruments | Supports the use of experiments in learning media |

Table 1 shows that previous studies have often focused on interactive or digital media and inquiry-based learning models, while a light-maze teaching aid assessed in relation to conceptual understanding of both reflection and refraction has received less attention. This study addresses that gap by examining changes in students' understanding after learning with Light Labyrinth.

## THEORETICAL REVIEW

*Conceptual Understanding In Science Learning*

Conceptual understanding is the ability to construct meaning from learning material presented orally, in writing, through images, or through direct experience. In the revised taxonomy by Anderson and Krathwohl, understanding involves interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining. Cognitive processes show that understanding a concept differs from merely memorizing its definition.

In science learning, conceptual understanding underpins other abilities, including problem-solving, critical thinking, and applying knowledge to new situations. Students who only memorize definitions or formulas may struggle with questions requiring explanations or applications. Therefore, conceptual understanding should be assessed with items asking students to interpret diagrams, identify examples and non-examples, and explain why a phenomenon occurs. This approach is consistent with research on recognizing reflection and refraction in multiple representational formats.

*Light Reflection*

Light reflection is the return of light to its original medium when it strikes the surface of an object. The law of reflection states that the incident ray, reflected ray, and normal line lie in the same plane, and that the angle of

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incidence equals the angle of reflection. Based on surface regularity, reflection is classified as regular reflection from a smooth surface, such as a plane mirror, and diffuse reflection from a rough surface, which scatters reflected rays in different directions. A plane mirror forms a virtual image that is the same size as the object and located the same distance behind the mirror as the object is in front of it.

These concepts may appear simple, but students must apply them when drawing or tracing a ray path involving multiple reflections. They need to identify the normal line, compare the angles of incidence and reflection, and predict the next direction of the ray. These tasks arise naturally in a light-maze arrangement of mirrors.

*Light Reflaction*

Light refraction is the change in the direction of light propagation when light crosses the boundary between two media with different optical densities. This bending occurs because the speed of light differs between media. When light travels from an optically less dense medium to a denser one, such as from air into water, the ray bends toward the normal. Conversely, when light travels from a denser medium to a less dense medium, it bends away from the normal [9]. The quantitative relationship between the angles of incidence and refraction is expressed by Snell's law:

$$n_1 \sin \theta_1 = n_2 \sin \theta_2 \quad (1)$$

Here, n is the refractive index of the medium and θ is the angle between the ray and the normal. Refraction cannot always be observed directly and is often noticed through its effects, such as an object appearing shallower in water. Students therefore need observation activities that help them connect ray direction with differences between media. Without such experience, students may memorize the rules about bending toward or away from the normal without understanding why.

*Instructional Media in Physics Learning*

Instructional media include anything used to convey information, attract attention, and help students gain learning experiences. For abstract topics, media can bring objects or events into the learning process so students can observe and experiment rather than rely only on imagination. Previous studies indicate that interactive media can support conceptual understanding, interactive multimedia can be used to teach reflection, and laboratory-based or experimental learning can support student engagement with light and optical instruments.

The studies cited here mostly focus on digital media or multimedia. In contrast, concrete teaching aids that guide students in tracing light paths directly have received less attention. This gap provides an opportunity for the present study, which applies the same general principle of visualization and active learning to help students understand abstract concepts [10]..

*Light Labyrinth Media*

Light Labyrinth is a maze-shaped teaching aid made from simple materials such as cardboard, transparent plastic, and light-reflecting components. The maze walls define the path, while optical components change the direction of the light. Students trace or direct light through the path while identifying where reflection and refraction occur.

From a learning perspective, the activity has three important characteristics. First, students observe light phenomena directly. Second, they predict and record the direction of the light. Third, they discuss their observations and explain the reasons in their own words. These characteristics align with the conceptual-understanding indicators: interpreting, exemplifying, classifying, inferring, comparing, and explaining.

*Conceptual Framework and Hypotheses*

Learning activities that allow students to observe light paths, record observations, and explain changes in light direction are expected to help them connect phenomena with the concepts of reflection and refraction. Accordingly, students' conceptual understanding after instruction is expected to be better than before instruction. The statistical hypotheses are:

$H_0$: There is no significant difference between students' mean conceptual-understanding scores before and after learning with Light Labyrinth media.

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$H_1$: There is a significant difference between students' mean conceptual-understanding scores before and after learning with Light Labyrinth media.

## RESEARCH METHODS

This study used a quantitative approach with a one-group pretest–posttest design. The design was selected to identify changes in students' conceptual understanding before and after instruction using Light Labyrinth media. The design can be expressed as $O_1$–X–$O_2$, where $O_1$ is the pretest, X is instruction using Light Labyrinth, and $O_2$ is the posttest [11, 12].

The study was conducted on September 12, 2026, at MTs Nur-Rahma in Bengkulu City. The participants were 20 seventh-grade students. They were selected in the context of classroom instruction on light reflection and refraction.

### *Research Variables*

The study involved two variables. The independent variable was the use of Light Labyrinth media to teach light reflection and refraction, while the dependent variable was students' conceptual understanding. A one-group pretest–posttest design is a pre-experimental design because it does not include a control group [12]. Therefore, the findings are interpreted as score changes after the intervention, not as a comparison with another teaching approach.

### *Materials and Media Development*

Light Labyrinth was made from readily available materials: cardboard for the frame and maze walls, transparent plastic as a medium through which light could pass, an LED flashlight as the light source, and optical components. The maze measured 60 cm × 40 cm. Its components included an LED flashlight, plane mirrors, a container of water, a glass prism, maze walls, and a target point.

The media was developed in several steps. First, the path was designed to include points where light would be reflected and refracted. Second, the cardboard frame and walls were assembled. Third, the reflective components and transparent plastic were installed according to the design. Fourth, the media was tested to ensure that the light path was visible and changes in direction could be observed. Finally, adjustments were made based on the trial before the media was used in instruction.

The research instrument was a conceptual-understanding test administered before and after instruction. The items were designed around indicators for light reflection and refraction: interpreting, exemplifying, classifying, inferring, comparing, and explaining. Evidence of validity and reliability should be reported based on the instrument testing actually conducted.

**Table 2.** Blueprint of the Conceptual Understanding Test on Light Reflection and Refraction.

| Indicator | Description in the light topic | Item numbers |
|---|---|---|
| Interpreting | Interpreting ray-path diagrams for reflection and refraction | 1–3 |
| Exemplifying | Giving everyday examples of reflection and refraction | 4–6 |
| Classifying | Classifying events as regular reflection, diffuse reflection, or refraction | 7–9 |
| Inferring | Inferring the ray's direction after it strikes a mirror or passes between media | 10–12 |
| Comparing | Comparing ray behavior in reflection and refraction | 13–15 |
| Explaining | Explaining the reasons for changes in light direction in one's own words | 16–20 |

The study began with a pretest to assess students' initial abilities. Students then learned using Light Labyrinth. They observed light paths, identified reflection and refraction, recorded observations, discussed the reasons for changes in direction, and connected their observations with the concepts being learned. After the lesson, they completed a posttest with indicators equivalent to those of the pretest.

The teacher acted as a facilitator by asking guiding questions, while students worked in small groups so that each member had an opportunity to observe and contribute.

**Table 3.** Stages of Learning Activities Using Light Labyrinth.

| Stage | Student activities | Teacher's role |
|---|---|---|
| Orientation | Recall properties of light propagation and learn the task in the maze | Introduce the media and learning objectives |
| Prediction | Predict the direction of light at each maze component | Ask guiding questions |

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| | | |
|---|---|---|
| Observation | Trace the light path and record points of reflection and refraction | Observe and guide groups |
| Discussion | Compare predictions with observations and explain the reasons | Encourage scientific reasoning |
| Conclusion | Connect observations with the law of reflection and the concept of refraction | Reinforce concepts and correct misconceptions |

N-Gain categories followed Hake's classification [9]. The Shapiro–Wilk test was used to examine normality for the data being analyzed. A paired-samples t-test at a significance level of 0.05 was planned if the assumptions were met; otherwise, the analysis method needed to be adjusted. The manuscript states that IBM SPSS Statistics version 27 was used. Final values and decisions should be consistent with the actual statistical output.

**Table 4.** N-Gain Score Categories.

| N-Gain range | Category |
|---|---|
| $g \geq 0.70$ | High |
| $0.30 \leq g < 0.70$ | Moderate |
| $g < 0.30$ | Low |

## RESULTS AND DISCUSSION

This study examined changes in students' conceptual-understanding scores on light reflection and refraction after learning with Light Labyrinth media. It was conducted on September 12, 2026, with 20 seventh-grade students at MTs Nur-Rahma, Bengkulu City, using a one-group pretest–posttest design. The instrument was described as a multiple-choice test administered before and after instruction. The manuscript reports mean, minimum, and maximum scores, statistical analysis, and N-Gain. Before publication, the number of items described in the methods should be aligned with the test blueprint.

### *Pretest and Posttest Results*

The analysis of pretest and posttest scores showed an increase in students' average conceptual understanding scores after learning using the Light Labyrinth instructional media. A summary of the measurement results is presented in Table 5.

**Table 5.** Pretest and Posttest Results of Students' Conceptual Understanding

| Statistic | Pretest | Posttest |
|---|---|---|
| Number of students | 20 | 20 |
| Mean score | 55 | 80 |
| Minimum score | 30 | 60 |
| Maximum score | 75 | 95 |

As shown in Table 5, the mean pretest score was 55, while the mean posttest score increased to 80. Thus, the mean score rose by 25 points after students learned using Light Labyrinth. The minimum score increased from 30 to 60, and the maximum score increased from 75 to 95.

These results show that students' conceptual-understanding scores were higher after instruction than before it. Light Labyrinth was used to help students learn about reflection and refraction through observations of light paths, plane mirrors, water, and a prism.

Nevertheless, the increase in pretest and posttest scores is not sufficient to conclude that the increase was entirely caused by the media. The study involved one group without a control group, so other factors during instruction cannot be ruled out.

### *Statistical Analysis and N-Gain Results*

Statistical analysis was conducted to determine changes in students' conceptual understanding scores and measure learning gains based on pretest and posttest scores. The statistical analysis results presented in the manuscript are shown in Table 6.

**Table 6.** Statistical Analysis Results of Students' Conceptual Understanding

| Analysis | Reported result |
|---|---|
| Shapiro–Wilk significance for pretest | 0.124 |
| Shapiro–Wilk significance for posttest | 0.087 |
| N-Gain | 0.56 |

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| | |
|---|---|
| Paired t-value | 8.25 |
| Degrees of freedom (df) | 19 |
| t-test significance | $p < 0.001$ |

The manuscript reports Shapiro–Wilk significance values of 0.124 for pretest scores and 0.087 for posttest scores. Both values exceed 0.05, but these results alone do not establish the normality assumption for a paired-samples t-test. Normality should be checked for the paired pretest–posttest difference scores using the raw data before confirming the t-test decision.

The manuscript reports a paired-samples t-test result of $t = 8.25$, $df = 19$, and $p < 0.001$. These figures are retained from the original manuscript but must be verified against students' raw data and the complete statistical output. If the calculations and test assumptions are confirmed, the result indicates a statistically significant difference between pretest and posttest scores.

The N-Gain of 0.56 was calculated from the mean pretest score of 55 and posttest score of 80, with a maximum score of 100. It falls in the moderate category under the criteria in Table 4. This value describes improvement relative to the remaining opportunity for score improvement, but does not by itself prove that the media was the sole cause.

*Improvement in Conceptual Understanding Based on Indicators*

Further analysis was conducted on six indicators of conceptual understanding: interpreting, exemplifying, classifying, inferring, comparing, and explaining. The results of the analysis for each indicator are presented in Table 7.

**Table 7.** Analysis Results of Conceptual Understanding Based on Indicators

| Indicator | Pretest mean | Posttest mean | N-Gain |
|---|---|---|---|
| Interpreting | 55.00 | 80.00 | 0.56 |
| Exemplifying | 60.00 | 85.00 | 0.63 |
| Classifying | 55.00 | 80.00 | 0.56 |
| Inferring | 50.00 | 75.00 | 0.50 |
| Comparing | 55.00 | 80.00 | 0.56 |
| Explaining | 45.00 | 70.00 | 0.45 |

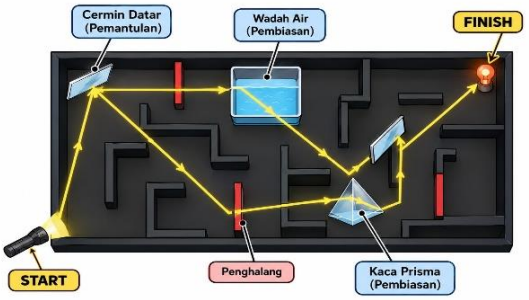
Based on Table 7, all indicators showed an increase in average scores from the pretest to the posttest. The exemplifying indicator increased from 60 to 85, with an N-Gain of 0.63. This was the highest N-Gain among the reported indicators, indicating the greatest relative improvement based on the calculations presented in the manuscript.

The interpreting and classifying indicators each increased from 55 to 80, while the comparing indicator also increased from 55 to 80. The inferring indicator improved from 50 to 75, with an N-Gain of 0.50. Meanwhile, the explaining indicator increased from 45 to 70, with an N-Gain of 0.45, making it the indicator with the lowest average posttest score.

Descriptively, improvements occurred across all analyzed indicators, although the magnitude of improvement varied. This interpretation should be considered in light of the alignment between test items and their respective indicators, as well as the need to recheck the score calculations and N-Gain values.

*Discussion*






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**Figure 1.** Light Labyrinth Instructional Media for the Topics of Light Reflection and Refraction

*The Use of Light Labyrinth Media in Teaching Light Reflection and Refraction*

Light Labyrinth is designed to help students learn about light reflection and refraction through observations of light paths. The media described in the manuscript uses cardboard, transparent plastic, an LED flashlight, plane mirrors, a container filled with water, and a glass prism. These components are used to create a light path that students can observe during learning activities.

For the concept of reflection, a plane mirror can be used to observe changes in the direction of light when it strikes a reflective surface. For the concept of refraction, water and a glass prism can help demonstrate changes in the direction of light propagation as it passes across the boundary between media with different optical properties, particularly when the light strikes the boundary at an oblique angle.

These observations can help students connect theoretical explanations with visible phenomena. However, the clarity of the observed phenomena depends on the design of the light path, lighting conditions, component positions, and how the teacher guides the observation process. Therefore, the use of this instructional media should be accompanied by questions that encourage students to make predictions, compare their predictions with the observed results, and explain their reasoning.

*Changes in Students' Conceptual Understanding After the Use of the Learning Media*

The students' mean conceptual understanding score increased from 55 on the pretest to 80 on the posttest, representing a gain of 25 points. This result indicates that students achieved higher scores after the learning intervention than before it. However, because the research design did not include a control group, this improvement cannot be attributed solely to the use of the learning media.

The increase in scores may be associated with opportunities for students to observe the paths of light rays and connect their observations to the concepts of reflection and refraction. Nevertheless, this explanation should be regarded as a plausible interpretation rather than a mechanism that was independently examined in this study.

The normalized gain (N-gain) of 0.56 falls within the moderate category according to the classification criteria adopted in this study. This finding indicates an improvement in conceptual understanding scores among the participating students following instruction using Light Labyrinth. However, it does not establish that the learning media were the sole factor contributing to the observed improvement.

*Discussion of Improvements in Each Conceptual Understanding Indicator*

The exemplifying indicator had the highest N-Gain value of 0.63, with the average score increasing from 60 to 85. This result indicates an improvement in scores on questions measuring students' ability to provide examples of light reflection and refraction. However, these data are insufficient to conclude that students have mastered all applications of the concepts beyond the test items administered.

The interpreting, classifying, and comparing indicators each increased from an average score of 55 to 80. Descriptively, students achieved higher posttest scores on items measuring these abilities. Explanations for the improvement should nevertheless be presented cautiously because the study did not examine the contributing factors separately.

The inferring indicator increased from an average score of 50 to 75, with an N-Gain of 0.50. This result indicates an increase in scores on items related to drawing conclusions. As a follow-up learning activity, students can be encouraged to connect their observations with scientific principles.

The explaining indicator had an average posttest score of 70 and an N-Gain of 0.45, the lowest N-Gain among the reported indicators. This suggests that the ability to explain concepts requires further attention in subsequent learning activities, for example, through exercises that encourage students to express scientific reasoning and cause-and-effect relationships in their own words.

Differences in scores across indicators can serve as a basis for designing follow-up learning activities. Teachers can ask students to explain their observations in their own words, draw light paths, compare two phenomena, and provide explanations based on scientific concepts.

*Research Limitations*

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The findings should be interpreted in consideration of the limitations of the research design and sample size. This study involved 20 students and employed a one-group pretest-posttest design without a control group. Therefore, the results describe changes in scores within the group studied but cannot establish that these changes were caused solely by the use of Light Labyrinth media.

Other factors, such as teacher explanations, practice during learning activities, prior experience with the pretest questions, and differences in student characteristics, may also have contributed to the changes in scores. Furthermore, findings from a single group with a limited number of participants cannot be directly generalized to all students or schools.

Future research could involve a larger number of students and a comparison group to enable a more robust analysis of the contribution of the instructional media. Instrument testing should also be reported clearly, including evidence of validity, reliability testing procedures, and the alignment of each test item with the conceptual understanding indicators. Statistical analyses should be conducted using students' raw data and appropriate test assumptions.

*Relationship Between Media Characteristics and Conceptual Understanding*

For the concept of reflection, Light Labyrinth can be used to trace the path of light after it strikes a reflective surface. With teacher guidance, students can examine the relationship between the angles of incidence and reflection and use the normal line to predict the direction of the subsequent light ray.

For the concept of refraction, the media can help students observe changes in the direction of light as it passes across the boundary between two different media. Teachers need to ensure that the arrangement of the water or prism produces clearly observable phenomena. The observations can then be connected to the concepts of optical density and changes in the speed of light, allowing students to move beyond memorizing rules about whether light bends toward or away from the normal line.

The potential of the media depends not only on the equipment used but also on the learning activities accompanying it. Prediction, recording observations, discussion, and observation-based explanations can help students connect evidence with scientific concepts. Previous studies on guided inquiry and scientific argumentation in optics are also relevant as a foundation for these activities [6].

Light Labyrinth uses simple materials and therefore has the potential to serve as an alternative for schools with limited laboratory facilities. However, claims that it is less expensive or superior to other media should be supported by cost data or measurable comparisons if they are to be discussed as research findings.

Overall, Light Labyrinth has the potential to support the teaching of light reflection and refraction. To ensure that learning activities go beyond simply experimenting with the equipment, worksheets should ask students to predict light paths, record observations, identify the types of phenomena observed, and explain their reasoning scientifically.

*Examples of Guiding Questions in the Worksheet*

The worksheet accompanying Light Labyrinth can include guiding questions aligned with the conceptual understanding indicators. The examples in Table 8 are proposed questions that can be adjusted to match the light paths and media components actually used.

**Table 8.** Examples of Guiding Questions for Each Indicator

| Indicator | Example guiding question |
|---|---|
| Interpreting | Draw the light path you observed and mark the point where the light changed direction. |
| Exemplifying | Give one everyday example similar to the change in light direction at this point. |
| Classifying | Is the change in light direction at this point reflection or refraction? Explain your answer. |
| Inferring | Based on the preceding path, in which direction will the light travel after it reaches the next component? |
| Comparing | How does light behave differently when it strikes a reflecting surface and when it passes through transparent plastic? |
| Explaining | Why does the light bend at this point? Explain in your own words. |

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Guiding questions can be arranged progressively, beginning with describing observations and moving toward explaining cause-and-effect relationships. Teachers can also ask students to compare their predictions with the observed results and provide reasons based on the concepts they have learned.

*Implications for Science Learning*

The research findings have practical implications for science teachers. Instructional aids should be accompanied by worksheets containing prediction, observation, and explanation activities to ensure that hands-on experiences are followed by reasoning processes. Teachers should also provide students with sufficient time to compare their predictions with the observed results and correct any misconceptions. Light sources must be used safely and directed away from students' eyes.

For schools with limited laboratory facilities, Light Labyrinth can be considered an alternative instructional aid. Teachers should test the media before the lesson to ensure that the positions of the reflective components and transparent media produce consistent light paths.

## CONCLUSION

Based on the indicator-by-indicator analysis presented in the manuscript, the highest N-Gain was found in the exemplifying indicator (0.63), while the lowest was found in the explaining indicator (0.45). Therefore, exercises that develop students' ability to construct explanations and provide scientific reasoning should be strengthened in subsequent learning activities.

These findings indicate an increase in scores among the group studied following instruction using Light Labyrinth. However, the one-group design without a control group and the sample size of 20 students limit causal conclusions and the generalizability of the findings. Future research is recommended to use a comparison group, a larger number of participants, and instruments whose validity and reliability have been transparently reported.

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## REFERENCES

[1] D. J. Tadeo and J. Yoo, "Students' Recognition of Concepts of Reflection and Refraction in Multiple Representational Formats," Jurnal Pendidikan Fisika, vol. 10, no. 2, 2022, doi: 10.26618/jpf.v10i2.7639.

[2] D. Sriyani, I. Koto, A. Defianti, I. Sakti, and M. Uliyandari, "The Effect of Interactive Learning Media on Student's Conceptual Understanding," Journal of Teaching and Learning Physics, vol. 8, no. 2, pp. 111–124, 2023, doi: 10.15575/jotalp.v8i2.27705.

[3] S. H. Yanti, Yennita, and Syahril, "Improving the Understanding of Students' Learning Concepts on Optical Equipment Materials through Interactive Learning Media," Journal of Educational Sciences, vol. 6, no. 3, pp. 459–471, 2022, doi: 10.31258/jes.6.3.p.459-471.

[4] R. Aprianti, K. Nadiyyah, V. Y. K. Gusti, and F. Herliana, "The Development of Physics E-Module CTL-Based for Reflection and Refraction of Light Topic," Jurnal Penelitian & Pengembangan Pendidikan Fisika, vol. 9, no. 1, pp. 23–34, 2023, doi: 10.21009/1.09103.

[5] F. X. Dolo, M. Y. Kua, and P. Y. Djawaria, "Meningkatkan Pemahaman Konsep Siswa dengan Multimedia Interaktif pada Materi Pemantulan Cahaya," Jurnal Pendidikan Tambusai, vol. 6, no. 1, pp. 484–489, 2022, doi: 10.31004/jptam.v6i1.2935.

[6] R. Rahayu, S. Siswanto, C. A. Ramadhanti, and B. Subali, "Guided Inquiry Learning Model Using Scientific Argumentation Activities to Improve Concept Understanding on Optical and Light," Jurnal Pendidikan Fisika Indonesia, vol. 19, no. 1, 2023, doi: 10.15294/jpfi.v19i1.36626.

[7] R. Rahmati and N. T. Sari, "Peningkatan Keterampilan Berpikir Kritis Siswa Melalui Model Pembelajaran Inkuiri Berbasis Laboratorium Pada Materi Pemantulan Cahaya," Intelektualita: Journal of Education Sciences and Teacher Training, vol. 13, no. 2, 2024, doi: 10.22373/ji.v13i2.29080.

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[8] N. Aini and D. Rusdiana, "Development of Android-based Interactive Learning Media to Improve Student Understanding Through Experiments on Optical Equipment Materials," Berkala Ilmiah Pendidikan Fisika, vol. 12, no. 1, 2024.

[9] R. R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," American Journal of Physics, vol. 66, no. 1, pp. 64–74, 1998.

[10] L. W. Anderson and D. R. Krathwohl, Eds., A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. New York: Longman, 2001.

[11] A. Arsyad, Media Pembelajaran. Jakarta: Rajawali Pers, 2017.

[12] Sugiyono, Metode Penelitian Kuantitatif, Kualitatif, dan R&D. Bandung: Alfabeta, 2019.

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