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# Strengthening Creative Thinking Ability: A Project-Based Physics Assessment Instrument

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**ABSTRACT**

Creative thinking is one of the skills needed in education in the 21st century which requires students to think appropriately in accordance with relevant and diverse sources of information. This study examines students' creative thinking skills during project-based physics learning In the subject of work and energy. The study was conducted by 36 students in their first year of high school. It was obtained using a simple random sampling technique in one of the high schools in Kotaagung, Tanggamus. The assessment tool utilized in the study was a project assessment tool supported by a worksheet on business and energy materials. It was a valid, reliable, and useful instrument. According to the research's findings, 36 students achieved the following levels of creativity in each indicator: 1) fluency (69%); 2) flexibility (80%); 3) originality (69%); and 4) elaboration (68%).

**INTISARI**

Berpikir kreatif merupakan salah satu keterampilan yang dibutuhkan pada dunia pendidikan di abad 21 yang menuntut siswa dapat berpikir dengan tepat sesuai dengan sumber informasi yang relevan dan beragam. Penelitian ini bertujuan untuk menganalisis kemampuan berpikir kreatif siswa pada pembelajaran fisika berbasis proyek pada materi usaha dan energi. Penelitian dilakukan pada 36 siswa kelas X yang diperoleh dengan menggunakan teknik *simple random sampling* di salah satu SMA di Kotaagung, Tanggamus. Instrumen penilaian yang digunakan dalam penelitian menggunakan instrumen yang valid, reliabel dan praktis berupa perangkat asesmen proyek berbantuan lembar tugas pada materi usaha dan energi. Berdasarkan hasil penelitian diperoleh, pencapaian kemampuan berpikir kreatif dari 36 siswa disetiap indikatornya yaitu: 1) berpikir lancar *(fluency)* sebesar 69%; 2) berpikir luwes *(flexibility)* sebesar 80%; 3) berpikir orisinal *(originality)* sebesar 69%; 4) memperinci *(elaboration)* sebesar 68%.

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Instrumen asesmen, kemampuan berpikir kreatif, pembelajaran berbasis proyek.

## A. Introduction

Creative thinking skills are a challenge in the world of education in the 21st century. These skills require students to think correctly about relevant and diverse sources of information. In line with some of the following expert opinions: According to NSTA, various 21st century skills, such as creative thinking skills, can be developed during the educational process [1]. The educational process equips students with the right way of thinking and accurate information to develop creative thinking skills [2].

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Thinking skills are processes and student behaviors that are integrated as a means of learning and comprehending learning material [3]. Related to this, the challenges of 21st century education require teachers to optimize the process of creating superior generations who are able to think creatively. Therefore, it is necessary to direct the learning process that leads to solving contextual problems. According to Yusnaeni et al., it is necessary to guide students in solving everyday problems using science [4].

The ability to think creatively is one of the skills that must be trained in order to prepare skilled students for the 21st century. The ability to think creatively is the ability to think that is trained to turn on the imagination and reveal new possibilities by opening broad perspectives to find new ideas [5]. The ability to think creatively can be interpreted as an activity to produce an idea or ideas for solving problems, as well as connecting one thing with another to find its true meaning [6]. In ref. [7], it is explained that creative thinking is a habit of the mind that is trained by paying attention to intuition, turning on imagination, expressing new possibilities, opening amazing perspectives, and generating unexpected ideas. Creative thinking is one of the important abilities that students must have in physics lessons. Through creative thinking, students are expected to be able to see physical phenomena from various perspectives. Students are also able to provide various answers to the physics problems they face. so that students have many ways to solve problems or understand physical phenomena. This has a good impact on students because they can find a way to solve physics problems that is most effective and efficient.

Creative thinking is a process that involves the elements of originality, fluency, flexibility, and elaboration. This shows that creative thinking can develop thinking skills that include insights with broad elements [8]. In ref. [7], it is explained that creative thinking is a habit of the mind that is trained by paying attention to intuition, turning on imagination, expressing new possibilities, opening amazing perspectives, and generating unexpected ideas. Another opinion explains that creative thinking is a type of thinking that leads to the acquisition of new insights, new approaches, new perspectives, or new ways of understanding something [9]. Based on this description, it can be said that the ability to think creatively is a person's ability to think from different perspectives and turn on his imagination to produce new ideas that are used to solve a problem.

Creative thinking skills as the embodiment of creative thinking, some experts reveal: (1) The ability to think differently, be sensitive to a problem, solve problems, and find unusual solutions to these problems [10]. (2) The process of creative thinking is characterized by the ability to define, analyze, and solve problems [11]. (3) There are four main components of creative thinking skills, which include fluency, flexibility, originality, and elaboration [12].

Based on the results of studies that have been conducted by researchers regarding the needs analysis carried out in one of the public high schools in Kotaagung Regency using a questionnaire, it is known that students' creative thinking abilities

are still relatively low due to the lack of availability of learning tools or media in project-based learning to measure students' creative thinking abilities in material work and energy. Paying attention to the reality at school is one of the efforts to improve students' creative thinking skills by implementing project-based learning assisted by project-based worksheets. In this study, assessment of students' creative thinking abilities was identified using an assessment instrument that included an assessment rubric. An assessment rubric can measure the quality of students' arguments or answers with clear and measurable criteria [13]. The assessment instrument used is in the form of observation sheets, assisted by the use of student assignment sheets (SAS), which help direct student activities at each PjBL steps.

## B. Method

The research design used in this study is Design and Development (D&D), which prioritizes processes and products. Richey & Klein [14] define design and development methods as "the systematic study of design, development, and evaluation processes with the aim of establishing an empirical basis for the creation of new or enhanced instructional and non-instructional products, tools, and models." Design and development planning is a way to build or create knowledge based on systematic data from the application of a product.

The population in this study was made up of 11th grade science students, with a total of 216 students. The sample selection in this study was based on ref. [15]: if there are less than 100 subjects, then all of them must be sampled; if the subject is more than 100 people, then the sample can be taken at 10-15%, 20-25%, or more [15]. In this study, 16.7% of the total population was taken as a sample, namely 36 students who had studied the material physics of work and energy. This sampling technique is called simple random sampling.

The project-based learning model consists of several stages, where each phase must be completed according to a predetermined timetable. The PjBL stages are introduction, an essential question, research and writing, product creation, presentation, evaluation, and reflection [16]. Students' creative thinking abilities are measured using assessment instruments that have been prepared at the design stage and perfected at the development stage. The project-based material physics assessment instrument has been validated by experts, declared valid, reliable and and useful instrument, with several suggestions for improvement. The instrument compiled is in the form of an observation sheet containing descriptions of activities that are in accordance with indicators of scientific literacy and creative thinking of students with PjBL learning stages. Project-based learning activities are carried out with the help of Student Assignment Sheets (SAS) by considering activities during the learning process and student answers in answering questions on SAS.

Guidelines for scoring instruments for assessing students' abilities and creative thinking are carried out by changing the raw score into a percentage value by using the formula 1:

$$S = \frac{\sum X}{\sum M} 100\% \quad (1)$$

Descriptions:

$S$ : Final Score

$\sum X$ : Total score obtained by students in the assessment

$\sum M$ : Total maximum score for each statement item that can be obtained by students in the assessment The total score for each statement item in this instrument is the number of items multiplied by the maximum score for each item

Then an interpretation of the assessment of students' creative thinking abilities was carried out with a scale criterion of 0–100% [17] as shown in Table 1.

Table 1. Criteria for Assessment of Creative Thinking Ability

| Percentage (%) | Criteria |
|---|---|
| 81 - 100 | Very Good (A) |
| 61 - 80 | Good (B) |
| 41 - 60 | Adequate (C) |
| 21 - 40 | Bad (D) |
| < 21 | Very bad (E) |

## C. Result and Discussion

Students' creative thinking abilities in project-based learning on work and energy materials are measured and assessed with the help of student assignment sheets (LTS) so that students' scientific literacy and numeracy skills are well honed. The results of this study obtained quantitative data in the form of students' achievements in scientific literacy and creative thinking integrated with the PjBL stage. Based on the results of the assessment using the assessment instrument for students' scientific literacy and creative thinking skills, it can be seen in Figure 1.

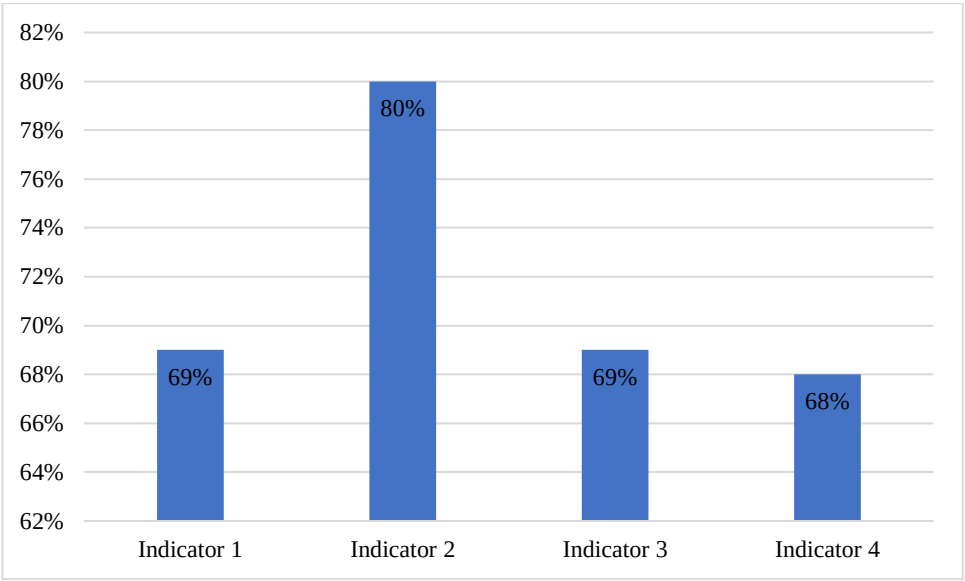



Figure 1. Achievement of Each Indicator of Creative Thinking Skills

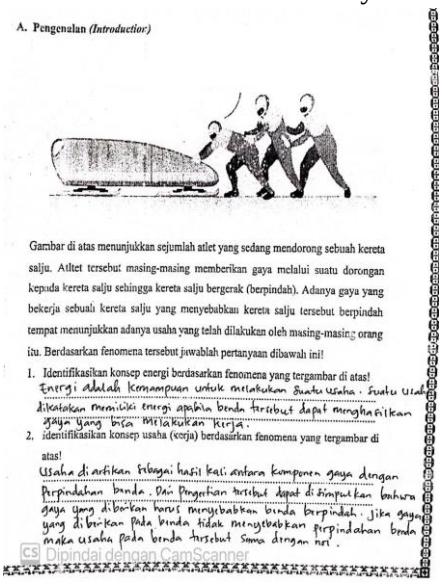
Based on Figure 1, the average score for the achievement of indicators for the ability to think creatively is obtained from 36 students for each indicator, namely: 1) thinking fluently (fluency) of 69%; 2) thinking flexibly (flexibility) of 80%; 3) original thinking (originality) of 69%; and 4) elaboration of 68% [18]. The following is presented in Table 2, which contains the distribution of indicators for each ability based on the stages of project-based learning that researchers use.

Table 2. Distribution of Students' Science Literacy and Creative Thinking Ability

| Indicators of Creative Thinking Ability | PjBL Steps |
|---|---|
| Fluency | 1. Essential question<br>2. Research and write<br>3. Product creation |
| Flexibility | 1. Introduction<br>2. Evaluation and reflection |
| Originality | 1. Essential question<br>2. Research and write<br>3. Prestentation |
| Elaboration | 1. Product creation<br>2. Presentation |

Based on Table 2, the first distribution of creative thinking ability indicators is fluency. Fluency refers to students' ability to produce various and correct answers. Answers are said to be varied if they appear different and follow a certain pattern. Student productivity to produce various and correct answers and difficulties in solving problems will also be assessed and explored to add to the results of the description of the level of students' creative thinking abilities [18]. At the essential question activity

stage, research, writing, and product creation refer to the ability of students to produce various and correct answers. Answers are said to be varied if they appear different and follow a certain pattern. Student productivity to produce various and correct answers and difficulties in solving problems will also be assessed and explored to add to the results of the description of the level of students' creative thinking abilities. Figure 2 below is an example of student work that illustrates student productivity in producing various and correct answers as a manifestation of fluency.


A. Pengenalan *(Introductior)*

Gambar di atas menunjukkan sejumlah atlet yang sedang mendorong sebuah kereta salju. Atltet tersebut masing-masing memberikan gaya melalui suatu dorongan kepada kereta salju sehingga kereta salju bergerak (berpindah). Adanya gaya yang bekerja sebuah kereta salju yang menyebabkan kereta salju tersebut berpindah tempat menunjukkan adanya usaha yang telah dilakukan oleh masing-masing orang itu. Berdasarkan fenomena tersebut jiwablah pertanyaan dibawah ini!

1. Identifikasikan konsep energi berdasarkan fenomena yang tergambar di atas!
   Energi adalah kemampuan untuk melakukan suatu usaha. Suatu Utah dikatakan memiliki energi apabila benda tersebut dapat menghasilkan gaya yang bisa melakukan kerja.
2. identifikasikan konsep usaha (kerja) berdasarkan fenomena yang tergambar di atas!
   Usaha di artikan sebagai hasil kali antara komponen gaya dengan perpindahan benda. Dari pengertian tersebut dapat di simpulkan bahwa gaya yang diberikan harus menyebabkan benda berpindah. Jika gaya yang diberikan pada benda tidak menyebabkan perpindahan benda maka usaha pada benda tersebut sama dengan nol.

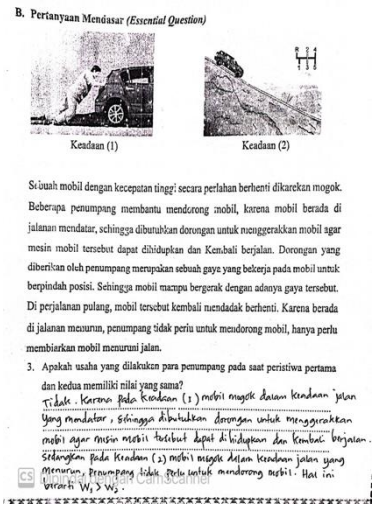


Figure 2. Examples of students' work to think fluently (fluency)

Figure 2 represents students' ability to think creatively with indicators of fluency; previously, students were given the problems contained in the questions, which directed students to be able to identify energy concepts based on phenomena. In this case, students have succeeded in producing various and correct answers. The problems presented in Figure 2 require students to find concepts by utilizing their curiosity. Conceptual statements that were successfully built by students were "Energy is the ability to do business," while statements that describe students' curiosity were built with the statement "that an object is said to have energy when the object is able to produce a force that can do work." The second statement produced by students illustrates the number of ideas students have, which is represented by reinforcing the answers to the first statement. The second statement also describes the ability to think fluently by thinking of more than one answer. This means that at this stage, the demands of students to collect information or data to solve the problems they face have been successfully carried out using alternative problem-solving ideas supported by the knowledge and experience they have. Individuals now try to explore possible paths to solve these problems. In line with the opinions of several experts, (1) "creative thinking" means thinking in different directions and obtaining unique answers that are different but correct [19]. (2) These thinking skills are a process and

student behavior that work together to learn and comprehend the content of learning material [20]. And (3) students' ability to specify answers is an indicator of detailed thinking, as is the enthusiasm of students making two different statements based on problems [21].

The second indicator of the ability to think creatively is flexible thinking. That refers to the ability of students to generate various kinds of ideas with different approaches to solving problems.


B. Pertanyaan Mendasar *(Essential Question)*

Keadaan (1) Keadaan (2)

Sebuah mobil dengan kecepatan tinggi secara perlahan berhenti dikarekan mogok. Beberapa penumpang membantu mendorong mobil, karena mobil berada di jalanan mendatar, sehingga dibutuhkan dorongan untuk menggerakkan mobil agar mesin mobil tersebut dapat dihidupkan dan kembali berjalan. Dorongan yang diberikan oleh penumpang merupakan sebuah gaya yang bekerja pada mobil untuk berpindah posisi. Sehingga mobil mampu bergerak dengan adanya gaya tersebut. Di perjalanan pulang, mobil tersebut kembali mendadak berhenti. Karena berada di jalanan menurun, penumpang tidak perlu untuk mendorong mobil, hanya perlu membiarkan mobil menuruni jalan.

3. Apakah usaha yang dilakukan para penumpang pada saat peristiwa pertama dan kedua memiliki nilai yang sama?
   Tidak. Karena pada keadaan (1) mobil mogok dalam keadaan jalan yang mendatar, sehingga dibutuhkan dorongan untuk menggerakkan mobil agar mesin mobil tersebut dapat dihidupkan dan kembali berjalan. Sedangkan pada keadaan (2) mobil mogok dalam keadaan jalan yang menurun, penumpang tidak perlu untuk mendorong mobil. Hal ini berarti $W_1 > W_2$.

Figure 3. Examples of students' work to think flexibly (flexibility)

Figure 3 represents an example of student work for indicators of creative thinking skills to think flexibly (flexibility). The statement of questions presented in Figure 3 refers to the ability of students to generate various ideas with different approaches to solving problems. Students are expected to be able to explain every method used to solve the problem. Student productivity in changing the point of view of completion and the level of difficulty of students in solving problems will also be assessed and explored to add to the description of the results of the level of students' creative thinking ability [15].

Figure 3 presents students with scientific phenomena in the matter of work and energy, and then students are asked to identify the concepts of energy and work based on the phenomena depicted. In this stage, students need to capture a number of key or essential concepts to be able to understand certain natural phenomena and changes that occur as a result of human activities [22]. Students are presented with two phenomena at the fundamental question stage (essential question), namely circumstances (1) and circumstances (2). Students are asked to answer basic questions related to the phenomena presented, and they are also asked to interpret business relationships and energy changes based on the phenomena described. This is so that students are able to apply scientific knowledge to a situation, describe or interpret phenomena, and predict changes by identifying appropriate descriptions, explanations, and predictions [23]. At the presentation stage, students make PPTs as

presentation material for the results of simple teaching aids for work and energy, which they then present. The following is the result of student work with correct answers.

The third indicator of the ability to think creatively is originality. refers to the ability of students to give answers that are unusual, different from the others, and have the correct value. Students are expected to solve problems with their own thinking. The originality of students' answers will be assessed and further explored to measure the level of students' creative thinking ability [15]. At this stage of the activity, students give unusual answers that are different from the ones given by others and have a true value, meaning that students are expected to solve the problem with their own thinking.

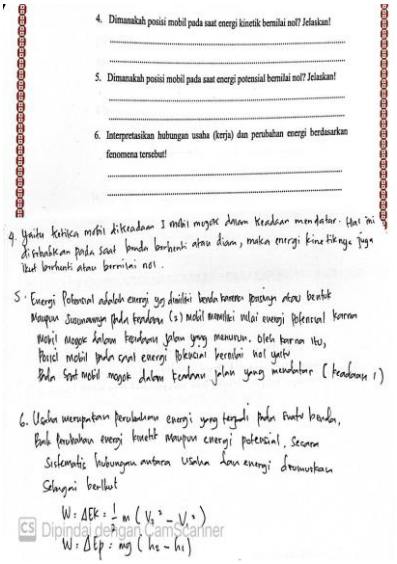
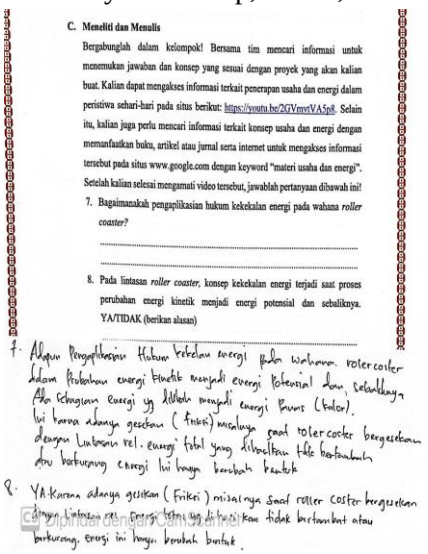



Figure 4. Examples of students' original work (originality)

Figure 4 presents an example of students' ability to elaborate by expressing new ideas and ideas that can simplify complex problems. This means that students have met the indicators of creative thinking, namely original thinking. It can be further explained that the statement in Figure 4 is able to motivate students to be involved in carrying out problem-solving activities, namely the ability to come up with unique ideas or the ability to come up with original ideas. In line with the opinion of Amtiningsih et al. [22] that the ability to think originally does require the development of aspects of fluency and flexibility first, if these two aspects have not been fulfilled, it will be difficult to achieve students' original thinking skills [24]. At this stage of activity, students are presented with a link related to the application of work and energy in daily events. Students are expected to be able to find information related to the concept of work and energy by utilizing books, articles, or journals, as well as the internet, to access this information.

The fourth indicator of creative thinking ability is elaboration. refers to the ability of students to develop, add to, and enrich an idea. Students are encouraged to add

additional information or information to clarify their answers. Productivity in providing additional information will be assessed and further explored to measure the level of students' creative thinking skills [15]. The product creation and presentation stages refer to the students' ability to develop, add to, and enrich an idea.



C. Menelitl dan Menulis

Bergabunglah dalam kelompok! Bersama tim mencari informasi untuk menemukan jawaban dan konsep yang sesuai dengan proyek yang akan kalian buat. Kalian dapat mengakses informasi terkait penerapan usaha dan energi dalam peristiwa sehari-hari pada situs berikut: https://youtu.be/2GVmvtVA5p8. Selain itu, kalian juga perlu mencari informasi terkait konsep usaha dan energi dengan memanfaatkan buku, artikel atau jurnal serta internet untuk mengakses informasi tersebut pada situs www.google.com dengan keyword "materi usaha dan energi". Setelah kalian selesai mengamati video tersebut, jawablah pertanyaan dibawah ini!

7. Bagaimanakah pengaplikasian hukum kekekalan energi pada wahana *roller coaster*?

.....

.....

8. Pada lintasan *roller coaster*, konsep kekekalan energi terjadi saat proses perubahan energi kinetik menjadi energi potensial dan sebaliknya. YA/TIDAK (berikan alasan)

.....

7. Adapun Pengaplikasian Hukum kekekalan energi pada wahana roler coster dalam Perubahan energi Kinetik menjadi energi Potensial dan sebaliknya. Ada sebagian energi yg diubah menjadi energi Panas (kalor). Ini karena adanya gesekan (friksi) misalnya saat roler coster bergerakan dengan lintasan rel. energi total yang dihasilkan tdk bertambah atau berkurang energi ini hanya berubah bentuk

8. YA Karena adanya gesekan (Friksi) misalnya saat roller coster bergerakan dengan lintasan rel. Energi total yg dihasilkan tidak bertambah atau berkurang. Energi ini hanya berubah bentuk.

Figure 5. Examples of students' work thinking in detail (elaboration)

Figure 5 represents a continuous process of solving problems with reflective thinking. This is intended to encourage students to be able to identify and solve problems in other contexts based on what they have learned [22], as in the question at this stage, "How to apply the law of conservation of energy to roller coaster rides?" "As for the application of the law of conservation of energy on roller coaster rides, there is some energy that turns into heat energy (heat), this is due to friction, for example when the roller coaster rubs against the rail track. The total energy that is produced does not change or decrease; this energy only changes form," the students responded. Statements expressed by students are based on their concepts and understanding of previous learning experiences. In addition, the statements produced by students in Figure 5 illustrate that students already have the ability to enrich and develop an idea.

## D. Conclusion

Based on the results of the research and discussion, it can be concluded that the assessment instrument developed is valid and reliable for use in trials. The use of assessment instruments in project-based learning to measure students' scientific literacy and creative thinking abilities on business and energy materials with the help of student assignment sheets (LTS) can have a positive influence on students' scientific literacy skills and creative thinking skills with the following percentages: 2) thinking flexibly (flexibility) by 80%; 3) original thinking (originality) by 69%; and 4) detailing (elaboration) by 68%. This research is not without shortcomings. The

shortcomings in this study are that researchers only focus on scientific literacy skills and creative thinking. In addition, researchers only conduct research by implementing the 2013 curriculum. Researchers provide suggestions for further research to be carried out in assessing the abilities needed in the 21st century and using the latest curriculum.

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