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Analysis of Learning Outcome Indicator Completion through Verification of Concept Maps and Mind Maps in the Discovery Learning Model

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A B S T R A C T

A less systematic conceptual understanding can hinder the completion of student learning outcomes. This study aims to compare the verification of concept maps and mind maps in improving student understanding in the Discovery Learning model. The method used is descriptive comparative, with two experimental groups each using concept maps and mind maps. The research process includes pretest, intervention with verification, posttest, and student reflection. Data collection was carried out through learning outcome tests, assessment rubrics, and observations. The results of the study showed that concept maps support more systematic understanding, while mind maps are more effective in developing flexibility of thinking. The verification process plays a role in correcting students' conceptual errors. These findings provide insight for educators to adjust learning methods to improve learning outcomes.

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INTRODUCTION

21st century learning demands an approach that allows students to think critically, creatively, and independently. One method that is widely used to achieve this goal is the Discovery Learning Model. (Aldowah et al., 2019)). In this model, students are encouraged to discover concepts independently through exploration and problem solving. However, although this model is effective in increasing learning independence, one of the challenges that arises is the completion of learning outcome indicators.

The completion of learning outcome indicators refers to the extent to which students can achieve the competencies that have been set in learning. In the Discovery Learning Model, this completion is often hampered by a misconception of concepts or a lack of structure in students' thinking. To overcome this problem, concept maps and mind maps are introduced as tools in organizing and visualizing information. A concept map is a graphical representation that presents the relationship between various concepts in a hierarchical structure (Buzan, 2009). This map helps students understand the relationships between concepts systematically. While mind maps, as developed by (Buzan, 2009) allows students to associate ideas freely so that they can strengthen memory and creativity in understanding the material.

However, using only concept maps and mind maps is not enough. Without a verification process, students can build a wrong or inaccurate understanding of the learning material. Therefore, verification of concept maps and mind maps is an important element in improving the completion of learning outcome indicators. Verification allows students to correct errors in understanding the relationship between concepts, as well as refine their thinking structure before using it in further learning processes.

Several previous studies have shown that the use of concept maps and mind maps can improve students' understanding in various subjects (Wang et al., 2018) However, there has not been much research that specifically examines the role of verification in concept maps and mind maps on the completion of learning outcome indicators in the Discovery Learning Model. Therefore, this study aims to analyze the extent to which verification of concept maps and mind maps contributes to the completion of learning outcome indicators in the Discovery Learning Model (Mazini Rodrigues et al., 2024).

Thus, this study contributes to the enrichment of visual learning theory by adding the verification aspect as an important step in concept map and mind map-based learning. In addition, this study also provides practical implications for educators, especially in helping them determine the most effective methods in improving the completion of student learning outcome indicators.

Based on this background, this study examines the role of concept map and mind map verification on the completion of learning outcome indicators in the Discovery Learning Model.

THEORETICAL REVIEW

Discovery Learning Model in Education

The Discovery Learning model was introduced by (Bruner, 1977) which emphasizes that students learn more effectively when they actively discover

concepts and principles themselves rather than passively receiving information. This model is based on the constructivist approach, which states that deep understanding is formed through exploratory experiences and direct interaction with the learning environment (Thibaut et al., 2018).

In several recent studies, Discovery Learning has been shown to have a positive impact on student learning outcomes. The study conducted by(Sun & Chen, 2016)found that the use of an exploration-based approach in education improves students' understanding of the material, especially in the context of technology-based learning. In addition, the study(Herlanti et al., 2017); (Muhali & Sukaisih, 2023); (Tella & Ogundiya, 2022) shows that Discovery Learning contributes significantly to improving students' critical and analytical thinking skills. However, research also reveals that discovery-based learning conducted without guidance or verification can lead to conceptual errors that impact the completeness of learning outcomes (Mawaddah et al., 2023).

In line with these findings, research by (Sari & Cahyo, 2020) shows that the use of Discovery Learning in the context of local culture helps improve students' mathematical understanding, but this success is highly dependent on the concept verification mechanism carried out in the learning process. Therefore, in the Discovery Learning model, concept verification becomes an important element in ensuring that students achieve the completion of learning outcome indicators correctly.

Concept Maps and Mind Maps in Learning

Concept maps were first introduced by(Novak, 1984)as a learning tool that allows students to organize and connect information hierarchically. In recent studies, concept maps have been shown to improve conceptual understanding by providing a clear visual structure for students to understand the relationships between concepts (Tella & Ogundiya, 2022).

Meanwhile, the mind map developed by (Buzan, 2009) offers a more flexible approach in helping students associate ideas in a more creative and individual way. The study conducted by(Beal & Hontvedt, 2023)) found that the use of mind maps in learning improves students' memory and creative thinking skills.

Although both have their own benefits, research by (Aldowah et al., 2019)shows that without adequate verification process, both concept maps and mind maps can lead to incorrect or incomplete understanding, which results in low completion of learning outcome indicators. Therefore, a strategy is needed that combines concept map and mind map techniques with appropriate verification mechanisms to ensure that students' understanding remains accurate and focused.

Verification of Concept Maps and Mind Maps for Learning Outcome Indicator Completion

The completion of learning outcome indicators is greatly influenced by the validity of students' understanding of the concepts they have learned. In research conducted by (Leonard, 2020), it was found that students who re-verified the

concepts in learning had a higher level of understanding compared to those who did not verify. This study is in line with research (Sedrakyan et al., 2020) which states that the verification process helps students identify their own misunderstandings and provides an opportunity to correct them before the concept is applied further in learning.

In the context of Discovery Learning, research by (Sedrakyan et al., 2020) confirmed that students who verified their concept maps or mind maps experienced significant improvements in analytical and problem-solving skills. Therefore, this study places verification of concept maps and mind maps as a key component in supporting the completion of learning outcome indicators.

Research Hypothesis

H1: Concept map verification has a positive influence on the completion of learning outcome indicators in the Discovery Learning Model.

H2: Mind map verification has a positive influence on the completion of learning outcome indicators in the Discovery Learning Model.

H3: There is a significant difference between the effectiveness of concept map and mind map verification on the completion of learning outcome indicators in the Discovery Learning Model.

Based on the literature review above, this study develops a conceptual framework that describes the relationship between verification of concept maps and mind maps with the completion of learning outcome indicators in the Discovery Learning Model.

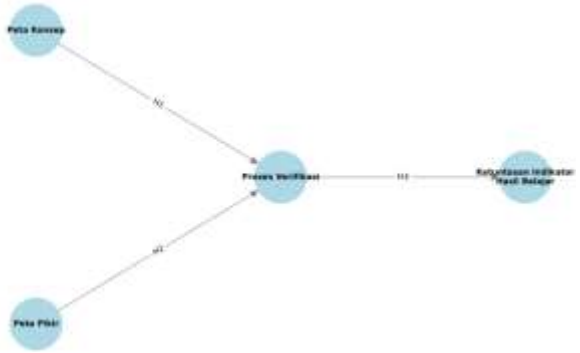


Figure 1. Conceptual Framework

This diagram shows the relationship between concept maps and mind maps with the verification process, which then affects the completion of learning outcome indicators in the Discovery Learning model. Hypotheses H1 and H2 show the direct influence of concept maps and mind maps on the verification process, while H3 shows the influence of the verification process on the completion of learning outcome indicators.)

METHODOLOGY

This study uses a quantitative approach with a comparative descriptive method to analyze the differences between concept map verification and mind map verification on the completion of learning outcome indicators in the Discovery Learning model. The research design used is pretest-posttest group comparison, where two experimental groups, namely the concept map group

and the mind map group, are compared to see the effectiveness of each intervention in improving student learning outcomes.

The population of this study was high school students who were accustomed to using the Discovery Learning model in learning. The research sample was selected using a purposive sampling technique, with the criteria of students who had a similar level of initial understanding based on the results of the pretest, students who were involved in the learning process using concept maps and mind maps, and students who participated in full learning during the research period. The sample was divided into two experimental groups, namely a group of students who used concept maps with a verification process, and a group of students who used mind maps with a verification process.

This study involved independent variables in the form of verification of concept maps and mind maps, and dependent variables in the form of the completeness of student learning outcome indicators. The instruments used included: Learning outcome tests in the form of multiple-choice questions and essays to measure the achievement of student learning outcome indicators before (pretest) and after (posttest) the intervention. The concept map and mind map assessment rubric was used to evaluate the quality of the maps produced by students, with assessment aspects including completeness of concepts, relationships between concepts, and logical consistency. Observation sheets were used to monitor the student learning process during the study, especially in the verification process.

This research was conducted in three stages. The preparation stage included the preparation of research instruments, validity and reliability tests of the instruments, and the division of students into two experimental groups. In the implementation stage, a pretest was conducted to measure the level of students' initial understanding, followed by intervention, where the concept map group created a concept map that was verified with teacher guidance, while the mind map group created a verified mind map. After the intervention, a posttest was conducted to measure the level of students' understanding. The final stage was data analysis, where the results of the pretest and posttest were analyzed descriptively to compare the effectiveness of concept map and mind map verification on the completion of learning outcome indicators.

The research data were analyzed using descriptive techniques, namely calculating the percentage of completion of learning outcome indicators in each group. Learning outcome data were also supported by qualitative analysis, in the form of student reflection results and interviews to explore student perceptions of the effectiveness of the concept map and mind map verification methods. This research was conducted for six weeks, which included preparation and testing of the instrument in the first week, implementation of the pretest, intervention, and observation in the second to fourth weeks, implementation of the posttest in the fifth week, and data analysis and preparation of the research report in the sixth week.

RESEARCH RESULT

This study aims to analyze the comparative effectiveness of concept map and mind map verification in improving the completion of student learning outcome indicators in the Discovery Learning model. Based on a comparative descriptive approach, the results of the study are focused on the percentage of completion of learning outcome indicators.

1. Description of Learning Outcome Statistics

Student learning outcome data from experimental class 1 (concept map verification) and experimental class 2 (mind map verification) are presented in Table 1.

Table 1. Descriptive Statistics of Student Learning Outcomes

Group	Pretest	Posttest	Increase (%)
Concept Map Verification	33.20	74.18	37.2%
Mind Map Verification	41.60	78.78	34.4%

Based on Table 1, there was a significant increase in learning outcomes in both groups. The concept map verification group experienced an average increase in learning outcomes of 37.2%, while the mind map verification group experienced an increase of 34.4%.

2. Percentage of Completion of Learning Outcome Indicators

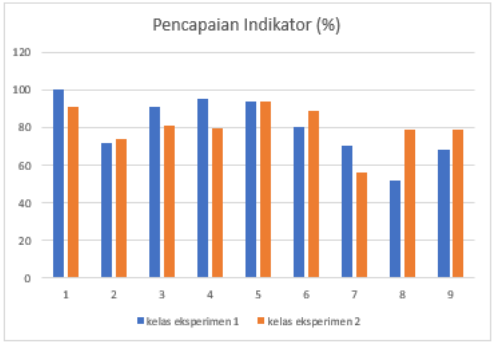
The completion of learning outcome indicators is measured based on the achievement of each predetermined indicator. The data is summarized in Table 2.

Table 2. Percentage of Completion of Learning Outcome Indicators

Indicator	Concept Map Verification (%)	Mind Map Verification (%)
Explaining the difference between system and environment	100.00	90.62
Explaining the meaning of enthalpy change (ΔH)	71.87	73.95
Analyzing the differences between endothermic and exothermic reactions	90.62	81.25
Analyzing thermochemical equations and energy diagrams	95.31	79.68
Explain the types of standard enthalpy changes (ΔHo)	93.75	93.75
Explaining Hess's law and its applications	81.25	76.56
Analyzing bond energy in chemical reactions	85.94	82.81

Indicator	Concept Map Verification (%)	Mind Map Verification (%)
Explaining the enthalpy of formation of substances	87.50	85.94
Explaining combustion enthalpy and its applications	84.37	79.68

From Table 2, the concept map verification group has a higher percentage of completion on most indicators, especially on indicators that require hierarchical and systematic understanding such as analyzing thermochemical equations and energy diagrams (95.31%). The mind map verification group is superior on indicators that require flexible understanding, such as explaining the concept of enthalpy change (73.95%). Both groups have the same completion on the indicator of types of standard enthalpy changes (93.75%), indicating balanced effectiveness in this aspect.



Concept maps are superior in most indicators, especially those requiring a hierarchical and systematic structure, such as indicators 1, 3, 4, and 6.

Mind maps are more effective on indicators that require flexibility and creativity, such as indicator 2 (ΔH). Both methods are equally effective on indicator 5, indicating that certain materials can be understood well using both methods. The verification process is key to improving student understanding, both in using concept maps and mind maps

DISCUSSION

This study compares the learning outcomes of students using concept map verification and mind map verification in the Discovery Learning model. Based on the descriptive data obtained, it can be seen that both methods provide different contributions to the achievement of student learning outcome indicators. Based on the data that has been presented, both methods show positive contributions with their respective advantages according to the type of learning indicator.

Groups that used concept maps showed better results on indicators that required systematic and hierarchical understanding (Novak, 1984) explains that concept maps help students construct logical relationships between concepts, which makes learning materials easier to understand in a structured manner. In the context of Discovery Learning, the hierarchical structure of concept maps provides a clear exploration framework for students. A study by (Al-Omari et al.,

2024) also supports this finding, stating that concept maps are effective in evaluating students' level of understanding, especially in engineering disciplines. This finding is consistent with indicators such as "analyzing thermochemical equations" which require logical and systematic organization of concepts.

Based on descriptive data analysis, the group using concept map verification had a higher percentage of completion in most indicators, especially in indicators that require hierarchical and systematic understanding. For example, in the indicator of analyzing thermochemical equations and energy diagrams, the concept map group achieved a completion of 95.31%, while the mind map group only achieved 79.68%. This shows that concept maps are more effective in helping students understand the relationship between concepts logically and structured.

The group that used mind maps showed better results on indicators that required flexibility of thinking, such as "explaining the concept of enthalpy change". This is in line with research (Buzan, 2009), which emphasizes that mind maps encourage students to connect ideas freely, which supports creativity and exploration of concepts. Research conducted by (Simonova, 2014) highlighted that the use of mind maps allows students to explore complex concepts in a non-linear approach, thereby assisting in learning indicators that require free interpretation and creative exploration.

The group that used mind map verification showed better results on indicators that required flexibility of thinking and creativity. On the indicator explaining the meaning of enthalpy change (ΔH), the mind map group achieved 73.95%, slightly higher than the concept map group which achieved 71.87%. This finding is in line with the theory (Buzan, 2009), which states that mind maps allow students to creatively connect ideas without being tied to a hierarchical structure, making them more suitable for indicators that require free exploration of concepts.

The verification process also plays an important role in helping students achieve learning outcomes. The verification process applied to both methods plays an important role in ensuring accurate student understanding. According to (Aldowah et al., 2019), verification in concept-based learning helps students correct misconceptions, thereby increasing the accuracy and completeness of learning outcome indicators. In this study, verification allowed students in the concept map group to correct hierarchy errors, while in the mind map group it helped refine irrelevant concept relationships. In the concept map group, verification allowed students to construct more accurate relationships between concepts, especially for indicators that require in-depth analysis, such as analyzing endothermic and exothermic reactions. On the other hand, in the mind map group, verification helped students correct irrelevant relationships, so that the concepts they produced were more in line with the material being studied. Teacher guidance in the verification process provided important input regarding the completeness of concepts, logical consistency, and relationships between concepts, which ultimately improved the quality of concept maps and mind maps produced by students.

The difference in learning outcomes between the two groups shows that concept maps and mind maps have their respective advantages. Concept maps are superior for materials that require a hierarchical understanding structure, such as

thermochemical equations and energy diagrams. Meanwhile, mind maps are more suitable for indicators that require flexibility in connecting ideas, such as understanding enthalpy changes. These two methods can complement each other in Discovery Learning. The combination of concept maps and mind maps can be used strategically. Research by (Sari & Cahyo, 2020) shows that the combination of concept-based methods and flexible exploration can improve learning outcomes in various educational contexts. For example, concept maps can be used at the initial stage to build a framework for understanding, while mind maps can be used at the exploration stage to support students' creativity in developing concepts. This provides insight that these two methods can not only be used separately, but can also be combined to meet diverse learning needs.

Overall, this study shows that both concept map verification and mind maps can help students achieve learning outcomes, but with different approaches. Teachers can combine these two methods to provide a more comprehensive learning experience according to students' needs and the characteristics of the material being taught.

CONCLUSIONS AND RECOMMENDATIONS

Based on descriptive data and relevant literature, concept maps and mind maps have their respective advantages in supporting the completion of learning outcome indicators:

1. Concept maps are superior in indicators that require systematic understanding.
2. Mind maps excel in indicators that require flexibility of thinking.

The verification process is an important element to improve the accuracy of students' understanding.

FURTHER STUDY

This study has several limitations that need to be considered. First, the limited sample size of high school students may limit the generalization of the results to other levels of education. Second, the descriptive approach used only provides data-based comparisons without inferential analysis, so the conclusions drawn do not reflect statistically significant differences. For further research, it is recommended to expand the population and sample, such as involving other levels of education or students with different backgrounds, and integrate inferential statistical analysis to support the validity of the results. In addition, further research can explore the combination of concept maps and mind maps to improve the effectiveness of learning, as well as develop more comprehensive evaluation instruments to measure student learning outcomes more objectively. Longitudinal research is also recommended to examine the impact of using this method in the long term.

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