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The Influence of Mind Mapping Learning Strategies on Creativity and Sustainability Awareness of Elementary School Students in Motion Energy Learning

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Abstract: This study aims to analyze the influence of Mind Mapping learning strategies on the creativity and sustainability awareness of elementary school students in motion energy learning. This study uses a quantitative approach with a quasi-experimental research method with a nonequivalent control group design. The research subjects consisted of elementary school students who were divided into experimental groups with the application of Mind Mapping strategies and control groups with conventional learning. The research data was collected through creativity test instruments, sustainability awareness questionnaires, and observation of learning activities, then analyzed using inferential statistical tests. The results of the study show that the application of the Mind Mapping strategy has a positive influence on increasing students' creativity and sustainability awareness in motion energy materials. Students who participate in Mind Mapping-based learning show better ability to organize concepts, develop ideas, and understand the relationship between energy use and environmental sustainability. These findings suggest that the Mind Mapping strategy can be an innovative learning alternative that supports the development of creative thinking skills and sustainability literacy in primary schools. Thus, the Mind Mapping strategy contributes to creating science learning that is more meaningful, contextual, and oriented towards 21st century competency development.

Keywords: Creativity; Mind Mapping; Motion energy; Sustainability awareness

Introduction

Science learning of motion energy materials is often considered abstract by grade IV students. Conventional methods make students passive and hinder their creative development. In fact, creativity is a crucial skill of the 21st century that must be honed from an early age. . At the elementary school level, learning is not only geared towards mastering the content of the subject but also on the development of essential thinking skills that allow students to understand problems, connect ideas, and express their own perspectives. This research is important to provide practical solutions through mind mapping strategies. This strategy helps students visualize the concept of motion energy in a concrete and interesting way. The novelty of this research lies in the focus of its testing. While previous research measured cognitive learning outcomes or memory, this study specifically tested how mind mapping can stimulate the creative ideas and imagination of elementary school students in understanding science phenomena. However, conventional learning practices often place students in a passive position, where they primarily receive information from the teacher rather than actively exploring, organizing, and presenting their ideas. These conditions can limit students' opportunities to develop creativity, especially in learning environments where visual and interactive information becomes increasingly familiar to children (Bassan-Cincinatus, 2020; Bressler, 2022; Bhijakkanarin & Kenaphoom, 2024; Fadilla et al.,

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2021; Ji et al., 2023; Gao & Hall, 2026; Isrokatun et al., 2024).

Creativity is an important ability that needs to be developed from the early stages of education. In classroom learning, creativity allows students to generate a variety of ideas, look at problems from different perspectives, and develop flexible ways to understand abstract concepts. Creative students are generally more willing to express opinions, ask questions, take risks, and explore alternative solutions. Therefore, creativity should not be understood only as the ability to create something completely new, but also as the ability to combine existing information, modify ideas, and present concepts in a meaningful way. In the topic of motion energy, this ability is particularly relevant because students are required to relate scientific concepts to real-life situations, such as moving objects, daily activities, and energy use in their environment (Soares et al., 2024; Santillán & Cedano, 2023).

Motion energy learning in elementary school should provide students with a direct and meaningful experience. Through these topics, students can develop curiosity, active participation, conceptual understanding, and practical skills. Movement energy is also considered suitable for elementary school students because examples can be found easily in daily life, making the learning process more concrete and accessible. Nevertheless, students' understanding of the material does not automatically indicate that their creativity has developed well. In many classroom situations, learning is still focused primarily on completing material and achieving cognitive scores, while students' ability to express original ideas, organize thoughts, and present creative responses receives less attention. Based on the above background, this study aims to examine the influence of Mind Mapping learning strategies on the creativity of grade IV students in movement energy learning. This research is expected to provide empirical evidence on the use of Mind Mapping as an alternative learning strategy that can support more interesting, visual, and creativity-oriented science learning in elementary schools (Lee, 2023; Sukmawati et al., 2022).

One of the learning strategies that can support students' understanding of concepts and creativity is Mind Mapping. Mind Mapping is a visual learning technique developed by Tony Buzan to help students organize information through hierarchical and associative relationships using keywords, branches, symbols, colors, and images. This strategy allows students to formulate concepts systematically as well as connect various information related to a learning topic. In the learning of motion energy (Sari et al., 2021). Mind Mapping has relevance because it can help students visualize the relationship between scientific concepts, phenomena in daily life, and the application of energy in the surrounding environment. Thus, learning is not only oriented towards the mastery of concepts, but also encourages students to build a more contextual and meaningful understanding. In learning the energy of motion, Mind Mapping can help students visualize the relationship between scientific concepts, examples from everyday life, and the possibility of energy application, so that learning becomes more active, meaningful, and creative (Damanik et al., 2023; Schimpf et al., 2024; Syaflin et al., 2021; Tsai, 2023; Denning et al., 2026; Sari et al., 2021.

In addition to functioning as a tool for organizing information, Mind Mapping plays a role in improving students' cognitive processes through the activity of choosing, connecting, and representing ideas creatively. The use of visual elements such as colors, symbols, and images can stimulate divergent thinking so that students can more easily generate new ideas and see the relationships between concepts from different perspectives. The process of preparing mind maps involves the ability to analyze, synthesize, and elaborate, because students must determine the main information and develop its relevance in the form of visual representations that are in accordance with their understanding. However, the effectiveness of this strategy is still influenced by the teacher's ability to manage learning activities, provide relevant learning resources, and provide space for the diversity of students' creativity in producing Mind Mapping products. However, the implementation of Mind Mapping still requires careful classroom management because student participation, learning resources, and differences in students' visual products can affect the effectiveness of the learning process (Budiarto et al., 2026; Han & Abdrahim, 2023; Cromdal & Stoewer, 2022; Sukmawati et al., 2025, 2026; Sulistiani & Sukmawati, 2024).

Some learning problems point to the need for a more varied and student-centered strategy in teaching motion energy. Student creativity in this material remains a concern because learning activities are often less varied, visual techniques such as Mind Mapping have not been used optimally, and empirical evidence is still needed to assess its effectiveness in increasing student creativity. In addition, creativity must be measured through an objective approach so that the contribution of a learning strategy can be evaluated more clearly. Mind Mapping is assumed to provide students with the opportunity to actively organize concepts, connect ideas, and communicate their understanding in creative ways (Istiqomah &

Sukmawati, 2023; Izzati & Sukmawati, 2024; Nurliana & Sukmawati, 2023).

Method

Research Objectives

Based on the problems described in the previous section, this study aims to find out whether the implementation of Mind Mapping learning strategies has a positive and significant influence on the creativity of grade IV students in the topic of motion energy. Creativity in this study refers to students' creative thinking ability in solving problems or pouring ideas related to motion energy matter (referring to Torrance's theory). The aspects measured include fluency, flexibility, originality, and elaboration. This variable was measured quantitatively based on the score of the results of the Creative Thinking Ability Test (Motion Energy) given through pretest and posttest in both experimental and control classes.

Research Setup and Time

This research was conducted at SDN East Jakarta. This research was conducted from April to May of the 2026/2027 academic year.

Research Methods and Design

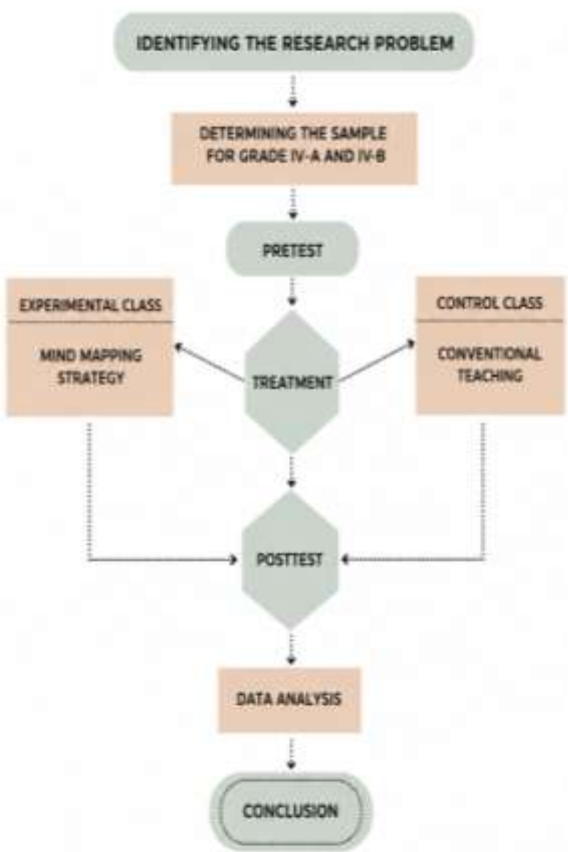

Figure 1. Research implementation flow

This study uses a quantitative approach with a quasi-experimental method using a Pretest–Posttest Control Group Design. This design was chosen to test the influence of Mind Mapping learning strategies on the creativity and sustainability awareness of elementary school students. The research involved two groups, namely the experimental class and the control class. Before the treatment was given, both groups took a pretest to find out the student's initial ability. Furthermore, the experimental class obtained learning using the Mind Mapping strategy, while the control class obtained conventional learning. After the entire learning process was completed, both groups took a posttest using the same instrument to find out changes in students' creativity and sustainability awareness after the treatment. This design allows comparison of learning outcomes between the two groups so that the influence of the Mind Mapping strategy can be analyzed objectively. After the learning process was completed, both groups were given a posttest using the same instrument to find out changes in students' creativity and sustainability awareness after the treatment (Saputri & Sukmawati, 2024; Lamanauskas & Malinauskienė, 2024; Fauziah & Sukmawati, 2023; Novianti et al., 2023).

Population and Sample

The population in this study is all grade IV students of SDN East Jakarta, consisting of two classes, namely class IV-A and class IV-B, with a total of 62 students. Population refers to all research subjects with specific characteristics that the researcher focuses on.

A sample is a part of a population that is selected to represent the entire population. The sampling technique used in this study is saturated sampling, which is a sampling technique in which all members of the population are used as samples. This technique is used because the population is relatively small, making it possible to study all members of the population.

In this study, class IV-A consisting of 31 students was designated as an experimental class, while class IV-B consisting of 31 students was designated as a control class. The division of classes is based on the conditions of the existing classes in the school without rearranging or randomizing students.

Research Variables

A research variable is something that is the object of observation and has certain variations to study and conclude. The study consists of two main variables: independent variables and dependent variables.

The independent variable in this study is the Mind Pemapping learning strategy. This variable refers to a variable that affects or causes changes in other variables.

In this study, the Mind Mapping strategy is defined as a learning technique that uses mind maps to help students organize ideas visually (Istmadelia & Tyas, 2024).

The dependent variable is the creativity of fourth-grade students in the topic of motion energy. This variable refers to a variable that is influenced by an independent variable. In this study, creativity refers to students' ability to generate ideas, develop thoughts, and present learning outcomes in an innovative way (Majid et al., 2023).

Definition of Operational Variables

The operational definition of variables refers to the explanation of research variables into a more concrete form so that they can be measured empirically. Through operational definitions, researchers can determine the indicators, instruments, and measurement techniques used in the research.

The study consists of two main variables: independent variables and dependent variables. The independent variable is the Mind Mapping learning strategy, while the dependent variable is the student's creativity. The operationalization of variables is carried out by describing each variable into an observable and measurable indicator. These indicators are then used as the basis for the development of research instruments, including questionnaires, assessment rubrics, and observation sheets.

Mind Mapping learning strategies are learning techniques that use mind maps to organize information visually, making it easier for students to understand the material and develop ideas. Mind Mapping in this study was measured through the implementation of observed learning steps using observation sheets.

Student creativity in this study is defined as the ability of students to generate ideas, develop thoughts, and present learning results innovatively. Creativity is measured based on the indicators proposed, namely fluency, flexibility, originality, and elaboration. Creativity was measured by using questionnaires and assessment of students' mind map products to obtain more comprehensive data

Operational definitions are prepared to ensure that each variable can be measured objectively and systematically. The Mind Mapping variable was measured through observation of learning implementation, while student creativity was measured through questionnaires and product assessments. The use of two instruments for creativity variables aims to obtain more valid data, namely perception data through questionnaires and performance data through student work. Thus, the results of the research are expected to be able to describe student creativity more accurately (Rohmatulloh et al., 2022).

Research Instruments

Research instruments are tools used to collect data so that data can be processed and analyzed more easily. The instruments in this study were developed based on indicators that are relevant to the variables studied.

This instrument for measuring student creativity was developed based on Torrance's creativity indicators, namely fluency, flexibility, originality, and elaboration. These indicators reflect creative thinking skills, including the ability to generate multiple ideas, generate varied ideas, generate unique ideas, and develop ideas in detail (Hariyadi et al., 2023).

The instruments used were a Likert scale questionnaire and a product evaluation rubric. The Likert scale is used to measure students' attitudes and perceptions of learning, while the assessment rubric is used to evaluate student products in the form of a mind map.

For independent variables, the instrument used is an observation sheet for the implementation of learning. This instrument is used to observe the extent to which the Mind Mapping strategy is applied during the learning process. The scale used is the Guttman scale in the form of a checklist with "Yes" and "No" answers.

The percentage of creativity is calculated using the following formula:

$$\text{Percentage} = \frac{\text{Score obtained}}{\text{Maximum score}} \times 100\% \tag{1}$$

The categories of creativity are defined as follows: 81–100% = Very Creative, 61–80% = Creative, 41–60% = Moderately Creative, 21–40% = Less Creative, and 0–20% = Not Creative.

For the Mind Map variable, the instrument used is an observation sheet for the implementation of learning. The scale used is the Guttman scale.

Data Collection Techniques

The data collection techniques used in this study include tests, questionnaires, and observations. This test is used to measure students' creativity before and after treatment. The test is designed in the form of open-ended assignments that allow students to develop ideas creatively.

Questionnaires are used to measure creativity based on specific indicators using the Likert scale. Questionnaire is a data collection technique that is carried out by giving questions or written statements to respondents. Observation is used to observe the implementation of Mind Mape learning. Observations are made directly during the learning process.

Validity and Reliability Tests

Validity testing is performed to determine the extent to which the instrument is capable of measuring what it is intended to measure. In this study, validity was tested through content validity by requesting expert judgment and empirical validity using Product Moment correlation. An instrument item is declared valid if the r-count value is higher than the r-table at a certain significance level. Invalid items will be revised or removed so as not to affect data quality.

Reliability testing was carried out to determine the level of consistency of the instrument in measuring research variables. In this study, reliability was tested using Alpha Cronbach. This instrument is considered reliable if the Alpha Cronbach value ≥ 0.70, indicating that it has good internal consistency.

Data Analysis Techniques

Data analysis is carried out to process the data obtained in order to answer research problems and test research hypotheses. Data analysis begins with descriptive analysis to describe the general state of the data, including mean, median, mode, standard deviation, maximum score, and minimum score. This analysis aims to provide a preliminary idea of the level of student creativity.

The prerequisite analysis test includes normality and homogeneity tests. The normality test was performed to determine whether the data was distributed normally, while the homogeneity test was performed to determine whether the variance between groups was the same. The normality test uses the Shapiro-Wilk test, while the homogeneity test uses the Levene test.

Once the data met the necessary assumptions, the hypothesis was tested using an Independent Sample t-test to determine if there was a significant difference between the experimental class and the control class. If the significance value is less than 0.05, an alternative hypothesis is accepted.

In addition, effect size testing was carried out using d Cohen to determine the magnitude of the influence of the Mind Pemapping learning strategy. Effect size provides information about the practical strength of the effect, not just its statistical significance.

Results and Discussion

The research was carried out at SDN East Jakarta by involving 62 grade IV students who were divided into experimental classes (IV-A) and control classes (IV-B). The experimental class obtained learning using the Mind Mapping strategy, while the control class followed conventional learning. During the research, students in the experimental class actively compiled a mind map based on the concept of motion energy through group discussion activities, concept exploration, presentation of results, and learning reflection.

Figure 2. Documentation of the implementation of the mind mapping strategy

Learning Outcomes

The results of the pretest showed that the initial creativity of students in the experimental class and the control class were relatively the same. These conditions show that both groups have balanced initial characteristics that make them suitable for use in experimental research. The pretest is done before the treatment to identify the student's initial level of creativity, while the posttest is done after the learning process to determine the change in the student's creativity (Zerinou et al., 2020).

After treatment, the results of the posttest showed a clear difference between the two groups. The experimental class obtained posttest scores ranging from 80 to 91, while the control class obtained scores ranging from 67 to 75. These results show that students who learn through the Mind Mapping strategy show a higher increase in creativity than those who learn through conventional teaching. Higher and more evenly distributed posttest scores in experimental classes show that Mind Mapping encourages students to be more active in developing ideas and expressing creative thoughts (Sukmawati & Zulherman, 2023).

Discussion

The increase in students' creativity in the experimental class showed that the use of Mind Mapping was able to help students organize information visually so that the concepts of motion energy became easier to understand. Through the preparation of ideas branches, the use of colors, symbols, and images, students not only remember the material but also build relationships between concepts independently. This process encourages the development of creativity indicators in the form of fluency, flexibility, originality, and elaboration as stated by Torrance.

The results of this study are in line with research that states that Mind Mapping helps students understand the relationships between concepts so that learning becomes more meaningful. These findings are also supported by those who explain that visual activities in learning are able to improve creative thinking skills through the process of generating new ideas (Lestari et al., 2022; Azhari, 2024).

In addition to increasing creativity, Mind Mapping also encourages students to be more active during the learning process. Students not only receive information from the teacher, but also engage in discussions, express opinions, develop ideas, and present the results of their work to classmates. These activities are in accordance with the opinion that activity-based learning is able to increase student involvement in building knowledge independently (Ifdaniyah & Sukmawati, 2024).

The findings of this study also reinforce the results of research showing that visual-based learning strategies can increase the creativity of elementary school students. Similarly, the research explains that the use of media and innovative learning strategies is able to increase science literacy as well as students' creativity.

In the control class, the increase in creativity tends to be lower. Conventional learning is still dominated by the delivery of material by teachers, so students' opportunities to develop ideas, explore concepts, and produce visual representations are more limited. As a result, students' creativity develops more slowly than in the experimental class. These findings support research that student-centered learning has a greater impact on the development of higher-level thinking skills than conventional learning (Castañeda-Garza & Valerio-Ureña, 2023).

Overall, the results show that the Mind Mapping strategy not only increases students' creativity, but also creates more active, meaningful, collaborative, and 21st-century skills-development-oriented learning. Therefore, this strategy is feasible to be applied as one of the alternatives to science learning on motion energy materials in elementary schools (Sreepadi & Kunnampalli, 2026).

Table 1. Descriptive statistics of student creativity score

	Survive		Post-Tests	
	Experiment class	Control class	Experiment class	Control class
Average	60	60	85.67741935	71
Maximum	64	64	91	75
Minimum	56	56	80	67
Stdv	2.2576	2.2576	3.2268	2.2576

Further descriptive statistical analysis supports this pattern. The average score of the experimental and control class pretest was 60, with the same maximum score of 64, a minimum score of 56, and a standard deviation of 2.2576. These values affirm that both groups have the same level of initial creativity. After treatment, the average post-experimental class score increased to 85.68, with a maximum score of 91, a minimum score of 80, and a standard deviation of 3.2268. In contrast, the control class achieved a post-traumatic mean score of 71, with a maximum score of 75, a minimum score of 67, and a standard deviation of 2.2576. The difference between the two posttest means shows that the Mind Mapping strategy contributes more strongly to the development of students' creativity than conventional learning.

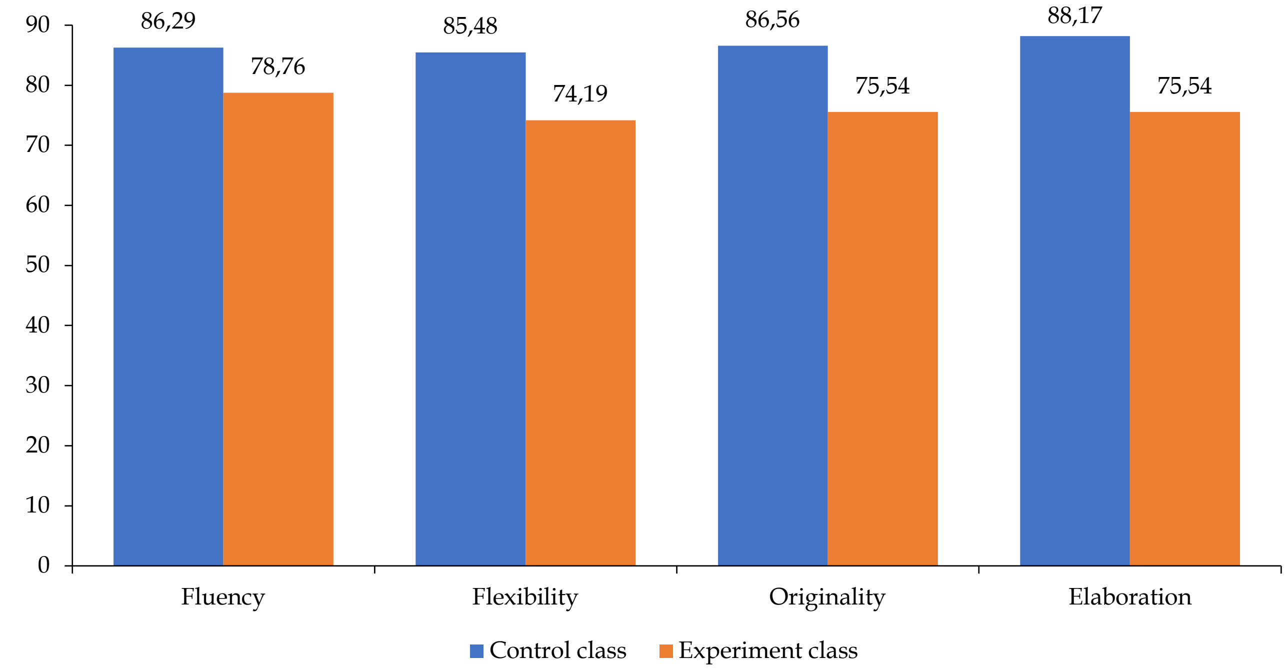

Figure 3. Student creativity score chart

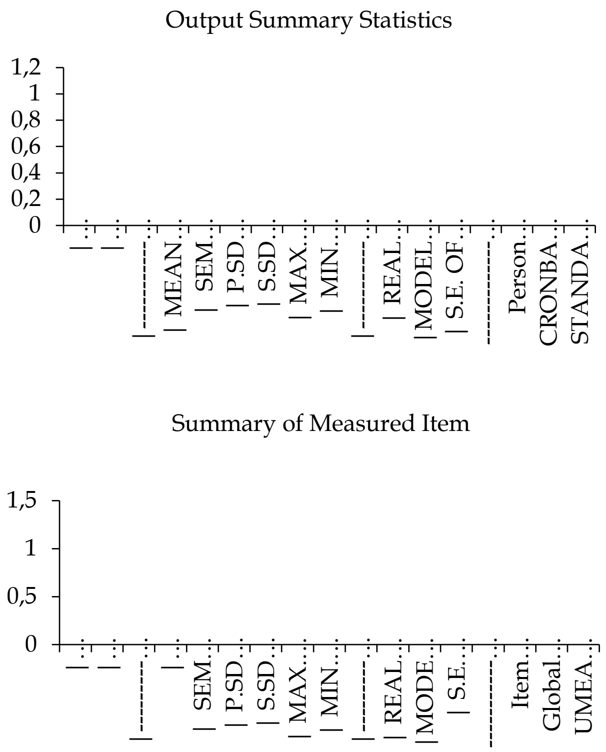

Figure 4. Summary of statistical outputs

The quality of the research instruments was checked using Rasch model analysis through Winsteps. Reliability analysis showed that the instrument had good consistency in measuring students' abilities. The Reliability Value of People was 0.87 in the real model and 0.89 in the model estimate, indicating that the instrument was able to distinguish the level of ability of students consistently. A Person Separation Score of 2.59 also indicates that the instrument can classify students into about three levels of ability: low, medium, and high.

The Item Reliability Value is 0.61 in the real model and 0.70 in the model estimate, indicating an adequate level of item consistency. Meanwhile, a Cronbach Alpha (KR-20) value of 0.92 indicates a very high internal consistency. This means that the interaction between respondents and items is strong, and the instrument can be relied upon to be used in research. The average values of INFIT MNSQ and OUTFIT MNSQ for people and goods are close to the ideal value of 1.00, indicating that the data generally conform to the Rasch model (Fauziah & Sukmawati, 2023).

An item suitability analysis is performed to check whether each item meets the criteria of the Rasch model. An item is considered suitable when the MNSQ Outfit value is between 0.5 and 1.5, the ZSTD value is between -2.0 and +2.0, and/or the Corr Pt-Mean value is between 0.4 and 0.85.

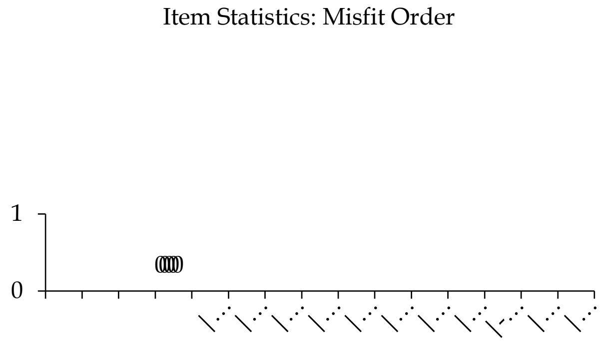

Figure 5. Misfit order output

Table 2. Item fit analysis based on Rasch model

Question Item Number	Clothes of MNSQ	ZSTD Clothing	PT-Average Corr	Measurement Accuracy Criteria	Decision
Item 1 (FL)	0.58	-1.07	0.65	Suitable	Retained
Item 2 (EU)	0.56	-1.11	0.53	Suitable	Retained
Item 3 (NC)	0.58	-1.21	0.78	Suitable	Retained
Item 4 (BI)	0.53	-1.44	0.85	Suitable	Retained
Item 5 (LI)	1.45	1.94	0.63	Suitable	Retained
Item 6 (TY)	0.52	-1.06	0.65	Suitable	Retained
Item 7 (OR)	0.62	1.13	0.54	Suitable	Retained
Item 8 (GI)	0.62	-1.02	0.55	Suitable	Retained
Item 9 (IN)	1.26	0.92	0.55	Suitable	Retained
Item 10 (EL)	0.61	-1.02	0.7	Suitable	Retained
Item 11 (BO)	1.41	1.22	0.62	Suitable	Retained
Item 12 (RA)	0.66	-1.13	0.92	Suitable	Retained

The results showed that all 12 items were suitable and maintained for use in this study. MNSQ Apparel Value ranges from 0.52 to 1.45, while ZSTD Apparel value ranges from -1.44 to 1.94. In addition, all items have a positive Pt-Mean Corr value. These findings suggest that the items are appropriate for measuring student creativity and are consistent with the requirements of the Rasch model.

Item difficulty analysis shows that the instrument has a balanced distribution of difficulty levels. Some items are categorized as easy, some are categorized as moderate, and two items are categorized as difficult. This distribution is important because it allows the instrument to measure students with different skill levels in a more proportional way.

Table 3. Item difficulty

Item	Measuring	Category
FL	0.49	Medium
WE	-0.25	Medium
NC	0.13	Medium
BI	-0.06	Medium
LI	1.31	Difficult
TY	-0.46	Medium
OR	-1.11	Easy
IG	-0.46	Medium
DI U	1.62	Difficult
THE	-0.88	Easy
BO	0.31	Medium
RA	-0.66	Medium

Wright's Map analysis shows the distribution of students' abilities and item difficulty on the same logit scale. Students' abilities are generally above the average item difficulty level, as many respondents are in the positive logit range, especially between 1 and 4 logits. Item 9 (IN) is the most difficult item, followed by item 5 (LI). Meanwhile, Item 7 (OR) is the easiest item, followed by Item 10 (EL). Most of the other items are in the intermediate range, indicating that the instrument has a fairly even level of difficulty and can measure students' creativity at different skill levels.

Hypothesis testing was performed using an Independent Sample t-test to determine if there was a significant difference between the experimental class and the control class. The results show a significance value of 0.000, which is lower than 0.05. Therefore, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. This means that the Mind Mapping learning strategy has a significant influence on the creativity of fourth grade students in the topic of motion energy.

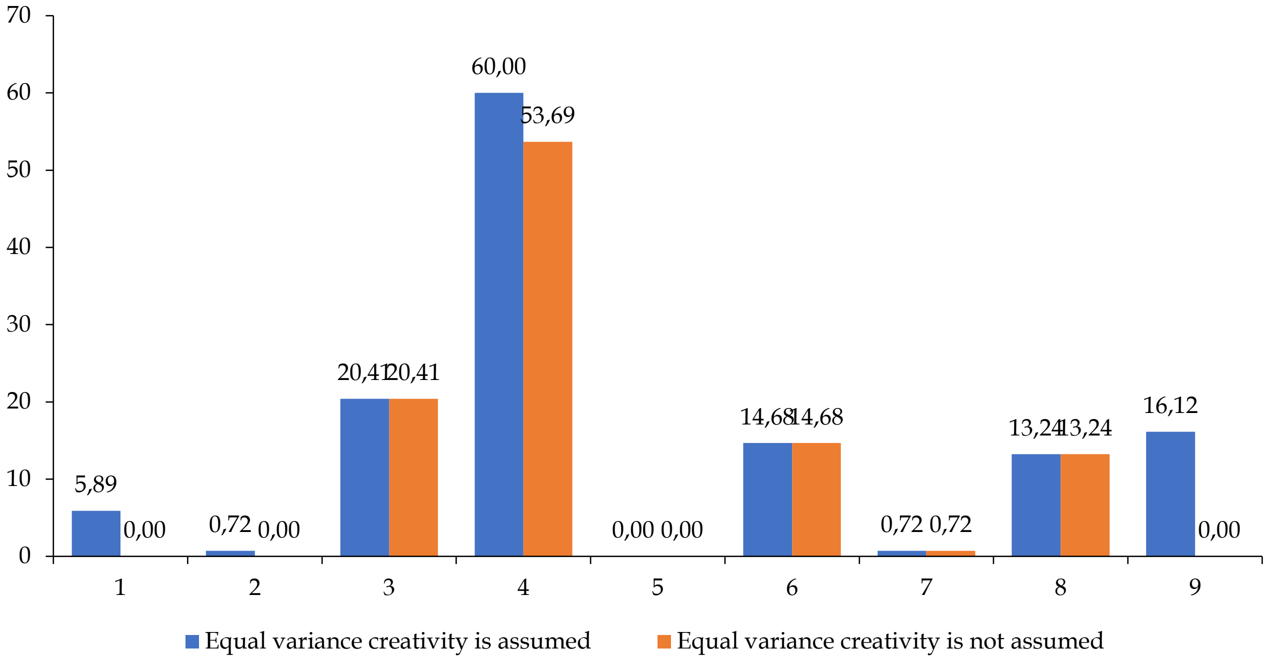

Figure 6. Independent sample t-test results

The t-test results also showed an average difference of 14.67742, indicating that the creativity score of the experimental class was higher than that of the control class. This difference is not only statistically significant but also meaningful in the context of learning. The calculation of the effect size using d Cohen yielded a value of 4.02, which falls into the large category. These results show that the Mind Mapping strategy has a very strong practical effect in increasing students' creativity (Bassan-Cincinatus, 2020; Bressler, 2022; Isrokatun et al., 2024).

The findings show that Mind Mapping supports students in organizing information visually and systematically. Through this strategy, students are not only required to remember the material but also to formulate ideas, connect concepts, and present their understanding in a creative form. This learning process provides more space for students to express ideas, use visual symbols, and develop their own interpretations of the concept of motion energy (Bhijakkanarin & Kenaphoom, 2024; Fadilla et al., 2021; Gao & Hall, 2026).

The improvement in the experimental class can be understood through the nature of Mind Mapping itself. In the learning process, students are encouraged to identify key ideas, develop related branch concepts, and use colors or visual shapes to represent their thoughts. This activity helps students practice aspects of creative thinking such as fluency, flexibility, originality, and elaboration, as proposed by Torrance. Therefore, Mind Mapping is not only useful as a note-taking technique but also as a learning strategy that stimulates students' creative expression (Martínez-Borreguero et al., 2020; Deng & Shen, 2024; Fitriadi et al., 2025; Kervinen et al., 2020).

In contrast, the control class showed a lower increase in creativity. Conventional learning tends to provide fewer opportunities for students to explore ideas independently. When learning is more teacher-centered, students may understand the material but have limited space to turn that understanding into original and varied responses. This explains why the graduate score in the control class increased, but the increase was not as strong as in the experimental class (Cromdal & Stoewer, 2022; Setiawan & Islami, 2020; Soares et al., 2024).

These results are also consistent with research, which found that the use of Mind Mapping has a positive effect on students' understanding of motion-related concepts. In this study, the strategy also showed a strong contribution to creativity, especially since students were actively involved in producing visual representations of the material (Han & Abdrahim, 2023; Lee, 2023; Mayhoffer et al., 2026).

Overall, the results of the study show that the Mind Mapping learning strategy is effective in increasing the creativity of grade IV students in the topic of motion energy. The significant t-test results and large effect sizes suggest that the difference between the experimental and control classes is not only statistically evident but also educationally meaningful. Therefore, Mind Mapping can be considered an innovative learning strategy that helps create a more active, visual, and creativity-oriented classroom experience (Lu et al., 2022).

Conclusion

This study shows that Mind Mapping learning strategies are effective in increasing the creativity and sustainability awareness of elementary school students in motion energy materials. The application of Mind Mapping helps students visually organize concepts, connect ideas, and develop more creative and meaningful thinking during the learning process. Thus, Mind Mapping can be an innovative alternative learning strategy to support science learning in elementary schools while developing 21st century skills. Therefore, Mind Mapping can be considered an effective alternative learning strategy to increase students' creativity, particularly in the topic of motion energy at the elementary school level.

Suggestions

Based on the results of the research, elementary school teachers are advised to apply the Mind Mapping strategy as one of the learning alternatives that can increase students' creativity and sustainability awareness, especially in conceptual materials such as motion energy. Further research is suggested to involve a larger number of samples, carried out at different levels of education and learning materials, and examine the influence of Mind Mapping on other skills, such as critical thinking, problem-solving, collaboration, and science literacy, so as to obtain a more comprehensive understanding of the effectiveness of these strategies.

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Author's contributions

Conceptualization, methodology, H.A. and W.S.; investigation, data curation, formal analysis, visualization, writing—preparation of original drafts, acquisition of funding, H.A.; writing—review and editing, supervision, provision of resources, project administration, W.S. All authors have read and approved the final version of the published manuscript.

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Conflicts of Interest

The authors declare that there are no conflicts of interets.

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