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The Influence of Synectics, Mind Mapping, Cooperative Learning (SM2CL) Models on Creative Thinking Skills and Understanding of Nutritional Concepts in Digestive System Material in Students

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Abstract: This study aims to determine the effect of the Synectics, Mind Mapping, Cooperative Learning (SM2CL) learning model on creative thinking skills and understanding of the concept of the human digestive system in class XI students of MAN 3 Bone. This type of research is a quasi-experimental study with a quantitative approach. The research design is a pretest-posttest control group design. The population in the study were all class XI students in the 2025/2026 academic year who were spread into 2 study groups. The sampling technique used was non-probability sampling, namely saturation sampling. A total of 2 study groups were used in this study, namely, study group XI A5 as the experimental class applied the SM2CL model and study group XI A6 as the control class applied the Direct Instruction model. Based on the results of the Ancova test, the significance value of the creative thinking skills variable was 0.001 < 0.05 and the significance value of understanding learning concepts was 0.041 < 0.05, so it can be concluded that the application of the synectics, mind mapping, cooperative learning (SM2CL) learning model has a significant or real effect on creative thinking skills and understanding concepts in class XI students of MAN 3 Bone.

Keywords: Concept understanding; Creative thinking skills; Learning model

Introduction

Education is a planned effort to develop students' potential and skills (Law of the Republic of Indonesia No. 20 of 2003). In the 21st century, the paradigm has shifted from teacher-centered to student-centered, integrating knowledge, technology, and skills (Hadiyanto, 2024). This transformation requires assessment standards, curricula, and learning environments that support student skill development (Rivas et al., 2025; Vlachopoulos & Makri, 2024). However, observations at MAN 3 Bone revealed low levels of creative thinking and understanding of biological concepts, particularly in the digestive system. This material is considered difficult due to its abstract physiological processes (Kim et al., 2025; Lee et al., 2025). However, critical and creative thinking are complementary cognitive processes for problem-solving (Álvarez-Huerta et al., 2022; Liu et al., 2025).

Critical thinking helps evaluate information in real-life situations (Golden, 2023; Witarsa & Muhammad, 2023), which is crucial in science (Batdı et al., 2024). Meanwhile, creative thinking enables the discovery of innovative and original solutions (Isaksen, 2023), which benefits motivation and learning independence (Larraz-Rábanos, 2021). Despite its importance, student creativity in biology is often low (Meldrum & Yakubov, 2025). Integrating nutritional concepts in digestive

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system material is crucial for fostering a holistic understanding of health (Vlaicu et al., 2023). While students may have good theoretical knowledge, awareness of healthy eating patterns is often low due to a lack of contextual relevance (Huang et al., 2025). The integration of nutrition material has been shown to be effective in meaningfully strengthening understanding of the digestive system (Hamamah et al., 2024).

The use of mind mapping in this model provides a visual tool that helps students systematically discover ideas and concepts, thus facilitating their understanding of the material. Although the SM2CL model has been proven effective in improving critical and creative thinking skills, research integrating this model into biology learning, particularly regarding nutritional concepts in the digestive system, is still limited. To achieve this learning effectiveness, educators need to update their strategies and models (Freitas et al., 2025). One relevant, innovative model is SM2CL (Synectics, Mind Maps, and Cooperative Learning) (Thornhill-Miller et al., 2023). Developed by Sani et al. (2025), this model combines analogies, mind mapping, and group work to develop critical, analytical, and creative thinking skills (Faradiba et al., 2024). Research shows that the use of mind mapping in SM2CL facilitates the systematic visualization of ideas (Undari et al., 2023). Given the limited research on SM2CL on nutrition, this study aims to examine the model's influence on creative thinking skills and understanding of nutrition concepts at MAN 3 Bone.

Based on the background above, the research objectives to be achieved are as follows: To determine the creative thinking skills of students through the application of the SM2CL model on the digestive system material of class XI MAN 3 Bone; To determine the conceptual understanding of students through the application of the SM2CL model on the digestive system material of class XI MAN 3 Bone; To determine the effect of the application of the SM2CL model on the creative thinking skills of students on the digestive system material of class XI MAN 3 Bone; To determine the effect of the application of the SM2CL model on the understanding of the nutritional concept of students on the digestive system material of class XI MAN 3 Bone.

Method

Research Type

This research is an experimental study, using a quasi-experimental approach. Quasi-experimental research is research that approximates a real experiment, testing the effect of one variable on another (Carter et al., 2024).

Research Time and Location

This research was conducted in the odd semester of the 2025-2026 academic year. The research location was MAN 3 Bone, located in Bengo District, Bone Regency, South Sulawesi Province.

Research Design

This study used a pretest-posttest control group design. In this research design, two groups were selected, the experimental class and the control class. The research design can be seen in Table 1.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experimental	O_1	X_1	O_2
Control	O_3	-	O_4

Research Type and Design

This research is a quantitative study using a Quasi-Experimental approach. The design used was a Non-Equivalent Control Group Design, in which an experimental class and a control class were given a pre-test and post-test to measure the effect of the treatment.

Population and Sample

The research population was all 11th-grade students at MAN 3 Bone. The sampling technique used purposive sampling, selecting two classes with equivalent characteristics: one class as the experimental group (applying the SM2CL model) and one class as the control group (applying the conventional model).

Research Procedure

The research was conducted in three main stages:

Preparation Stage: Includes initial observations, obtaining permits, and preparing learning materials (RPP, LKPD) and research instruments; Implementation Stage: Administering a pre-test, implementing the Digestive System and Nutrition material (the SM2CL model in the experimental class), and concluding with a post-test; Final Stage: Data processing, statistical analysis, and drawing conclusions.

Research Instruments

Data were collected using two instruments that had undergone validity and reliability testing: the Creative Thinking Skills Test: An essay-based test designed based on creative thinking indicators (fluency, flexibility, originality, and elaboration); the Nutrition Concept Understanding Test: An objective, multiple-choice test to measure mastery of the digestive system and integration of nutrition concepts.

Data Analysis Techniques

Data analysis was conducted through several statistical stages: Descriptive Analysis: To describe the average score, highest score, and lowest score; Prerequisite Test: Includes normality and homogeneity tests to ensure the data is suitable for further analysis; Hypothesis Test: Using a MANOVA (Multivariate Analysis of Variance) test to simultaneously test the effect of the SM2CL model on both dependent variables (creative thinking and conceptual understanding).

$$\text{Mark} = \frac{\sum Score\ obtained}{\sum Maximum\ score} \text{ X } 100\% \quad (1)$$

Description:
Σ Score obtained: total score obtained by the student
Σ Maximum score: total maximum score

Inferential Data Analysis

Before data analysis is carried out, a requirements test is first carried out which consists of a data distribution normality test and a homogeneity test.

Prerequisite Testing

Before testing the hypothesis, prerequisite tests were conducted to ensure the validity of the data: Normality Test: Using the Kolmogorov-Smirnov test to determine whether the data were normally distributed. Data were considered normal if the significance value was >0.05; Homogeneity Test: Using the Levene's test to ensure that the sample groups had equal variances. The homogeneity requirement was met if the significance value was >0.05.

Hypothesis Testing

Hypothesis testing was conducted to determine the effect of the SM2CL learning model on critical thinking skills, creative thinking skills, and conceptual understanding: Primary Analysis: Using the Analysis of Covariance (ANCOVA) test with SPSS software; Further Testing: If the ANCOVA results showed a significant effect, the analysis continued with the Least Significant Difference (LSD) test to determine which variable produced the most significant difference.

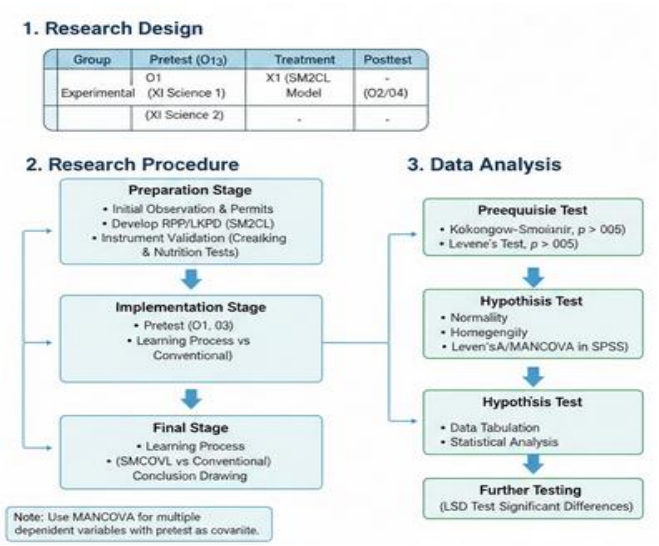

Figure 1. Research flow chart

Result and Discussion

Research Results

The results of this study, examining the influence of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) model on critical thinking skills, creative thinking skills, and understanding of nutritional concepts in the digestive system of eleventh-grade students at MAN 3 Bone, will be presented in two formats: descriptive and inferential.

Descriptive Statistical Analysis

The results of the descriptive statistical analysis are as follows:

Critical Thinking Skills of Students Taught Using the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) Models and Direct Instruction

The data from this study demonstrate the influence of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) model on critical thinking skills in the digestive system of eleventh-grade students at MAN 3 Bone. The results of this descriptive analysis of students' critical thinking skills before and after the learning process using the SM2CL model are shown in Table 2.

Table 2. Descriptive Analysis of Critical Thinking Skills for Each Class

Variables		Number of Samples	Average	Standard Deviation	The highest score	Lowest Value
SM2CL	Pretest	30	25.50	11.59	45.00	1.67
	Posttest	30	78.67	4.51	88.33	68.33
Direct Intruction	Pretest	30	25.67	11.29	45.00	3.33
	Posttest	30	76.00	4.83	83.33	63.33

Table 2 shows the results of the pretest of critical thinking skills of the experimental class taught with the SM2CL model, obtained an average value of 25.50 ± 11.59, the highest value of 45.00 and the lowest value of 1.67. The posttest results obtained an average value of 78.67 ± 4.51, the highest value of 88.33 and the lowest value of 68.33. The control class taught with the direct instruction model, the pretest results obtained an

average value of 25.67 ± 11.29, the highest value of 45.00 and the lowest value of 3.33. The posttest results obtained an average value of 76.00 ± 4.83, the highest value of 83.33 and the lowest value of 63.33. The frequency distribution and categories of critical thinking skills scores in classes taught using the SM2CL model are presented in Table 3.

Table 3. Frequency Distribution and Categories of Critical Thinking Skills Values of Students Taught Using the SM2CL Model

Interval	Category	Pretest		Posttest	
		Σ PD	Percentage (%)	Σ PD	Percentage %)
81 - 100	Very High	0	0.00	10	33.33
61 - 80	High	0	0.00	20	66.67
41-60	Fair	4	13.33	0	0.00
21-40	Low	17	56.67	0	0.00
0 - 20	Very Low	9	30.00	0	0.00
Total		30	100	30	100

Σ PD: Number of Students

Table 3 shows that 9 students (30.00%) had critical thinking skill scores in the pretest, 17 students (56.67%) had very low scores, and 4 students (13.33%) had moderate scores. The posttest results for all students' critical thinking skills were in the high score category, with 20 students (66.67%) and 10 students (33.33%) in the very high score category. Therefore, it can be concluded that the implementation of the SM2CL model has an impact on students' critical thinking skills.

The frequency distribution and categories of critical thinking skill scores in classes taught using the Direct Instruction model are presented in Table 4. Table 4 shows that 9 students (30.00%) had critical thinking skills in the pretest, 17 (56.67%) had very low scores, and 4 (13.33%) had moderate scores. The posttest results for all students' critical thinking skills were in the high category, with 24 (80.00%) and 6 (20.00%) having very high scores. Therefore, it can be concluded that the implementation of the Direct Instruction model has an impact on students' critical thinking skills.

Table 4. Frequency Distribution and Categories of Critical Thinking Skills Values of Students Taught Using the Direct Instruction Model

Interval	Category	Pretest		Posttest	
		Σ PD	Percentage (%)	Σ PD	Percentage (%)
81 - 100	Very high	0	0.00	6	20.00
61 - 80	Tall	0	0.00	24	80.00
41-60	Enough	4	13.33	0	0.00
21-40	Low	17	56.67	0	0.00
0 - 20	Very Low	9	30.00	0	0.00
Total		30	100	30	100

Σ PD: Number of Students

Students' Creative Thinking Skills Taught Using the Synectics, Mind Mapping, Cooperative Learning (SM2CL), and Direct Instruction Models

Research data on the influence of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) models on creative thinking skills in the digestive system topic of 11th-grade students at MAN 3 Bone. The results of the descriptive analysis of students' creative thinking skills before and after the learning process using the SM2CL model can be seen in Table 5.

Table 5. Descriptive Analysis of Creative Thinking Skills for Each Class

Variables		Number of Samples	Average	Standard Deviation	The highest score	Lowest Value
SM2CL	Pretest	30	27.83	10.86	57.50	7.50
	Posttest	30	80.75	4.06	87.50	70.00
Direct Intruction	Pretest	30	27.42	7.84	40.00	7.50
	Posttest	30	76.67	4.47	85.00	67.50

Table 5 shows the results of the pretest of the creative thinking skills of the experimental class taught with the SM2CL model, obtained an average value of 27.83 ± 10.86, the highest value of 57.50 and the lowest value of 7.50. The posttest results obtained an average value of 80.75 ± 4.06, the highest value of 87.50 and the lowest value of 70.00. The control class taught with the direct instruction model, the pretest results obtained an

average value of 27.42 ± 7.84, the highest value of 40.00 and the lowest value of 7.50. The posttest results obtained an average value of 76.67 ± 4.47, the highest value of 85.00 and the lowest value of 67.50. The frequency distribution and categories of creative thinking skills values in the class taught with the SM2CL model are presented in Table 6.

Table 6. Frequency Distribution and Categories of Creative Thinking Skills Values of Students Taught Using the SM2CL Model

Interval	Category	Pretest		Posttest	
		Σ PD	Percentage (%)	Σ PD	Percentage (%)
81 - 100	Very Creative	0	0.00	13	43.33
66-80	High	0	0.00	17	56.67
56-65	Medium	1	3.33	0	0.00
41-55	Low	1	3.33	0	0.00
0 - 40	Very Low	28	93.34	0	0.00
Total		30	100	30	100

Σ PD: Number of Student

Table 6 shows that 28 students (93.34%) were in the very low category in the pretest, 1 student (3.33%) in the low category, and 1 student (3.33%) in the moderate category. The posttest results for all students' creative thinking skills were in the high category (17 students (56.67%) and 13 students (43.33%) in the very creative category. Therefore, it can be concluded that the implementation of the SM2CL model has an impact on students' creative thinking skills. The frequency distribution and categories of creative thinking skills scores in classes taught using the Direct Instruction model are presented in Table 7.

Table 7 shows that 30 students (100%) scored in the very low category on the pretest for creative thinking skills. The posttest results for all students were in the high category for creative thinking skills (25 students (83.33%), and 5 students (16.67%) were in the very creative category. Therefore, it can be concluded that the implementation of the Direct Instruction model has an impact on students' creative thinking skills.

Table 7. Frequency Distribution and Categories of Creative Thinking Skills Scores of Students Taught Using the Direct Instruction Model

Interval	Category	Pretest		Posttest	
		Σ PD	Percentage (%)	Σ PD	Percentage (%)
81 - 100	Very Creative	0	0.00	5	16.67
66-80	High	0	0.00	25	83.33
56-65	Medium	0	0.00	0	0.00
41-55	Low	0	0.00	0	0.00
0 - 40	Very Low	30	100	0	0.00
Total		30	100	30	100

Σ PD: Number of Students

Students' Understanding of Nutrition Concepts Taught Using the Synectics, Mind Mapping, Cooperative Learning (SM2CL), and Direct Instruction Models

Research data on the effect of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) models on the understanding of nutrition concepts in the digestive system topic of grade 11 students at MAN 3 Bone. The results of the descriptive analysis of students' understanding of nutrition concepts before and after the learning process using the SM2CL model can be seen in Table 8.

Table 8. Descriptive Analysis of Understanding of Nutrition Concepts by Each Class

Variables		Number of Samples	Average	Standard Deviation	The highest score	Lowest Value
SM2CL	Pretest	30	36.67	20.78	71.43	0.00
	Posttest	30	74.29	20.34	100	28.57
Direct Intruction	Pretest	30	41.91	20.87	71.43	0.00
	Posttest	30	69.05	20.92	100	14.29

Table 8 shows the results of the pretest of the understanding of nutritional concepts of the experimental class taught with the SM2CL model, obtained an average value of 36.67 ± 20.78, the highest value was 71.43 and the lowest value was 0. The posttest results obtained an average value of 100 ± 20.34, the

highest value was 100 and the lowest value was 0.00. The control class taught with the direct instruction model, the pretest results obtained an average value of 41.91 ± 20.87, the highest value was 71.43 and the lowest value was 0. The posttest results obtained an average value of 69.05 ± 20.92, the highest value was 100 and the lowest value was 14.29. The frequency distribution and categories of nutritional concept understanding scores in classes taught using the SM2CL model are presented in Table 9.

Table 9. Frequency Distribution and Categories of Nutrition Concept Understanding Scores for Students Taught Using the SM2CL Model

Interval	Category	Pretest		Posttest	
		Σ PD	Percentage (%)	Σ PD	Percentage (%)
81 - 100	Very high	0	0.00	13	43.33
66-80	Tall	3	10.00	8	26.67
56-65	Enough	6	20.00	5	16.67
41-55	Low	6	20.00	3	10.00
0 - 40	Very Low	15	50.00	1	3.33
Total		30	100	30	100

Σ PD: Number of Students

Table 9 shows that the pretest scores for understanding nutrition concepts were categorized as very low (15 students) (50.00%), low (6 students) (20.00%), and sufficient (6 students) (20.00%). The posttest results showed that all students' understanding of nutrition concepts was in the very low category (1 student) (3.33%), low (3 students) (10.00%), sufficient (5 students) (16.67%), high (8 students) (26.67%), and very high (13 students) (43.33%). Therefore, it can be concluded that the implementation of the SM2CL model has an impact on students' understanding of nutrition concepts. The frequency distribution and categories of understanding nutrition concepts scores in classes taught using the Direct Instruction model are presented in Table 10.

Table 10. Frequency Distribution and Categories of Understanding Nutrition Concept Scores for Students Taught Using the Direct Instruction Model

Interval	Category	Pretest		Posttest	
		Σ PD	Percentage (%)	Σ PD	Percentage (%)
81 - 100	Very high	0	0.00	10	33.33
66-80	Tall	5	16.67	8	26.67
56-65	Enough	6	20.00	8	26.66
41-55	Low	8	26.67	2	6.67
0 - 40	Very Low	11	36.67	2	6.67
Total		30	100	30	100

Σ PD: Number of Students

Table 10 shows that the pretest scores for understanding nutrition concepts were categorized as very low for 11 students (36.67%), low for 8 students (26.67%), moderate for 6 students (20.00%), and high for 5 students (16.67%). The posttest results showed that all students' understanding of nutrition concepts fell into the very low category (2.67%), low for 2 students (6.67%), moderate for 8 students (26.67%), high for 8 students (26.67%), and very high for 10 students (33.33%). Therefore, it can be concluded that the implementation of the Direct Instruction model has an impact on students' understanding of nutrition concepts.

Inferential Statistical Analysis

The results of the inferential statistical analysis are as follows:

Prerequisite Test

Normality Test

Data from the normality test for the influence of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) model on the understanding of nutrition concepts in the digestive system material of grade 11 students at MAN 3 Bone. The results of the normality test are shown in Table 11.

Table 11 shows the results of the Kolmogorov-Smirnov normality test for data on students' critical thinking skills, creative thinking skills, and understanding of nutritional concepts. The pretest and posttest scores showed a significance value of >0.05 (a significance value greater than 0.05). Therefore, it can be concluded that the data on critical thinking skills, creative thinking skills, and understanding of nutritional concepts are normally distributed.

Table 11. Results of the Kolmogorov-Smirnov Normality Test for Students' Critical Thinking, Creative Thinking, and Understanding of Nutrition Concepts

Variables	Class		Sig.	Information
Critical Thinking Skills	SM2CL		0.200	Normal
	Direct Intruction		0.200	Normal
Creative Thinking Skills	SM2CL		0.200	Normal
	Direct Intruction	Pretest	0.153	Normal
Understanding Nutrition Concepts	SM2CL		0.076	Normal
	Direct Intruction		0.077	Normal
Critical Thinking Skills	SM2CL		0.200	Normal
	Direct Intruction		0.200	Normal
Creative Thinking Skills	SM2CL		0.138	Normal
	Direct Intruction	Postest	0.134	Normal
Understanding Nutrition Concepts	SM2CL		0.101	Normal
	Direct Intruction		0.078	Normal

Homogeneity Test

Data from the homogeneity test of the influence of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) models on the understanding of nutritional concepts in the digestive system material of grade 11 students at MAN 3 Bone are shown in Appendix D.2.4, page 100. The results of the homogeneity test are shown in Table 12.

Table 12. Results of the Homogeneity Test for Students' Critical Thinking, Creative Thinking, and Understanding of Nutrition Concepts

Variables		Sig.	Information
Critical Thinking Skills		0.880	Homogen
Creative Thinking Skills	Pretest	0.100	Homogen
Understanding Nutritional Concepts		0.695	Homogen
Critical Thinking Skills		0.701	Homogen
Creative Thinking Skills	Posttest	0.509	Homogen
Understanding Nutritional Concepts		0.904	Homogen

Table 12 shows the results of the homogeneity test for the variables of critical thinking skills, creative thinking, and understanding of nutritional concepts in both the pretest and posttest, with a significant value > 0.05 (a significance value greater than 0.05). Therefore, it can be concluded that the data for the variables of critical thinking skills, creative thinking, and understanding of nutritional concepts are homogeneous. After the prerequisite tests are met, the next step is to conduct a hypothesis test using Analysis of Covariance (ANCOVA). The ANCOVA test aims to determine the effect of each independent variable on the dependent variable. In this ANCOVA test, there are control variables or covariates.

Hypothesis Test

The Effect of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) Model on Critical Thinking Skills in the Digestive System Material of Grade XI Students at MAN 3 Bone

Data from the ANCOVA test show the effect of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) model on critical thinking skills in the digestive system material of grade XI students at MAN 3 Bone. The results of the ANCOVA test are shown in Table 13.

Table 13. ANCOVA Test Results: The Effect of the SM2CL Model on Critical Thinking Skills

Source	Type III Sum of Squares	Db	Mean Square	F	Sig.
Intercept	49295.69	1	49295.69	3376.27	<0.001
Pretest	434.71	1	434.71	29.77	<0.001
Model	109.80	1	109.80	7.52	0.008
Error	832.23	57	14.60		
Total	360197.13	60			

Table 13 shows the results of the Ancova test using the between-subjects effect test on the model. With an F-value of 7.521 and a sig. 0.008 < 0.05 (a significance value of less than 0.05), H0 is rejected. This indicates a significant effect of the learning model on students' critical thinking skills. If the learning model implementation does influence critical thinking skills, the analysis is continued with a further test using the

Least Significant Difference (LSD) test to determine which independent variable has the most significant influence on the dependent variable. The LSD test data show the effect of the learning model on critical thinking skills in the digestive system topic for grade 11 students at MAN 3 Bone. The LSD test results are shown in Table 14.

Table 14. Results of the LSD Further Test: The Effect of the Learning Model on Critical Thinking Skills

Variables	Class	Average Difference	Sig.	Description
Critical Thinking Skills	SM2CL and Direct instruction	2.70*	0.008	Significant

Table 14 shows the average differences between each class for the critical thinking skills variable. Decision-making is based on the average difference and significance value. If the average difference is marked with an asterisk and the significance value is less than 0.05, the decision is significant, or significantly different. If the average difference is not marked with an asterisk and the significance value is greater than 0.05, the decision is not significant. Furthermore, to determine the class that best applies the critical thinking skills variable, the corrected average value can be seen. The corrected average value for the critical thinking skills variable can be seen in Table 15.

Table 15. Corrected Average Value of the Effect of Learning Models on Critical Thinking Skills

Model	Average
SM2CL	78.68a
Direct Intruction	75.98b

Table 15 shows a significant difference between the two classes. This difference can be seen in the average scores, indicating a difference in the influence of learning models on critical thinking skills in each class. The SM2CL model appears to have a more optimal impact on critical thinking skills, followed by the Direct Intuition model.

The Effect of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) Model on Creative Thinking Skills in the Digestive System Material of Grade XI Students at MAN 3 Bone

Data from the ANCOV test on the effect of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) model on creative thinking skills in the digestive system material of grade XI students at MAN 3 Bone. The results of the ANCOV test are shown in Table 16.

Table 16. Results of the ANCOV Test on the Effect of the SM2CL Model on Creative Thinking Skills

Source	Type III Sum of Squares	Db	Mean Square	F	Sig.
Intercept	34964.20	1	34964.20	2015.04	<0.001
Pretest	67.00	1	67.00	3.86	0.054
Model	244.22	1	244.22	14.07	<0.001
Error	989.04	57	17.35		
Total	372006.25	60			

Table 16 shows the results of the Ancova test using the between-subjects effect test on the model. With an F-value of 14.075 and a sig. <0.001 <0.05 (a significance value of less than 0.05), H0 is rejected. This indicates a significant effect of the learning model on students' creative thinking skills. If the learning model implementation does influence creative thinking skills, the analysis is continued with further testing using the Least Significant Difference (LSD) test to determine which independent variable has the most significant influence on the dependent variable. The LSD test data demonstrate the effect of the learning model on creative thinking skills in the digestive system topic for grade 11 students at MAN 3 Bone. The LSD test results are presented in Table 17.

Table 17. Results of the LSD Further Test: The Effect of the Learning Model on Creative Thinking Skills

Variables	Class	Average Difference	Sig.	Description
Critical Thinking Skills	SM2CL and Direct instruction	4.03*	<0.001	Significant

Table 17 shows the average differences between each class for the creative thinking skills variable. Decision-making is based on the average difference and significance value. If the average difference is marked with an asterisk and the significance value is less than 0.05, the decision is significant, or significantly different. If the average difference is not marked with an asterisk and the significance value is greater than 0.05, the decision is not significant. Furthermore, to determine the class that best applies the critical thinking skills variable,

the corrected average value can be seen. The corrected average value for the creative thinking skills variable can be seen in Table 18.

Table 18. Corrected Average Value of the Effect of Learning Models on Creative Thinking Skills

Model	Average
SM2CL	80.726a
Direct Intruction	76.690b

Table 18 shows a significant difference between the two classes. This difference can be seen in the average scores, indicating a difference in the influence of learning models on creative thinking skills in each class. The SM2CL model appears to have a more optimal effect on creative thinking skills, followed by the Direct Intuition model.

The Effect of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) Model on Understanding Nutrition Concepts in the Digestive System Material of Grade XI Students at MAN 3 Bone

The results of the ANCOV test on the effect of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) model on understanding nutrition concepts in the digestive system material of grade XI students at MAN 3 Bone. The results of the ANCOV test are shown in Table 19.

Table 19. Results of the ANCOV Test on the Effect of the SM2CL Model on Understanding Nutrition Concepts

Source	Type III Sum of Squares	Db	Mean Square	F	Sig.
Intercept	27582.29	1	27582.29	110.09	<0.001
Pretest	10405.13	1	10405.13	41.53	<0.001
Model	1093.47	1	1093.47	4.36	0.041
Error	14280.46	57	250.53		
Total	333256.69	60			

Table 19 shows the results of the Ancova test using the between-subjects effect test on the model. With an F value of 4.365 and a significance value of 0.041 < 0.05 (a significance value of less than 0.05), H0 is rejected. This indicates a significant effect of the learning model on students' understanding of nutrition concepts. If the learning model application does influence understanding of nutrition concepts, the analysis will continue with further testing using the Least Significant Difference (LSD) test to determine which independent variable has the most significant influence on the dependent variable. Data from the LSD test on the effect of the learning model on understanding of nutrition concepts in the digestive system material for grade 11 students at MAN 3 Bone. The results of the LSD test can be seen in Table 20.

Table 20. Results of the Further LSD Test: Effect of Learning Model on Understanding of Nutrition Concepts

Variables	Class	Average Difference	Sig.	Description
Critical Thinking Skills	SM2CL and Direct instruction	8.60*	0.041	Significant

Table 20 shows the average differences between each class for the nutritional concept understanding variable. Decision-making is based on the average difference and significance value. If the average difference is marked with an asterisk and the significance value is less than 0.05, the decision is significant, or significantly different. If the average difference is not marked with an asterisk and the significance value is greater than 0.05, the decision is not significant. Furthermore, to determine the best class for the nutritional concept understanding variable, the corrected average value can be used. The corrected average value for the nutritional concept understanding variable can be seen in Table 21.

Table 21. Corrected Average Value of the Effect of Learning Models on Nutrition Concept Understanding

Model	Average
SM2CL	75.97a
Direct Intruction	67.36b

Table 21 shows a significant difference between the two classes. This difference can be seen in the average scores, indicating a difference in the influence of learning models on understanding nutrition concepts in each class. The SM2CL model appears to have a more optimal effect on understanding nutrition concepts, followed by the Direct Intuition model.

Discussion

Based on the analysis of the research data, the research discussion aims to explain the research findings related to students' critical thinking skills, creative thinking skills, and understanding of nutritional concepts. The discussion of these three variables focuses on the alignment between the research objectives and the research hypotheses. This experimental study examined the effect of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) model on critical thinking skills, creative thinking skills, and

understanding of nutritional concepts in the digestive system topic of grade 11 students at MAN 3 Bone. The study consisted of five sessions: one pretest, three learning sessions, and one posttest.

The Effect of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) Model on Critical Thinking Skills in the Digestive System Topic of Grade 11 Students at MAN 3 Bone

Research conducted at MAN 3 Bone showed a significant effect of the SM2CL learning model on students' critical thinking skills compared to the direct instruction model (Table 2). The results of the ANCOV test showed that the SM2CL and direct instruction learning models had an effect on critical thinking skills at a significance level <0.05 (Table 13). Further LSD test results indicated that each learning model had a different effect on critical thinking skills (Table 14). The best learning model for influencing critical thinking skills was the SM2CL model (Table 15). The use of the SM2CL model in learning can influence students' critical thinking skills. This is because the SM2CL model applies a combination of synectics, mind maps, and cooperative learning, which stimulates students' critical thinking skills in learning. This is consistent with research by (Loyens et al., 2023), which found that the synectics pattern in the SM2CL model leads to an increase in students' critical thinking levels and dimensions (evaluation, deduction, analysis, deductive reasoning, and inductive reasoning).

Another study supporting mind mapping, based on research by Nuraini et al. (2024), suggests that mind maps are suitable for any classroom because they teach students to think critically about subjects and form connections between disciplines. By seeing their thoughts unfold before them, they are better equipped to make connections and develop deeper knowledge and understanding of concepts. One critical mind mapping strategy involves incorporating imagery, visual-spatial organization, and color into the teaching and learning process. This activity significantly improved retention and memory in the mind mapping group compared to the conventional lecture method group (Aljamal et al., 2025). Nurhuda et al. (2024) also stated that the SM2CL learning model has been shown to influence students' critical thinking skills, as the SM2CL learning model encourages students to think critically. This also aligns with research by Barta et al. (2022), which states that SM2CL syntax works through the use of analogies in synectics, mind maps as a medium for organizing information, and cooperative strategies that encourage students to exchange ideas and opinions.

The teacher provides analogies about the material to be learned. Mind maps are used as route maps that utilize the full potential of the brain, optimally integrating cognition and imagination. Furthermore, the combination of colors, symbols, shapes, and so on can facilitate the brain's absorption of the information received. Cooperative learning encourages students to work together to exchange ideas about how they understand what they have learned from the learning process. These process characteristics make SM2CL more effective than the Direct Instruction model, which tends to be teacher-centered and emphasizes direct delivery of material. In Direct Instruction, students passively receive information without the use of analogies, mind map visualizations, or cooperative discussions that can stimulate analysis and in-depth thinking. Therefore, the differences in processes between the two models make SM2CL more capable of improving students' critical thinking skills (Hidayatullah et al., 2025).

The Effect of Synectics, Mind Mapping, and Cooperative Learning (SM2CL) Models on Creative Thinking Skills in the Digestive System Subject of Grade XI Students at MAN 3 Bone

Research conducted at MAN 3 Bone showed a significant effect of the SM2CL learning model on students' creative thinking skills compared to the direct instruction model (Table 5). An ANCOV test results indicated that both the SM2CL and direct instruction learning models had an effect on creative thinking skills at a significance level <0.05 (Table 16). Further LSD test results indicated that each learning model had a different effect on creative thinking skills (Table 17). The SM2CL model was found to be the best learning model for influencing creative thinking skills (Table 18). The use of the SM2CL model in learning can influence students' creative thinking skills. This is because the SM2CL syntax combines synectics, mind mapping, and cooperative learning, all of which encourage students to generate new ideas, view concepts from multiple perspectives, and reorganize information in creative ways. Koronis et al. (2023) and Skrbinjek et al. (2024) research states that the synectics model encourages openness and creative expression because the teacher acts as a catalyst for the emergence of new analogies that help students think.

In synectics activities, the analogy process creates conceptual distance, encouraging students to think reflectively and view concepts from different perspectives. This generates new ideas and enhances students' imagination (Falloon, 2019). Furthermore, mind mapping activities conducted during learning also play a significant role in enhancing student creativity. Through mind mapping, students are free to choose images, colors, symbols, branches, and other visual patterns to illustrate relationships between concepts. This activity not only strengthens information

organization but also trains students to develop ideas, make new connections, and produce creative visual representations. Mind maps provide space for students to express their understanding in unique ways, allowing creativity to develop more naturally. This aligns with research by Haka et al. (2023), which states that mind maps help students think critically and creatively by forming connections between concepts visually. Fang et al. (2024) also confirmed that color, images, and patterns in mind maps improve retention while encouraging creativity in learning.

The results of mind maps produced by students during learning indicate that students not only construct concepts but also express their understanding through images, colors, and symbols of their own choosing (Appendix D.3.3). This is an indicator of developing creativity. Research by Novia et al. (2022) also supports this finding, stating that the application of the Synectics, Mind Maps, and Cooperative Learning (SM2CL) model can improve students' creative thinking skills, both in class and individually, in biology. Furthermore, SM2CL is more effective than Direct Instruction because the learning process in Direct Instruction is one-way and teacher-centered (Guzmán & Payá, 2020; Sari & Murdiono, 2021). Students are not involved in the analogy process, do not construct their own mind maps, and do not discuss ideas. The opportunity for creativity to emerge in Direct Instruction is much smaller than in SM2CL, which is designed from the outset to stimulate imagination, conceptual exploration, and the development of new ideas.

The Effect of Synectics, Mind Mapping, and Cooperative Learning (SM2CL) Models on Understanding Nutrition Concepts in the Digestive System Subject of Grade XI Students at MAN 3 Bone

Research conducted at MAN 3 Bone showed a significant effect of the SM2CL learning model on students' understanding of nutrition concepts compared to the direct instruction model (Table 8). Ancova results showed that both the SM2CL and direct instruction learning models had an effect on understanding nutrition concepts at a significance level <0.05 (Table 19). Further LSD test results indicated that each learning model had a different effect on understanding nutrition concepts (Table 20). The SM2CL model was the best learning model for influencing understanding nutrition concepts (Table 21). The use of the SM2CL model in learning can influence students' understanding of nutrition concepts. This is because the SM2CL model combines synectics, mind mapping, and cooperative learning, which stimulates students' understanding of nutrition concepts. All stages in this model involve students directly in the concept-building process, rather than simply receiving information.

In the Synectics stage, students are encouraged to use analogies to understand the function of nutrients and the digestive process. This method helps them connect abstract concepts to everyday experiences, making their understanding more concrete and memorable. The mind mapping activity in the SM2CL syntax reinforces this understanding. Students create mind maps about the relationships between nutrients, digestive organs, enzymes, the absorption process, and their impact on health. This visual arrangement makes it easier for them to see the connections between concepts. This aligns with Alsuraihi (2022), and Kefalis et al. (2025) findings that mind maps help students organize and connect concepts, deepening their understanding. At this stage, information about nutrition is not simply memorized but stored as a coherent conceptual structure. Group work in the Cooperative Learning approach makes the learning process more effective. Students explain and check each other's understanding. This activity encourages them to reprocess information, which directly impacts conceptual understanding. Research by Nguyen et al. (2025) shows that cooperative learning deepens understanding through interaction and support between students. Research by Kasmiruddin et al. (2025) also supports the ability of SM2CL to significantly improve biological knowledge and conceptual understanding.

The effect of SM2CL on understanding nutrition concepts appears stronger than that of Direct Instruction. In Direct Instruction, students tend to be passive recipients, so understanding often stops at the memorization level. The SM2CL model allows students to learn nutrition concepts through analogies, visualizations, and discussions, allowing students to truly process and construct their own knowledge. Overall, the synectics stage, which stimulates understanding through analogies, mind maps that organize concepts visually, and group work that reinforces explanations and meanings, contribute to SM2CL's significantly better understanding of nutrition concepts than direct instruction. This model not only helps students understand "what" nutrients are, but also "how" and "why" these processes are important in the digestive system.

Conclusion

Based on the results of the research and discussion in this study, several conclusions were obtained as follows: Students' creative thinking skills through the application of the SM2CL model on the digestive system material of class XI MAN 3 Bone are in the very creative category; Students' understanding of the concept of nutrition through the application of the SM2CL model on the digestive system material of class XI MAN 3 Bone

is in the very high category; The SM2CL model has a positive effect on students' creative thinking skills through the application of the SM2CL model on the digestive system material of class XI MAN 3 Bone; The SM2CL model has a positive effect on students' understanding of the concept of nutrition through the application of the SM2CL model on the digestive system material of class XI MAN 3 Bone. Based on the results of the study, several suggestions can be put forward as follows: For students, it can be easier to understand the material; For educators, it can be a guideline, a reference, in carrying out the teaching process using the SM2CL model; For further researchers, if they want to continue similar research, it is recommended to use more variables and a wider population.

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Conceptualization; methodology; validation.; formal analysis; investigation; resources; L. P. data curation.;.; writing—original draft preparation; writing—review and editing; visualization: A. M. P. All authors have read and approved the published version of the manuscript.

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