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# The effect of the SM2CL learning model on students' critical thinking skills in the digestive system topic

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**Abstract**

The demands of 21st-century education emphasize critical thinking in learning. Critical thinking is essential in learning biology, especially in the topic of the human digestive system. However, the limited use of varied learning models reduces opportunities to develop students' critical thinking skills. Therefore, an appropriate learning model is needed, namely the SM2CL model. This model is appropriate because it combines learning models, strategies, and methods. This study aims to analyze the effect of the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) learning model on critical thinking skills among class XI students in the digestive system material at MAN 3 Bone. This study used a quasi-experimental method with a pretest-posttest control group design. The study consisted of 60 samples, comprising 2 classes of students. The study, using ANCOVA to test the hypothesis, showed a significant effect of the SM2CL model ($p < 0.05$). Furthermore, the LSD test indicated a significant difference between students taught using the SM2CL model and those taught using the direct instruction model. These findings suggest that the SM2CL model is more effective in enhancing students' critical thinking skills in biology learning, particularly in the digestive system topic. This study contributes to biology education by providing empirical evidence on the effectiveness of integrated learning models in promoting critical thinking skills.

***Abstrak.*** *Tuntutan pendidikan abad ke-21 menekankan pemikiran kritis dalam pembelajaran. Pemikiran kritis sangat penting dalam pembelajaran biologi, khususnya pada topik sistem pencernaan manusia. Namun, penggunaan model pembelajaran yang beragam yang terbatas mengurangi kesempatan untuk mengembangkan kemampuan berpikir kritis siswa. Oleh karena itu, dibutuhkan model pembelajaran yang tepat yaitu model SM2CL. Model ini tepat karena memadukan model, strategi dan metode pembelajaran Penelitian ini bertujuan untuk menganalisis pengaruh model pembelajaran Synectics, Mind Mapping, dan Cooperative Learning (SM2CL) terhadap kemampuan berpikir kritis siswa kelas XI pada materi sistem pencernaan di MAN 3 Bone. Penelitian ini menggunakan metode quasi-eksperimental dengan desain kelompok kontrol pretest-posttest. Penelitian ini terdiri dari 60 sampel yang terdiri dari dua kelas siswa. Hasil penelitian, menggunakan uji ANCOVA untuk menguji hipotesis, menunjukkan pengaruh signifikan model SM2CL dengan nilai signifikansi $p < 0,05$. Selanjutnya, uji LSD menunjukkan perbedaan signifikan antara siswa yang diajar menggunakan model SM2CL dan siswa yang diajar menggunakan model pengajaran langsung. Temuan ini menunjukkan bahwa model SM2CL lebih efektif dalam meningkatkan kemampuan berpikir kritis siswa dalam pembelajaran biologi, khususnya pada topik sistem pencernaan. Studi ini berkontribusi pada pendidikan biologi dengan memberikan bukti empiris tentang efektivitas model pembelajaran terintegrasi dalam meningkatkan kemampuan berpikir kritis.*

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# A. Introduction

Contextual learning emphasizes students' active knowledge to connect learning materials with real-life experiences, making it a student-centered approach, in line with the demands of 21st-century education, which includes critical thinking, creativity, collaboration, and communication (Ennis, 2015; Alamsyah et al., 2025).

Critical thinking skills are essential for solving problems in a structured manner. These abilities fall under the category of higher-order thinking skills (Agnesa & Rahmadana, 2022; Prameswari et al., 2018). Critical thinking involves a reflective and purposeful decision-making process to understand information, analyze, evaluate, and draw conclusions based on evidence, concepts, or criteria relevant to the context (Facione, 2011; Wijnen et al., 2023; Misliyanti et al., 2024).

Students who possess critical thinking skills will be better able to master the concepts and issues presented in learning and apply them to real-life situations. Critical thinking skills are necessary in biology learning because it is part of science, which includes facts and principles resulting from scientific processes that require analysis and problem-solving (Nahadi et al., 2021; Ariadila et al., 2022; Ishma et al., 2023).

Critical thinking skills are among the most important, yet they have not been fully developed in the learning process at all levels of education (Palennari, 2016; Syawal et al., 2023). Data released by the Programme for International Student Assessment (PISA) in 2022 shows that students' critical thinking skills, especially in Indonesia, remain low. Indonesia ranks 69th or 12th from the bottom with a score of 1108. Based on this, the development of critical thinking skills must be a primary goal of education. Critical thinking is fundamental to science because it requires rationality in designing experiments and testing theories. Critical thinking skills are needed in the field of biology (King et al., 2010).

At every level of education, students need to continuously develop and practice critical thinking skills (Nainggolan et al., 2018). Strengthening these skills helps them express ideas, solve problems, and filter the information they obtain (Siska et al., 2019). From an early age, students are expected to grow into responsible, meticulous, and resilient individuals. However, field conditions still indicate that students' critical thinking skills are relatively low (Utomo et al., 2020).

Based on interviews with biology subject teachers and initial tests of class XI students at MAN 3 Bone, the results showed that students' critical thinking skills were 26.67% in the low category. This is due to limited ideas and a lack of varied, appropriate learning models in biology lessons, especially in the digestive system material. According to Permata et al. (2025), critical thinking skills in biology learning certainly require strategies to achieve them. Teachers must be able to facilitate learning so that students can learn effectively. Educators need to update their teaching methods and models so students can better understand the material (Rahmaniati & Umami, 2021).

One learning model that is appropriate for helping students develop their thinking skills in innovative biology learning and that emerged from the development of other learning models is the SM2CL model. The SM2CL learning model is a thinking learning model that combines learning models, strategies, and methods. The SM2CL model, as a learning model that combines synectics (analogy activities), mind maps, and cooperative learning (small group learning), is a learning model that can develop students' thinking skills, particularly their creative, analytical, and critical thinking skills in learning biology in general (Mustami, 2017; Tewal et al., 2025).

The SM2CL model makes mind mapping one of the important stages. Mind mapping is related to critical thinking because mind mapping requires students to analyze and connect concepts (Elviana, et al., 2024). Mind-mapping media helps students think critically, express the information they have obtained as thoughts, and develop concepts derived from socio-scientific issues (Rodiyah, 2023). In line with this, mind maps are used as learning tools to systematically represent, organize, and analyze content. As a cognitive regulator, mind maps stimulate thinking activities, thereby supporting more optimal and effective information processing (Hung et al., 2014; Li et al., 2021; Badriah et al., 2023; Chen et al., 2024).

Previous studies have shown that the SM2CL learning model can improve students' critical and creative thinking skills. The use of mind mapping in this model provides a visual tool that helps students systematically discover ideas and concepts, making it easier for them to understand the material (Damayanti et al., 2022; Tewal et al., 2025). Based on the theoretical review and problems described above, this study aims to determine the effect of the SM2CL model on critical thinking skills in the digestive system material of grade XI students at MAN 3 Bone.

# B. Material and method

This study is an experimental study involving two classes, using a quasi-experimental method with a pretest-posttest control-group design (see Figure 1 for the research design). The study population consisted of all 11th-grade students in two classes at MAN 3 Bone. The sample comprised 60 students from 2 classes. Sampling in this study used non-probability sampling techniques, specifically Saturation Sampling, which aims to include all members of the population as samples (Fadillah et al., 2022). This technique was chosen because the number of grade XI students was relatively limited. This study systematically collects

and analyzes data to determine the effect of the SM2CL learning model on students' critical thinking skills.

The instrument used to assess critical thinking skills is a test. This test is used to assess students' critical thinking skills before and after using the SM2CL model. The test consists of six essay questions and assesses the critical thinking indicators according to Ennis (2011), namely focus, reason, inference, situation, clarity, and overview. Each question is scored on a scale of 0 to 10, so the score obtained reflects the level of mastery of each critical thinking indicator. To ensure clarity and validity, the instrument was reviewed by two academic experts, who provided feedback and input. The results of the instrument's validity are shown in Table 1.

**Table 1 Validity of critical thinking skills test instruments**

| Validity of critical thinking skills test instruments | | |
|---|---|---|
| **Assessment aspect** | **Assessment score** | **Category** |
| Content/Material | 4.60 | Very valid |
| Construction | 4.75 | Very valid |
| Language | 4.67 | Very valid |
| **Average** | **4.67** | **Very valid** |

Description: The validity category is determined based on the 1–5 Likert scale score range, namely: 1.00–1.80 = Not Valid; 1.81–2.60 = Less Valid; 2.61–3.40 = Quite Valid; 3.41–4.20 = Valid; and 4.21–5.00 = Very Valid (Widoyoko, 2012).

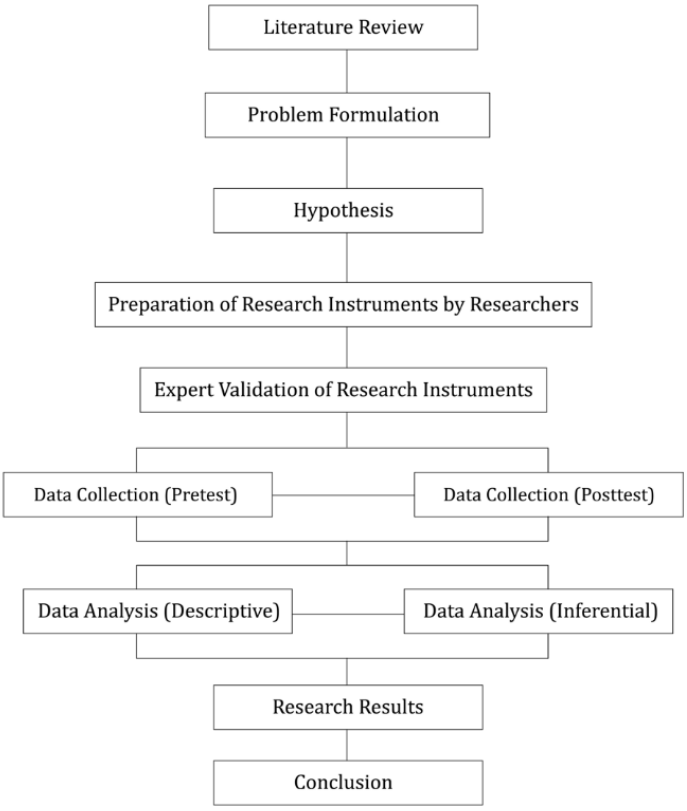


Figure 1 Research design

The inferential test used to test the hypothesis was an ANCOVA examining the effect of the SM2CL model on critical thinking skills. This was followed by the LSD (Least Significant Difference) test to see the difference in the effect of the SM2CL model. The researcher first conducted normality and homogeneity tests to ensure the data were valid before testing the hypothesis. The overall normality test results showed a p-value of 0.200, indicating that all data were normally distributed (more detailed results can be seen in Table 2). Meanwhile, the overall data homogeneity test produced p-values ranging from 0.701 to 0.880, indicating homogeneous data across all groups (more detailed results can be seen in Table 3).

## C. Results and discussion

**Implementation of the synectics, mind mapping, cooperative learning (SM2CL) model**

The lesson began with explaining the learning objectives and motivating the students. The material was then presented and explained. The experimental class was taught using the SM2CL model, and the control class was taught using the direct instruction

model. After that, the students were divided into several groups to complete the student worksheets and present their results.

The experimental class used the SM2CL model according to the model's syntax sequence. Students worked in groups to create mind maps based on the material. Teachers also delivered lessons by analogizing the material to help students understand it more easily.

Meanwhile, the control class used a direct instruction model in accordance with the syntax. Students learned through the teacher's presentation of material, then formed groups to work on worksheets and present their results. The SM2CL model was applied in the experimental class, and the direct instruction model in the control class used the same material: food nutrition, organs, glands, stages of the digestive system, organ disorders, gland disorders, malnutrition, and nutritional deficiencies.

The results of the descriptive analysis show that, for all students, the posttest results of the SM2CL model for critical thinking skills were in the high category for 20 students (66.67%) and in the very high category for 10 students (33.33%). The posttest results of the direct instruction model for critical thinking skills showed that 24 students (80.00%) were in the high category and 6 students (20.00%) were in the very high category. These results indicate a significant difference in influence (more detailed results can be seen in Table 4).

**Table 2 Normality test of critical thinking skills scores**

| Data | | Kolmogorov-Smirnov normality test | | | Description |
|---|---|---|---|---|---|
| | | Statistics | df | p | |
| Experimental class | Initial critical | .117 | 30 | .200* | Normally distributed |
| Control class | thinking skills | .125 | 30 | .200* | Normally distributed |
| Experimental class | Final critical | .130 | 30 | .200* | Normally distributed |
| Control class | thinking skills | .130 | 30 | .200* | Normally distributed |

**Table 3 Homogeneity test of critical thinking skills scores**

| Data | Levene's statistic | df1 | df2 | p | Description |
|---|---|---|---|---|---|
| Initial critical thinking skills | .023 | 1 | 58 | .880 | Homogeneous |
| Final critical thinking skills | .148 | 1 | 58 | .701 | Homogeneous |

**Table 4 Categories of critical thinking skills scores of students**

| Interval | Category | SM2CL model | | | | Direct instruction model | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Initial | | Final | | Initial | | Final | |
| | | N | % | N | % | N | % | N | % |
| 81-100 | Very high | 0 | 0.00 | 10 | 33.33 | 0 | 0.00 | 6 | 20.00 |
| 61-80 | High | 0 | 0.00 | 20 | 66.67 | 0 | 0.00 | 24 | 80.00 |
| 41-60 | Moderate | 4 | 13.33 | 0 | 0.00 | 4 | 13.33 | 0 | 0.00 |
| 21-40 | Low | 17 | 56.67 | 0 | 0.00 | 17 | 56.67 | 0 | 0.00 |
| 0-20 | Very low | 9 | 30.00 | 0 | 0.00 | 9 | 30.00 | 0 | 0.00 |
| **Total** | | **30** | **100** | **30** | **100** | **30** | **100** | **30** | **100** |

Description: N = number of students, % = percentage of students' critical thinking skills scores

Table 2 shows the results of the Kolmogorov-Smirnov normality test on the critical thinking skills data of students on the pretest and posttest values, with a significance level. value > 0.05 (significance value greater than 0.05). Thus, the data on critical thinking skills are normally distributed. Table 3 shows the results of the homogeneity test for the critical thinking skills variable data for students on the pretest and posttest, with the significance level. value > 0.05 (significance value greater than 0.05). Thus, it can be concluded that the critical thinking skills variable data is homogeneous.

Table 4 shows that both learning models are equally capable of improving student learning outcomes, as indicated by the shift in categories from low and very low at the beginning of learning to high and very high at the end of learning. However, the SM2CL model shows a stronger effect than direct instruction.

In classes that implemented the SM2CL model, 33.33% of students achieved the very high category, whereas in direct instruction classes, only 20.00% did. This difference shows that SM2CL is more effective in encouraging students to achieve the optimal level of mastery. Meanwhile, although in direct instruction most students were in the high category (80.00%), the proportion who reached the very high category was still lower than in SM2CL.

**The effect of the SM2CL model on critical thinking skills**

The effect of the SM2CL learning model on students' critical thinking skills is evident in the ANCOVA results (Table 5). The ANCOVA test results for the between-subjects effect on the media yielded a value of f = 7.521 and a p-value of 0.008 < 0.05 (significance), indicating a significant effect on critical thinking skills between students taught using the SM2CL model and the direct instruction model.

The LSD posttest shows the difference in the effect of each learning model (Table 6). Based on the LSD posttest results, it is known that the SM2CL model presented in the experimental class and the direct instruction model have different or significantly different effects.

**Table 5 ANCOVA test of the effect of the SM2CL model on critical thinking skills**

| Source | Type III sum of squares | df | Mean square | f | p |
|---|---|---|---|---|---|
| Intercept | 49295.694 | 1 | 49295.694 | 3376.270 | <.001 |
| Initial critical thinking skills | 24.928 | 1 | 434.711 | 29.773 | <.001 |
| **Model** | **109.808** | **1** | **109.808** | **7.521** | **.008** |
| Eror | 832.236 | 57 | 14.601 | | |
| Total | 360197.134 | 60 | | | |

**Table 6 LSD further test of the effect of SM2CL model on critical thinking skills**

| Variable | Model | Mean difference | p | Testing | Description |
|---|---|---|---|---|---|
| Critical thinking skills | SM2CL and direct instruction | 4.036* | <.001 | Sig <0.05 | Different |

The use of the SM2CL model in learning affects students' critical thinking skills. This effect is related to the characteristics of the SM2CL model, which integrates synectics, mind mapping, and cooperative learning approaches into a series of learning activities. This integration provides students with opportunities to analyze problems, connect concepts, and actively develop their reasoning during the learning process. The SM2CL model is recommended for improving students' critical thinking skills because its synectic characteristics systematically facilitate higher-order thinking at every stage of learning. In teaching material on the digestive system, the SM2CL stages applied provide opportunities for students not only to receive information but also to actively process, analyze, and evaluate concepts. These findings align with Taufik et al. (2025) research, which shows that applying the Synectics model significantly improves critical thinking skills, including analysis and evaluation. Utami et al. (2021) also state that the use of mind maps is effective in helping students build relationships between concepts, improve analysis and evaluation, thereby encouraging the development of critical thinking skills and a deeper understanding of concepts. In addition, Ogunleye and Ojekwu (2020) found that mind mapping strategies involving visual-spatial elements, images, and colors can improve retention and memory compared to conventional lecture methods.

Taufik et al. (2018) reported that the SM2CL model enhances students' critical thinking skills by requiring active student involvement in the learning process. These findings are reinforced by Riskawati et al. (2023) who explain that SM2CL combines analogies in synectics, mind maps to organize information, and cooperative strategies that encourage the exchange of ideas and opinions among students.

The relationship between the SM2CL model and Ennis' critical thinking indicators is evident in each stage of learning. The synectics stage helps students determine the problem's focus, state reasons, and draw conclusions through analogical reasoning. The use of mind maps supports the ability to understand the situation of the problem (situation) and clarify the structure of thinking (clarity) through the visual organization of concepts. Meanwhile, the application of cooperative learning provides students with space to review their thinking processes (overview) through discussion and joint evaluation.

The characteristics of this process make SM2CL more effective than the direct instruction model, because direct instruction tends to be teacher-centered and emphasizes the direct delivery of material. In direct instruction, students receive information passively without engaging in analogies, mind-mapping, or cooperative discussion, which can trigger analysis and deep thinking (Damayanti et al., 2022). Thus, the difference in the processes between the two models makes SM2CL better able to improve students' critical thinking skills.

## D. Conclusion

This study shows that the Synectics, Mind Mapping, and Cooperative Learning (SM2CL) learning model has a significant effect on the critical thinking skills of grade XI students at MAN 3 Bone in the subject of the digestive system. The ANCOVA results show a significant difference in critical thinking skills between students taught using the SM2CL model and those taught using the direct instruction model. The LSD follow-up test also confirmed that the SM2CL model had a better effect than the conventional learning model. The advantages of the SM2CL model lie in integrating analogy activities through synectics,

organizing concepts using mind mapping, and fostering collaborative learning through cooperative learning. The combination of these three components encourages students to be more active in analyzing, evaluating, and relating biological concepts, thereby optimally improving their critical thinking skills. In contrast, the direct instruction model tends to be teacher-centered and offers fewer opportunities for students to develop higher-order thinking skills. The findings of this study have important implications for biology education, particularly in selecting innovative and effective learning models to improve students' critical thinking skills. The SM2CL model can serve as an alternative learning model for complex biological material. However, this study is still limited to a single level of education and a single learning material. Therefore, further research is recommended to examine the application of the SM2CL model across different levels of education and with different learning materials to obtain more comprehensive results.

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