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Profile of Physics Creative Thinking Skills for High School Students in The 21st Century

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Abstract

Creative thinking is one of the 21st-century skills that every individual should possess. These skills facilitate the individual in realizing the imagination, providing an opportunity to think and express ideas. So knowing the profile of creative thinking skills is considered very important. This study aims to analyze creative thinking skills in learning activities teaching physics subjects on the topic of temperature and heat. This type of research is quantitative descriptive research with test methods. Class XI students of one of the public high schools in Central Bangka became the population in this study. The sample in this study was 64 students who were selected by purposive sampling. Data were collected using Creative Thinking Skills Physics SMA (PhysCreTHOTS). The results showed students' creative thinking skills on temperature and heat material were at a percentage of 54.40% with sufficient categories. And there are no students who are in the category of very good and very less. Then students' creative thinking skills based on creative thinking indicators are all classified as sufficient with a percentage of 57.81% (fluency), 45.57% (flexibility), 56.25% (originality), and 58.59% (elaboration). The results of this discovery can be used as empirical evidence and reference that in the implementation of physics learning students' creative thinking skills still need to be improved. Further research is needed to overcome the low ability to think creatively.

Keyword*s:* creative thinking, 4C skills, industrial revolution 4.0, physics learning, temperature, and heat.

INTRODUCTION

The 21st century is fast-paced and often unpredictable (Rizal et al., 2019; Susilowati et al., 2022). Some researchers even reveal that this century is the most uncertain (Callanan et al., 2017; Geltner et al., 2012). This has an impact on all areas of life there is a big and significant change and produces a new era in terms of information and globalization (Abdurrahman, 2019; Rizal et al., 2020; Wiyono et al., 2020). So that to be able to adapt well to these changes, individuals must be able and have the skills to think out of the box (Akyıldız & Çelik, 2020; Nikmah et al., 2021). Some of the skills needed include collaboration, communication, critical thinking, and creative thinking, or known as "The 4Cs" (Partnership for 21st Century Skills, 2008).

Knowledge and technology in modern life that is currently enjoyed are inseparable from the scientific aspect (Rizal et al., 2020). Various inventions in theory and technology are always assessed in scientific aspects. These scientific discoveries reflect the creativity of scientists. Creative thinking skills are defined as a habit of thinking that is trained by reviving imagination, paying attention to intuition, and revealing new things that need to be explored (Yasiro et al., 2021). One of the outputs of this skill is shown by the ability of students during teaching and learning activities in generating new ideas and solving problems and questions in life. The new idea can be in the form of development from pre-existing ideas (Herlina & Qurbaniah, 2017). Students have good creative thinking skills shown by confidently conveying arguments

from existing phenomena, producing dissimilar ideas and views, being able to see relationships between variables, and having a high tendency to imagine in applying physical concepts (Setyarini et al., 2020).

Physics is one of the natural sciences that studies natural phenomena or phenomena with thought processes that start from observation, measurement, analysis, and conclusion (Rizal et al., 2020). One of the important thinking skills to improve in the physics learning process is creative thinking skills (Türkmen & Sertkahya, 2015). This skill is very compatible with the process of learning physics which contains abstract concepts (Susilowati et al., 2022). Students must be able to imagine in understanding the concept of physics so that the concept is easier to understand. However, the concept of physics cannot be observed directly so it requires higher thinking skills (Sari et al., 2020). For the topic of temperature and heat for example, students can mention the concept directly but to understand it they need observation and a deep thought process (Nazhifah et al., 2022). One such thinking process is the skill of creative thinking. Therefore, mastery of creative thinking skills is very important in learning physics (Batlolona et al., 2019).

Creative thinking skills are not skills that can only be possessed by a few individuals but basically, every student can master these skills (Akyıldız & Çelik, 2020; Davis, 2018). Sometimes, creative thinking skills do not appear in students not because they do not have these skills, but because these abilities are poorly trained (Susilowati et al., 2022). Like other abilities, creative thinking skills can be acquired through practice and habituation of the learning process (Zhou, 2022). So that teachers and learning environments have a very large role in training and improving students' creative thinking skills by providing and familiarizing thinking activities in the classroom (Sari et al., 2020). Such as through teacher training and improving the quality of the learning environment that encourages the availability of questions that support students to think, open-mindedness to new ideas, and readiness to learn failure (Trilling & Fadel, 2009). And create an atmosphere of an interactive and fun learning process to facilitate students in conveying ideas (Wulandari et al., 2021).

Studies on creative thinking skills have been conducted by several previous researchers, Hürsen et al., (2014) stated that research related to creative thinking skills in several countries, such as Hong Kong, Germany, India, Romania, and Israel is classified in the low category. In addition, similar research was also conducted in Indonesia showing results that varied with the majority of results in the low and medium categories (Goran et al., 2021; Meiarti, 2021; Paryumi, 2022; Sugiyanto et al., 2018; Trisnayanti et al., 2020; Wulandari et al., 2021; Yasiro et al., 2021). Based on this, it can be seen that students have not been able to apply creative thinking skills (Lestari et al., 2018). This can happen because students have not been able to understand the topic being studied, one of which is understanding the topic of temperature and heat. The findings are contrary to 21st-century skill expectations, which state that every individual must have good creative thinking skills (Wulandari et al., 2021).

Based on this explanation, to increase these skills, it is necessary to make changes in the context of thinking and implementing the right learning process. This of course requires high and solid integration by all aspects of education (Komaria & Wicaksono, 2019; Ndiung et al., 2019). Therefore, it is important to carry out further research related to learning models and methods, media, and teaching materials. However, before conducting the research, it is necessary to carry out further analysis related to students' creative thinking skills. Observing the importance of these skills in physical learning, this research was conducted to determine the profile of students' creative thinking skills, especially in the subject of temperature and heat. The results of this discovery can be used as a reference, introduction to learning, and evaluation in the implementation of physics learning, especially to improve students' creative thinking skills.

METHOD

This study is a quantitative descriptive study with test methods. 11th-grade students at public senior high school number 1 Namang, Central Bangka became the population in the study. Research samples are students selected through research sample selection techniques with some special considerations referred to as purposive sampling (Creswell & Poth, 2018). The purposive sampling technique used refers to the categorization of classes (low and high categories). Class categorization is based on the analysis of the results of daily replays of Physics, then two classes were selected with a total of 64 students who will be a research sample.

The test uses Creative Thinking Skills Physics (PhysCreTHOTS) questions developed by Istiyono et al., (2018). This instrument consists of multiple-choice questions reasoned on the subject of temperature and heat. It is then assessed based on test scoring criteria which are arranged into four categories. Category 1 is if the student's questions and reasons are wrong. Category 2 answers the question correctly but for the wrong reason. Category 3 is if the learner answers the question incorrectly and the reason is correct. Category 4 if the question or reason is answered correctly. The table below shows the distribution of creative thinking test for PhysCreTHOTS.

Table 1. Distribution of creative thinking test item (PhysCreTHOTS)

Aspect	Sub aspect	Indicators of creative thinking	Total
Fluency	Formulating Answers	Answer some questions with some facts.	2
	Expressing ideas	Smoothly create ideas/hypotheses	2
	Criticize an object	Seeing the error of an object	2
Flexibility	Doing the interpretation.	Provides a point of view	2
Originality	Planning something new	Resolving new issues	1
	Troubleshooting with detailed procedures	Seek a deeper understanding of a problem	2
Elaboration	Developing ideas	Enriching other people's ideas	2
	Testing	Trying to make something new	2

The test is carried out with a Computer Based Test (CBT) which requires researchers to change the form of the problem that was originally only in the form of a hard file into a problem in the form of CBT. Researchers chose an online survey platform called Google Forms because this platform makes it easier for researchers to create quizzes. After creating an online quiz, test questions are distributed in the form of links to students. Students can access and do the test using a mobile phone or laptop, so it does not make it difficult for students. The results of students' answers will then be analyzed and grouped into categories of creative thinking skills with the following formula:

$$Score = \frac{\sum Correct\ Score}{\sum Maximum\ Score} x\ 100\ \%$$

Then the proportion of students' creative thinking is interpreted based on the categories in Table 2 (Sugiyanto et al., 2018).

Table 2. Creative Thinking Criteria

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

RESULT AND DISCUSSION

RESULT

Learner Creative Thinking Skill Level

The data obtained from the students' answers were then analyzed to determine the level of creative thinking skills in physics learning, especially in temperature and heat materials. The results of the analysis can be seen in Table 3 and 4.

Table 3. Data Recapitulation of Students' Creative Thinking Skill Acquisition

Category	Percentage
Average Score	54.40
Minimum Score	34.09
Maximum Score	70.45
Standard Deviation	7.84

Table 4. Results of Percentage Recapitulation Analysis of the Number of Students in Each Category of Creative Thinking Skills

Definition	Criteria	Number of Students	%
81-100	Very Good	0	0
61-80	Good	27	42
41-60	Quite	30	47
21-40	Deficient	7	11
0-20	Very Deficient	0	0

Based on Table 3, the average score of test data on creative thinking skills of students in class XI of one of the public high schools in Central Bangka is 54.40, which is in the category of creative thinking. Then from 64 students, the highest score was 70.45 while the lowest score was 34.09. Table 4 presents information that there are no students who are in the very good and very poor categories. There are 27 students in the good category with a percentage of 42%, students in this category are those who score 4 out of 11 available questions, or in other words, they can answer questions correctly and give reasons for the answers given. But the majority still get a score of 3 and 2, this is what underlies the absence of students with maximum scores or belong to very good categories. Then as many as 30 students belong to the sufficient category for creative thinking skills with a percentage of 47%. While the students who intended the category enough are those who get a score of 3, namely wrong answering questions and giving the right reasons, majorities still get a score of 2 and 1. Furthermore, as many as 7 students were referred to in the less category with a percentage of 11%. The majority of students in this category get a score of 2 and 1, namely providing answers and wrong reasons and answering right and wrong reasons.

Percentage of Creative Thinking Skills of Learners of each indicator

Students' creative thinking skills in physics learning have four indicators consisting of flexibility, fluency, elaboration, and originality, and (Rizal et al., 2020; Wulandari et al., 2021). The percentage of indicator creative thinking skills test results can be seen in Figure 1.

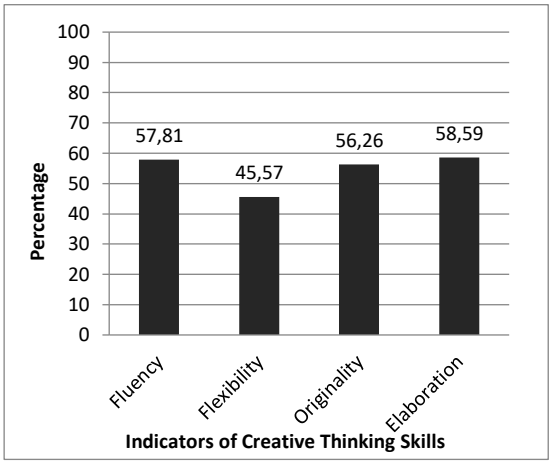

Figure 1. Students' Creative Thinking Skills for each indicator

Based on the results of the study showed that of the four indicators of creative thinking skills, there were no students who belonged to the category of very good and very deficient. Students who have the highest percentage value on the indicator originality of 56.25% are classified as a sufficient category. While the other three indicators of creative thinking skills are also in the sufficient category. On indicators flexibility at 45.57%, indicator

fluency at 57.81%, and indicators elaboration at 58.59%. The results of these findings show that the creative thinking skills of 11th-grade students at public senior high schools number 1 Namang Central Bangka vary greatly where the dominating category is the sufficient category. However, the results of this study show some differences and similarities with the results of previous studies.

DISCUSSION

This study was conducted to analyze the creative thinking skills of high school class XI students in physics learning, especially in temperature and heat materials. Creative Thinking Skill is defined as the cognitive ability that allows individuals to develop their imagination in generating new ideas as a development of previous ideas as well as the ability to use those ideas to get solutions to a problem (Kampylis & Berki, 2014; Wahsheh, 2017). Measuring and knowing the level of creative thinking skills is just as important as practicing those skills in physics learning (Susilowati et al., 2022).

Students at public high school number 1 Namang do not belong to the very lacking category or get a score of zero on the creative thinking ability test. This is in line with the results of research conducted by Armandita et al., (2017) which shows that there are no students who get a score of zero on the test of creative thinking skills. This means that there are no students who do not have creativity. This statement is by Treffinger on Armandita et al., (2017) statement in stating that no one student has zero intelligence. As with creative thinking skills, there are no students who do not have creative thinking skills at all. Sometimes, these skills are poorly mastered by students not because they do not have these skills, but because they are poorly trained (Susilowati et al., 2022). Like other abilities, creative thinking skills can be acquired through practice and habituation of the learning process (Zhou, 2022). Students' creative thinking skills in physics learning have four indicators consisting of flexibility, fluency, elaboration, and originality (Munandar, 2009; Wulandari et al., 2021; Yolanda et al., 2021). The following is an explanation of the creative thinking skills of students of each indicator.

Creative Thinking Skills Based on Fluency Indicators

The average value of the results obtained by students in the fluency indicator is 57.81% based on the table of creative thinking skills category, the value is included in the sufficient category. The findings are not in line with the research by Trisnayanti et al., (2020) that shows students' creative thinking skills on the fluency indicator by 75% and are included in the high category. Then another study also showed that fluency indicators students' creative thinking skills at a percentage of 61.11%. The value is the highest gain from the four indicators and belongs to the good category.

Creative thinking skills in fluency indicators are defined as the ability of students to see the relationship between concepts in a short and precise time (Trianggono, 2017). So that the understanding of the concept of students becomes one of the factors that cause students to be categorized as good or lacking in this indicator. Students who have a good understanding of concepts will easily connect between physical concepts based on phenomena that occur daily (Trianggono, 2017). In addition, several factors affect students' ability to think smoothly, such as knowledge, intelligence, motivation, and personality (Chang, 2013). Then students have not been able to develop their ideas because they tend to answer questions based on the knowledge they get from reading materials (Goran et al., 2021).

Creative Thinking Skills Based on Flexibility Indicators

Flexible thinking can be defined as the ability of students to face various alternative ways or approaches to solving problems (Munandar, 2009; Trisnayanti et al., 2020). Each student always has a different direction in solving a phenomenon, problem, or situation in the surrounding environment (Prasetiyo, 2014). The research data in Figure 1 shows that

students have flexibility thinking skills of 45.57%. The low average value identifies that the Flexibility skills of students are classified as sufficient. The findings are in line with previous findings that show student's creative thinking skills in the flexibility indicator of 57.78% and are intended in the sufficient category. Students have not been maximal in expressing ideas or ideas that vary, the reasons for the answers expressed are monotonous or only seen from one point of view because students are less accustomed to representing a phenomenon or problem by the surrounding environment in everyday life (Kaleka & Nur, 2018).

Creative Thinking Skills Based on Originality Indicators

Originality is a skill of students in producing unique and new ideas or ideas and can combine various elements or parts in an unusual way (Munandar, 2009). Data from the results showed that the average value of student answers in this indicator was 56.25%. This means that students' creative thinking skills on the originality indicator are in the sufficient category. This means that some students can issue expressions, ideas, or ideas to solve a problem or make a combination of parts or elements that are unusual, unique, new, or rarely encountered (Wulandari et al., 2021). However, some of them have not been able to develop this ability. This finding is in line with the results of previous studies which revealed that the originality of students is at the percentage of 54% (Armandita et al., 2017). Then the research conducted showed Meiarti (2021) that on the indicator of originality, students' creative thinking skills were classified as sufficient criteria with a percentage of 57.78%.

Creative Thinking Skills Based on Elaboration Indicators

Elaboration skills are defined as the skills of students in describing or elaborating something simple into a broader definition (Prasetiyo, 2014). This skill is also defined as the ability to develop and enrich an idea, object, or situation and then add and detail it so that it becomes something more interesting (Munandar, 2009). Based on the results of the analysis in Figure 1, shows that students' elaboration skills amounted to 58.59%. From these values, it can be seen that the skill of elaborating on students is intended in the sufficient category. The results of the test are in line with research by Meiarti (2021) that states that students are classified as sufficient criteria on the indicator of elaboration of creative thinking skills with a percentage of 50.00%. This is because, not all students can pay attention to the details of the concept of temperature and heat in each question (Trisnayanti et al., 2020).

Overall, students' creative thinking skills are classified into enough categories with a percentage of 54.40%. The results of these findings are in line with the previous findings made by Meiarti (2021) which showed that after carrying out a test of creative thinking in physics learning, students were included in the sufficient criteria with a percentage of 56.67%. However, these findings are also different from several previous studies showing that students' creative thinking skills are meant on low criteria (Wulandari et al., 2021; Sugiyanto et al., 2018; Saprudin et al., 2019; Trisnayanti et al., 2020;). All the research shows that the skills of students are still relatively lacking and have not been trained optimally.

Based on the entire analysis, it was found that there were variations in the results of creative thinking skills. The main factors are the differences in the instruments used by each researcher, there are differences in the material tested, different levels of difficulty from each question of each indicator, and the lack of skills of students in understanding the information provided. To cause errors in providing answers, and a lack of sensitivity in students in answering questions. Sensitivity to the problems that have been given is needed by students in bringing up new ideas or ideas that have never been thought of before so that they can realize creative thinking skills (Armandita et al., 2017).

Another factor that affects the thinking skills of students is learning outcomes (Rapika et al., 2018). Students with high cognitive learning outcomes can remember facts, formulas, and concepts in learning materials and can apply theories in daily life (Okyranida,

2017). So that students with good learning outcomes are better able to use their creative thinking skills to the maximum. In addition, Rapika et al., (2018) also mention that the cognitive style of students affects their level of creativity. The cognitive style of students is divided into two, namely impulsive and reflective cognitive styles (Rapika et al., 2018). Impulsive cognitive style students have low creative skills while reflective cognitive style children have high creative skills (Khamida et al., 2017).

Each student has creative thinking skills, but these skills are often not a concern (Akyıldız & Çelik, 2020; Davis, 2018; Susilowati et al., 2022). So it has an impact on the low creative thinking skills of students such as those aimed at the results of this study and some previous studies. Creative thinking skills can appear in each individual through a process of habituation and training (Zhou, 2022). Thus, it is important to familiarize creative thinking skills in the learning process, especially in physics learning. Conducive learning activities contribute to the improvement of creative thinking skills and focus on strategies related to idea generation, conceptual, problem definition, and implementation (Mumford et al., 2012).

In addition, a supportive learning approach is also needed in the process of habituating students to think creatively, for example, teachers can apply learning approaches such as stem (Nazifah & Asrizal, 2022; Saputri et al., 2022), Project Based Learning (PjBL) (Muchsin & Mariati, 2020; Nafiah et al., 2023), and Problem-Based Learning (PBL) (Neswary & Prahani, 2022; Suharno et al., 2022). As well as teachers need to create an atmosphere of teaching and learning activities in classes that are oriented to creative thinking skills (Rizal et al., 2020). Then teachers as educators play a big role in developing self-confidence and minimizing the fear of students so that they can convey ideas and innovations in the learning process so that creative thinking skills are created in students (Kau, 2017; Wiyono et al., 2022). Teachers utilize more interactive learning media such as games(Anggraeni & Sole, 2020), online learning, and electronic books(Irwandani et al., 2020; Rahayu et al., 2022) (Adawiyah et al., 2019), so that they can be used in the learning process to improve creative thinking skills(Yulianci et al., 2021). Based on the results of this study and several previous studies, it is expected to be an evaluation material for education in Indonesia to innovate in improving the skills of students, especially the ability to think creatively to face challenges in the 21st century.

CONCLUSION

Based on the analysis of research data on the skills of students in the test of creative thinking skills of temperature and heat materials at one of the public high schools in Central Bangka is in the category of sufficient with a percentage of 54.40%. Based on the category of creative thinking skills, 42% (good), 47% (enough), 11% (less) and no students are in the category of very good and very less. Then the students' creative thinking skills based on all creative thinking indicators are classified as sufficient with a percentage of 57.81% on the fluency indicator, 45.57% on the flexibility indicator, 56.25% on the originality indicator, and 58.59% on the elaboration indicator. This study provides information about the level of creative thinking skills of high school students. So for further research, the researchers suggest developing and implementing interactive learning media such as online learning and game learning, applying learning approaches such as stem, Project Based Learning (PjBL), and Problem-Based Learning (PBL), as well as creating a learning atmosphere that supports the improvement of students' creative thinking skills in physics learning.

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