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Research-based learning: creative thinking skills of primary school pupils in science learning

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ABSTRACT
Creative thinking as a 21st-century skill is fundamental to human development and a catalyst for innovation. Researchers often study it because it encourages students to analyze, synthesize and evaluate information from various angles, which is essential for making decisions and solving complex problems. This study aimed to determine the difference in creative thinking skills between pupils who follow the research-based learning (RBL) and cooperative learning models. Data were collected from 60 primary school pupils using creative thinking skills instruments within a quasi-experimental design. Data analysis involved Analysis of Covariance (ANCOVA) to answer the research questions. The findings show that based on the results of the research and discussion, it can be concluded that the RBL learning model has a significant effect on learners' creative thinking skills in science learning. Where there are differences in creative thinking skills between pupils who follow the RBL learning model and those who follow the Cooperative Learning learning model, it can be seen from the results obtained in the experimental class and control class. Thus, RBL can be recommended for improving pupils' creative thinking skills rather than cooperative learning in science classes at the primary level.

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Introduction

Creativity and innovation are necessary to survive in the ever-changing modern world (Rumanti et al., 2023). The capacity for technological achievement, creativity, innovation diffusion, and knowledge generation are fundamental conditions for providing competitive advantage, economic growth, and sustainable development in the global arena (Khan et al., 2022). The 2016 Technology Achievement Index reported that Switzerland ranked 1st and Indonesia ranked 83rd out of 105 countries (Guz et al., 2017). The Frontier Technologies Readiness Index report in 2023 reported that the USA occupied position one and Indonesia occupied position 85 (WOF, 2023). One of the fundamental components of the UN's 2030 sustainable development agenda is the quality of education (Haleem et al., 2022). In education, it is necessary to develop generic competencies such as creativity and innovation (Vuk, 2023). Creative thinking helps professionals to succeed in complex problem-solving and decision-making processes and successfully adapt to the demands of everyday life (Khalil et al., 2023).

Creativity is a hot topic right now. Creativity is often equated with innovation as the spread of new ideas. Nevertheless, innovation arises from the belief that individuals can be persuaded to be creative (Anderson et al., 2014). However, some have also conceived of creativity as an innate and individualistic process that results in innovation. Creativity as an artistic practice has been attributed to the cognitive thought processes of individuals in a state of deep reflection (De Souza E Silva & Xiong-Gum, 2021). The evidence in the Faculty of Pedagogy at the Sofia University St. Kliment Ohridski-Bulgaria, where the teachers successfully developed students' skills from the 4C group through independent work (realized through research and creative tasks). Students involved in the study showed that independent tasks require creativity and innovative approaches as well as the development of learning skills (Batlolona et al., 2019). Students had enough to develop their creative skills through various forms of individual and group work, in line with the skills required for 21st-century teachers (Gyurova, 2020).

Creativity is also associated with other cognitive activities, such as leadership, critical thinking, decision-making, metacognition, motivation and behaviour (Karunarathne & Calma, 2024). Research suggests that teachers need to be trained and supported to equip students with strategies, approaches, resources and environments to promote creativity (Ruiz-del-Pino et al., 2022). In today's rapidly evolving and changing world, creative and productive people who can solve problems using different perspectives are needed (Wenno, 2021). In the world of education, productive teachers who never stop working and always renew themselves and their students to new things are needed (Batlolona, 2023). In this case, the education provided in schools must be open and make a difference (Malkoç, 2015). Creative thinking has acquired an important position due to its importance in preparing a new productive generation capable of taking the initiative (Tawarah, 2017). Global data shows that education in Latin American countries has shortcomings and is still far from reaching the highest levels when compared to developed countries (Hernandez-Leal, Duque-Mendez, and Cechinel, 2021).

The EU also recognizes the importance of creativity for the economy and science and social development, especially in reference to global challenges such as climate change. According to it, creativity is the main source of innovation and encouraging creativity is the goal of the European community (Andiliou & Murphy, 2010). Creativity is, therefore, a requirement for school graduates, yet in Germany, it is still not an integral part of school education (Semmler & Pietzner, 2018). Creative thinking is an essential skill for teachers, enabling them to adapt to the environment and curriculum, solve problems, design engaging lessons, manage the classroom, and develop a positive learning environment (Fredagsvik, 2023). It is important to incorporate creative thinking into classroom activities to achieve educational goals. Many students in the Asian region receive little exposure to creative teaching practices during their studies that must be why they are so successful and their hi-tech economies are so vibrant. It may be because traditional educational approaches are prioritized, which are structured around curriculum and academic outcomes, reducing the scope for originality and creative thinking that’s because they realise that one needs a solid base of factual knowledge before one can be creative and build on it. As a result, some may lack confidence in their ability to think creatively, thus limiting their ability to integrate creative thinking into the classroom effectively. Thus, students and teachers can benefit from continuous professional development, training programs, workshops, mentoring, and guidance from experienced teachers to enhance their creativity in designing and managing classroom activities. (Suchyadi et al., 2020; Siagian et al., 2023).

Undoubtedly, primary school children have different characteristics and learning processes than adults. The prioritisation scale in the USA for 21st-century skills includes life and vocational skills, learning and innovative skills, and information, media and technical skills. Innovative learning and skills emphasise the importance of problem-solving. For science education, problem-solving helps pupils make connections between science concepts by actively working to find solutions, rather than passively receiving information. This approach is effective after students have built a foundational knowledge base (Chen & She, 2015). The main goal of learning biological science in primary school is for children to gain a conceptual understanding of fundamental concepts, rather than simply memorizing a large number of biological facts, which is often seen as a limiting approach. However, one might question how understanding can be cultivated in the absence of factual knowledge (McDaniel et al., 2022). Research shows that biology, of all science subjects, has the most interest among school learners (Nwuba et al., 2023), while girls tend to like biology more than boys (England et al., 2019). Whereas the results of a different study from Finland on 3626 for pupils at the age of 15 years showed that more boys than girls were interested in basic processes in biology, while more girls than boys studied human biology and health education (Uitto et al., 2006). A number of studies on pupils' learning strategies have been conducted, focusing on learners' behaviours and thoughts that influence their cognition process in learning. Implementing modern learning designs can encourage pupils to utilize active learning strategies to learn biology. The application of active learning strategies can influence their biological conceptual understanding, attitude and motivation. Therefore, it is crucial to explore their biology learning strategies (Shen et al., 2018). One of the strategies that can be applied in increasing their conceptual biology to become better scientists in the future is research-based learning (RBL).

Research results that focus on creativity can create new products, which can then improve conditions in the socio-economic community and improve the identity of a nation. Innovation through quality research and patents also has an additional impact on improving the finances of business people which has a positive effect on improving the economy and welfare of the community. China is increasing its capacity in a range of disciplines to better understand the social impact of new fields, such as nanotechnology and artificial intelligence, and to drive innovation in digital health (Cao, 2023). China has successfully lifted its 700 million population through domestic innovation. South Korea and Israel have significantly strengthened their economies through intensive research and development, followed by successful integration into global markets. Israel, in particular, serves as an exemplary case of how a country with largely arid lands has become one of the largest exporters of agricultural commodities. This transformation has been driven by ongoing innovation and uninterrupted research efforts. Additionally, North America and Western Europe account for a majority of global research, comprising 46.1%, while East Asia and the Pacific follow with 40.6% (Acharya & Pathak, 2019).

RBL is a learning model for students to learn new skills and knowledge by working on a project (Thiem et al., 2023). A key aspect of RBL is that students are required to take an active role in their learning, meaning that students can identify and explore problems and questions, conduct research, and develop solutions themselves. Previous research shows that RBL increases students' research skills and interest in pursuing a research degree in the future (Camacho et al., 2021). RBL can improve retention and develop scientific character. In addition, RBL helps students contribute to faculty research productivity when integrated into academic activities, arouses subject motivation, and develops an understanding of research methods (Fuller et al., 2014). RBL, a synonym of inquiry-based learning, which links research and teaching in the academic environment (Yeoman & Zamorski, 2008).

RBL is a student-centred pedagogy where students conduct research projects under the guidance of a supervisor: they pose and frame research questions, review literature, collect and analyse data, propose answers and explanations, and communicate the results. RBL facilitates active student engagement and promotes deep learning (Archer-Kuhn et al., 2020). Effective RBL learning experiences are largely evidenced in science, technology, engineering, and mathematical disciplines, thus leaving room for further research in other disciplines (Wessels et al., 2021). Research results show that RBL is challenging for undergraduate students but also beneficial in developing their work readiness and professional identity skills. It is demonstrated by the experiences of academics and undergraduates in two business faculties, one in Australia and the other in Finland (Bowyer & Akpinar, 2024). Proponents of research-based learning have pointed out the need to develop enthusiasm for critical questioning, resourcefulness and creative solutions in undergraduate students (Guinness, 2012). One of the most advanced ways is RBL, where students actively participate in the research process. The purpose of RBL is not only to improve students' research competence but also to improve their general professional qualifications by teaching them key competencies such as communication, presentation, and problem-solving skills. Therefore, RBL is considered a 'panacea' to address the various demands in basic education and higher education. The purpose of this study is to determine the difference in creative thinking ability between students who follow the RBL learning model.

RBL has proven its superiority in overcoming various learning problems related to cognitive aspects, behaviour, and affective experiences for pupils. Some of the related reports include learning outcomes and academic performance (Worapun, 2021); critical thinking and self-regulation (Reyk et al., 2022; Salvador & Buque, 2024); Critical thinking (Usmeldi et al., 2017); scientific questioning and experimental skills of primary school pupils) (Khumraksa & Burachat, 2022), scientific process skills (Usmeldi, 2016; Behrmann, 2019); analytical thinking skills (Suyatman et al., 2021); creative thinking (Khwanchai et al., 2017; Supit & Winardi, 2024); attitude (Dvorak et al., 2021; Usmeldi, 2016); problem solving (Suyatman et al., 2021). With this information in mind, there is still a lack of studies that reveal the effect of RBL on creative thinking variables. The potential of RBL to creative thinking skills is very limited, in addition to the lack of related research results, and this model is rarely widely known in the community. The information that has not been revealed must be followed up in research. Thus, the question that needs to be answered in this study is whether RBL influences students' creative thinking skills in science learning for primary school pupils.

Aims

This study aimed to analyze the effect of the RBL learning model on students' creative thinking skills in Biology science learning in primary schools.

Rationale

The goal of science education in primary schools is to introduce pupils to basic science concepts that are relatable to their everyday lives. This means that the content should focus on the real-world experiences of the students and connect with their existing knowledge. In particular, the biology curriculum for primary schools encompasses factual, conceptual, procedural, and metacognitive knowledge (Jeronen et al., 2017). To effectively teach biology to primary school pupils, it is essential to employ a strategy, approach, or learning model that is appropriate for their developmental level.

In Indonesia, many schools still implement the 2013 curriculum, although some have switched to the Merdeka curriculum. The Government, through the Ministry of Education and Culture, highly recommends the 2013 curriculum. This curriculum requires teachers to fully and consistently apply the Scientific Approach. The Scientific Approach is aligned with the scientific method, which involves collecting data through observation or experimentation, followed by processing the information, analyzing it, and testing hypotheses (Emden, 2021). Learning Biology through a scientific approach encourages students to think like scientists, helping primary school pupils develop higher-order thinking skills, including creativity and innovation in achieving the learning objectives set by their teachers. In teaching Biology, in addition to adopting the scientific approach, teachers have the flexibility to choose learning models that align with the subject matter, student characteristics, and the scientific approach. One effective learning model for this purpose is the Research-Based Learning (RBL) model. The RBL model is grounded in the philosophies of constructivism, behaviorism, and cognitive learning. Its main characteristics include helping pupils construct their understanding, build on prior knowledge, foster social interaction, and achieve meaningful learning through real experiences (Estuhono & Efendi, 2024). This student-centered learning model integrates research activities and can be implemented both inside and outside the classroom or in laboratory settings (Kerimbayev et al., 2023).

Research activities conducted within the RBL (Research-Based Learning) model offer a unique experience for primary school pupils in science-biology education. These activities highlight the importance of research for aspiring scientists and stimulate students' curiosity and creative thinking skills. Pupils are likely to find joy in engaging in hands-on learning activities that incorporate scientific practice and evidence, rather than relying solely on lectures or group discussions commonly used in traditional learning environments.

This enthusiasm among pupils is anticipated to foster the development of creative thinking skills, encouraging them to adopt various perspectives when presenting scientific explanations or devising problem-solving solutions. The lack of scientific information and studies examining the impact of RBL on pupils' creative thinking in science-biology education underscores the necessity of research in this area, especially for primary school pupils.

Research Question

Does the RBL learning model influence the creative thinking skills of primary school pupils in Science-Biology learning?.

Methods

Research Design

This type of research is *quasi-experimental and* conducted under conditions that do not allow controlling or manipulating all relevant variables (Harris, 2006). The research design used in this study was *pretest-posttest control group design*. This research design involves two classes, namely the experimental class and the control class. Before treatment, both groups were given a *pretest,* and after treatment, both groups were given a *posttest*. The design of this study is presented in Table 1.

Table 1

Pretest-posttest control group design

Group	Pretest	Treatment	Posttest
A	T_1	X	T_2
B	T_1	Y	T_2

Note. Description: A = Experiment Class, X = Application of *Research-Based Learning* Model, B = Control Class, Y = Application of *Cooperative Learning* Model, T_1=*Prestest* administration, T_2= *Posttest* administration

Population, Sample and Procedures

The population in this study were pupils of class IV primary school cluster V Inamosol sub-district, which amounted to 79 pupils. The sample in this study amounted to 60 children, consisting of 30 as a control class and 30 as an experimental class. determination of the experimental class and control class is based on the results of the lottery. The implementation of learning was carried out eight times in class meetings. The biology topics taught were: 1) Plant parts and their functions; 2) Classification of animals based on the type of food; 3) Cycle of living things and efforts to preserve it; 4) The life cycle of animals and how to keep pets.

The independent variable (X) is the RBL model, while the dependent variable (Y) is the ability to think creatively. The techniques used in this study were direct and tests to obtain scores of creative thinking (an initial test and a final test). The instrument used was a description test.

Learning with RBL was carried out in the experimental group, while the control group used the learning model used by the teacher, namely the Jigsaw cooperative learning model. Learning refers to the theme of Caring for living things, with subthemes 1) animals and plants in my home environment (2 lessons), 2) diversity of living things in my environment (3 lessons), and 3) let us love the environment (3 lessons). Before the treatment, each group took a pretest of creative thinking skills. 2) Learning in the experimental and control groups was conducted with the same teacher, teaching materials, and all learning-related matters except for the learning model. The time allocation for learning is 105 minutes. The subject matter that was taught included 1) the structure and function of plant organs, 2) types of animals based on their food, 3) and the cycle of living things. The lesson plan was developed by researchers referring to the thematic curriculum in the fourth grade of primary school using the learning model used in this study. Of course, in developing learning, it must refer to the Core Competencies, which have then been translated into basic competencies (KDs). There are 2 basic competencies used as a reference, namely KD. 3.1 Analyse the relationship between the form and function of body parts in animals and plants (cognitive aspects) and KD 4.1 Present reports on observations about the form and function of body parts in animals and plants (psychomotor aspects). From the KD, indicators of competency achievement and learning objectives are formulated and arranged in learning activities 8 times.

Learning with RBL was carried out following the syntax of the RBL learning model. The learning steps consisted of 5 phases, namely 1) formulating problems, 2) reviewing theories, 3) planning investigations, 4) researching and analysing data, and 5) explaining research results. Before formulating the problem, pupils were given readings about the subject matter. The content of the subject matter was related to the theory or basic concepts according to the subject matter being taught. When planning the investigation, the teacher gave directions to the pupils to prepare tools and materials and understand research procedures by reading several times. If it was clear enough, they were asked to conduct research according to the research procedures the teacher had designed according to their learning needs. The results of the research were entered in the existing observation table. The group discussed entering data into the formats according to the teacher's instructions. In class, groups were asked to explain the research results they obtained in front of the class.

Instrument

The test used in this study is a test of creative thinking skills based on the subject matter of plant parts and their functions, the classification of animals based on the type of food, and the life cycle of living things. A valid and reliable creative thinking skills test instrument was used to collect creative thinking skills data. Data collection was done twice, namely pretest and posttest, on the three learning models. The scoring key was modified from Treffinger et al. (2002), with a range of 0-4. The assessment key was developed from each indicator of creative thinking skills. The creative thinking skills assessment rubric is presented in Table 2.

Table 2

Scoring rubric of creative thinking skills

Indicator	Criteria	Score
Fluency	Mentioning/writing five or more ideas, suggestions or different alternative answers	4
	Mentioning/writing three ideas, suggestions or different alternative answers	3
	Mentioning/writing some ideas, suggestions or alternative answers that are not very different	2
	Mentioning/writing one idea, suggestion, or alternative answer	1
	Not answering or giving a wrong answer	0
Originality	Mentioning/writing several interesting, unique ideas that are logical, relatively new and relevant to the given problem	4
	Mentioning/writing several interesting, unique ideas that are logical, relatively new, but not quite relevant to the given problem	3
	Mentioning/writing quite interesting, unique ideas that are quite logical, relatively new and quite relevant to the given problem	2
	Mentioning/writing an ordinary idea that is logical and relevant to the given problem	1
	Not answering or giving a wrong answer	0
Elaboration	Explaining several logical details of an existing idea so that the formulation of the idea becomes clearer and can be applied more easily	4
	Explaining one logical detail of an existing idea so that the formulation of the idea becomes clearer and can be applied more easily	3
	Giving several logical details of an existing idea but not quite relevant to the concept of the main idea, so does not make the idea clearer.	2
	Not adding any details of an existing idea so that the formulation of the idea cannot be applied well	1
	Not answering or giving a wrong answer	0
Flexibility	Writing several alternative answers that are very logical and relevant to the given problem from different points of view	4
	Writing a few alternative answers that are quite logical and relevant to the given problem from different points of view	3
	Writing several alternative answers that are quite logical but less relevant to the given problem from different points of view	2
	Writing one alternative answer that is quite logical and relevant to the given problem with only one point of view	1
	Not answering or giving a wrong answer	0

Note. Modified from Treffinger et al. (2002)

Data Analysis

The creative thinking test data is obtained, processed and analyzed to be able to answer the formulation of problems and research hypotheses. The data analysis used is hypothesis testing regarding differences and population averages. The test used is the ANCOVA test. The ANCOVA test was used to determine whether or not there is a significant difference (convincing) between the two *mean* (average) samples. Before hypothesis testing was carried out, the prerequisite analysis tests were carried out, namely the normality test and the homogeneity test. Prerequisite test analysis consists of a normality test in which the data were analysed first to determine the normality of the research data, to test whether the creative thinking ability data (*posttest*) obtained from the control group and the experimental group came from a normally distributed population or not. Then, the homogeneity test was carried out after the normality test. The homogeneity test was used to determine whether the variances of the two groups have the same population (homogeneous) or not.

Furthermore, if the population data is normally distributed and the data is homogeneously distributed, the ANCOVA test is carried out with a significant level of 0.05. This hypothesis testing aimed to determine whether the average value of the creative thinking ability of experimental class students was higher than the control class. The experimental class used the RBL learning model, while the control class used the cooperative learning model.

Findings

The data report of the findings showed that RBL greatly contributed to improving the creative thinking skills for each indicator, namely fluency (F), flexibility (Fe), originality (O), and elaboration (E) of pupils when compared to the cooperative class. This can be found in Figure 1.

Figure 1

Description of students' creative thinking skills for each indicator in rbl and cooperative classes

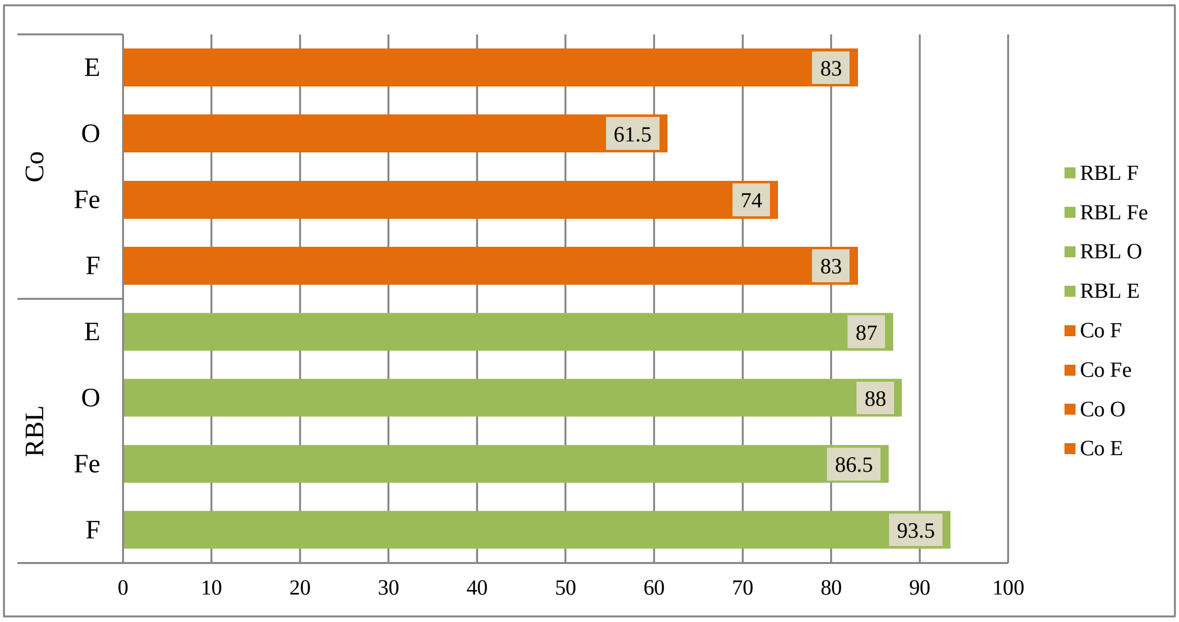
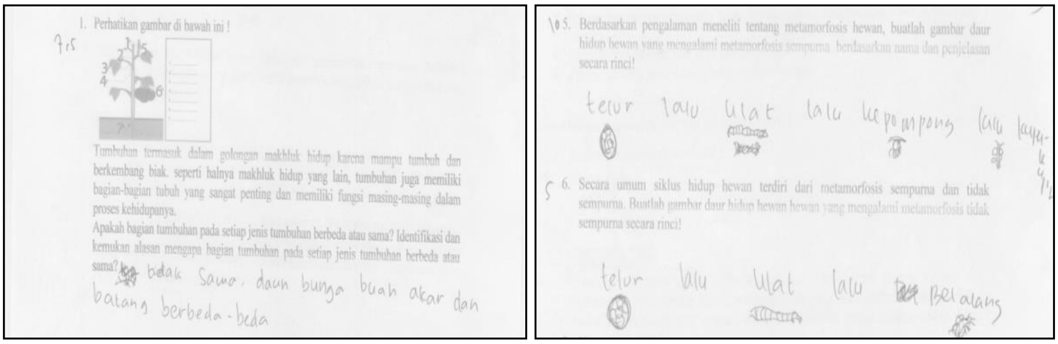


Figure 1 shows that the most prominent indicator of creative thinking skills in both learning models is fluency. This means that students can provide more than one solution to the problems given related to plant organ material. Students can describe or write their ideas creatively when they are taught with two different learning models. They use imagination in describing one of the life cycles that experience perfect metamorphosis in butterflies. Some of the students' work on their worksheets are shown in Figure 2.

Figure 2

a) Results of Creative Thinking Answers in the Flexibility (RBL) and b) Elaboration (Cooperative



(a) (b)

Based on the results of the *pretest* and *posttest* calculations of the experimental group and control group consisting of 60 attachment pupils, the data obtained are as shown in Table 3.

Table 3

Results of pretest and posttest data calculation

Frequency distribution	Experiment		Control	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Lowest score	24	68	24	48
Highest score	64	92	72	76
Mean	45.20	79.80	47.16	64.83
Median	42.00	80.00	46.00	64.00
Standard deviation	11.17	7.61	11.12	7.18

Before researching the experimental group and control group, a *pretest* was conducted to determine the initial ability of the pupils. from the pretest results, the average score of the experimental group is 45.20, and the control group is 47. Table 4 shows that there were changes after the intervention. The biggest change occurred in the experimental group, namely the increase in the average value from 45.20 to 79.80, which is 34.6. Similarly, the control class experienced an average increase from 47.16 to 64.83, which is 17.67. It means that the increase in the average value after being given treatment in the experimental class is higher than in the control class.

The data on the creative thinking ability of the two groups in this study are normally distributed and homogeneous, so the data testing on the creative thinking ability of the two groups is continued in the next data analysis, namely hypothesis testing using one-way ANCOVA test using the assistance of the IBM SPSS for windows programme, namely by comparing the calculated significance of each independent variable with the dependent variable with a significance level of 5%. Decision-making for the ANCOVA test follows the following guidelines: If the Significance (Sig) value is less than 0.05, then Ha accepted; otherwise, if the Sig value is greater than 0.05 then Ha rejected. Therefore, there is a difference in creative thinking skills between students who follow the RBL learning model and students who follow the CL learning model. The results of the hypothesis test is presented in Table 4.

Table 4

Hypothesis test calculation results

Tests of Between-Subjects Effects						
Dependent Variable: creative thinking skills posttest						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3501.255[a]	3	1167.085	21.515	.000	.535
Intercept	16368.576	1	16368.576	301.752	.000	.843
Class	606.998	1	606.998	11.190	.001	.167
Prekbk	21.783	1	21.783	.402	.529	.007
class * prekbk	124.094	1	124.094	2.288	.136	.039
Error	3037.728	56	54.245			
Total	320321.000	60				
Corrected Total	6538.983	59				

a. R Squared = .535 (Adjusted R Squared = .511)

The results of the study in the *Test of Between-Subjects Effects* table obtained sig. in the class row of 0.001> 0.05 so that it was declared H_a accepted. This shows that there are differences in creative thinking skills between students who follow the RBL learning model and students who follow the *Cooperative Learning* model [F (1,56) = 11.190, p = 0.001, np^2= 0.535].

Discussion

Based on the research results obtained during the implementation of the *pretest* for students in the primary school cluster V Inamosol sub-district before learning activities, it shows that the average value of experimental class students is 45.20 with the highest score of 64 and the lowest score of 24 while the average value of the control class is 47.16 with the highest score of 72 and the lowest score of 24. The *posttest* was carried out after learning activities were carried out, where the two classes had been given material about plant parts and their functions, types of animals based on their food and animal life cycles and how to care for animals based on learning competency indicators using the RBL learning model for the experimental class and the CL learning model for the control class. The *posttest* results of creative thinking skills show that the average value of the experimental class is 79.80, with a highest score of 92 and the lowest score of 68, while the average value of the control class is 64.83, with a highest score of 76 and the lowest score of 48. This shows that pupils have well understood the learning competency indicators.

The learning process that took place in the experimental and control classes was carried out based on the Learning Implementation Plan (RPP) that had been designed and carried out for eight meetings. In the learning process that took place in the experimental class, the researcher showed the material (types of plants, types of animal food, types of animals) which made students interested in observing and knowing more about the material being studied. Then, the researcher asked questions about the material shown and provided opportunities for the children not only to answer but match each other's answers and discuss differences. Furthermore, the researcher explains the material that has been shown and other things related to the material. It makes pupils focus and look for information related to the material to re-discuss their answers. Furthermore, the researcher provides an opportunity for students to choose material (plants in the surrounding environment, plants that animals can eat, animals in the surrounding environment) and make a list of questions related to the selected material. It makes pupils curious so that they eagerly choose material and ask questions. Furthermore, the researcher divides the children into groups, gives directions on research procedures, and helps students prepare tools and materials. It makes them work together in teams to make research plans. Furthermore, they conduct research and present the results thereby practising what has been obtained and find what they are looking for. Then, students make reports and present the results so that learners are more thorough, creative and brave in conveying what has been obtained both in writing and orally.

The data above shows that RBL is superior to cooperative research because the RBL model can make innovations in each specific field, and also contributes to the creative and analytical abilities of learners. The research process can help learners to manage their knowledge, shape learning autonomy behaviour and understand the learning environment. In conducting research, a researcher needs to process and present data systematically. Therefore, learners in courses designed for research-based learning are instructed to process information to synthesize problems, select methods to find solutions, systematically design data collection processes, and present research results scientifically (Worapun, 2021). RBL is beneficial to the development of teaching skills between students and teachers. In addition, it trains both learners' and teachers' active learning skills and brings satisfaction to learning (Salvador & Buque, 2024). RBL can increase cognitive, affective and psychomotor, which is effective for increasing pupil engagement (Wessels et al., 2021). The results of an RBL study for Computational Engineering undergraduate students at Tecnologico de Monterrey, Mexico City Campus showed that students were able to work in teams for a semester. Most teams, guided by the instructor, were able to develop high-quality monographs and sketches suitable for their team's proposed research paper (Noguez & Neri, 2019).

RBL is different from cooperative learning even though both are student-centered models. RBL focuses on research, while cooperative learning focuses on cooperation between students in groups to complete group assignments. The concept of research in primary school pupilss can be designed simply by presenting phenomena that exist in their environment, in addition to providing stimuli in the form of questions that help students think to solve problems by conducting investigations. The research procedure is explained in detail to students, so that they understand the research procedure. The most important thing here is that students realize the importance of the research, why, for what and how to do it.

In the cooperative learning model pupils learn in small groups of 4-6 students heterogeneously, providing opportunities for them to work together, positive interdependence among students and be able to take responsibility independently (Mallick et al., 2023). Previous findings Janah & Subroto (2019) stated that RBL is superior to a cooperative learning model. The teacher conveys learning objectives and motivates pupils then the teacher presents information through media or learning resources. In conclusion, the learning outcomes in experimental group differ from control group. from the learning source after the teacher organises students into groups and guides them in working on problems. Then, the teacher evaluates the learning outcomes achieved. This means that passive students in the group only follow active students, so only active students understand the problems given by the teacher better.

With the application of the RBL model, students feel happy and interested in participating in learning; students are also more creative, critical and confident in conveying ideas and solving problems. This is evidenced by an increase in motivation and science learning outcomes (Tupan et al., 2024) and an increase in students' analytical thinking skills (Liline et al., 2024). In contrast to the above research, this study states that RBL is a learning model that has an influence on students' creative thinking skills where RBL is able to improve students' creative thinking skills significantly; this can be seen from the average value of the experimental class *posttest* which is 79.66 or in the high category (Zubaidah et al., 2017), this proves that the RBL model is a learning model that affects students' creative thinking skills. From some of the findings and explanations above, it is evident that there is an influence of the RBL model on students' creative thinking skills.

RBL can help students and teachers innovate in experimentation. This is how new practices are integrated into existing practices in school learning. With RBL implementation, students improved by 67%, compared to Cooperative, which was only 40% (Siegel, 2005). Research results (Gillies, 2023) showed that RBL consistently demonstrated that students achieved higher learning outcomes when compared to peers taught with a cooperative approach. RBL will help students develop an understanding of the content, but also dialogic practices that will help them to engage in constructive discussions and facilitate critical thinking in learning. When teachers dialog with students, they not only provide different models and scaffolds but also provide feedback to help students develop clearer and deeper understanding.

The results of the ANCOVA test analysis on the creative thinking ability of the experimental class and control class based on *pretest* and *posttest* data of 60 students, obtained a significance value of 0.001 ($p = <0.05$) so it can be concluded that the hypothesis stating the effect of the RBL model on creative thinking ability is accepted. This is evidenced by the frequency distribution data of the *posttest of* creative thinking skills, where in the experimental class, there were 7 students in the medium category and 23 students in the high category. In contrast, in the control class, there were 3 students in the low category, 23 students in the medium category and 4 students in the high category. In addition, descriptive data of the research results that followed the RBL learning model showed an average value of 79.80 or in the high category, while the control class was 64.83 or in the low category. In addition, the percentage of creative thinking skills in the experimental class for *flexibility* indicators 86.5, *originality* 88, *elaboration* 87, and *fluency* 93.5, while the percentage of creative thinking skills in the control class for *flexibility* indicators 74, *originality* 67, *elaboration* 61.5, and *fluency* 83 means that the experimental class has higher creative thinking skills than the control class.

In RBL, students were assisted in improving creative thinking skills through activities carried out by the teacher. The progress of creative thinking skills can be measured, and progress from each indicator can be measured. Students must think directly in making their ideas. The selection of essential problems must be considered because to provide solutions to agreed problems, and questions are designed to stimulate student thinking to create various ideas so as to improve the fluency aspect (Yustina, 2022). The problems chosen by students are problems that exist in the surrounding environment. Research results Leasa et al. (2023) stated that projects implemented based on problems from the surrounding environment have a relationship with students' creative, critical, and metacognitive thinking. Science learning is closely related to the creative process and does not focus on one method but uses different scientific (Markula & Aksela, 2022). The phases of creative thinking skills help students develop ideas both individually and in groups. Students explore knowledge to understand basic concepts related to problems related to the material through various sources and write the results in the form of summaries or concepts (Batlolona et al., 2020). This situation is in line with Jean Piaget's theory which states that students will compile their knowledge after understanding concepts through various learning sources (Hammond, 2014).

Conclusion

Based on the results of research and discussion, it can be concluded that the RBL learning model has a significant effect on young children’s creative thinking skills in science learning where there are differences in creative thinking skills between students who follow the RBL learning model and students who follow the *Cooperative Learning* model. It can be seen from the results obtained in the experimental class and control class. Based on the results of the research that has been obtained, suggestions that can be proposed are that in the learning process, the RBL learning model should be considered for frequent use in order to help students hone their creative thinking skills so that students are able to face the challenges of 21st-century learning. For further research, it is recommended to use observation sheets to determine the achievement of the learning process when activities take place, make a questionnaire that is useful for knowing how students perceive learning activities using the RBL learning model, manage time well so that all stages in the RBL learning model are carried out and completed on time.

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Appendix 1

Student Worksheet for Learning with Rbl Model in Fourth Grade of Elementary School Students

Activity Title: Simple Research on Vegetative Organs of Plants

- **Activity Objective**

1. Identify the structure of plant vegetative organs
2. Explain the function of plant vegetative organs
3. Analyze the function of plant vegetative organs for human life

- **Activity steps**

1. The teacher divides students into groups
2. Each group is given an LKPD (student worksheet)
3. Students read the discourse provided several times and then formulate a problem.
4. Students observe the plant stem types in the school environment and fill in the observation table.
5. Students answer the questions provided to exercise creative thinking skills.
6. The time to do the activity is 40 minutes
7. Follow all learning instructions according to the activity steps.

- **Phase 1 Formulating the Problem**

Each group is asked to write down some questions about vegetative plant organs. Then, they think of a hypothetical answer to the question.

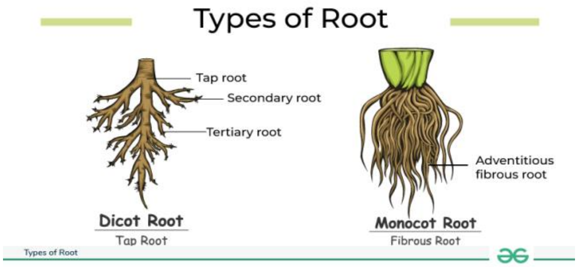
No.	Question	Provisional Answer

- **Phase 2 Reviewing Theory**

Read the discourse below on Vegetative Organs of Plants

Vegetative Organs of Plants

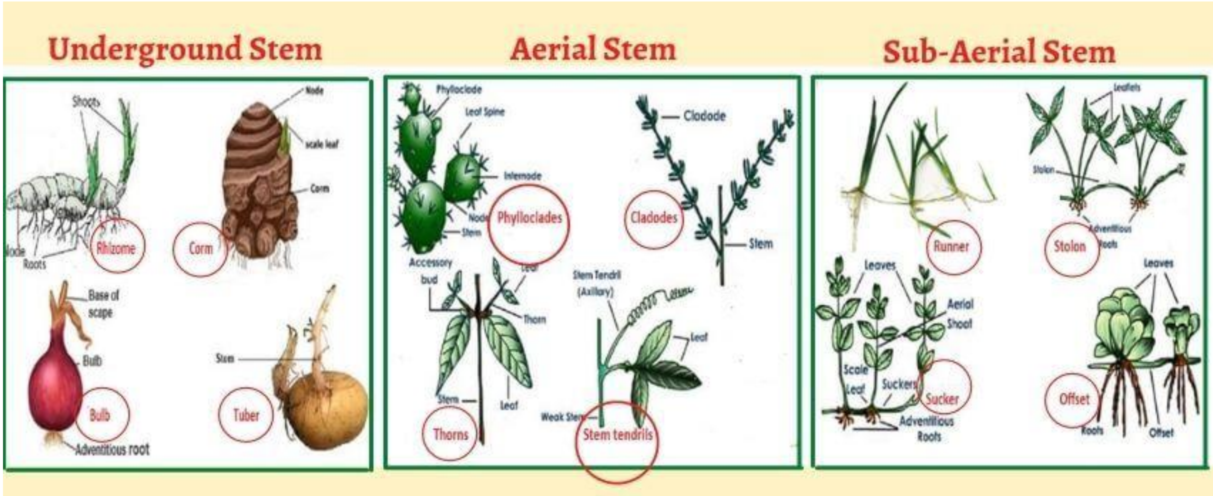
Plants are included in living things because they can grow and reproduce. Plants consist of vegetative organs and generative organs. Plant vegetative organs include roots, stems, and leaves. Roots are part of the plant that grows downward in the soil as a reinforcement and absorber of water and food substances and storage of food reserves. The root structure consists of the root shaft, root hood, root branches, and root hairs. Plant roots can be fibrous roots and taproots.



Source: https://www.geeksforgeeks.org/tap-root-diagram/

Leaves are the green part of the plant. The main function of leaves is as a place for photosynthesis. Chlorophyll is one of the main ingredients plants need to carry out the photosynthesis process. After getting chlorophyll and sunlight, plus water and minerals from the soil, plants can make their food through the process of photosynthesis. Leaves also act as a means of breathing plants through stomata.

The stem is the part of the plant that stands above the roots, where twigs and leaves grow. The stem serves as a means of transporting water and food substances and storing food reserves. There are two vessels in a stem: wood vessels (xylem) and vessels tapis (phloem). Wood vessels (xylem) transport water and nutrients from roots to leaves. Vessel tapis (phloem) is useful for transporting photosynthetic products from the leaves to all parts of the plant. The types of stems can be seen in the following figure.



Source: https://smartclass4kids.com/plant-stem/

Phase 3 Planning Investigations

The research will be conducted by observing plant organs in the environment around the school. Each group will observe the shape of the roots, stems, and leaves of plants found in the environment. Each group can use at least 5 types of plants in the neighborhood. During the observation, students are accompanied by the teacher.

Phase 4 Researching and Analyzing Data

Each group can pick the stems and leaves of plants in the environment and bring them to class to make careful observations. The observation data can be written in the following table.

Table of Plant Organ Shape Observation Results

No.	Plant Name	Root Shape	Leaf Shape	Rod Shape

Table of Plant Organ Function Observation Results

No.	Plant Name	Root Function	Leaf Function	Trunk Function

Afterward, the group discusses the following questions:

1. Plants should have 3 main vegetative organs: roots, stems, and leaves. Think of 4 possibilities of what happens to a plant that only has 2 vegetative organs.
2. Plant organs can be utilized for human life. Write down 4 forms of utilization of plant roots for human life.
3. Describe the shape of the stem organs in all the plants observed. Is the shape of the stem the same or different? Give your group at least four reasons.
4. Is the shape of the leaf organ observed in all the plants the same or different? Why is this the case?
5. Think of four possibilities of what would happen if no plants were around!

- **Phase 5 Explaining Research Results**

In this phase, the teacher organizes students to present the research results in class. The teacher's role is to facilitate this activity so that students' work can be appreciated. After that, the teacher guides students to make conclusions at the end of the lesson.