Received : 30 March 2025
Revised : 30 May 2025
Accepted : 17 June 2025
Published: 30 June 2025
Issued : 30 June 2025

DOI: doi.org/10.21009/1.11107

Quantitative Analysis of Creative Thinking Skills and Concept Mastery in Physics: Temperature & Heat

Sri Mindia Vanessa Pratiwi[1], Ketang Wiyono[1,a)], Ismet[1], Yeni Utami[2]

[1]*Master of Physics Education Study Program, Faculty of Teacher Training and Education, Universitas Sriwijaya, Jl. Palembang-Prabumulih, Sumatera Selatan 30662, Indonesia*
[2]*SMA Negeri 2 Palembang, Jl. Puncak Sekuning No.84, Lorok Pakjo, Palembang, Sumatera Selatan 30137, Indonesia*

✉: [a)]ketang_wiyono@fkip.unsri.ac.id

Abstract

This study aims to identify students' creative thinking skills and concept mastery in the context of temperature and heat material at SMA Negeri 2 Palembang and to explore the relationship between these two variables. A quantitative descriptive research design was employed, involving 60 students from class XI. Data was collected using the PhysCreTHOTS test, which assesses creative thinking and concept mastery. The results showed that students' creative thinking skills averaged 48.3%, falling within the "sufficient" criteria. Specifically, scores for fluency, flexibility, originality, and elaboration were 55%, 44.9%, 44.8%, and 46.7%, respectively, all within the "sufficient" range. Concept mastery scores were 50.2% for C4, 51.9% for C5, and 46.4% for C6, indicating "moderate" criteria. A significant positive correlation ($r = 0.512$, $p < 0.01$) was found between creative thinking skills and concept mastery. The findings indicate that while students exhibit moderate levels of creative thinking and concept mastery, there is a significant relationship between these skills. This underscores the importance of fostering creative thinking to enhance conceptual mastery in physics education, especially in the context of temperature and heat materials.

Keywords: creative thinking skill, mastery of concepts, temperature and heat

INTRODUCTION

The low quality of education can cause backwardness in a nation's or country's development (Kurniawati, 2022). Education is a crucial element for the future because it is always emphasized as a preparation for the roles that students will play in the future. If a nation's education is successful, the quality of its human resources will improve. The success of education must be supported by the presence of creativity in the learning process (Hasanah, Parno, and Hidayat, 2021; Armandita, 2018). In the 21st century, learning consists of 4C (Critical Thinking, Communication, Collaboration Skills, and Creative Thinking). These skills can generate superior human resources (HR), especially in the development and application of creative thinking skills (Damayanti, Santyasa, and Sudiatmika, 2020; Sutriyono, Ismet, and Wiyono, 2022). Creative thinking skills are essential for solving problems and finding alternative solutions, and these skills become valuable assets in facing challenges, especially in the current era of globalization (Rofiqoh, Subiki, and Budiarso, 2020). According to Widana et al. (2021), in the current era, creative thinking skills are very important for students because they help them adjust to the dynamics of change and development of the times. Creative thinking skills enable students to generate new ideas and concepts, find innovative solutions to problems, and

anticipate potential possibilities (Kamid et al., 2022; Nazhifah and Wiyono, 2023). Indicators of creative thinking skills consist of four, namely (1) fluency, This is the skill to find relevant concepts to solve a problem; (2) flexibility, Skills to find a variety of diverse ideas; (3) originality, which Is the capacity to create new ideas that come from one's own thinking; and (4) elaboration, which is the skill to think in detail and systematically (Siswanto, 2018). These skills enable individuals to find new approaches to problem-solving and adapt to rapid change. Therefore, the integration of creative thinking skills in education is necessary to prepare an innovative and adaptive generation (Mursidik, Samsiyah, and Rudyanto, 2015; Usman and Gorontalo, 2024). Creative thinking skills will be more meaningful if supported by strong concept mastery.

Concept mastery occurs when the knowledge provided to students is not just memorization but also an understanding of basic concepts, enabling students to comprehend better the nature of the material being taught (Hara, Astiti, and Lantik, 2023). Students' active participation in scientific activities, exploration, and direct experience in learning helps develop concept mastery skills (Sundari, 2019). To master the concept, one must master six categories of cognitive processes in the revised Bloom's taxonomy (Sihaloho et al., 2023). Based on the revised Bloom Taxonomy, concept mastery develops through several levels, namely remembering, understanding, applying, analyzing, evaluating, and creating. To achieve a deeper understanding, students need to go beyond mere memorization and develop higher-order thinking skills, enabling them to apply and analyze concepts in various contexts (Wijaya, Jamaluddin, and Hadiprayitno, 2020). Good conceptual mastery will trigger and demonstrate good learning outcomes, building solid knowledge. Creative thinking skills and concept mastery have an interrelated relationship and are also positively correlated, meaning that the higher a person's creative thinking skills, the more likely they are to be accompanied by strong concept mastery. This is due to the encouragement of creative thinking skills, which foster individuals' curiosity, exploration, and desire to try new things related to the concepts being studied, thereby enhancing their understanding (Etikamurni and Sutopo, 2019). Creative thinking skills and concept mastery mutually support one another in physics learning. Strong concept mastery is the basis for developing creativity, while creative thinking allows the application of concepts in new situations and innovative problem-solving (Ningrum, Rahman, and Riandi, 2022). Therefore, the relationship between concept mastery and creativity in physics learning helps students understand the material more deeply and face real challenges (Ismail, 2022). This not only helps students understand the material deeply but also prepares them to face challenges and complex problems in the real world (Hasanah, Parno, and Hidayat, 2021).

Creative thinking skills and concept mastery are very important in physics education because they interact with each other and can help solve physics problems. This statement is supported by previous research that both are very important and complementary in physics education, creative thinking skills help students to understand physics concepts in a more in-depth and innovative way, while mastery of physics concepts provides a solid foundation for creative thinking in the context of physics (Nuriyah, Suwarma and Kaniawati, 2021; Andriani, 2023). Therefore, creative thinking skills and concept mastery are worth studying from any perspective, especially in physics education. Physics is a scientific discipline that examines the reasons, causes, and processes of natural phenomena and answers the questions of why, how, and why natural phenomena occur. One of the objectives of physics learning is to enhance students' knowledge, understanding, and analytical skills of the surrounding environment and its context (Wulandari, 2023). Temperature and Heat is one of the physics subject topics. Physics is often considered a challenging subject because it involves the use of formulas and complex calculations. A small percentage of high school students show interest in physics, but some of them may choose a major without physics because of the perception that physics material is difficult to understand, scary, and involves a lot of calculations and equations (Syamsul Mawardi, Muh. Yusuf Hidayat, 2023). For grade XI high school students, temperature and heat materials are not easy to understand. According to Rusilowati (2006), as cited in Darma Wulan, Sutarman, and Tahan Sungkowo (2021), temperature and Heat are often the main challenges in learning physics for students. This concept is often difficult to understand because it uses complex terms, giving rise to various interpretations and thoughts among students when they learn it. Learning difficulties are a factor that can cause failure or at least interfere with learning progress. In addition, understanding creative thinking skills and the concepts of temperature and Heat are very important in education because of their wide application in life and science, Mastery of these concepts helps students understand thermal

energy transfer, changes in form, and increased energy efficiency. In addition, creative thinking allows students to find innovative solutions, such as designing better thermal insulation or analyzing the impact of temperature on technology and the environment; this understanding is relevant in engineering, health, and climate change (Hara, Astiti, and Lantik, 2023; Mulder and Siswanto, 2023; Indiana, Amaliyah and Hartini, 2024; Rini, Sitompul, and Hamdani, 2024).,

Based on the results of previous research conducted by (Windiarti and Mayasari, 2019) the results of students' creative thinking skills were obtained with a presentation of 80% in the low category. Research conducted by (Muhsin Hidayat, Sidin Ali and Jln Daeng Tata Raya, 2018)found that the results of students' creative thinking skills in class 11 mipa with a score of 22.4 out of a maximum score of 40. (Rohman, Ishafit and Husna, 2021) stated that one of the high schools found many students who were less active and creative in learning physics. And according to (Reynawati and Purnomo, 2018) the data shows that the average value of students' creative thinking skills is 28.53, which is included in the less creative category then according to research (Sirait, Sinaga, and Mulyono, 2018) states the results of the student creative thinking skills test are not optimal, with students only being able to provide one solution so that in the dimensions of creative thinking skills such as fluency, flexibility, and originality, there are still visible deficiencies. As for mastery of concepts that have been carried out by (Intisavira, Sari Mustika, and Karim, 2023) stated that high school students still have difficulties in mastering the concepts of temperature and heat. Only about 6.87% of Indonesian students have adequate skills in understanding the concepts of temperature and heat, while about 93.13% of other students have insufficient skills in this regard, so from this study that students still do not have complete mastery of concepts for temperature and heat material. Then in a study conducted by (Hara, Astiti and Lantik, 2023) stated that students who experienced errors in concept mastery were 54%.

SMA Negeri 2 Palembang was established in 1957 with the current accreditation is “A” for class XI with 30 students per class. The results of interviews with physics teachers of SMA Negeri 2 Palembang said that the ability to think creatively and mastery of physics concepts in class XI is still lacking, this is supported by a small number of students whose scores are still below the KKM which is 75. According to the physics teacher of SMA Negeri 2 Palembang, students' thinking skills are still lacking because students still lack curiosity in their interest in learning, the apperception of class XI students still has to be provoked. And students must use examples of everyday items. And student language is still lacking in idealistic language. Students understand better by using their mother tongue (regional). Based on the above background, this study aims to identify creative thinking skills and concept mastery in learning physics on the subject of temperature and heat at SMA Negeri 2 Palembang, as well as the relationship between creative thinking skills and concept mastery.

METHODS

The method applied in this research is a descriptive quantitative method with a test method. The quantitative descriptive method is a research approach that focuses on one case to be investigated in detail by limiting observations to other cases. The quantitative approach was chosen because this research involves standardized measurements, specifically using test instruments with results in the form of numerical data that are analyzed statistically. Quantitative descriptive analysis was used to describe the pattern of participants' answers in the form of percentages so as to provide an objective picture of the pattern of their answers. This research focuses on a phenomenon, specifically creative thinking skills and the mastery of the concept of temperature and heat materials.

The population in this study consisted of students from Class XI at SMA Negeri 2 Palembang. The sample used in this study employed a purposive sampling technique (W John and N C, 2018). This technique was chosen because it provides equal opportunities for each member of the population to become a respondent so as to reduce sample bias (Firmansyah and Dede, 2022). The criteria used in selecting this sample are students who have studied temperature and heat material, so they have sufficient basic knowledge to answer the test. As well as students from classes with relatively uniform academic backgrounds to ensure the accuracy of the comparison of results. Thus, two classes with a total of 60 students were selected as research samples. The selection of grade XI students as research subjects was based on the consideration that they already have a fairly strong foundation of physics

concepts, so they can more easily understand the material provided. In addition, at this level, students begin to be directed to develop higher-order thinking skills, which is the focus of this study.

The test instrument used is a creative thinking skills test developed by Istiyono, Dwandaru Brams, and Rahayu (2018), namely the PhysCreTHOTS test, which measures creative thinking skills equipped with concept mastery. This instrument was chosen because it measures creative thinking skills in more depth through reasoned multiple-choice questions, integrates aspects of concept mastery with creative thinking skills, and has a structured scoring system to classify student answer patterns. This test contains multiple-choice questions on temperature and heat, requiring reasoning. Then, the assessment is based on four categories. Category 1 is when the student's question and reason are wrong; Category 2 is when the student answers the question correctly, but the reason chosen is wrong; Category 3 is when the student answers the question incorrectly, but the reason used is correct; Category 4 student answer the question and reason correctly.

We used a computer-based test (CBT), which required us to convert the hard file questions into CBT-based questions. The researcher chose Google Forms, an online survey platform that facilitates the process of making tests. The data collection stage begins with the creation of a form through the Google Forms platform. This form is designed with various types of questions, in accordance with the research objectives, presented in multiple-choice format. To improve data accuracy, the answer key feature and automatic scoring are enabled for multiple-choice questions. Students receive test questions in the form of a link, after which students can take the test using their cell phones or laptops, making the exam easier for students. Google Forms automatically collects and stores all responses in a Google Spreadsheet, which facilitates further data analysis (Pramadjaya et al., 2021; Widayanti, 2021). In addition, Google Forms provides data visualization features in the form of graphs and diagrams, which helps in processing information quickly and systematically, as well as data accuracy and structurability, making it an effective choice in this study (Asqia and Nabarian, 2021). The data provided by the respondents were kept confidential and only used in this study. To find the relationship between creative thinking skills and concept mastery using person correlation. Furthermore, the results of students' answers after answering the test were analyzed using the formula and SPSS:

$$score = \frac{\sum score}{\sum maximum\ score} \times 100\% \quad (1)$$

The criteria for assessing students' creative thinking skills are presented in TABLE 1, while the concept mastery criteria are interpreted and presented in TABLE 2. These tables serve as references to classify and interpret students' performance, ensuring that the analysis results are systematic, transparent, and in line with the objectives of this research..

TABLE 1. Criteria for Creative Thinking Skills (Nazhifah *et al.*, 2023)

Percentage %	Criteria
81 – 100	Very Good
61 – 80	Good
41 – 60	Quite
21 – 40	Deficient
0 – 20	Very Deficient

TABLE 2. Concept Mastery Criteria (Azizah, Parno and Supriana, 2019)

Score Range %	Criteria
$66.68 < Z < 100$	High
$33.34 < Z < 66.67$	Moderate
$0 < Z < 33.33$	Low

TABLE 3 provides guidelines for interpreting correlation coefficients, indicating the strength and direction of the relationship between variables.

TABLE 3. Correlation coefficient guidelines (Auw et al., 2023)

Correlation Coefficient Value	The Power of Correlations
0.00 – 0.25	The correlation is *very weak*
0.26 – 0.50	The correlation is *sufficient*
0.51 – 0.75	The correlation is *strong*
0.76 – 0.99	The correlation is *very strong*
1.00	The correlation is *perfect*

RESULTS AND DISCUSSION

Result

Creative Thinking Skills

The results of the data obtained from student answers were then analyzed to evaluate the extent of students' creative thinking skills on temperature and heat material. The results of the analysis can be seen in TABLE 4 and TABLE 5.

TABLE 4. Recapitulation of Data on the Acquisition of Students' Creative Thinking Skills

Category	Percentage
Average Score	48.3
Minimum Score	27
Maximum Score	80
Standard Deviation	12.04

TABLE 5. Results of Recapitulation of Percentage Analysis of the Number of Students for Each Criterion of Creative Thinking Skills

Definition	Criteria	Number of Students	Percentage
81 – 100	Very Good	0	0
61 – 80	Good	7	12
41 – 60	Quite	35	58
21 – 40	Deficient	18	30
0 – 20	Very Deficient	0	0

Based on TABLE 4, after testing the creative thinking skills of class XI students at SMA Negeri 2 Palembang, the average score was 48.3, which falls within a sufficient category. From a total of 60 students, the highest score is 80, and the lowest score is 27. The standard deviation obtained is 12.04. TABLE 5 shows that there are no students in the very good and very poor categories. In the good criteria, as many as seven students, with a percentage of 12%, meet this criterion. These students receive a score of 4 out of 11 available questions; in other words, they can answer the questions correctly and provide the right reasons. However, most of them still receive scores of 3 and 2, so that no student has reached the maximum score or entered the excellent category. A total of 35 students, representing 58% of the class, met the sufficient criteria.

FIGURE 1 presents an overview of creative thinking skills analyzed based on several important indicators. Creative thinking skills encompass various aspects, such as fluency in generating ideas, flexibility in finding alternative solutions, originality of ideas, and the ability to elaborate ideas in more detail. Understanding each of these indicators is essential to see the extent to which students are able to apply creative thinking in the learning process.

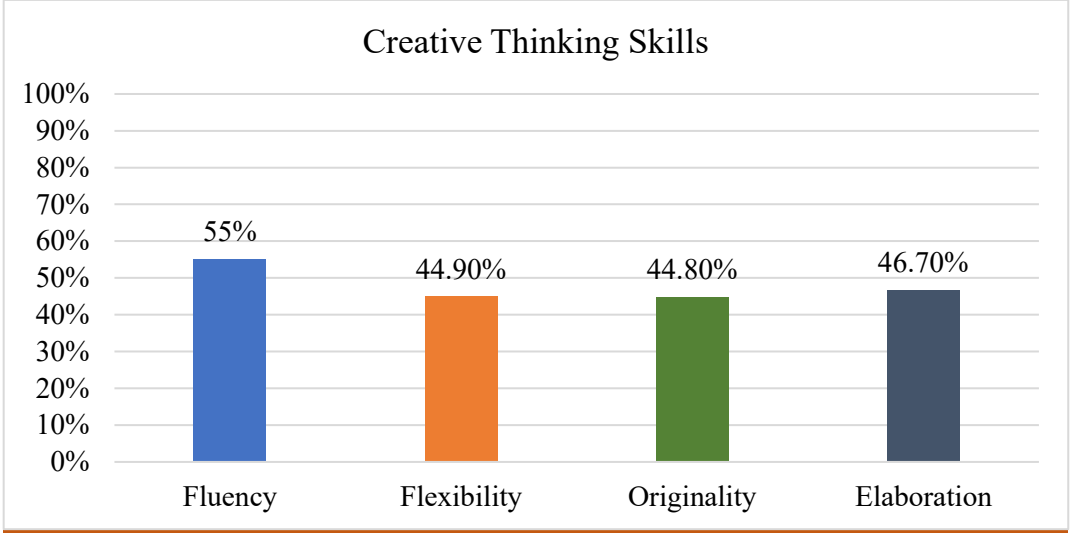

FIGURE 1. Percentage of students' creative thinking skills on each indicator

Based on the study's results, it appears that none of the four indicators of creative thinking skills fall into the very good or very poor criteria. Of the four indicators of students' creative thinking skills, the indicator with the highest percentage value of 55% and sufficient criteria is the fluency indicator. The flexibility indicator has a percentage value of 44.9%, the originality indicator has a value of 44.8%, and the elaboration indicator has a value of 46.7%. The three indicators are sufficient criteria for assessing creative thinking skills. The results of the research that has been done for creative thinking skills shows the results that in the creative thinking skills of students in class XI SMA Negeri 2 Palembang have diverse creative thinking skills with the prominent criteria are sufficient criteria.

Concept Mastery

Data on the level of concept mastery is also analyzed through student answers based on the cognitive level of the test questions given. The data obtained were collected to be analyzed and determine the extent of the students' mastery of the concept of temperature and heat. The results of the analysis for concept mastery are presented in FIGURE 2, as well as in TABLE 6 and TABLE 7.

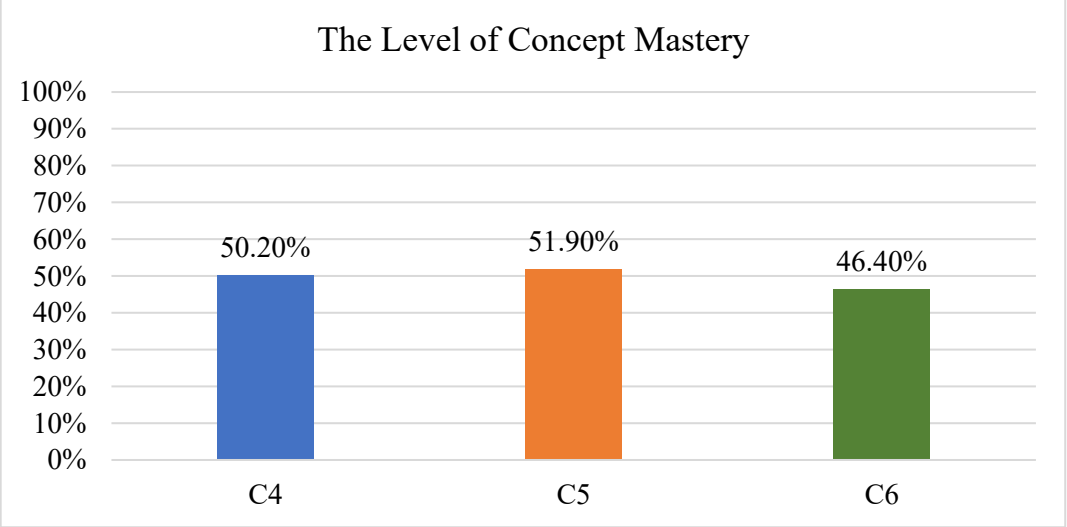

FIGURE 2. Students' Concept Mastery Level

Based on the results of the research, the level of mastery of concepts is classified using the cognitive domain that exists in the test questions given to students, for the level of mastery of concepts with the highest value is in the cognitive domain C5 of 51.9 and the value of the lowest level of mastery of concepts is in the cognitive domain C6 with a value of 46.4. C4 cognitive domain gets a value of 50.2. For the three average values of the cognitive domain C4 - C6 classified as moderate criteria.

TABLE 6. Level of Concept Mastery of All Class XI Students on Temperature and Heat Material

Criteria	Percentage Number of Students						Average
	C4		C5		C6		
High	13	22%	14	23%	3	5%	17%
Moderate	33	55%	32	53%	46	77%	62%
Low	14	23%	14	23%	9	15%	20%

TABLE 6 presents the results of concept mastery for 60 students in Class XI. In the high criteria of the cognitive domain, C4, as many as 13 students, with a percentage of 22%, C5, as many as 14 students, with a percentage of 23%, and then C6, with 3 students, a 5% percentage value. While in the moderate criteria for C4 there were 33 students with a percentage of 55%, C5 with 32 students with a percentage of 53% then C6 with a percentage of 77% with 46 students. In the low criteria, C4 had 14 students, representing 23% of the total, C5 had 14 students, representing 23% of the total, and C6 had 9 students, representing 20% of the total. This indicates that the level of mastery of concepts on temperature and heat material for class XI at SMA Negeri 2 Palembang falls within the moderate criteria, with an average of 62%.

TABLE 7. Criteria for Mastery of Student Concepts Based on Indicators for Each Temperature and Heat Sub Matter

No	Indicator	Percentage Number of Students		
		High	Moderate	Low
1	Answer the problem of changes in the form of substances and changes in temperature on a graph based on facts (C5)	22%	33%	45%
2	Fluency express ideas about the water anomaly event (C6)	57%	13%	30%
3	Seeing errors or assessing the effect of heat on changes in the form of objects (C5).	43%	10%	47%
4	Provide a point of view on the application of the black principle in everyday life (C4).	42%	10%	48%
5	Thinking about problem solving to find out the meaning of heat and type of a substance (C6)	15%	12%	73%
6	Classify expansion events based on the properties of expanding substances (C6)	20%	22%	58%
7	Solve new problems through experiments to prove the expansion of gas (C6)	28%	11%	62%
8	Seek deeper meaning of convection in three metal rods based on experiment (C6)	13%	17%	70%
9	Enrich the idea of expansion of solids in daily life (C4)	30%	20%	50%
10	Try to make meaning about heat transfer (C6)	55%	8%	37%
	Average	30%	14%	47%

TABLE 7 shows the percentage of the number of students who have completed the test questions on temperature and heat material on each indicator that has been categorized. In the high criteria for concept mastery 57% of students. Furthermore, in the low criteria, the largest percentage of 73% lies in the indicator of question number 5 with the cognitive domain C6.

Relationship Between Creative Thinking Skills and Concept Mastery

The relationship between creative thinking skills and concept mastery is an important focus to be analyzed in this study. TABLE 8 presents data that illustrate the correlation between these two variables.

Table 8. Results of the analysis of the relationship between creative thinking skills and concept mastery.

		Correlation	Creative Thinking Skill	Concept Mastery
Spearman's rho	Creative Thinking Skill	Correlation Coefficient	1.000	.512**
		Sig. (2-tailed)	.	.000
		N	60	60
	Concept Mastery	Correlation Coefficient	.512**	1.000
		Sig. (2-tailed)	.000	.
		N	60	60

**. Correlation is significant at the 0.01 level (2-tailed).

Based on TABLE 8, the Sig. (2-tailed) value is <0.000. Then the value of Sig. (2-tailed) <0.05, then there is a significant relationship between creative thinking skills and mastery of the concept of class XI students of SMA Negeri 2 Palembang on temperature and heat material, so H0 is rejected and H1 is accepted. This is in accordance with the statement of (Ramadhan and Theresia, 2022) that if the significance value <0.05 then the two variables are correlated. Based on Figure 3, it is also obtained a correlation coefficient value of 0.512, so the correlation creative thinking skills and mastery of the concept of class XI students of SMA Negeri 2 Palembang is strong. the correlation coefficient value obtained is positive, meaning that the relationship between the two variables is in the same direction.

Discussion

This research was conducted to identify students' creative thinking skills and concept mastery of temperature and heat materials. This study was also conducted to determine the relationship between students' creative thinking skills and mastery of the concept of grade XI students on temperature and heat material. Creative thinking skills are very important for current and future technological advances and are even one of the indicators that measure the quality of education in countries around the world (Habibi et al., 2020) Meanwhile, concept mastery is a high-level thinking ability or concept mastery is the cognitive ability of students on the material studied (Eliyarti, Rahayu and Zakirman, 2020; Widya and Adri, 2021). Creative thinking skills and concept mastery complement each other, also contributing to student development (Ode et al., 2016).

Creative Thinking Skill

The following is an explanation of students' creative thinking skills for each indicator. There are no students in SMA Negeri 2 Palembang who are in the very poor category. Many students are in the sufficient category. In this case, the sufficient criterion is students who get a score of 3, which means they answered the question incorrectly but provided the correct reason. Then, as many as seven students fell into the lower criteria, with a percentage of 12%. Students who met this criterion mostly received a score of 2, which means they not only gave the wrong answer but also provided the right and wrong reasons. This is aligned with the research proposed by Armandita (2018), which suggests that there are no students who possess no creative thinking skills or zero intelligence. The same point was also made by Susilowati et al. (2022), who noted that students lack mastery of this skill because they are less trained, not because they do not understand creative thinking skills. Creative thinking skills comprise four indicators: fluency, flexibility, elaboration, and originality (Rohmantika and Pratiwi, 2022). The explanation of each indicator of creative thinking skills is as follows.

Creative Thinking Skills Based on Fluency Indicators

The average value of the results obtained by SMA Negeri 2 Palembang students for the fluency indicator is 55%. According to the creative thinking skills criteria table, the value is in the sufficient criteria. In the fluency indicator, creative thinking skills are defined as students' skills to see the relationship between concepts in a short and precise time. Concept understanding is one of the factors that determines whether students are categorized as good or less on this indicator. Students who understand the concept well will find it easy (Trianggono, 2017). The fluency indicator is one of the indicators of creative thinking skills, placed as one of the highest indicators of creative thinking ability, emphasizing that the ability to speak fluently is very important in the development of creative thinking ability (Firdaus, Widodo, and Rochintaniawati, 2018).

Creative Thinking Skills Based on Flexibility Indicators

Creative thinking skills for flexibility indicators are thinking by expressing ideas from perspectives that are different from the views of others (Rahmawati, 2022; Nazhifah et al., 2023). Based on the data in FIGURE 1, the percentage value for the flexibility indicator is 44.9%. This percentage is classified as sufficient criteria. The data aligns with research (Kaleka and Nur, 2018), which indicates that the flexibility indicator, with a value of 57.78%, meets the sufficient criteria; however, students are not yet fully effective in conveying various concepts. Because they have no experience in describing phenomena or problems that occur in everyday life, their answers tend to be monotonous or limited to one perspective.

Creative Thinking Skills Based on Originality Indicators

Thinking originality means that they are able to think innovatively and creatively (Wahyuni and Palupi, 2022). Based on the values shown in FIGURE 1, it shows that the originality indicator obtained a percentage of 44.8% with sufficient criteria. then these findings are in line with the results of research conducted by (Umamah and Andi, 2019) with the results of 63.64% on the originality indicator with sufficient criteria, this is caused by students who have not been trained to face problems that involve new ideas and discoveries due to their lack of experience in this regard.

Creative Thinking Skills Based on Elaboration Indicators

Elaboration is a skill in developing ideas (Mulder and Siswanto, 2023). Based on FIGURE 1, it shows that students have elaboration skills of 46.7%. These values indicate that their elaboration skills are sufficient. This finding is in line with research conducted by (Qomariyah and Subekti, 2021) with a percentage of 46% with a sufficient category, and based on findings conducted by (Mulder and Siswanto, 2023) with a percentage of 68% saying that students' creative thinking skills are still lacking due to the level of activity of the teaching and learning process in the classroom. This is due to the level of activity of the media, methods, models, and approaches used in the teaching and learning process.

Concept Mastery

The overall results of the concept mastery analysis in FIGURE 2 show that SMA Negeri 2 Palembang students are classified as moderate. This finding is not in line with research conducted by (Mufidah and Dimas, 2022) that concept mastery is at a percentage of 61%, this is influenced because the learning style of each student is different, so teachers must know and understand the learning style of each student so that they can understand the material better.

Mastery of the Concept of All Students in Grade XI Temperature and Heat Material

Based on TABLE 6 the level of mastery of the concept of class XI students of temperature and heat material is more dominant in the Moderatecriteria. In high criteria, especially the C6 cognitive domain, only 5% or only 3 students can answer. According to (Sadiqin, Santoso and Sholahuddin, 2017) said

the development of students' ability to reason concepts, including the ability of abstraction and discrimination contributed to the improvement of their concept mastery. Previous research (Azizah, Parno and Supriana, 2019) also said that students face difficulties when answering questions about temperature and heat material because they tend to misunderstand concepts, make calculation errors, and have difficulty applying these concepts in the context of everyday life. Even though they have learned it since junior high school, students still have difficulty solving problems that test their mastery of the concept.

Percentage of Students' Concept Mastery Based on Indicators of Each Temperature and Heat Sub Matter

High Criteria Concept Mastery

Concept mastery in high criteria is in question number 2 with the indicator of fluently expressing ideas about the water anomaly event (C6). Students who meet these criteria are students who get a score of 4 and a score of 3. Previous study research proposed by (Docktor et al., 2015) shows that if students face problems with temperature and heat, it shows that they lack understanding of the concept.

Mastery of Moderate Criteria Concepts

The largest percentage for moderate criteria is 33%, located in question number 1 with the indicator Answer the problem of changes in the form of substances and changes in temperature on a graph based on facts (C5). According to (Yuliana, Kusairi and Taufiq, 2019) this shows that students still have difficulty in solving problems regarding temperature and heat, therefore students' mastery of concepts must be improved so that they no longer experience mistakes in understanding the concept of the material provided.

Mastery of Low Criteria Concepts

Based on TABLE 7 for low criteria, the largest percentage value is 73% with the indicator that students can think of problem solving to find out the meaning of heat and the type of a substance (C6) in question 5. This is in accordance with previous research which shows that ideas about temperature and heat, which include temperature, heat, heat transfer, and how heat affects objects, including expansion, temperature changes, and shape changes, are difficult for students to understand (Wahidah S., Kusairi and Zulaikah, 2017).

The Relationship Between Creative Thinking Skills And Mastery Of The Concept Of Temperature and Heat Material

The relationship between creative thinking skills and concept mastery was analyzed using Spearman Rank Order Correlation analysis. Spearman Rank Order Correlation analysis is a nonparametric statistical analysis used to estimate the relationship between independent variables and dependent variables (Akhri Julian and Yanti Apriza, 2022). The purpose of this analysis is to find the relationship. Based on Table 7, it shows that the value of Sig. (2-tailed) value is <0.000. Then the value of Sig. (2-tailed) <0.05, then there is a significant relationship between creative thinking skills and mastery of the concept of class XI students of SMA Negeri 2 Palembang on temperature and heat material. And based on table 7, the correlation coefficient value is 0.512, so the relationship between creative thinking skills and mastery of the concept of class XI students of SMA Negeri 2 Palembang is strong. This finding is supported by the statement (Ode et al., 2016; Hara, Astiti, and Lantik, 2023). Creative thinking skills have a very important relationship with the mastery of temperature and heat concepts in physics learning. With creative thinking skills, students can generate innovative ideas and solve complex problems related to the concepts of temperature and heat. Conversely, strong concept mastery of temperature and heat material allows students to understand and apply physics principles related to temperature and heat in various situations.

Based on the research, the overall creative thinking skills of students are categorized at 48.3% as sufficient. The results of this study align with the findings of previous research conducted by Meiarti (2021), Riyaldo et al. (2021), and Wafa et al. (2025), which indicate that after completing the creative thinking test in physics learning, students fall into the moderate category. However, this finding is different from some previous studies which show that students' creative thinking skills are in the high and medium categories (Armandita, 2018; Mako, Harso and Kaleka, 2020; Qomariyah and Subekti, 2021). In addition, the study's results also revealed that creative thinking skills fell into the low category (Saprudin et al., 2019; Trisnayanti et al., 2020; Hasanah, Parno, and Hidayat, 2021; Wulandari et al., 2021; Mulder and Siswanto, 2023). All of these studies show that students' skills are still relatively low and have not developed optimally. The results of research on the mastery of the concept of class XI students at SMA Negeri 2 Palembang on temperature and heat material show that the majority of students are in the medium criteria with an average percentage of 62%. In detail, in the C4 cognitive domain, 55% of students were in the moderate criteria, while for C5 and C6, the percentage of students in the moderate criteria was 53% and 77% respectively. This indicates that most students have achieved sufficient conceptual understanding, but still have difficulty in higher-order thinking aspects, especially at the C6 level which only reached 5% at the high criteria. This result is in line with research in Samarinda which showed the level of concept mastery at the C4 (analysis) level was 63% (Sari, Qadar and Hakim, 2023), which is almost similar to the findings at SMA Negeri 2 Palembang where the majority of students (55%) were at the medium criteria for C4. There was a significant difference at the C6 (creation) level, where this study showed a dominance at the moderate criteria (77%), in contrast to the previous study which only reached 50% (Sari, Qadar and Hakim, 2023). In a study conducted by Khoiri, Ristanto and Kurniawan (2022) found the majority of students were at a moderate level of mastery (55-77%), especially in basic conceptual understanding (C2-C3). However, the ability to analyze (C4) is still weak (57%). This could happen because both of them identified conventional learning methods and a lack of complex problem-solving exercises as inhibiting factors (Fatmawati, Parno, and Diantoro, 2025). This discrepancy may be due to the different learning strategies used. In SMA Negeri 2 Palembang, the dominance of moderate criteria may indicate that the learning approach is still conventional, so it does not encourage the development of creative thinking skills.

Based on a thorough analysis, it was found that there were differences in creative thinking skills and concept acquisition. This difference is primarily influenced by several key factors, including variations in the instruments used by each researcher, differences in the materials tested, the level of difficulty of the questions on each indicator, and students' limitations in understanding the provided information (Ismail, 2022; Paryumi, 2022). Additionally, the instruments used to measure creative thinking skills and concept mastery have limitations in capturing all aspects of students' creativity and conceptual mastery. This results in errors in answering questions and low student sensitivity to the questions given. Sensitivity to the problems presented is crucial for students to generate new ideas or concepts that have never been considered before, thereby developing creative thinking skills and concept mastery (Arisanti, Sopandi, and Widodo, 2017; Armandita, 2018; Sihaloho et al., 2023). All students have the potential for creative thinking and also high concept mastery, but these abilities often receive less attention (Susilowati et al., 2022; Mulder and Siswanto, 2023). As a result, students' creative thinking skills and concept mastery tend to be low, as shown in the results of this study and previous studies. In addition, a supportive learning approach is needed to familiarize students with creative thinking and improve concept mastery.

Previous research (Misbah et al., 2021; Muttaqiin, 2023; Sari, Qadar and Hakim, 2023) found that STEM-based learning methods can significantly improve student creativity. Then educators can use problem-based learning approaches, as well as project-based learning (PJBL) In addition, according to (Sari et al., 2021; Safitri and Salma, 2023; Atiqoh, Lokal and Kritis, 2024) said that the integration of local-based learning can improve creative thinking skills and concept mastery, but there are still challenges in increasing the percentage of students who reach the high understanding category. The difference in results in the low concept mastery category can be caused by several factors, such as limited student experience in using a STEM-based approach that integrates local wisdom. that the level of student familiarity with the applied learning approach affects its effectiveness in improving creative thinking skills and concept mastery. Furthermore, teachers as educators have an important role in fostering self-confidence and reducing the fear of students so that they are more willing to convey ideas

and innovations in the learning process, so that creative thinking skills can develop (Wiyono et al., 2022). In supporting this, teachers are increasingly utilizing interactive learning media, such as educational games (Anggraeni and Sole, 2020), online learning, and electronic books (Adawiyah et al., 2019; Irwandani et al., 2020; Rahayu et al., 2022), which can be used to improve students' creative thinking skills and concept mastery (Yulianci et al., 2021). In this study, it was also found that there was a strong relationship between creative thinking skills and concept mastery as evidenced by the significance value of 0.512. This shows that there is a positive relationship between creative thinking skills and concept mastery. That is, the higher the students' creative thinking skills, the better their concept mastery tends to be. However, this relationship is not entirely strong, which means there are other factors beyond creative thinking skills that also affect students' concept mastery. These factors could include teaching methods, learning environment, student motivation, or even the curriculum used (Siburian et al., 2019; Bhuttah et al., 2024).

Based on the results of this study as well as previous research, the findings are expected to be an evaluation material for the education system in Indonesia in developing innovations to improve learners' skills. The findings can provide insights for educators in designing more effective learning strategies to improve creative thinking skills as well as those that support the development of students' understanding to the students' higher levels. Teachers can develop problem or project-based approaches that emphasize concept exploration and creativity in physics problem solving (Muliyani, Suhandi and Prima, 2023; Bhuttah et al., 2024; Muftidafila and Rosyida, 2025). These results suggest that the physics curriculum in schools can further emphasize aspects of creativity by providing space for students to explore concepts through experiments and open discussions. Curriculum development is also needed that emphasizes STEM-based activities that have been proven effective in improving concept mastery (Hasanah Purnama et al., 2023). Curriculum adjustments that are more flexible in presenting investigation-based materials can help students understand the concepts of temperature and heat more deeply. As well as policies that are more supportive of the application of learning approaches that are oriented towards the development of creative thinking skills and mastery of student concepts. This policy can include teacher training in implementing innovative learning methods and providing facilities and infrastructure that support exploration and experiment-based learning (Kusumaningtyas et al., 2023). Further research to be conducted in the future can focus on the integration of technology such as augmented reality or virtual labs in physics learning to see its impact on students' creative thinking skills and concept mastery.

CONCLUSION

The results of data analysis showed that the creative thinking skills of class XI students on temperature and heat material at SMA Negeri 2 Palembang had an average percentage of 48.3%, which was in the sufficient category. Based on the creative thinking indicators, the fluency value was 55%, flexibility 44.8%, originality 44.7%, and elaboration 44.6%, all of which were in the sufficient category. Meanwhile, students' concept mastery in the C4 cognitive domain has a percentage of 50.2%, C5 of 51.9%, and C6 of 46.4%, which is classified in the moderate category. In addition, this study found a strong and positive relationship between creative thinking skills and mastery of temperature and heat concepts, indicating that improving creative thinking skills can encourage better conceptual understanding. These findings provide insight that the development of creative thinking skills can contribute to improved understanding of physics concepts at the secondary level. One recommendation for educators is to adopt more interactive learning strategies, such as the use of technology-based media and project-based approaches, to improve students' creative thinking skills as well as concept mastery. In addition, this study revealed that although creative thinking skills have a positive relationship with concept mastery, the percentage of achievement in both aspects is still moderate. This indicates the need for innovation in teaching methods that are more student-centered, such as inquiry-based learning or collaborative discussions, so that students are more active in exploring physics concepts. Thus, this study contributes to understanding the relationship between creative thinking skills and concept mastery in physics education and provides a perspective for future research. The implications of the findings encourage further reflection on how more innovative learning strategies can improve the

quality of physics learning in secondary schools as well as contribute to the development of higher order thinking skills among students.

REFERENCES

Adawiyah, R. *et al.* (2019). Interactive e-book of physics to increase students' creative thinking skills on rotational dynamics concept. *Journal of Physics: Conference Series*, 1153(1).doi: https://doi.org/10.1088/1742-6596/1153/1/012117.

Akhri Julian, I. and Yanti Apriza, C. (2022). Perbedaan Uji Korelasi Pearson, Spearman Dan Kendall Tau Dalam Menganalisis Kejadian Diare. *Jurnal Endurance*, 6(1), pp. 51–58. doi: https://doi.org/10.22216/jen.v6i1.137.

Andriani, N. (2023). Peningkatan Penguasaan Konsep Fisika Siswa Kelas X TKJ2 pada Materi Gerak dengan Menggunakan Video Rekam Layar O-Cam. *Jurnal Karya Ilmiah Multidisiplin (JURKIM)*, 3(3), pp. 192–199. doi: https://doi.org/10.31849/jurkim.v3i3.16267.

Anggraeni, D.M. and Sole, F.B. (2020). Developing creative thinking skills of STKIP weetebula students through physics crossword puzzle learning media using eclipse crossword app. *Journal of Physics: Conference Series*, 1521(2). doi: https://doi.org/10.1088/1742-6596/1521/2/022045.

Arisanti, W.O.L., Sopandi, W. and Widodo, A. (2017). Analisis Penguasaan Konsep Dan Keterampilan Berpikir Kreatif Siswa Sd Melalui Project Based Learning. *EduHumaniora | Jurnal Pendidikan Dasar Kampus Cibiru*, 8(1), p. 82. doi: https://doi.org/10.17509/eh.v8i1.5125.

Armandita, P. (2018). Analisis Kemampuan Berpikir Kreatif Pembelajaran Fisika Di Kelas Xi Mia 3 Sma Negeri 11 Kota Jambi Analysis the Creative Thinking Skill of Physics Learning in Class Xi Mia 3 Sman 11 Jambi City. *Jurnal Penelitian Ilmu Pendidikan*, 10(2), p. 129. doi: https://doi.org/10.21831/jpipfip.v10i2.17906.

Asqia, M. and Nabarian, T. (2021). Pemanfaatan Google Sheets dan Google Form untuk Layanan Administrasi Mahasiswa Menggunakan Konsep Electronic Service Quality. *Jurnal Teknologi Terpadu*, 7(1), pp. 15–22. doi: https://doi.org/10.54914/jtt.v7i1.339.

Atiqoh, F., Lokal, K. and Kritis, K.B. (2024). Efektivitas LKPD Berbasis Kearifan Lokal Batik Tulis Gedog Untuk Meningkatkan Keterampilan Berpikir Kritis Peserta Didik SMA', *Jurnal Review Pendidikan dan Pengajaran*, 7, pp. 11407–11415.

Auw, D.N. *et al.* (2023) 'Analisis Korelasi Faktor – Faktor Yang Mempengaruhi Tingkat Pendapatan Kepala Keluarga. *Jurnal Ilmiah Matematika Dan Terapan*, 20(2), pp. 165–180. doi: https://doi.org/10.22487/2540766x.2023.v20.i2.16546.

Azizah, U., Parno, P. and Supriana, E. (2019). Identifikasi Penguasaan Konsep Fisika Siswa SMA Kelas XI dan XII pada Materi Suhu dan Kalor. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 4(4), p. 484. doi: https://doi.org/10.17977/jptpp.v4i4.12284.

Bhuttah, T.M. *et al.* (2024). Enhancing student critical thinking and learning outcomes through innovative pedagogical approaches in higher education: the mediating role of inclusive leadership. *Scientific Reports*, 14(1), pp. 1–13. doi: https://doi.org/10.1038/s41598-024-75379-0.

Damayanti, S.A., Santyasa, I.W. and Sudiatmika, A.A.I.A.R. (2020). Pengaruh Model Problem Based-Learning Dengan Flipped Classroom Terhadap Kemampuan Berpikir Kreatif. *Jurnal Kependidikan: Penelitian Inovasi Pembelajaran*, 4(1), pp. 83–98. doi: https://doi.org/10.21831/jk.v4i1.25460.

Darma Wulan, D., Sutarman, S. and Tahan Sungkowo, B. (2021). Pengaruh model pembelajaran inkuiri terbimbing terhadap penguasaan konsep fisika siswa kelas X SMA Negeri I Lawang pokok bahasan suhu dan kalor. *Jurnal MIPA dan Pembelajarannya*, 1(7), pp. 570–577. doi: https://doi.org/10.17977/um067v1i7p570-577.

Docktor, J.L. *et al.* (2015). Conceptual problem solving in high school physics. *Physical Review Special Topics - Physics Education Research*, 11(2), pp. 1–13. doi: https://doi.org/10.1103/PhysRevSTPER.11.020106.

Eliyarti, E., Rahayu, C. and Zakirman, Z. (2020). Penerapan Bahan Ajar Fisika Dengan Variasi Bentuk Tugas Berbasis Web Untuk Meningkatkan Hasil Belajar Mahasiswa Teknik. *Jurnal Pendidikan Fisika Undiksha*, 10(2), p. 82. doi: https://doi.org/10.23887/jjpf.v10i2.29910.

Etikamurni, D.P. and Sutopo, S. (2019). Peningkatan Penguasaan Konsep Siswa Kelas XI IPA pada Materi Suhu dan Kalor melalui Modeling Instruction. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 4(2), p. 172. doi: https://doi.org/10.17977/jptpp.v4i2.11935.

Fatmawati, F., Parno, P. and Diantoro, M. (2025). Identification of Students ' Mastery Level of Physics Concepts in Static Fluid Material. *Jurnal Pendidikan Fisika dan Teknologi (JPFT*, 11(1), pp. 1–8. doi: https://doi.org/https://dx.doi.org/10.29303/jpft.v11i1.8360.

Firdaus, H.M., Widodo, A. and Rochintaniawati, D. (2018). Analysis of Creative Thinking Ability and Process of Creative Thinking Ability Development of Junior High School Students on Biology Learning. *Assimilation: Indonesian Journal of Biology Education*, 1(1), pp. 21–28.

Firmansyah, D. and Dede (2022). Teknik Pengambilan Sampel Umum dalam Metodologi. *Jurnal Ilmiah Pendidikan Holistik (JIPH)*, 1(2), pp. 85–114.

Habibi *et al.* (2020). Project brief effects on creative thinking skills among low-ability pre-service physics teachers. *International Journal of Evaluation and Research in Education*, 9(2), pp. 415–420. doi https://doi.org/10.11591/ijere.v9i2.20531.

Hara, A.K., Astiti, K.A. and Lantik, V. (2023). Analisis Penguasaan Konsep Fisika pada Materi Suhu dan Kalor Pasca Pembelajaran Online di Kelas XI SMA Negeri 12 Kota Kupang. *Jurnal Ilmu Pendidikan (JIP) STKIP Kusuma Negara*, 14(2), pp. 118–126. doi: https://doi.org/10.37640/jip.v14i2.1548.

Hasanah Purnama, A.N. *et al.* (2023). Fostering Students' Concept Mastery Through Stem-Engineering Design Process in Thermal Energy and Heat Transfer Topic. *INSECTA: Integrative Science Education and Teaching Activity Journal*, 4(2), pp. 209–230. doi: https://doi.org/10.21154/insecta.v4i2.7240.

Hasanah, S., Parno, P. and Hidayat, A. (2021). Identifikasi Kemampuan Berpikir Kreatif Siswa pada Materi Termodinamika. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 6(9), p. 1406. doi: https://doi.org/10.17977/jptpp.v6i9.14987.

Indiana, S., Amaliyah, N. and Hartini, T.I. (2024). Hubungan Antara Kemampuan Berpikir Kritis Dan Kemampuan Berpikir Kreatif Dengan Penguasaan Konsep Dasar Ipa Pada Siswa Kelas V Di Sdn Gugus 2 Kecamatan Cipayung Kota Depok. *Pedagogi: Jurnal Penelitian Pendidikan*, 11(1), pp. 86–104. doi: https://doi.org/https://doi.org/11.25134/pedagogi.v11i1.8507.

Intisavira, T., Sari Mustika, I. and Karim, S. (2023). Profil Pemahaman Konsep Suhu dan Kalor Pada Siswa Sekolah Menengah Atas di Indonesia. *Prosiding Seminar Nasiola Fisika*, 2(1), pp. 509–514.

Irwandani *et al.* (2020). Effectiveness of Physics Learning Media Course assisted by Instagram on Student's Creative Thinking Skill. *Journal of Physics: Conference Series*, 1467(1). doi: https://doi.org/10.1088/1742-6596/1467/1/012006.

Ismail, S. (2022). Penerapan Model Pembelajaran Berbasis Masalah Untuk Meningkatkan Penguasaan Konsep Dan Keterampilan Berpikir Kreatif Siswa Pada Materi Bunyi. *Jurnal Ilmiah Wahana Pendidikan*, 8(3), pp. 178–183. doi: https://doi.org/10.5281/zenodo.6466586.

Istiyono, E., Dwandaru Brams, W. and Rahayu, F. (2018). Pengembangan Tes Creative Thinking Skills Fisika SMA (PhysCreTHOTS) Berdasarjan Teori Tes Modern. *Jurnal Cakrawala Pendidikan*, 37(2), pp. 190–200. doi: https://doi.org/http://dx.doi.org/10.21831/cp.v37i2.19233.

Kaleka, M. and Nur, F.D.M. (2018). Experimental-Based Scientific Approach toward the improvement of Science Process Skill and Scientific Attitudes of Grade X Student MAN Ende. *Journal of Science Education Research*, 2(1), pp. 13–20. doi: https://doi.org/10.21831/jser.v2i1.19328.

Kamid, K. *et al.* (2022). Comparison and Correlation between Attitude and Process Skills in Mathematics: The Case of Public and Islamic Middle School in Indonesia. *Jurnal Pendidikan Progresif*, 12(2), pp. 511–528. doi: https://doi.org/10.23960/jpp.v12.i2.202210.

Khoiri, N., Ristanto, S. and Kurniawan, A.F. (2022). Profile of Students' Conceptual Understanding of Physics in Senior High School. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, 8(2), pp. 241–248. doi: https://doi.org/10.21009/1.08206.

Kurniawati, F.N.A. (2022). Meninjau Permasalahan Rendahnya Kualitas Pendidikan Di Indonesia Dan Solusi. *Academy of Education Journal*, 13(1), pp. 1–13. doi: https://doi.org/10.47200/aoej.v13i1.765.

Kusumaningtyas, D.A. *et al.* (2023). Enhancing Learning Outcomes: A Study on the Development of Higher Order Thinking Skills based Evaluation Instruments for Work and Energy in High School Physics. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, 6(1), pp. 14–31. doi: https://doi.org/10.23917/ijolae.v6i1.23125.

Mako, S.Y., Harso, A. and Kaleka, M.B.U. (2020). Profil Kemampuan Berpikir Kreatif Siswa Kelas X Smk Negeri 7 Ende', *EduFisika*, 5(02), pp. 124–130. doi: https://doi.org/10.22437/edufisika.v5i02.10500.

Meiarti, D. (2021). Profil Profil Keterampilan Berpikir Kreatif Peserta Didik SMK. *JIPFRI (Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah)*, 5(2), pp. 116–121. doi: https://doi.org/10.30599/jipfri.v5i2.684.

Misbah, M. *et al.* (2021). The validity of introduction to nuclear physics e-module as a teaching material during covid-19 pandemic. *IOP Conference Series: Earth and Environmental Science*, 1796(1). doi: https://doi.org/10.1088/1742-6596/1796/1/012070.

Mufidah, A.M.I. and Dimas, A. (2022). Profil Pemahaman Konsep Pada Mater Suhu Dan Kalor Kelas VII Siswa SMP Negeri 4 Ngawi Tahun Ajaran 2021/2022. *Wacana Akademika: Majalah Ilmiah Kepandidikan*, 6(2), pp. 121–128. Available at: https://jurnal.ustjogja.ac.id/index.php/wacanaakademika/article/view/12307%0Ahttps://jurnal.ustjogja.ac.id/index.php/wacanaakademika/article/download/12307/5371.

Muftidafila, K. and Rosyida, I. (2025). Enhancing students ' critical thinking skills in physics : Exploring problem-based learning and mobile technology integration in rotational dynamics education. *Advances in Mobile Learning Educational Research*, 5(1), pp. 1301–1313. doi: https://doi.org/10.25082/AMLER.2025.01.006.

Muhsin Hidayat, A., Sidin Ali, M. and Jln Daeng Tata Raya, P. (2018). Analisis Kreativitas Peserta Didik Kelas XI MIPA SMA Negeri 5 Makassar. *Jurnal Sains dan Pendidikan Fisika. Jilid*, 14, pp. 1–8. Available at: http://ojs.unm.ac.id.

Mulder, W.R.S.P. and Siswanto, J. (2023). Analisis Kemampuan Berpikir Kreatif Siswa Kelas Vii Smp Negeri 65 Maluku Tengah Pada Materi Suhu Dan Kalor. *Jurnal Inovasi Penelitian dan Pembelajaran Fisika*, 4(1), p. 1. doi: https://doi.org/10.26418/jippf.v4i1.56629.

Muliyani, R., Suhandi, A. and Prima, E.C. (2023). Investigating Strategies and Best Practices in Teaching Heat and Temperature: a Systematic Review in Science and Physics Education. *Jurnal Penelitian Pendidikan IPA*, 9(7), pp. 263–269. doi: https://doi.org/10.29303/jppipa.v9i7.4328.

Mursidik, E.M., Samsiyah, N. and Rudyanto, H.E. (2015). Creative Thinking Ability in Solving Open-Ended Mathematical Problems Viewed From the Level of Mathematics Ability of Elementary School Students. *PEDAGOGIA: Journal of Education*, 4(1), pp. 23–33.

Muttaqiin, A. (2023). Pendekatan STEM (Science, Technology, Engineering, Mathematics) pada Pembelajaran IPA Untuk Melatih Keterampilan Abad 21. *Jurnal Pendidikan Mipa*, 13(1), pp. 34–45. doi: https://doi.org/10.37630/jpm.v13i1.819.

Nazhifah, N. *et al.* (2023). Profile of Physics Creative Thinking Skills for High School Students in The 21st Century. *JIPFRI (Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah)*, 7(1), pp. 1–11. doi: https://doi.org/10.30599/jipfri.v7i1.2131.

Nazhifah, N. and Wiyono, K. (2023). Development of STEM-Based E-Learning on Renewable Energy Topic to Improve the Students Creative Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 9(11), pp. 9575–9585. doi : https://doi.org/10.29303/jppipa.v9i11.5206.

Ningrum, R., Rahman, T. and Riandi, R. (2022). Penerapan STEM From Home dengan Model PjBL untuk Meningkatkan Penguasaan Konsep dan Keterampilan Berpikir Kreatif Siswa SMP. *PENDIPA Journal of Science Education*, 6(1), pp. 299–307. doi: https://doi.org/10.33369/pendipa.6.1.299-307.

Nuriyah, H., Suwarma, I. and Kaniawati, I. (2021). Penerapan Pembelajaran Flipping STEM Classroom terhadap Penguasaan Konsep dan Kreativitas Siswa Pada Materi Usaha dan Energi. *WaPFi (Wahana Pendidikan Fisika)*, 6(2), pp. 240–247. doi: https://doi.org/10.17509/wapfi.v6i2.37248.

Ode, W. *et al.* (2016). Analisis Penguasaan Konsep Dan Keterampilan Berpikir Kreatif Siswa SD Melalui Project Based Learning. oleh : Universitas Pendidikan Indonesia Pendahuluan Ilmu Pengetahuan Alam (IPA). *EduHumaniora*, 8(1), pp. 82–95. doi: https://doi.org/http://dx.doi.org/10.17509/eh.v8i1.5125.

Paryumi, P. (2022). Profil Keterampilan Berpikir Kreatif Siswa SMA Negeri 1 Karangrayung pada Konsep Fluida Statis. *Jurnal Kualita Pendidikan*, 3(1), pp. 21–24. doi: https://doi.org/10.51651/jkp.v3i1.182.

Pramadjaya, A. *et al.* (2021). Pemanfaatan Google Form Sebagai Media Pengumpulan Data Dan Evaluasi Pembelajaran Di Man 2 Kabupaten Serang. *Abdi Laksana: Jurnal Pengabdian Kepada Masyarakat*, 2(3), pp. 565–573.

Qomariyah, D.N. and Subekti, H. (2021). Pensa E-Jurnal : Pendidikan Sains Analisis Kemampuan Berpikir Kreatif: Studi Eksplorasi Siswa Di Smpn 62 Surabaya. *PENSA E-JURNAL: Pendidikan Sains*, 9(2), pp. 242–246. Available at: https://ejournal.unesa.ac.id/index.php/pensa/index.

Rahayu, S. *et al.* (2022). The Effectiveness of Creative Problem Solving-Flipped Classroom for Enhancing Students' Creative Thinking Skills in Online Physics Educational Learning. *Jurnal Pendidikan IPA Indonesia*, 11(4), pp. 649–656. doi: https://doi.org/10.15294/jpii.v11i4.39709.

Rahmawati, I. (2022). Mengembangkan Keterampilan Berpikir Kreatif Calon Guru Fisika melalui Model Project Based E-Learning. *Jurnal Ilmiah Pendidikan Fisika*, 6(2), p. 283. doi: https://doi.org/10.20527/jipf.v6i2.4158.

Ramadhan, B. and Theresia, M. (2022). Analisis Faktor Yang Berpengaruh Terhadap Kinerja Pekerja Dari Segi Rencana Keselamatan Kontruksi (Studi Kasus: Proyek Pembangunan Gedung Kuliah Fakultas Teknik Universitas Negeri Padang) Analysis of Factors Influencing Workers Performance From the Perfor. *Journal of Applied Engineering Scienties*, 5(3), pp. 186–194. Available at: https://ft.ekasakti.org/index.php/JAES/index/.

Reynawati, A. and Purnomo, T. (2018). Penerapan Model Problem Based Learning pada Materi Pencemaran Lingkungan untuk Melatihkan Keterampilan Berpikir Kreatif Siswa. *Pendidikan Sains*, 6(2), pp. 325–329.

Rini, R.M., Sitompul, S.S. and Hamdani, H. (2024). Efektivitas google sites untuk meningkatkan penguasaan konsep peserta didik kelas xi tentang suhu dan kalor. *Jurnal Pendidikan Informatika dan Sains*, 13(1), pp. 9–17. doi: https://doi.org/10.31571/saintek.v13i1.7399.

Riyaldo, M.A. *et al.* (2021). Analisis keterampilan berpikir kreatif fisika peserta didik kelas XI IPA SMA Srijaya Negara Palembang. *Prosiding Seminar Nasional Pendidikan IPA Tahun 2021*, 26(2), pp. 173–180. Available at: http://www.ufrgs.br/actavet/31-1/artigo552.pdf.

Rofiqoh, I.F., Subiki, S. and Budiarso, A.S. (2020). Identifikasi Kemampuan Berpikir Kreatif Siswa Dengan Metode Mind Mapping Pada Pembelajaran Fisika Pokok Bahasan Optik Di Sma', *Jurnal Pembelajaran Fisika*, 9(4), p. 139. doi: https://doi.org/10.19184/jpf.v9i4.18359.

Rohman, A., Ishafit and Husna, H. (2021). Effect of Project Based Learning Model integration with STEAM on Creative Thinking Based on the Understanding of the Physics Concepts of High School Students on Rotation Dynamics. *Jurnal Pendidikan Fisika Tadulako Online*, 9(1), pp. 15–21. Available at: http://jurnal.fkip.untad.ac.id/index.php/jpft.

Rohmantika, N. and Pratiwi, U. (2022). Pengaruh Metode Eksperimen Dengan Model Inkuiri Terbimbing Terhadap Kemampuan Berpikir Kreatif Peserta Didik Pada Pembelajaran Fisika. *Lontar Physics Today*, 1(1), pp. 9–17. doi: https://doi.org/10.26877/lpt.v1i1.10340.

Sadiqin, I.K., Santoso, U.T. and Sholahuddin, A. (2017). Pemahaman konsep IPA siswa SMP melalui pembelajaran problem solving pada topik perubahan benda-benda di sekitar kita *Jurnal Inovasi Pendidikan IPA*, 3(1), p. 52. doi: https://doi.org/10.21831/jipi.v3i1.12554.

Safitri, A.N. and Salma, V.M. (2023). Analisis Konsep Fisika pada Kearifan Lokal Petik Laut Situbondo sebagai Sumber Belajar Fisika di SMA. *Jurnal Inovasi Pendidikan Sains dan Terapan (INTERN)*, 2(1), pp. 27–32.

Saprudin, S. *et al.* (2019). Profile of pre-service physics teachers' creative thinking skills on wave and optics course. *Journal of Physics: Conference Series*, 1157(3). doi: https://doi.org/10.1088/1742-6596/1157/3/032030.

Sari, R.I. *et al.* (2021). Pengembangan E-Modul Materi Suhu Dan Kalor Sma Kelas Xi Berbasis Ethnophysics. *Physics and Science Education Journal (PSEJ)*, 1(April), p. 46. doi: https://doi.org/10.30631/psej.v1i1.697.

Sari, Y., Qadar, R. and Hakim, A. (2023). Analysis of High School Students' Conceptual Understanding of Physics on Temperature and Heat Concepts', *International Journal of STEM Education for Sustainability*, 3(1), pp. 212–224. doi: https://doi.org/10.53889/ijses.v3i1.92.

Sihaloho, M. *et al.* (2023). Analisis penguasaan konsep siswa kelas XI IPA dalam menyelesaikan soal kimia pada materi Konsep Mol. *Jambura Journal of Educational Chemistry*, 5(1), pp. 60–66. doi: https://doi.org/10.34312/jjec.v5i1.16672.

Sirait, A.R., Sinaga, B. and Mulyono (2018). Analysis Difficulty Of Mathematical Creative Thinking Ability Reviewed From Learning Styles Through Problem Based Learning. *Advances in Social Sciences Research Journal*, 5(10), pp. 395–404.

Siswanto, J. (2018). Keefektifan Pembelajaran Fisika dengan Pendekatan STEM untuk Meningkatkan Kreativitas Mahasiswa. *Jurnal Penelitian Pembelajaran Fisika*, 9(2), pp. 133–137. doi: https://doi.org/10.26877/jp2f.v9i2.3183.

Sundari, P.D. (2019). Profil Penguasaan Konsep Siswa Pada Materi Suhu Dan Kalor Dalam Peer Instructions', *Physics Education*, 12(4), pp. 889–895.

Susilowati, N.E. *et al.* (2022). Pisa 2021 Creative Thinking Instrument for Students: Physics Teachers' Perceptions', *Indonesian Journal of Science and Mathematics Education*, 5(2), pp. 194–209. doi: https://doi.org/10.24042/ijsme.v5i2.12439.

Sutriyono, S., Ismet, I. and Wiyono, K. (2022). Efektivitas Model Blended Learning berbasis Media Microsoft Teams pada Materi Elastisitas untuk Meningkatkan Kemampuan Berpikir Kreatif Siswa. *Jurnal Ilmiah Pendidikan Fisika*, 6(1), p. 36. doi: https://doi.org/10.20527/jipf.v6i1.4451.

Syamsul Mawardi, Muh. Yusuf Hidayat, N. (2023). Analisis Kesalahan Peserta Didik Dalam Menyelesaikan Soal-Soal Suhu Dan Kalor. *Jurnal Pendidikan Fisika*, 5(2), pp. 120–127. Available at: http://journal.uin-alauddin.ac.id/indeks.php/PendidikanFisika%0AISSN.

Trianggono, M.M. (2017). Analisis Kausalitas Pemahaman Konsep Dengan Kemampuan Berpikir Kreatif Siswa Pada Pemecahan Masalah Fisika. *Jurnal Pendidikan Fisika dan Keilmuan (JPFK)*, 3(1), p. 1. doi: https://doi.org/10.25273/jpfk.v3i1.874.

Trisnayanti, Y. *et al.* (2020). Creative thinking profile of junior high school students on learning science. *Journal of Physics: Conference Series*, 1511(1). doi: https://doi.org/10.1088/1742-6596/1511/1/012072.

Umamah, C. and Andi, H.J. (2019). Pengaruh model Project Based Learning terhadap keterampilan berpikir kreatif dalam pembelajaran fisika terapan. *Jurnal Pendidikan Fisika dan Keilmuan (JPFK)*, 5(1), p. 7. doi: https://doi.org/10.25273/jpfk.v5i1.3033.

Usman, N.F. and Gorontalo, U.N. (2024). Mengembangkan Media Pembelajaran Biologi Berbasis Proyek. *Jurnal Normalita*, 11(3), pp. 516–523.

W John, C. and N C, P. (2018). *Qualitative Inquiry & Research Design: Choosing Among Five Approaches*. 3rd edn. Edited by L. Habib et al. SAGE.

Wafa, A.S. *et al.* (2025). Profil Keterampilan Berpikir Kreatif Peserta Didik Pada Pembelajaran Fisika. *EDUTECH : Jurnal Inovasi Pendidikan Berbantuan Teknologi*, 5(1), pp. 1–23. doi: https://doi.org/https://doi.org/10.51878/edutech.v5i1.

Wahidah S., S.N., Kusairi, S. and Zulaikah, S. (2017). Diagnosis Miskonsepsi Siswa SMA di Kota Malang pada Konsep Suhu dan Kalor Menggunakan Three Tier Test. *Jurnal Pendidikan Fisika dan Teknologi*, 2(3), pp. 95–105. doi: https://doi.org/10.29303/jpft.v2i3.295.

Wahyuni, D. and Palupi, B.S. (2022). Analisis Kemampuan Berpikir Kreatif Matematis Siswa Kelas V Sekolah Dasar Melalui Soal Open-Ended. *Jurnal Kiprah Pendidikan*, 1(2), pp. 76–83. doi: https://doi.org/10.33578/kpd.v1i2.30.

Widana, I.W. and Septiari, K.L. (2021). Kemampuan Berpikir Kreatif dan Hasil Belajar Matematika Siswa Menggunakan Model Pembelajaran Project-Based Learning Berbasis Pendekatan STEM. *Jurnal Elemen*, 7(1), pp. 209–220. doi: https://doi.org/10.29408/jel.v7i1.3031.

Widayanti, T. (2021). Use of Google Form in Support of Data Collection for Student Scientific Work. *Judimas*, 1(1), p. 85. doi: https://doi.org/10.30700/jm.v1i1.1015.

Widya, N. and Adri, R.F. (2021). Pengembangan Bahan Ajar Virtual Learning Model Pada Mata Kuliah Hama dan Penyakit Hutan di Fakultas Kehutanan. *Menara Ilmu*, XV(02), pp. 76–82.

Wijaya, L.T.T., Jamaluddin, J. and Hadiprayitno, G. (2020). Penguasaan Konsep Sains Peserta Didik SMP Berdasarkan Dimensi Proses Kognitif dan Dimensi Pengetahuan. *Jurnal Pijar Mipa*, 15(4), pp. 357–361. doi: https://doi.org/10.29303/jpm.v15i4.1912.

Windiarti, T. and Mayasari, T. (2019). Analisis Kemampuan Berfikir Kreatif Siswa Kelas X Pada Materi Listrik Dinamis. *SNPF (Seminar Nasional …*, pp. 69–72.

Wiyono, K. *et al.* (2022). STEM-based E-learning: Implementation and Effect on Communication and Collaboration Skills on Wave Topic. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, 8(2), pp. 259–270. doi: https://doi.org/10.21009/1.08208.

Wulandari, D. *et al.* (2021). Profile of students' creative thinking skills on global warming material: Gender perspective in physics learning. *Journal of Physics: Conference Series*, 2110(1), pp. 0–7. doi: https://doi.org/10.1088/1742-6596/2110/1/012028.

Wulandari, K.. K.M.. & P.S. (2023). Pengembangan Instrumen Penilaian Formatif Materi Usaha Dan Energi Pada Mata Pelajaran Fisika SMA/MA. *DIFFRACTION: Journal for Physics Education and Applied Physics*, 5(1), pp. 1–7. Available at: http://jurnal.unsil.ac.id/index.php/Diffraction.

Yuliana, I., Kusairi, S. and Taufiq, A. (2019). Profil Penguasaan Konsep Siswa SMA pada Materi Suhu dan Kalor', *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 4(5), p. 572. doi: https://doi.org/10.17977/jptpp.v4i5.12384.

Yulianci, S. *et al.* (2021). The Effect of Interactive Multimedia and Learning Styles on Students' Physics Creative Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 7(1), pp. 87–91. doi: https://doi.org/10.29303/jppipa.v7i1.529.