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Applying the concept map of audio-visual learning in improving science learning outcomes on dynamic electricity

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Article info	Abstract
Keywords audio-visual, concept map, dynamic electricity, science learning outcomes	The present study is motivated by ninth-grade students' low science learning outcomes at SMP Negeri 2 Labuhan Deli. The study aimed to improve students' science learning outcomes using the concept map method. The research instruments used in this study were observation and test questions. The data analysis shows an improvement in students' learning outcomes. In the pre-test on dynamic electricity, only seven students (33.3%) achieved a score of 70 or above, while 14 students (66.6%) did not. The average pre-test score was 62. After being taught using the concept map method, in the post-test, 18 students (85.7%) were deemed to have achieved mastery if their scores were equal to or above the minimum passing grade of 70, while three students (14.3%) did not achieve mastery. Thus, applying the concept map learning method to dynamic electricity material is quite effective because it can improve student learning outcomes. The N-gain test data calculation also yielded an N-Gain score of 46.01%, which falls under the Effective N-Gain Interpretation Category. -Gain Interpretation Category, where a score of 46–75 is interpreted as sufficiently effective in improving student learning outcomes.

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1. Introduction

Education is one of the efforts in advancing a nation; by creating human resources, a nation will be more advanced and developed. Based on what has been published by World Population Review, in 2021, Indonesia ranked 54th out of 78 countries. This position is at least better because Indonesia has risen one rank from the previous year in 2020, which was ranked 55th. The Minister of Education, Culture, Research, and Technology (Mendikbudristek), Nadiem Makarim, acknowledged that Indonesia's education system, before the pandemic, still had room for improvement compared to other countries. This is evident from the comparison of Programme for International Student Assessment (PISA) scores, which highlight areas that require attention.

Science education must also play an essential role in shaping the creative character of future generations who will become reliable figures. The desired generation has advantages and innovative abilities that exceed standards (Sunarno, 2018). In the science discipline, there is often a lack of facilities to measure the ideas students propose. In science education, students need to focus on accepting the lessons taught to foster curiosity and understanding. To achieve this goal, a learning system must be implemented to help students focus their minds and concentration when they receive teaching materials (Adilah, 2017).

Meanwhile, in Indonesia, the lecture method is one of the most commonly used teaching methods by teachers and instructors in the learning process. This is due to several factors, such as limited resources and established habits among teachers and students. The lecture method has advantages in terms of time efficiency, ease of implementation, and relatively low costs. However, despite these advantages, the lecture method also has disadvantages. According to Helmi (2016), the main limitation of the lecture method is that students can only master the learning provided by the teacher, without encouraging the development of broader knowledge. This is a very distinctive weakness, because whatever is conveyed by the teacher is limited to the knowledge he possesses. As a result, the students' abilities are also limited by the knowledge possessed by the teacher.

In traditional learning processes, conventional methods often involve discussions supported by explanations, as well as the completion of tasks and exercises. For a long time, teachers have used oral methods or lectures to transfer knowledge to students. According to Rambe et al (2022), in conventional learning methods (lecture methods), teachers act as readers who deliver prepared material, while students act as listeners who take careful notes and complete questions based on examples given by the teacher. In this process, students become passive and listen more than actively participate in learning.

Based on the author's experience during Internship 3 and AMSP activities at SMP Negri 2 Labuhan Deli, there were several problems regarding science learning. Students still considered science learning difficult. During science lessons, only a small number of students are actively engaged in class. When teachers ask students to ask questions about material they do not understand, students remain silent without providing clear responses. It is known that science teachers at SMP Negeri 2 Labuhan Deli use the lecture method in their classroom instruction. Out of 24 ninth-grade students, only 11 achieved scores above the minimum passing grade (≥70) in the mid-semester science exam. This means that most students, 13, have not yet reached the minimum passing grade.

The use of appropriate teaching methods is a strategy that can improve learning outcomes. Various teaching methods can be used in the 2013 curriculum, including the concept map method. Concept maps are a method and medium that help students understand learning, as they present concepts or key learning points. These aids help students memorise, recall, and summarise information more effectively (Wahyu Widyaningsih, 2016). By applying the concept map learning method, students can directly see the relationships and connections between ideas in the form of propositions. This causes students to be more actively involved in the knowledge absorption process, so that students can independently determine learning methods that are helpful and meaningful (Ismail et al., 2013).

In addressing the issue of science knowledge absorption in grade IX at SMP Negeri 2 Labuhan Deli, the researcher collaborated with educators to implement the concept map method as an effort to improve student learning outcomes, formulated under the title "The Application of the Concept Map Method Using Audio-Visual Media to Enhance Science Learning Outcomes on the Dynamic Electricity Materials in Grade 9 at SMP Negeri 2 Labuhan Deli in the academic year 2022/2023."

2. Literature Review

2.1 Understanding concept maps

Concept maps are a proven method for improving learning outcomes. The concept map method, often referred to as concept mapping, was introduced by British author and psychologist Tony Buzan in the early 1970s. Concept maps are an effective and creative method for organising one's thoughts. A concept map is a method used to illustrate significant relationships between ideas or concepts in the form of propositions. It consists of two or more concepts connected by words within a semantic unit. Not all concepts have the same level of significance. The relationships between these concepts are idiosyncratic, meaning that the meaning of these concepts is unique to each individual, so the concept maps created by each individual will be different.

According to Aisah Faradilla Arinda (2018), the concept map method has several advantages, including a well-organised structure, the ability to be understood and remembered more easily in teaching and learning, and can be applied as an assessment and evaluation tool, helping students build their understanding, facilitating the integration of previous and new knowledge. It can be applied as a more flexible and practical substitute for summaries, helping to clarify students' understanding and helping educators and students achieve a uniform perception. Furthermore, this method can also develop concepts, enhance students' creativity, and serve as one way to evaluate learning.

2.2 Types of concept maps

According to Erman (2002), four types of concept maps are commonly used: network trees, event chains, cycle concept maps, and spider concept maps. The following is an explanation of each type of concept map.

a) Network tree

In a network tree concept map, core ideas are arranged in a rectangular shape, while other words are connected by connecting lines. These connecting lines provide links between the concepts. When creating a network tree, the first step is to write down the discussion material and list the main concepts related to the topic. Then, the concepts or ideas are arranged from general to specific. Related concepts then branch out from the central concept and are connected by lines. Concept maps are ideal for visualising cause-and-effect relationships, hierarchies, and branching procedures. In a concept map, relevant terms can be used to explain these relationships.

b) Chain of events

A sequence diagram illustrates the sequence of events, steps in a procedure, or stages in a process. It can be used to explain the experimentation process. Sequence diagrams are suitable for visualising stages in a process, steps in a procedure, and specific sequences of events.

c) Concept map of the cycle

In a cycle concept map, the sequence of events does not have a specific result. The last event in the sequence is linked back to the first event. This process repeats continuously without a definite

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end. Cycle concept maps illustrate how a sequence of events interacts to produce a recurring set of results.

d) Spider concept map

In a spider concept map, it is used to illustrate a brainstorming session. In this process, ideas originate from a central idea, generating many diverse ideas. Many of these ideas are related to the central idea, although their connections may not be immediately apparent. One approach is separating and grouping terms based on specific relationships, making them more useful when written outside the central concept. Spider concept maps are suitable for visualising the following: 1) relationships that are not based on hierarchy, except within a category, 2) categories that are not parallel, and 3) brainstorming results.

2.3 Characteristics of concept maps

According to Rahman (2016), concept maps have the following characteristics:

a) They have a hierarchical structure, with general ideas at the top and more specific concepts at the bottom of the map.
b) The relationships between concepts are indicated by words placed above the lines connecting them.
c) Concept maps flow from the top to the bottom of the page, and arrows indicate the relationships between concepts.
d) Concept maps are representations or illustrations of an individual's understanding of a particular issue or subject matter.
e) The advantage of concept maps lies in the interconnection between ideas within and between them.
f) In concept maps, individuals can express their feelings by adding concepts that reflect empathy toward a concept, disagreement with a concept, or even feelings of stress, such as fear, anger, joy, pressure, and so on.

2.4 Advantages and disadvantages of concept maps

a) Advantages of the concept maps

The advantages of the teaching and learning process by applying concept maps, as described by Novak and Gowin (Shvoong, 2013), in Rahmawati (2017), are as follows:

For Teachers: (a) concept maps help educators organise all teaching and learning activities; (b) concept maps are the easiest way to present lesson topics because students can more easily see, read, and understand what is being conveyed without relying on verbal cues; (c) oncept maps help educators apply a hierarchical teaching sequence, given the large amount of material that must be conveyed; and (d) concept maps can improve the effectiveness and efficiency of the teaching and learning process.

For Students: (a) concept maps improve students' understanding and abilities; (b) oncept maps stimulate students' creativity and active thinking, encouraging learning independence; (c) concept maps instil a well-integrated cognitive structure and facilitate students' information absorption process; and (d) concept maps help students observe learning materials comprehensively, understand the components of concepts, and understand the relationships between them.

b) Weaknesses of concept maps

The following are some of the shortcomings of concept maps: (a) creating a concept map takes a long time, and class time is limited; (b) identifying relevant ideas and concepts in the material

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being studied is difficult; and (c) it is challenging to connect ideas and concepts. To overcome these weaknesses, several efforts can be made, including: (a) allow sufficient time for the concept mapping process; (b) use keywords or terms that help to identify existing ideas and concepts; and (c) use appropriate words to connect ideas and concepts, such as "consists of," "is divided into," "becomes," "contains," and so on.

3. Method

The research method used is experimental research. The method used is fundamental because it provides evidence for the researcher. The researcher used a quantitative experimental method. According to Noor (2017:42), experimental research is the core method of research models that use a quantitative approach. An experiment is a trial conducted in a study. According to Sugiyono, in experimental research, there is a treatment. Thus, the experimental research method can be defined as a method used to find the effect of a particular treatment on another under controlled conditions. In this experimental research, the researcher divides the objects or subjects being studied into two groups: the treatment group, which receives the treatment, and the control group, which does not. This research also uses an experimental model with two groups: the experimental class, which is given treatment using the concept map method, and the control class, which is not given treatment using the conventional model.

The research sample used at SMPN 2 Labuhan Deli was students from classes IX C and IX D. The researcher selected the sample randomly to ensure that the study obtained the required data clearly without any data manipulation. The research instruments were observation sheets and tests to collect data.

Noeng Muhadjir (Rijali, 2019) argues that data analysis is an effort to systematically search for and manage data from observations, interviews, and other sources in order to improve the researcher's understanding of the case being studied and present it as a finding for others. Meanwhile, to improve this understanding, the analysis needs to be followed up by an effort to find meaning. The data analysis methods applied in this study are as follows:

3.1 Student learning achievement test

The student learning achievement data generated are interval data. This study managed data, including pre-tests and post-tests, obtained from two groups: the experimental and control classes. Average student learning outcomes:

a. Calculating the Average Score (Mean)
   To calculate the average score, use Sudjana's formula (2002), which is:
   Formula: $X = (\sum fi.xi)/n$

b. Calculating the Standard Deviation
   Calculating the standard deviation using the variance formula as follows:
   $s^2 = 1/n \sum f_i \, [(x_i - \bar{x})]^2$

The square of the standard deviation (S) or standard deviation is called variance (Sudjana, 2005).

3.2 Data requirements test

Validity and reliability test

The validity of an instrument indicates the extent to which the instrument is accurate in assessing what it is supposed to measure. In other words, the validity of an instrument is the degree of accuracy of the measuring tool in measuring the intended variable (Haq, 2022). On the other hand, reliability refers to a measuring tool's level of trust or dependability. Reliability testing is used to evaluate the consistency of a measuring tool, i.e., how the tool can provide consistent results when measurements are repeated (Haq, 2022). The product-moment formula is used to calculate the correlation coefficient between two related variables.

Normality Test

The Lilliefors normality test is used to test whether a sample is normally distributed or not (Sudjana, 2005).

Homogeneity Test

Normally distributed data values indicate that the sample originates from a population that is also normally distributed. The homogeneity test is used to determine whether the variation (variance) between two or more sample groups is homogeneous or balanced (Sudjana, 2005). The testing criteria are to accept $H0$ if $F_{\text{count}} < F_{\text{table}}$, both sample groups are drawn from a homogeneous population at the significance level α = 0.05 with $dk = n1$ -1 and dk = n2-1. F_{table} can be seen from the F distribution table for other F values, so H_0 is rejected.

4. Results

The present study observed student learning outcomes at SMPN 2 Labuhan Deli using Pre-Test and Post-Test data in science lessons, specifically the Dynamic Electricity material. It was aimed to determine whether students had achieved learning mastery, which was determined by the Minimum Completion Criteria (KKM) of 70. At the beginning of the study, a pre-test was conducted to measure the average score between the experimental and control classes. After that, the Concept Maps learning method was applied to the experimental class, while the control class received conventional learning. The researcher used this method to see the difference in student learning outcomes in the Dynamic Electricity material.

At the end of the study, post-test and pre-test were conducted for both classes. This aimed to analyse the learning outcomes of students who had received the Concept Map learning method and the differences in learning outcomes between students who received the conventional learning method. Thus, this study was conducted to determine the extent to which the Concept Maps learning method influences student learning outcomes in the Dynamic Electricity material and the differences in learning outcomes between this method and conventional learning.

4.1 Learning outcomes of students taught using the concept maps

Based on the research data at SMP Negeri 2 Labuhan Deli for class IX C students, researchers obtained test instrument data through student pre-test and post-test scores. The following is the pre-test data obtained from the experimental class:

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Table 1. Pre-test scores of the experimental class

No	Pre–Test	
	Value	**Information**
1	55	Not Completed
2	40	Not Completed
3	65	Not Completed
4	60	Not Completed
5	70	Completed
6	65	Not Completed
7	60	Not Completed
8	70	Completed
9	65	Not Completed
10	60	Not Completed
11	70	Completed
12	75	Completed
13	60	Not Completed
14	65	Not Completed
15	55	Not Completed
16	70	Completed
17	70	Completed
18	40	Not Completed
19	65	Not Completed
20	45	Not Completed
21	75	Completed

Table 1 shows that seven students (33.3%) met the Minimum Completion Criteria (KKM) in the pre-test, while 14 students (66.6%) failed. Frequency distribution is used to find the average and standard deviation in the pre-test, and then use the Table 2. Table 2 shows that, from the study results with 21 students, the average Pre-test score was obtained as $\overline{X} = 62$ and a standard deviation of 10.1. To visualise the students' Pre-test score data more easily, the following is a histogram of the students' Pre-test score data.

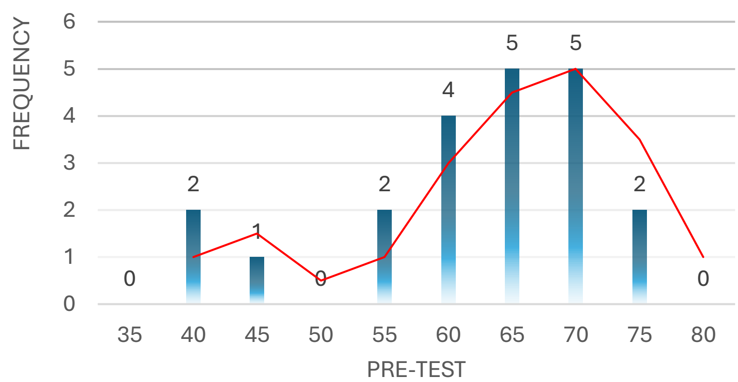

Figure 1. Histogram of pre-test values for experimental class

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Table 2. Frequency distribution pre-test experimental class

Interval	f_i	x_i	$f_i . x_i$	$x_i - \overline{x}$	$(x_i - \overline{x})^2$	$f_i(x_i - \overline{x})^2$	f relative
40 - 46	3	43	129	-19	361	1083	14,3 %
47 - 53	0	50	0	-12	144	0	0 %
54 - 60	6	57	342	-5	25	150	28,5 %
61 - 67	5	64	320	2	4	20	23,8 %
68 - 74	5	71	355	9	81	405	23,8 %
75 - 81	2	78	156	16	256	512	9,6 %
∑	**21**	**363**	**1302**	**-9**	**871**	**2170**	**100 %**

The post-test results data obtained from the experimental class can be seen in the following Table 3.

Table 3. Post-test scores of the experimental class

No	M/F	Post-Test	
		Value	Information
1	M	65	Not Completed
2	M	65	Not Completed
3	F	80	Completed
4	F	75	Completed
5	F	80	Completed
6	F	70	Completed
7	F	75	Completed
8	F	90	Completed
9	M	85	Completed
10	M	80	Completed
11	M	85	Completed
12	F	90	Completed
13	F	75	Completed
14	F	75	Completed
15	F	75	Completed
16	F	95	Completed
17	F	95	Completed
18	M	60	Not Completed
19	F	85	Completed
20	M	70	Completed
21	F	85	Completed

Table 3 reveals that of the 21 students who took the Post-Test, 18 students (85.7%) achieve scores following the Minimum Completion Criteria (KKM), while three students (14.3%) do not achieve that score. This data explicitly shows that student scores differ after applying the Concept Map learning method. This shows that applying the Concept Map learning method can improve student learning outcomes in science subjects, especially in the material of dynamic electricity. Frequency distribution to find the mean and standard deviation in the post-test, use the table below:

Table 4. Frequency distribution of post-test of experimental class

Interval	f_i	x_i	$f_i . x_i$	$x_i - \bar{x}$	$(x_i - \bar{x})^2$	$f_i(x_i - \bar{x})^2$	f relative
60 - 66	3	63	189	-17,3	299,3	898	14,3 %
67 - 73	2	70	140	-10,3	106,1	212	9,5 %
74 - 80	9	77	693	-3,3	10,9	98	42,9 %
81 - 87	4	84	336	3,7	13,7	55	19,0 %
88 - 94	2	91	182	10,7	114,5	229	9,5 %
95 - 103	1	99	99	18,7	349,7	349,69	4,76 %
∑	**21**	**470,5**	**1639**	**2,2**	**894,1**	**1841**	**100 %**

Table 4 shows that the average student post-test score is 78.0, with a standard deviation 9.3. To facilitate understanding of the student post-test score data, a histogram of the student post-test score data is presented as follows:

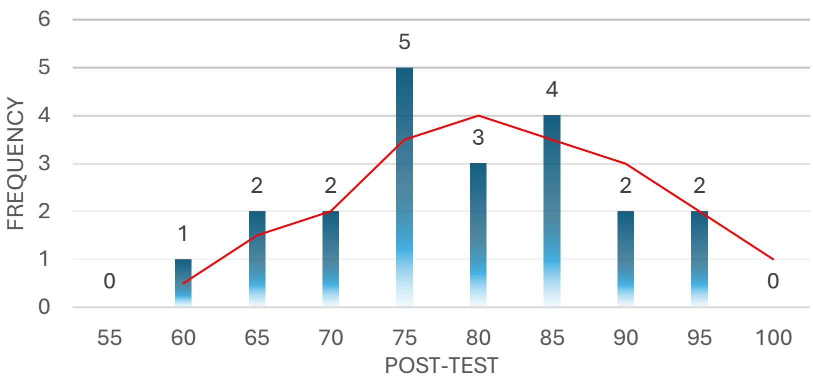

Figure 2. Histogram of post-test values for the experimental class

5. Discussion

After calculating the research data, the test results of student learning outcomes on dynamic electricity material when the pre-test was carried out were declared complete if the value was equal to or above the KKM 70, only seven students (33.3%) and those who did not complete were 14 students (66.6%). Moreover, the average pre-test score was 62. After being taught the Concept Map method in the post-test, students were declared complete if the value was equal to or above the KKM 70, 18 students (85.7%), and those who did not complete were three (14.3%). The average post-test score was 78. This value indicates an influence on student learning outcomes who receive instruction through the concept map learning method. The concept map helps students improve their learning outcomes. This is the same as the research results (Adilah, 2017). There are differences in student learning outcomes between the experimental class that uses the concept maps and the control class that uses the lecture method. Furthermore, the research results by Rahmawati (2017) significantly influence science learning outcomes, especially on the cognitive aspects of fifth-grade students at Krincing state elementary school Secang in Magelang. This influence is seen between the experimental group using the concept map method and the control group using the conventional method (lecture, question, and answer) in learning the material of the human digestive system in science subjects.

In the pre-test data calculation of the experimental class for the normality test, the data are said to be normal if $L_{count} < L_{table}$ using the Lilliefors formula, indicating that the data are typically distributed. The Lilliefors calculated value is 0.118, while the Lilliefors table value from 21 data and α = 0.05 is 0.190. L_{count} (0.118) < L_{table} (0.190), the data is typically distributed. In the post-test data calculation of the experimental class for the normality test, the data is said to be normal if L_{count} < L_{table} using the Lilliefors formula, indicating that the data is usually distributed. The Lilliefors calculated value is 0.142, while the Lilliefors table value from 21 data and α = 0.05 is 0.190. L_{count} (0.142) < L_{table} (0.190). Therefore, the data is typically distributed.

5.1 Science learning outcomes: students taught through the concept maps

In the research applied to the experimental class (IXC) which was taught using the concept map learning method for five meetings, the results of the test were obtained in the form of 20 multiple choice questions for the pre-test and 20 questions for the post-test which were used as an understanding test to determine the student's learning outcomes as well as the level of mastery of the student's material. Subsequently, the author applied data analysis testing to obtain a pre-test score with the highest score of 75, the lowest score of 40, a range of 35, an average score of 62 and a standard deviation of 10.1 and a post-test score with the highest score of 95, the lowest score of 60, a range of 35, an average score of 78.0 and a standard deviation of 9.3.

Therefore, it can be concluded that the learning outcomes of students in class (IX C) who implemented the concept map learning method are classified as good and quite effective for application because they maximise students' science learning abilities and outcomes. This is because the concept map learning method is easier to remember and understand in learning and can be used as a medium for assessment and evaluation, as well as helping students build their knowledge.

This study found that the average learning outcomes of students taught using the concept map learning method were significantly greater (78.0) than those taught using the conventional model (71.3). The data obtained shows an influence of the concept map learning method. Based on data processing obtained by students, leading and referring to relevant previous research, it can be concluded that the learning outcomes of students in class IX C who applied the concept map learning method were classified as good and were in the moderate category. This can be seen from the posttest average value of 78.0.

5.2 Science learning outcomes: students taught using conventional method

The conventional learning model was applied for five meetings based on the research data applied to the control class (IX D). After processing the data obtained from the results of the multiple-choice test of 20 questions for the pre-test and 20 questions for the post-test which were used as an ability test to determine the student's learning outcomes as well as the level of student mastery of the material, the researcher used student data analysis testing so that the maximum pre-test score was 75, the minimum score was 35, the range of scores was 40, the average score was 61.3 and the standard deviation was 14.4. The post-test score was the maximum score of 90, the minimum score was 55, and the range of scores was 35, with an average score of 71.3 and a standard deviation of 8.8.

6. Conclusion and Implications

Based on the research and processing of the data obtained, the author concludes that:

a. The concept maps on dynamic electricity material are pretty effective because they maximise students' science learning outcomes. This is based on the calculation of student learning outcomes using the N-gain test, which obtained an N-gain score of 46.01%, which falls into the

N-gain effectiveness interpretation category, where a score of 46-75 is interpreted as "sufficiently effective" in maximising student learning outcomes.

b. The learning outcomes of students in the experimental group taught using the concept maps achieved a higher average score than the average score of the control group taught using conventional learning methods.
c. Calculation with t-test, where the hypothesis can be accepted, proven by the existence of a significant influence by using the Concept Maps on student learning outcomes on dynamic electricity material in Class IX of SMP Negeri 2 Labuhan Deli, where t count (13.35) > t table (1.68). Ho is rejected as using Concept Maps cannot improve science learning outcomes at SMP Negeri 2 Labuhan Deli. Moreover, Ha is accepted, as applying the Concept Maps can improve science learning outcomes at SMP Negeri 2 Labuhan Deli.

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