EFFECTIVENESS OF MIND MAPPING-BASED FORMATIVE ASSESSMENT ON IMPROVING STUDENTS' LEARNING RETENTION ABILITIES ON THE CONCEPT OF LIGHT

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Abstract

This study aims to determine the effectiveness of mind mapping-based formative assessment on students' learning retention ability in the concept of light. A quantitative approach with a quasi-experimental method and One Group Pretest-Posttest design was used. The subjects were 29 eighth-grade students of SMP Negeri 9 Tegal in the 2025/2026 academic year, selected through purposive sampling. Data were collected through pretest-posttest tests, rubric-based mind mapping assessment, and a student response questionnaire, then analyzed using the Shapiro-Wilk normality test, simple linear regression, and N-Gain analysis. The results showed that mind mapping assessment scores had a positive and significant effect on students' learning retention, with a coefficient of determination (R^2) of 0.373 (a 37.3% contribution) and a significance value of 0.000 (<0.05). The average N-Gain score was 0.767, categorized as high. Among the retention indicators, recognition achieved the highest attainment (80.3%), followed by recall (75.5%) and concept implementation (69.8%). It can be concluded that mind mapping-based formative assessment is effective as an alternative assessment strategy in science learning to improve students' learning retention on the concept of light.

Keywords: formative assessment, mind mapping, learning retention, concept of light

1 INTRODUCTION

Science learning at the junior high school (SMP) level plays a crucial role in developing students' scientific thinking skills, conceptual understanding, and problem-solving skills. Science learning not only emphasizes conceptual mastery but also encourages students to construct knowledge through meaningful learning experiences, enabling them to retain information over a longer period of time (Taib, 2021). Formative assessment results provide teachers with information on student learning progress and serve as a basis for providing feedback to improve the quality of learning (Misnawati et al., 2025).

Students' low ability to understand science concepts causes them to have difficulty remembering, connecting, and applying learned concepts to different situations. Teaching methods that are still dominated by lectures and lack systematic formative assessment make it difficult for students to organize information and recall learned material ((Nadhifah et al., 2023; Defianty & Wilson, 2024).

Light is a science concept in eighth-grade junior high school that is abstract because it involves physical processes that cannot be directly observed, often causing learning difficulties (Rahmawati, 2021). When the concept of light is only presented through lectures and assessments that emphasize formula memorization, students tend to become bored and have difficulty connecting the concepts of reflection, refraction, and shadow formation to real-world situations, making the knowledge gained easily forgotten. Conversely, learning and assessment strategies that activate students' visual and cognitive engagement, such as mind-mapping-based formative assessments, are considered effective in helping students organize relationships between concepts, increase motivation, and strengthen retention of the material learned (Ruhama & Erwin, 2021).

Previous research has demonstrated the benefits of mind mapping and formative assessment separately. Anzelina & Tamba, (2020) demonstrated that mind mapping positively impacts student learning outcomes, while Putra Priyandana et al., (2021) found that mind mapping media assisted by

digital applications can improve science learning outcomes. Riana et al. reported that multimedia-based mind mapping models effectively improve science learning outcomes. However, research specifically examining the effect of mind mapping-based formative assessment on students' learning retention on light in eighth-grade junior high school is still limited. This gap underlies this research, which is to develop and test the effectiveness of mind mapping-based formative assessment as a source of information for teachers in providing appropriate feedback to improve student learning retention on the concept of light.

Based on the description, this study aims to: (1) determine the effectiveness of mind mapping as a formative assessment instrument in improving students' conceptual understanding; and (2) determine the increase in students' learning retention abilities on the concept of light after the application of mind mapping-based formative assessment. Learning retention abilities in this study were measured through three indicators, namely recall (recalling information without instructions), recognition (recognizing information that has been learned), and concept implementation (applying concepts to new situations) (Gunawan & Palupi, 2016).

2 METHODOLOGY

This study used a quantitative approach with a quasi-experimental research type and a One Group Pretest-Posttest Design, which provided a pretest before treatment and a posttest after treatment to determine changes in students' learning retention abilities (Maciejewski, 2020). The study population was all 319 eighth-grade students of SMP Negeri 9 Kota Tegal in the 2025/2026 academic year. The sample was determined using a purposive sampling technique, namely class VIII A with 29 students as the research class.

The independent variable in this study is a mind mapping-based formative assessment on the subject of light, while the dependent variable is students' learning retention ability measured through three indicators: recall, recognition, and concept implementation. The study was conducted at SMP Negeri 9 Tegal City on May 21–23, 2026. Before learning, students were given a pretest to determine their initial abilities on the subject of light. Furthermore, learning was carried out by implementing a mind mapping-based formative assessment, namely students compiled a mind map as part of the assessment process so that teachers could provide feedback on students' conceptual understanding. At the end of the learning, students were given a posttest and filled out a response questionnaire regarding the implementation of the assessment.

The data collection techniques consisted of: (1) a pretest-posttest consisting of 20 multiple-choice questions on the concept of light; (2) mind mapping assessment using a rubric covering four aspects, namely conceptual accuracy, conceptual relevance, conceptual application, and visualization; and (3) a student response questionnaire regarding the implementation of mind mapping-based formative assessment. All instruments were validated by the supervising lecturer and science subject teacher, then trialed to determine the validity, reliability, level of difficulty, and discriminatory power of the test items before being used in the research.

Data were analyzed using the Shapiro-Wilk normality test (because the sample size was less than 50 respondents), a simple linear regression test to determine the effect of mind mapping scores on learning retention abilities, and the N-Gain test to determine the level of improvement in students' learning retention abilities before and after treatment. Descriptive analysis was also conducted on the achievement of each learning retention indicator and the results of the student response questionnaire.

3 RESULTS

3.1 RESPONDEN CHARACTERISTICS

The respondents in this study were 29 students of class VIII A of SMP Negeri 9 Tegal, who served as the experimental class. All respondents participated in learning about light using a mind mapping-based formative assessment. Respondents were selected using a purposive sampling technique in accordance with the research needs. Thus, all students in the experimental class were used as research subjects to measure the improvement in learning retention abilities after the implementation of the mind mapping-based formative assessment.

Table 1. Respondent Characteristics

No.	Kelas	Jumlah (Orang)	Persentase (%)
1	VIII A (Kelas Eksperimen)	29	100

3.1.1 INSTRUMENT TESTING

The results of content validation of the pretest-posttest and self-assessment questionnaire instruments obtained an average validation coefficient of 0.5, which is included in the moderate category, so the instrument is declared suitable for use. The results of the empirical validity test show that all 20 pretest-posttest questions are declared valid. The results of the mind mapping assessment rubric reliability test using SPSS version 26 obtained a Cronbach's Alpha value of 0.724 (reliable category), so the instrument can be used. The results of the calculation of the level of difficulty show that 25% of the questions are categorized as easy and 75% are categorized as medium.

Tabel 2

Validity Test results Variable Peer Influence

Testing Aspect	Result	Category/Description
Content Validity (mean coefficient)	0,5	Moderate; instrument is suitable for use
Empirical Validity (20 items)	20 out of 20 items are valid	All items are valid
Reliability (Crobanch's Alpha mind mapping rubric)	0,724	Reliable
Item Difficulty Level	25% easy, 75% Moderate	Proportional

3.1.2 Prerequisite Analysis Test

The normality test using Shapiro-Wilk on the residual data of the regression model obtained a significance value of 0.818 (>0.05), so that the residual data was declared to be normally distributed and the simple linear regression analysis could be continued.

Table 3. *normality test.*

		Statistik	Sig
Standardized Residual	*Shapiro wilk*	0,979	0,818

3.1.3 The Effect of Mind Mapping-Based Formative Assesmet On Learning Retention

The results of the simple linear regression analysis produced the equation Y = -0.236 + 0.0125X, which shows that every one point increase in the mind mapping-based formative assessment score is followed by an increase in the N-Gain score of 0.0125. The t-test results show a calculated t value of 4.009 with a significance of 0.004 (<0.05), so H_0 is rejected and H_1 is accepted. The coefficient of determination (R^2) value of 0.373 shows that mind mapping-based formative assessment contributes 37.3% to increasing students' learning retention abilities, while the remaining 62.7% is influenced by other factors outside the study, such as learning motivation, learning styles, and students' learning environment.

Table 4. *Result of Simple Linear Regression Coeffient Test*

Model	Coefficient (B)	t count	Sig.
Constant	-0.236	-	-
Mind Mapping Score	0.0125	4,009	0,004

3.1.4 Increased Learning Retention Ability (N-Gain)

The results of the N-Gain analysis on 29 experimental class students showed the lowest value of 0.40 and the highest value reached 1.00, with an average (mean) of 0.767 and a standard deviation of 0.178. The average N-Gain value is included in the high category, which indicates that students' learning retention abilities have increased significantly after the implementation of mind mapping-based formative assessment.

3.1.5 Achievement of Learning Retention Ability Indicators

Analysis of the three learning retention indicators shows that the recognition indicator achieved the highest percentage of achievement at 80.3%, indicating that students were able to recognize the concepts of light that had been learned well. The recall indicator achieved 75.5%, indicating that most students were able to recall information or concepts that had been learned without the help of instructions, such as the properties of light, types of reflection, and the concept of refraction. Meanwhile, the concept implementation indicator achieved the lowest percentage of 69.8%, indicating that students still need further practice in applying the concept of light to new situations or problems.

Table 5. *Average Achievement of Learning Retention Ability Indicators*

Retention Indicators	Average	Percentage	Category
Recall	1.51	75.5%	Good
Recognition	2.41	80.3%	Good
Concept Implementation	10.48	69.8%	Good

3.1.6 Student Responses to Mind Mapping-Based Formative Assesment

The results of the student response questionnaire analysis showed an average score of 31.10 out of a maximum score of 40, which is considered good. This indicates that students responded positively to the implementation of mind mapping-based formative assessment in learning the concept of light.

3.1.7 Discussion

The findings of this study indicate that mind mapping-based formative assessment is effective in improving students' learning retention skills on the concept of light. The characteristics of mind mapping, which require students to identify important concepts, connect between concepts, and organize information into a systematic visual format, encourage students to actively process information. This process makes learning not only oriented towards memorization but also towards forming meaningful conceptual relationships, so that learned information is retained longer in memory and is more easily recalled during evaluation (Rita et al., 2021; Adam & Ayu, 2025).

In the recall indicator, students showed an increase in their ability to recall basic light concepts without the aid of instructions, such as the properties of light, types of reflection, and the concept of refraction. In the recognition indicator, students more easily recognized the correct concept when presented again in the form of multiple-choice questions or illustrations of optical phenomena, so that achievement in this indicator was the highest. Conversely, in the concept implementation indicator, students still showed relatively lower achievement because it requires higher-level thinking skills in connecting concepts to real situations, such as explaining the phenomenon of reflection or refraction of light in everyday life.

The results of a simple linear regression test also support the finding that the quality of students' mind maps contributes significantly to increased learning retention. The better the quality of the mind maps, the higher the student's learning retention rate. This finding aligns with previous studies demonstrating the benefits of mind mapping in supporting the learning process (Anzelina & Tamba, 2020; Putra Priyandana et al., 2021; Rita et al., 2021). It also broadens its scope by systematically integrating mind mapping as a formative assessment instrument, not simply as a learning strategy or medium.

However, this study has several limitations. The One Group Pretest-Posttest design without a control group means that the increase in learning retention cannot be fully confirmed as being solely due to the treatment given, as there are still possible factors outside the study that also influence student learning outcomes (Creswell, 2018). This study also only involved one class with 29 respondents and focused

on light material within a relatively short research period, so the results cannot be generalized to a wider population or describe student learning retention over a longer period.

4 CONCLUSIONS

Based on the research results and discussion, it can be concluded that the application of mind mapping as a formative assessment instrument has proven effective in improving students' conceptual understanding of light material. The results of simple linear regression analysis obtained a coefficient of determination (R^2) of 0.373 with a significance value of 0.000 (<0.05), which indicates that the mind mapping score has a significant effect on improving students' learning retention abilities. In addition, the application of mind mapping-based formative assessment is able to improve students' learning retention abilities on the concept of light, indicated by the average N-Gain value of 0.767 which is included in the high category. Thus, mind mapping-based formative assessment can be used as an alternative assessment in science learning to improve students' learning retention abilities, especially on the concept of light.

Further research is recommended to use an experimental design involving a control group, a larger sample size, more diverse learning materials, and a longer retention measurement period, so that more comprehensive research results are obtained and have a higher level of generalization

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