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Remap-GI in Biology Learning: Enhancing Creative Thinking and Cognitive Outcomes on Biodiversity Topics

Bea Hana Siswati[1*], Alwiana Hamidah Nugroho[2], Aulia Fitrotun Nurullah[3], Nadia Fatimah Az Zahra[4], Avril Ley Ann R. Llave[5]
[1,2,3,4]Universitas Jember
Kalimantan Street No. 37, Jember 68121, Indonesia
[5]Philippine Science High School
Agham Road, Diliman, Quezon City, Metro Manila, Philippines
*Corresponding author: beahana.fkip@unej.ac.id

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ABSTRACT

Creative thinking is an essential skill that must be explicitly and systematically taught in classrooms because of its significant contribution to student learning outcomes. However, many schools still rely on conventional teaching methods, which often lead to student boredom, reduced motivation, and low engagement. Therefore, an effective learning model is needed to address this issue. This study examines the effect of the Reading Map Group Investigation (Remap-GI) learning model on cognitive learning outcomes and creative thinking skills in Biodiversity material at SMAN 1 Muncar. This study employed a quantitative quasi-experimental approach using a non-equivalent control group design. The sample consisted of 70 students (36 in the experimental group and 34 in the control group) selected through random sampling. Creative thinking data were collected using open-ended test items based on four indicators, while cognitive learning outcomes were measured using pre-test and post-test scores. Data were analyzed using Analysis of Covariance (ANCOVA), preceded by normality and homogeneity tests. The results showed that the ANCOVA test for creative thinking skills produced a significance value of 0.000 ($p < 0.05$), indicating that the Remap-GI model significantly improved students' creative thinking compared to the control group. Similarly, the ANCOVA test for cognitive learning outcomes also showed a significance value of 0.000 ($p < 0.05$), indicating a positive effect on students' cognitive performance. Practically, this model can be an alternative teaching strategy to reduce boredom, increase active participation, and improve conceptual understanding, especially in agro-industrial school environments where students need support in developing independent learning habits.

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INTRODUCTION

Thinking is a fundamental mental activity that occurs when a person confronts a problem (Setiawan et al., 2024). In the context of learning, thinking abilities manifest in various forms, one of which is creative thinking. Students must develop and master creative thinking skills, particularly during the learning process (Listiana, 2020). Creative thinking is defined as the cognitive capacity to reason based on existing facts to produce new concepts and present alternative solutions to challenges. Unlike routine thinking, this skill involves looking at problems from different perspectives to create unique solutions. (Lubis et al., 2023).

Hutauruk et al., (2020) emphasize that creative thinking is a person's ability to find new ways, strategies, ideas, or concepts in finding solutions to solve a problem. In the world of education, every student is expected to be more creative in learning, because this creative thinking ability helps students combine and create new ideas (Mansur & Bare, 2019). These skills must be taught explicitly. Creative thinking comprises four key indicators: fluency (expressing opinions and ideas); flexibility (finding varied solutions); originality (providing novel ideas); and elaboration (detailing or sequencing answers) (Amri & Muhajir, 2022).

However, a gap exists between these educational ideals and classroom reality. According to Herayanti (2022), the low level of creative thinking is still often found in various schools in Indonesia, partly due to monotonous learning and the use of lecture-based learning models. In reality, many schools implement learning systems that do not support the development of students' creative thinking abilities. This is a critical issue because creative thinking significantly influences learning outcomes.

According to Manurung et al., (2020), creative thinking skills contribute to student learning outcomes. Cognitive learning outcomes serve as a benchmark for student success in understanding material, in accordance with the Regulation of the Minister of Education and Culture Number 23 of 2016. Cognitive aspects help teachers determine the extent to which students have acquired understanding of the material.

A specific instance of this problem is observed at SMAN 1 Muncar. Based on initial observations, most students tend to be passive during biology lessons. Only about 20% of students actively ask or answer questions, while the majority only take notes. Interviews with teachers indicate that the lecture method is still dominant, in line with students' initial pre-test scores, which average 45, below the KKM of 70. This passive learning behavior is further exacerbated by the specific environmental context of the school, which is located in an industrial agricultural (agro-industrial) area.

Schools in agro-industrial areas face unique challenges regarding student learning independence. According to Suratno et al., (2020), the agricultural environment influences educational aspects. In this region, many students assist their parents in agricultural work or wage labor after school hours (Faiqoh et al., 2019). Consequently, students have limited independent study time at home. This context necessitates a classroom learning model that maximizes student engagement and comprehension within school hours, reducing the reliance on independent study at home.

To address these challenges, the Reading Concept Mapping Group Investigation (Remap-GI) learning model is proposed. Remap-GI is a comprehensive instructional approach that synthesizes three strategies to support cognitive and creative growth. First, the 'Reading' stage ensures students acquire initial knowledge. Second, 'Concept Mapping' helps students organize complex information—such as Biodiversity material—enhancing their elaboration and cognitive structure (Amaliah et al., 2020). Third, 'Group Investigation' engages students in collaborative problem-solving, fostering fluency and flexibility in thinking through social interaction (Hayati et al., 2020).

The Remap-GI model is particularly suitable for this study's context. For students with limited study time at home due to agricultural work, the structured in-class investigation provides the necessary scaffolding to master complex concepts. Based on this background, researchers are encouraged to examine more deeply the effect of implementing the Remap-GI model on creative thinking skills and cognitive learning outcomes of grade 10 students on the topic of Biodiversity at SMAN 1 Muncar.

RESEARCH METHODS

This study employs a quantitative approach with a quasi-experimental design. The quantitative method is systematically structured to identify causal relationships between variables. A quasi-experimental design was selected because intact classroom groups could not be fully randomized, and several external variables could not be entirely controlled (Azhari et al., 2023). The specific design used was the non-equivalent control group design, represented as follows:

$$O_1 — X — O_2 \text{ (Experimental Class)}$$

$$O_1 — – — O_2 \text{ (Control Class)}$$

where O_1 = pre-test, O_2 = post-test, and X = Remap-GI intervention.

The research was conducted at SMAN 1 Muncar, located in an industrial agricultural area in Banyuwangi Regency. The school was selected using purposive sampling based on two considerations: (1) its strategic location adjacent to local agro-industrial activities, and (2) the heterogeneous distribution of male and female students in the available classes.

The study population consisted of all 10th-grade Mathematics and Natural Sciences students. Four parallel classes were available for selection. A random sampling technique was applied to determine the sample. Preliminary homogeneity and normality tests were administered to the four classes, and two classes with statistically equivalent pre-test characteristics were identified. A simple lottery method was then used to assign one class as the experimental group (n = 36) and the other as the control group (n = 34). Equivalence of groups was further confirmed through comparison of mean pre-test scores and homogeneity of regression slopes. Both groups were taught the same biodiversity content based on the Grade 10 biology syllabus.

The instruments consisted of (1) a creative thinking skills test and (2) a cognitive learning outcomes test. The creative thinking instrument was developed using four indicators: fluency, flexibility, originality, and elaboration, aligned with the 2013 Curriculum and the Grade 10 biology syllabus. Item development involved constructing open-ended prompts related to biodiversity; for example, students were asked to propose multiple solutions to biodiversity loss in local agro-industrial environments. A four-level scoring rubric was used, with specific criteria defining originality (novelty and uniqueness of ideas) and elaboration (depth and detail of explanations).

The cognitive test consisted of 20 multiple-choice questions covering core competencies in the Biodiversity chapter, including classification principles, species characteristics, and ecosystem variation. Content validity for both instruments was evaluated by two biology education lecturers and one senior biology teacher. Reliability testing produced coefficients of $\alpha = 0.84$ for the creative thinking instrument and $\alpha = 0.81$ for the cognitive test, indicating strong internal consistency.

The Remap-GI intervention was implemented over four meetings (4 × 90 minutes). The learning syntax included: (1) Reading, in which students read selected materials to construct foundational understanding; (2) Concept Mapping, where students summarized key biodiversity concepts through visual maps; and (3) Group Investigation, in which students collaboratively answered inquiry questions, analyzed biodiversity issues, and presented their findings. Prior to implementation, the biology teacher received a 1-hour training session on the Remap-GI procedure. Implementation fidelity was monitored using an observation checklist completed by two observers.

Data were analyzed using Analysis of Covariance (ANCOVA), with pre-test scores serving as the covariate to control baseline differences between groups. Assumption tests—normality, homogeneity of variances, and homogeneity of regression slopes—were all satisfied. ANCOVA was then used to determine the effect of the Remap-GI model on students' creative thinking skills and cognitive learning outcomes. All analyses were performed using SPSS Version 25.

RESEARCH RESULT

Data related to creative thinking skills were obtained through pre-test and post-test assessments. The instrument consisted of four descriptive questions developed based on standard creative thinking indicators, which included fluency, flexibility, originality, and elaboration. These indicators were adapted from widely accepted creative thinking frameworks and aligned with the learning objectives of the biodiversity topic. A summary of the students' creative thinking scores for both the experimental and control classes is presented in Table 3.1.

Table 3.1 Results of Creative Thinking Ability Data

Class	Test	Component		
		Lowest Score	Highest Score	Average ± SD
Eksperimental	Pre-test	20	65	43.75 ± 10.91
	Post-test	50	100	75 ± 11.21
Control	Pre-test	10	80	43.93 ± 15.03
	Post-test	5	85	47.94 ± 14.77

Table 3.1 shows the corrected descriptive statistics, indicating that the average post-test score for creative thinking in the experimental class was 75.00, whereas the control class scored 47.94. The earlier inconsistency where cognitive learning outcomes were mentioned in this paragraph has been corrected.

Table 3.2 Results of Covariance Analysis

Source	Type III SS	df	Mean Square	F	Sig.
Corrected Model	58.828	2	29.414	30.993	0.000
Intercept	308.973	1	308.973	325.561	0.000
Pre-test (Covariate)	0.222	1	0.222	0.234	0.630
Class	58.656	1	58.656	61.805	0.000
Error	62.637	66	0.949		
Total	4270.000	69			
Corrected Total	121.465	68			

The ANCOVA results indicate a significant effect of class on creative thinking skills (p

= 0.000), it can be concluded that there is a significant difference between the two classes. This indicates that the implementation of the Reading Map Group Investigation (Remap-GI) learning model has an impact on students' creative thinking skills. The Remap-GI model itself combines reading methods followed by mind mapping techniques, thus helping students understand the material more thoroughly and more firmly.

According to Syarifa *et al.,* (2024), learning activities that fully involve students, such as creating mind maps after reading the material, can improve students' comprehension and retention, and can help them grasp the subject matter comprehensively across all components of the learning concept. This aligns with the research findings of Zubaidah *et al.,* (2023), which stated that the Remap-GI learning model is an engaging approach and can improve thinking skills. This model focuses on entirely student-centered learning, with stages including reading activities, student concept mapping, and the application of group investigation (GI) as a means of conducting group case studies.

Research conducted by Muhlisin (2019) also revealed that the reading, mapping, and sharing method proved effective in improving students' conceptual understanding while fostering creative thinking skills. This is because the method involves various activities, such as individual and collaborative mind mapping, group discussions, and group presentations. These activities strengthen students' abilities, deepen their understanding, and encourage them to build new connections. This finding aligns with Kartikawati *et al.,* (2020), who asserted that learning models have a significant influence on student abilities. One example is the group investigation model, which has the potential to improve students' understanding of the material, thus implicating improved thinking skills.

The hypothesis testing criteria are: H0 is accepted and H1 is rejected if the significance value is >0.05. If the significance value is <0.05, H0 is rejected and H1 is accepted. Based on the results of the Ancova test in Table 4.4, it can be seen that the significance value obtained is 0.000 between the experimental class and the control class, there is a real difference. The significance value (0.000) <0.05, which indicates that H0 is rejected and H1 is accepted. Further elaboration regarding the results of students' creative thinking abilities, an analysis of the results of each indicator is carried out. The data on the results of the creative thinking abilities of each indicator are presented in Figure 3.1 below.

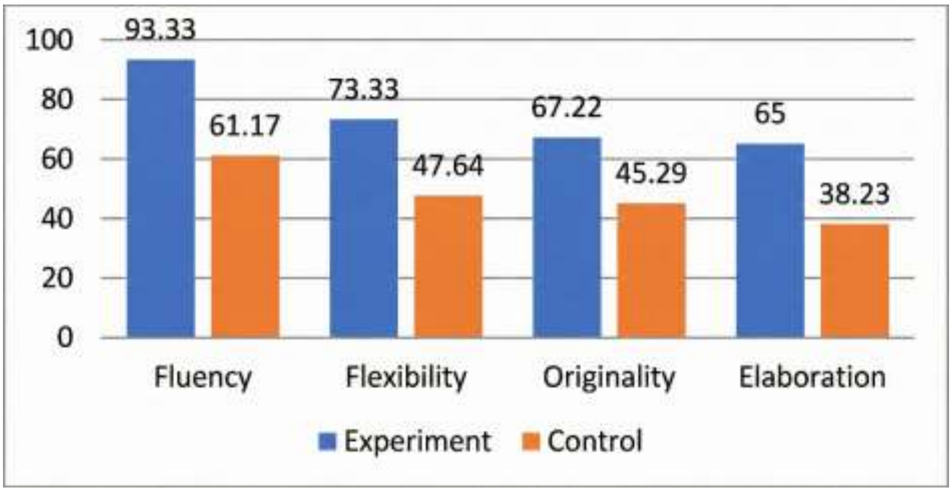

Figure 3.1 Graph of Each Indicator of Creative Thinking Ability

Figure 3.1 shows a graph of the average creative thinking ability scores for each indicator. A striking difference between the experimental and control classes was observed across almost all indicators. The highest-scoring indicator in both classes was the first indicator, fluency. The average fluency indicator score in the experimental class reached 93.33, while the control class scored 61.17. Although both indicators had the highest scores in their respective classes, a significant difference in results was still evident between the experimental and control classes. Meanwhile, the lowest-scoring indicator was the fourth indicator, elaboration. The experimental class averaged 65 for elaboration, while the control class only scored 38.23. These data demonstrate a clear difference between the two classes on this indicator. This finding is consistent with Setiani & Razak (2019) who found that reading and concept mapping activities in Remap-GI promote fluency, while elaboration skills require intensive practice because they require systematic and detailed idea development.

This condition can be explained because the fluency aspect is relatively easier for students to achieve, namely by quickly expressing many ideas or answers, especially when working in groups through discussion activities and creating concept maps. In contrast, the ability to elaborate requires students to develop ideas more deeply and systematically, which is still difficult to achieve. Students of SMAN 1 Muncar are accustomed to conventional learning patterns based on lectures and memorization, so they are less trained to expand answers or provide detailed arguments. Environmental factors also play a role, considering that students in industrial agricultural areas tend to have limited independent study time because they have to help with their parents' work. This is in line with the findings of Qomara, Siswati, & Wahono (2024) who stated that learning that still emphasizes memorization tends to limit students' opportunities to explore ideas in depth, so that elaboration skills do not develop optimally.

Based on the statement above, the experimental class experienced a greater increase in creative thinking skills than the control class. This is because the implementation of the Remap-Gi learning model in the experimental class allows students to develop their thinking skills by discussing with their group mates. Therefore, these students can better understand various ways to solve problems and are more enthusiastic and passionate during the learning process (Salsabila *et al.,* 2023). The increase in average grades in the experimental class using the reading map group investigation learning model is strongly supported by the Remap-Gi learning syntax, which emphasizes students' active role during learning. Involvement such as reading, presenting ideas or main concepts from the material studied in the form of mind maps, and discussions is one of the best strategies for gaining in-depth knowledge and developing comprehension skills (Voß & Blumenthal, 2020).

Table 3.3 Cognitive Learning Outcome Data Results

Class	Test	Component		
		Lowest Score	Highest Score	Average ± SD
Eksperimental	Pre-test	20	65	43.75 ± 10.91
	Post-test	50	100	75 ± 11.21
Control	Pre-test	10	80	43.93 ± 15.03
	Post-test	5	85	47.94 ± 14.77

Table 3.3 shows that the average post-test score for cognitive learning outcomes for students in the experimental class was 78.33, while the score for the control class was only 59.41. These findings indicate that cognitive learning outcomes for students in the experimental class were higher than those in the control class. This difference is influenced by the implementation of different learning models in each class, which have varying impacts on students' cognitive achievement.

Table 3.4 Results of Covariance Analysis

Source	Type III SS	df	Mean Square	F	Sig.
Corrected Model	24.121	2	12.060	22.314	0.000
Intercept	67.520	1	67.520	124.928	0.000
Pre-test (Covariate)	1.163	1	1.163	2.152	0.147
Class	15.398	1	15.398	28.490	0.000
Error	35.671	66	0.540		
Total	4800.000	69			
Corrected Total	59.792	68			

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DISCUSSION

Based on the results of the Analysis of Covariance (Ancova) on students' pre-test and post-test scores, a significance value of 0.000 was obtained, indicating that H0 is rejected and H1 is accepted. This confirms that the Reading Map Group Investigation (Remap-GI) learning model affects students' cognitive learning outcomes. In the context of this study, cognitive growth is reflected through the measurable improvement from pre-test to post-test scores, showing that students undergoing Remap-GI experience not only higher outcomes compared to the control group, but also meaningful development in their cognitive processes across the intervention period. Rather than focusing solely on statistical significance, the key point lies in understanding how the Remap-GI components reading, mind mapping, and group investigation, work together to strengthen and gradually expand students' cognitive abilities.

The comparison between the experimental and control classes also showed a significance value of 0.000, meaning that the two groups differed substantially. This difference is likely driven by the structured learning pathway in Remap-GI, in which students first construct foundational knowledge through reading, then reorganize that information visually through mapping, and finally deepen their understanding through collaborative investigation. In line with Ganaka (2023), the Remap-GI model promotes active meaning-making because students are continuously engaged in observing, discussing, and synthesizing information. Such continuous engagement contributes to cognitive growth by gradually improving recall, comprehension, and higher-order thinking developments that conventional instruction does not support as effectively.

Research by Ester et al. (2022) also supports the idea that the reading stage contributes significantly to improved cognitive learning outcomes and cognitive progress over time. The reading phase provides new information, enhances memory, trains thinking skills, and expands students' insights. In the context of biology learning (particularly biodiversity) the reading component helps students build initial conceptual frameworks before entering collaborative tasks. According to Hayati et al. (2020), completing the reading stage early increases learning efficiency and allows students more time to explore information independently. This aligns with the cognitive growth observed in this study, especially among students with initially low reading motivation.

Research by Abbod (2024) shows that cooperative learning models such as group investigation outperform individual learning approaches. Group learning encourages interaction and discussion, allowing students to communicate gaps in understanding and share existing knowledge. In the Remap-GI implementation of this study, the investigation phase played an important role because students were required to examine biodiversity cases, compare species characteristics, or analyze simple field-based observations related to agricultural ecosystems. Such tasks supported deeper reasoning and facilitated creative and cognitive growth through repeated cycles of inquiry. The analysis and synthesis stage further encouraged students to refine their understanding by exchanging perspectives, followed by presenting their group results (Widiastuti, 2021).

An additional insight from the findings is the contrast between high fluency but lower elaboration scores in creative thinking. This pattern suggests that students can generate many ideas but struggle to develop them in detail. The growth of creative thinking, therefore, appears uneven, with fluency improving more rapidly than elaboration. In agricultural-industrial learning contexts, where students may be accustomed to rote-based tasks, elaboration requires explicit scaffolding—such as modeling how to expand ideas, providing guided prompts, or integrating examples from local agroecosystem biodiversity. Strengthening elaboration should therefore be a pedagogical priority in future Remap-GI implementations to support more balanced growth in creative thinking skills.

Despite the positive outcomes, several limitations must be acknowledged. First, differences in teacher delivery between classes may threaten internal validity. Second, the duration of the intervention was relatively short, which may not fully capture long-term cognitive and creative thinking growth. Third, the sample size was limited to a single school, reducing the generalizability of findings. Fourth, measurement instruments—especially for creative thinking—may not fully capture nuanced improvements in elaboration or originality. Future studies could involve larger samples, longer interventions, and mixed-methods approaches to obtain richer descriptions of growth in cognitive and creative abilities.

Finally, although Remap-GI improved learning outcomes, the connection to the biodiversity topic could be strengthened further. Future research and practical implementation should include more concrete biodiversity tasks such as species inventory, ecosystem comparison, or simple field-based investigations to more clearly illustrate how the Remap-GI model supports both content mastery and the continuous growth of students' cognitive and creative competencies.

CONCLUSION

Based on the research results and discussion presented, it can be concluded that the Reading Map Group Investigation (Remap-GI) learning model significantly improves students' creative thinking skills and cognitive learning outcomes, as indicated by significance values of 0.000 (<0.05). Beyond statistical evidence, this study demonstrates that Remap-GI supports deeper conceptual understanding, encourages active participation, and strengthens students' ability to construct and connect biological knowledge particularly relevant in schools situated in industrial agricultural environments where contextual learning resources are abundant.

These findings offer several practical implications. For teachers, the Remap-GI model can be integrated into biology units such as biodiversity by incorporating structured reading tasks, mind mapping, and collaborative investigation related to local agroecosystem cases. For schools, Remap-GI may be adopted as part of routine instructional strategies to foster higher-order thinking. For curriculum developers, the model can inform enrichment modules, teacher training workshops, and locally contextualized curriculum adaptations that align with the competencies required in agricultural-industrial regions.

Several obstacles were encountered during the data collection process. Students in the experimental class were unfamiliar with the learning model and its syntax, making it difficult for them to follow the Remap-GI stages sequentially. These challenges highlight the need for preparatory steps, such as orientation sessions, explicit modeling of each syntax stage, and gradual introduction of mind mapping and group investigation procedures. Providing scaffolding—such as sample maps, guiding questions, and structured group roles—can reduce confusion and improve fidelity of implementation in future applications.

Future research should address the limitations of this study by examining the long-term effects of Remap-GI, employing mixed-method approaches (e.g., classroom observations, interviews, and artifact analysis), and involving larger or more diverse school contexts. Comparative studies between Remap-GI and other active learning models could also provide deeper insights into which pedagogical components most effectively improve creative thinking and cognitive outcomes. Additionally, further exploration of strategies to enhance elaboration skills within creative thinking is recommended, given students' initial difficulties in this area.

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