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PROBLEM-BASED LEARNING ASSISTED BY CRE-ASI (CREATIVE ASSESSMENT WITH SOLVING INSTRUMENT) TO IMPROVE STUDENTS' CREATIVE THINKING SKILLS

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ABSTRACT

This study aims to analyze the validity of the Cre-ASI instrument and its practicality and effectiveness when applied to PBL in improving creative thinking skills. The research design used the ADDIE model. The Analyze, Design, Development, Implementation, and Evaluation stages were used. The results of the Cre-ASI (Creative Assessment with Solving Instrument) instrument, which aims to improve creative thinking skills, have met the validity criteria and, when applied in PBL, meet the practical and effective criteria. The results of the Cre-ASI instrument development obtained a validity percentage value of 96.1%, which is a very valid category. When applying the instrument in PBL, a N-Gain score of 0.68 was obtained, and an increase in student answers was observed between the pre-test and post-test. The findings from the development of Cre-ASI in the PBL model revealed a positive correlation between indicators of problem-solving skills and creative thinking skills; students with low problem-solving skills tend to have low creativity. The integration of PBL and Cre-ASI has been shown to encourage knowledge construction, thinking strategies, learning motivation, and the development of students' cognitive abilities. This confirms that physics learning is not only focused on mastering concepts, but also on developing creativity and problem-solving skills. In the future, utilizing sophisticated technology to produce more efficient products with alternative costs and improved time and material efficiency is crucial, as this will enable the results of this study to serve as both an innovation and a benchmark in the selection and development of innovative assessment instruments in physics learning.

Keywords: Cre-ASI; creative thinking skills; PBL; physics learning; problem solving

INTRODUCTION

Providing quality education is one of the state's goals in the field of education. Quality education requires quality in accessibility, innovation, technology, social environment, and evaluation (González-pérez & Ramírez-montoya, 2022). Implementing quality education requires a well-organized and efficient education system to align with national education goals, which aligns with one of the SDG goals agreed upon by several developed countries, as identified in point 4 (Edwards et al., 2024). Quality education, as defined in point 4, relates to the quality of learning methods implemented in education that can improve the profile of graduates in various countries. This, of course, relates to the implementation of educational curricula. The national education system currently used in Indonesia is based on the implementation of an independent curriculum (Astuti et al., 2024). This curriculum places demands on the skills that students must possess

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in order to face competition in the 21st century. The demand for these skills is based on the need for collaboration between human resources and the era of globalization's needs (García-Morales et al., 2021). In this era of development, collaboration between technology, science, and the human management system is involved.

The development of the 21st century is marked by the term' global adoption era,' which is characterized by a worldwide approach, as if the boundaries between countries in the field of education no longer exist (Zhang et al., 2022). The education system should be closely aligned with students' cognitive development through thought patterns, problem-solving, decision-making, intelligence, and interests (Ratnaningsih, 2017; Grokholskyi et al., 2020). Cognitive development, as reflected in the abilities and skills of students in problem-solving and critical thinking, can lead to intelligent generation outputs (Shofiyah et al., 2024). With the optimization of intelligent generation, the country's development, especially in the education sector, will be more advanced (Kanim & Cid, 2020). In general, improving 21st-century skills is an effort to enhance the quality of education globally, in line with the goal of point 4 of the SDGs. This aligns with the primary goal of national education development at the time.

However, in the development of Industrial Revolution 4.0, which influenced the 21st century, technology and science have experienced changes or developments that are not evenly distributed. Based on PISA data, Indonesia is in a concerning position, ranking 62nd out of 72 OECD countries in science and mathematics skills in 2022 (Almarashdi & Jarrah, 2023; Ismawati et al., 2023). The contextual problem-solving and reasoning skills in the PISA assessment refer to a person's creative thinking abilities, specifically their fluency and flexibility (Susilowati et al., 2022; Shafa & Putri, 2023). This ability to generate novel and valuable ideas can also influence a child's intelligence level. One interesting fact is that the intelligence level of Indonesian human resources is still relatively low (Sari & Tiwari, 2024). In the education program, one factor that can impact intelligence is the method of learning (Gani et al., 2017). In addition, data from UNESCO on education regarding cognitive development and creativity among the younger generation and children in Indonesia currently falls into the low category (Habyarimana et al., 2022). The preliminary study also found that the creative skills of high school students are still relatively low. This low level of creative thinking is evident in the percentage of students achieving science learning outcomes, with fluency at 40%, flexibility at 32%, originality at 52%, and elaboration at 35%, which are well below the learning achievement standards. The younger generation, especially students, is currently facing a significant challenge in learning, particularly in science and physics. Students often have problems with physics learning provided in educational institutions (Lintangesukmanjaya et al., 2024).

According to national statistical data sources, physics is a learning with a higher level of difficulty than other learning (Isra & Mufit, 2023). Physics is considered difficult because learning physics subjects requires integrating physical theories with complex mathematical equations to explain phenomena (Körhasan & Gürel, 2019; Dwikoranto, 2022; Samadun & Dwikoranto, 2022). This has an impact on students' skills and abilities in everyday life. The problem is that the National Education System is still unable to improve all students' 21st-century skills. In 21st-century skills, it describes a person's ability to approach and deal with something in their own way (Ramalingam et al., 2020). In the 21st century, skills consist of the 6Cs (Anggraeni et al., 2022; Varas et al., 2023). There are several reasons to conclude that 21st-century skills are currently essential, even though their implementation requires a specific process.

The primary issue is the underutilization of one of the key thinking skills, specifically creative thinking, at this time. (Akpur, 2020; Ekayana et al., 2025). This problem is proven from previous preliminary data and relevant research. Creative thinking, or creativity itself, is a person's way of thinking in responding to problems, determining answers, and understanding concepts related to a particular phenomenon, by providing various alternative ideas for solutions (Asda et al., 2025; Yayuk et al., 2020). Creative thinking encompasses aspects of fluency, which involves providing several ideas; flexibility, which entails offering variations of ideas with different points of view; originality, which involves providing uniqueness of an idea; and elaboration, which involves providing details of the given ideas (Guilford, 1957; Ramalingam et al., 2020). However, in reality, creative thinking skills are still complex to improve, and the skills of students are currently still low (Mutohhari et al., 2021). One of the reasons why a person's thinking skills are low is that there is no appropriate evaluation instrument to assess and improve these skills, which are integrated into classroom learning (Dilekli & Tezci, 2022).

Schools rarely have specific guidelines and guidance for measuring student skills, making it difficult for teachers to conduct evaluations. Most conventional evaluation systems, both summative and formative, are less effective and on-target because they do not focus on the skills being achieved. Innovation is necessary in designing suitable products to assess the quality of students' knowledge and skills. This innovation can be realized through the development of assessment instruments (Pareek, 2019), such as essay questions that focus on problem-solving. Problem-solving itself is used as a means of distributing message delivery, so that students can think logically, critically, and creatively. This instrument is packaged in the form of a Cre-ASI (Creative Assessment with Solving Instrument), which is expected to improve students' creative thinking skills. Creative thinking involves thinking in order to solve problems (Simanjuntak et al., 2021). Problem-solving as a catalyst for developing knowledge, abilities, and understanding to create something new (Kwangmuang et al., 2021). Problem-solving is very important for maximizing understanding of concepts and developing deep thought patterns. According to Polya, the problem-solving stages consist of: 1) understanding the problem, 2) making a plan, 3) implementing the plan, and 4) looking back at the answers (Polya, 1957; Soebagyo et al., 2021). The problem-solving stages are related to constructing a mindset based on phenomena for innovative solutions. This innovative solution can be delivered through answers to the questions posed.

The purpose of this study is to develop a problem-solving-based assessment instrument linked to problem-based learning and structured in the form of the Cre-ASI (Creative Assessment with Solving Instrument) to enhance creative thinking skills. The instrument is designed to meet the standards of validity, practicality, and effectiveness as a developed tool (Almubarak & Saadi, 2022; Sinnema et al., 2023). Cre-ASI, which involves problem-solving, is packaged in the form of a contextual problem-solving assessment that can improve creative thinking skills in physics learning. This assessment utilizes systematic problem stages as an effort to reconstruct students' thinking processes in dealing with simple to complex problems (Dwikoranto et al., 2020). This is a form of implementing an innovative learning instrument to support the improvement of education quality, in accordance with point 4 of the SDGs (Lintangesukmanjaya et al., 2025).

METHODS

The research was conducted using R&D (Research and Development) methods with the ADDIE model approach, which is useful for researching and developing products, as well as testing the effectiveness of the products developed (Hardani et al., 2020). The stages used are the Analyze, Design, Development, Implementation, and Evaluation stages (Mulyadi et al., 2020), as presented in Figure 1.

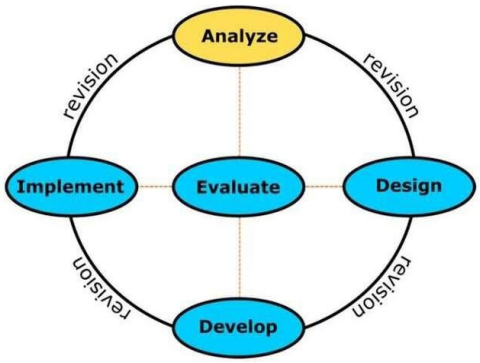

Figure 1. Research Design

The results of this study were obtained from primary and secondary data sources. Secondary data were obtained from the analysis of findings in previous studies relevant to reinforcing the primary data obtained directly through questionnaires and interview instruments. Literature reviews are used to support secondary data in the analysis and evaluation stages. The literature aims to identify research relevant to the topic in order to drive research innovation (Zulyusri et al., 2023). The research subjects in product development were 94 high school students in East Java, with the research sample being obtained from the entire population of one school. This was obtained from primary and secondary data sources. Secondary data were obtained from the analysis of previous research findings relevant to reinforcing the primary data obtained directly through the Cre-ASI instrument and interviews. At the needs analysis stage, a literature study analysis was carried out to analyze the importance of creative thinking ability measuring instruments for students to determine the level of need for the instruments developed (Zulyusri et al., 2023). During the analysis phase, initial observations and preliminary studies were also conducted to measure students' creative thinking skills. The literature review provided a strong foundation for the analysis phase in developing research instru-

ments and tools (Banda & Nzabahimana, 2021). In the design stage, the indicators and content of the assessment instrument were formulated to align with the research objectives. The instrument was designed to contain four contextual problem-solving assessments, each focused on the physics of renewable energy sources —water, wind, solar, and biomass —with correlations to four indicators of creative thinking (Spatioti et al., 2022). The design of this research instrument was tailored to meet the needs of students in order to improve their creative thinking skills.

The development stage involved testing the validity of the content, construction, and language domain instruments with three expert validators. The implementation stage was conducted with three classes of 10ᵗh-grade students at a school in East Java, Indonesia, by collecting research data in the form of pre-test scores and post-test scores after administering a series of prerequisite tests and difference tests (Rusdi et al., 2022). In this implementation activity, Cre-ASI is used as an instrument in the PBL (Problem-Based Learning) learning model. The PBL steps assisted by Cre-ASI include organizing students around the problem, organizing students to learn, guiding student investigations both individually and in groups, developing and presenting results, and analyzing and completing the problem-solving process (Dwikoranto et al., 2023; Gallagher, 2015; Stepien, 1993). The results of all ADDIE stages are evaluated at each stage to identify new findings and outcomes (Mudjisusatyo et al., 2024). Generalization in the final stage is an effort to produce answers in accordance with the problem formulation and research objectives.

RESULTS AND DISCUSSION

In this study, the results were obtained based on the research objectives, specifically analyzing the validity, practicality, and effectiveness of the devices that have been developed. The devices that are developed must undergo several stages according to the development design used (Pranoto & Suprayogi, 2020). Before that, to strengthen the research, it is necessary to analyze the relationship between two 21st-century skills: creative thinking and problem-solving (Thornhill-Miller et al., 2023). The correlation between problem-solving is used in the creative thinking indicator, which is one of the complex processes of 21st-century thinking. There are four indicators of creative thinking by Guilford that have a relationship to the problem-solving indicator, according to Polya (Polya, 1957; Maskur et al., 2020; Syahputra et al., 2023).

Table 1. Creative Thinking Indicators-Problem Solving

No	Creative Thinking Indicators	Problem Solving Indicators	Indicator Correlation
1	Fluency	Understanding the Problem	Able to find the main idea of the problem
2	Flexibility	Make a Plan	Able to make designs based on completion plans
3	Originality	Implementing the Plan	Able to solve problems with planned solutions
4	Elaboration	Looking Back at Answers	

Further relationships can be established through the effectiveness of developing instruments that link problem-solving with creative thinking skills (Chevalier et al., 2020). The causal relationship between the two skills provides its own main point in the collaboration of these skills. This relationship enables students to solve problems more effectively when the skills required for creative thinking indicators are high.

A total of 94 students were used as trial subjects in the evaluation of problem-solving-based essay instruments, and the following are the results of the Cre-ASI (Creative Assessment with Solving Instrument) validity values to improve creative thinking skills.

Table 2. Validity of Cre-ASI

No	Validated Aspects	Validator			Mode	Category
		V1	V2	V3		
	Material					
1	Question items according to indicators	3	3	4	3	(Very Valid)
2	The boundaries of questions and expected answers are clear	4	4	4	4	
3	The content of the material is in accordance with the measurement objectives.	4	3	4	4	
	Construction					
1	Sentence formulation in the form of questions or commands that require students to use scientific reasoning skills	4	4	4	4	(Very Valid)
2	There are clear instructions on how to work on the questions.	4	4	4	4	
3	There are scoring guidelines	4	4	4	4	
4	There is a relationship between the image and the problem being asked	4	4	4	4	
	Language					
1	Communicative sentence formulation	4	4	4	4	(Very Valid)
2	Sentences use good and correct language and are in accordance with the language variety.	4	4	4	4	
3	A variety of sentences does not give rise to multiple interpretations	3	4	4	4	
4	Using everyday language or verbs	4	4	4	4	
	Percentage of Agreement				96.10	(Very High)

The validation results assure that the developed device or instrument meets the requirements and is suitable for testing (Van Vo & Csapó, 2021). High validation results indicate that Cre-ASI (Creative Assessment with Solving Instrument) demonstrates clarity in the material, construction, and language used for physics learning (Knight et al., 2020).

Furthermore, the test of the essay instrument, which assessed problem-solving in improving creative thinking skills, was conducted twice: before learning (pre-test) and after learning (post-test). To verify that the data obtained were normally distributed, a normality and homogeneity test was conducted (Manurung & Panggabean, 2020; Risnita & Bashori, 2020; Adhelacahya et al., 2023). Table 3 presents the results of the prerequisite test, analyzed using SPSS software and the Kolmogorov-Smirnov test.

Table 3. Normality and Homogeneity

Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk			Homogeneity of Variance
	Statistic	df	Sig.	Statistic	df	Sig.	
Pre-test A	.265	30	.000	.820	30	.000	.000
Post-test A	.348	30	.000	.763	30	.000	
Pre-test B	.318	32	.000	.821	32	.000	
Post-test B	.238	32	.000	.888	32	.003	
Pre-test C	.224	32	.000	.914	32	.014	
Post-test C	.177	32	.012	.923	32	.025	

The results of the trials, based on the essay instrument values for problem-solving in creative thinking skills, yielded abnormal data due to a significant value (sig < 0.05) (Haw et al., 2022). The normality of data is influenced by distribution factors based on statistics (Rusnayati et al., 2023).

As an alternative, since the data obtained is indicated as not normal, a non-parametric test is carried out using a difference test (Orcan, 2020). The non-parametric test, which is appropriate for the category of data obtained in this study, uses the Wilcoxon Paired Sample Test, yielding results presented in Table 4.

Table 4. Difference Test

		N	Mean Rank	Sum of Ranks
Post test A - Pre test A	Negative Ranks	0[a]	.00	.00
	Positive Ranks	30[b]	15.50	465.00
	Ties	0[c]		
	Total	30		
Post test B - Pre test B	Negative Ranks	0[d]	.00	.00
	Positive Ranks	32[e]	16.50	528.00
	Ties	0[f]		
	Total	32		
Post test C - Pre test C	Negative Ranks	1[g]	1.00	1.00
	Positive Ranks	31[h]	17.00	527.00
	Ties	0[i]		
	Total	32		

Test Statistics[a]

	Post test A - Pre test A	Post test B - Pre test B	Post test C - Pre test C
Z	-4.862[b]	-4.969[b]	-4.922[b]
Asymp. Sig. (2-tailed)	.000	.000	.000

Based on the results of the Wilcoxon test, it was found that the Asyp. Sig value < 0.05, so it is known that there is an influence in the use of essay question instruments based on problem solving in learning (Blajvaz et al., 2022). Furthermore, in the negative ranks, the value in all low classes is close to zero (0), providing an understanding that the essay question instrument has a positive influence, as evidenced by an increase in post-test scores compared to pre-test scores (Ortloff et al., 2023).

In determining the effectiveness of the instrument, the magnitude of the increase in influence can be analyzed through the N-Gain test (Sumarni & Kadarwati, 2020). This increase in value can be attributed to the N-Gain results from the pre-test and post-test scores (Hake, 2002; Jumadi et al., 2021). The increase in creative thinking skills in this N-Gain is attributed to the use of problem-solving-based instruments that can provide attention and cognitive resources for students, particularly enhancing their creativity (Sardin et al., 2023). The following are the results of the N-Gain test obtained based on the pre-test and post-test results of students in three research classes

Table 5. N-Gain Test

Class	Score	Indicator
A	0.68	Medium
B	0.67	
C	0.69	
Average	0.68	

From the results of the N-Gain test, it was found that there was an increase in the number of students answering the pre-test and post-test in the moderate category. This demonstrates that the Cre-ASI (Creative Assessment with Solving Instrument), which was developed, has an effectiveness value in the product development research standards (Spatioti et al., 2022). The existing effectiveness can be a reason as well as a basis for implementing the instrument and making decisions about whether to distribute it to students and disseminate it.

In addition to understanding the validity, practicality, and effectiveness of problem-solving-based essay question instruments in enhancing creative thinking skills, an analysis of the results in the skill indicators involved is also necessary (Suherman & Vidákovich, 2022). The difference test revealed an increase in each indicator, as shown in Figures 2 and 3.

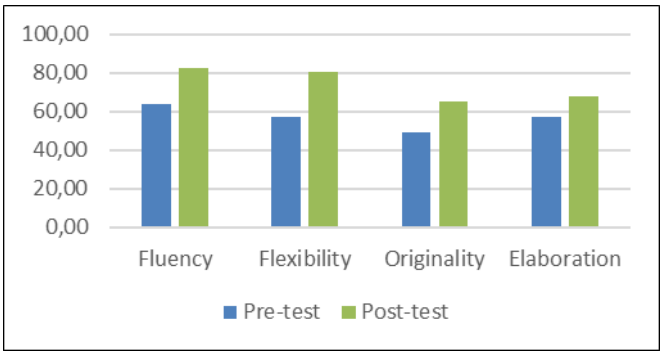

Figure 2. Student Test Results in Creative Thinking

In the indicators of creative thinking skills (fluency, flexibility, originality, and elaboration), there has been a general increase from the pre-test results to the post-test. However, the value of each indicator is different. The difference in value for each indicator is influenced by the understanding and level of difficulty of the indicator (Bouckaert et al., 2021; Supena et al., 2021). Based on the average value of the indicator, it was found that the fluency indicator has the highest value, as determining ideas is the most basic aspect (Yustina et al., 2020). Originality has the lowest value because it is difficult for students to provide discoveries in an original way (Kuo et al., 2022). On average, the results after using the problem-solving essay question instrument for each indicator have values that are not much different. This difference is strongly based on the diverse patterns of student answers and the varying skills of each student, particularly in creative thinking (Widodo & Gustari, 2020). In addition to creative thinking skills, the questions developed are also based on problem-solving with the following indicator value analysis

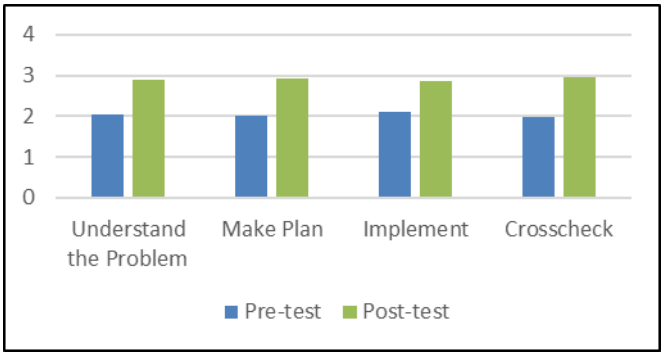

Figure 3. Student Test Results in Problem Solving

In the problem-solving skill indicators (understanding the problem, making a plan, implementing, and cross-checking), there is generally an increase from the pre-test results to the post-test. Based on Figure 3, the most appropriate reason for cross-checking is that it is easier to do if the problem and idea have been implemented well (Sigmund, 2022). While the reason for implementing has the lowest value is that implementing requires more effort and complex thinking (Flechsig et al., 2022). Essentially, individuals tend to find it easier to plan something but struggle to implement it according to the previous plan (Maulyda et al., 2019). When analyzed in terms of the correlation between previous creative thinking skills and problem-solving, as shown in Table 2, the following results, as illustrated in Figure 4, are obtained.

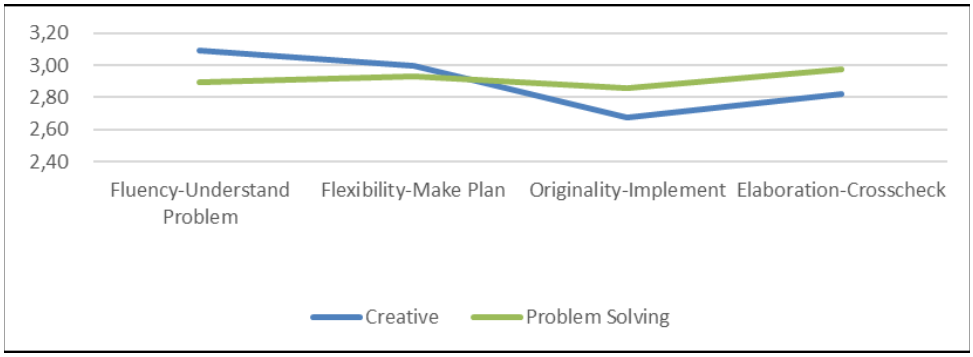

Figure 4. Correlation of Creative Thinking and Problem Solving Based on Average

The correlation between creative thinking skills and problem-solving, based on empirical data, can be clearly demonstrated (Luthfia, 2024). The manifestation of this correlation is evident in the diagram scheme shown in Figure 4. The pair of indicators with the highest level of difficulty, as determined by the small value obtained by students in the creative thinking and problem-solving indicators, is originality-implement. Theoretically, the research data is very relevant, as evidenced by the two indicators having an equivalent correlation, namely originality and implementation, both of which are the most challenging. This is because implementing the plan as proposed initially is difficult (Thukral, 2021).

The difference in the correlation of the easiest indicators in creative thinking and problem-solving. In creative thinking, fluency is the easiest indicator, but in problem-solving, cross-checking is the most effective indicator. The characteristics of students influence this difference in correlation in their answers to questions (Saini et al., 2023). However, although both skills have their own easiest indicators according to the student's answers, the relationship between each pair of indicators does not have a large gap. In addition to analyzing skill indicators, differences in the characteristics of students' answering methods are also worth considering. Figure 5 presents the analysis of differences in student answers, categorized by gender.

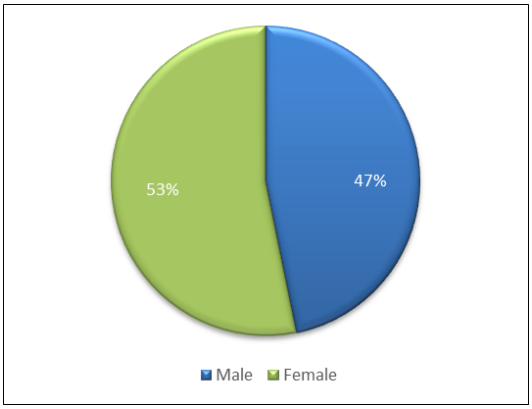

Figure 5. Differences in Post-Test Score Increases Based on Gender

In fact, gender itself influences the problem-solving and creative thinking indicators in the Cre-ASI (Creative Assessment with Solving Instrument), although its significance is not very substantial (He & Wong, 2021). This influence appears to be limited to this study. The results indicate that women's post-test scores are superior to those of men. Another analysis found that women have an advantage in the elaboration indicator of creative thinking and in cross-checking problem-solving related to the accuracy of answering questions (Löffler & Greitemeyer, 2023). Male students have an advantage in answering questions related to the originality indicator of creative thinking, which maximizes innovation abilities, and in the implementation indicator of problem-solving, which focuses on implementing plans through effective ideas (Xie et al., 2020). Insights from social-cognitive theory, particularly the concept of self-efficacy, suggest that males tend to demonstrate higher self-efficacy in areas such as mathematics, technology, and science.

In contrast, females tend to be more confident in social and verbal domains, exhibiting

both "masculine" and "feminist" traits (Lübeck et al., 2025). This does not always reflect actual ability, but is influenced by social stereotypes formed from an early age. In problem-solving and creativity-based learning, such as Cre-ASI, differences in self-efficacy can influence how male and female students respond to challenges, particularly in fields like technology, science, and mathematics (Paz-Baruch, 2025). Students with high self-efficacy tend to be more persistent, creative, and resilient in the face of failure. Meanwhile, female students tend to have a reflective and organized learning style, which supports the ability to develop ideas in depth and supports the elaboration aspect of creativity (Baherimoghadam et al., 2021). This means that the implementation of instruments such as Cre-ASI needs to be accompanied by strategies that support self-efficacy equally for all genders, such as providing positive feedback, exposure to diverse role models, and creating a comfortable learning environment.

In PBL learning assisted by the Cre-ASI instrument, to improve students' creative thinking skills, the values of validity, practicality, and effectiveness have been met through the analysis of the validation sheet and test results (Almelhi, 2021). The implementation of the PBL model with Cre-ASI is highly relevant in enhancing students' creative thinking skills. PBL's syntax, with its inherent problem-solving approach, fosters a creative environment that enables students to generate ideas and find solutions to the problems they encounter (Astuti et al., 2022; Ekayana et al., 2025). Creative thinking skills are closely related to information processing in the mind when students understand a concept during problem-solving. Based on the results presented in the previous data section, the following are some key points from Cre-ASI's findings on improving creative thinking skills.

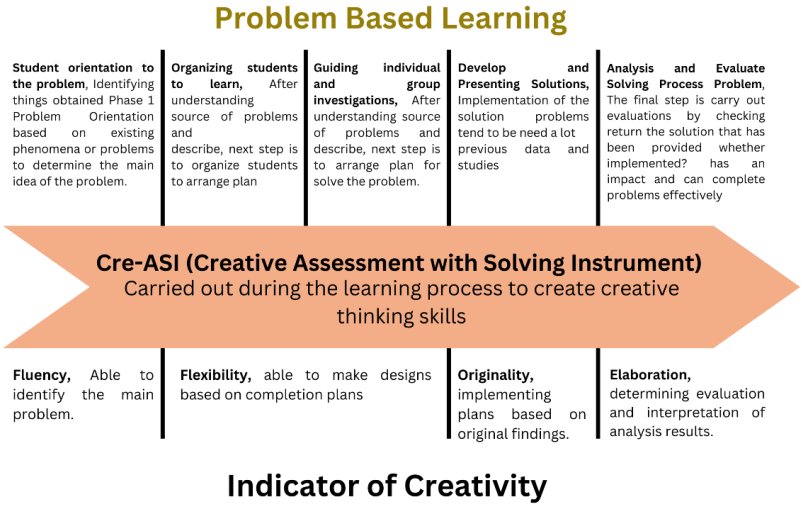

Figure 6. Implementation of Cre-ASI in Problem-Based Learning with Creative Thinking Indicators

Through indicators of creative thinking skills (fluency, flexibility, originality, and elaboration), along with problem-solving stages, the advantages of the Cre-ASI (Creative Assessment with Solving Instrument) instrument are evident. A precise problem-solving flow can reconstruct the creative thinking process of students (Ramalingam et al., 2020). Creativity develops in individuals in the form of attitudes, habits, and actions that produce something new and original in solving a problem, which is characteristic of a creative person (Suyidno et al., 2017; Fitria, 2024). Clear procedures, as well as factual problems, are brought to students' attention when they are working on questions. The encouragement of problem-solving provides enthusiasm to stay focused on solving the given questions (Dwikoranto et al., 2021). Therefore, improving creative thinking skills through problem-solving stages is very suitable for implementation as an innovation in learning assessment.

The interactive impression in the innovation of learning instruments with Cre-ASI (Creative Assessment with Solving Instrument) is one of the key advantages of the device developed in this study. Cre-ASI integrates the syntax of systematic problem-solving within a Problem-Based Learning (PBL) framework, where students are

guided through stages of identifying problems, exploring concepts, proposing solutions, and reflecting on their reasoning process. This structured interaction pattern not only increases students' comfort in answering descriptive questions but also reduces the sense of boredom and fatigue often associated with essay assessments (Dwikoranto, 2022). The integration of PBL encourages students to construct knowledge actively, collaborate in solving contextual problems, and develop higher-order thinking skills. Evidence from post-test results, as shown in Figures 3 and 4, indicates that the implementation of problem-solving-based essay instruments within the PBL model significantly improves students' test performance, demonstrating the effectiveness of Cre-ASI in fostering engagement and creativity in learning.

The right correlation in problem-solving indicators and creative thinking skills (Fluency-Understand Problem; Flexibility-Make Plan; Originality-Implement; Elaboration-Crosscheck) is an innovation in 21st-century skill collaboration (Wulandari, 2021). Generally, someone who can solve problems is characterized by a certain level of creativity (Behnamnia et al., 2020). However, someone with a high level of creativity is able to solve problems using their creative ideas. Creativity is the ability to produce new and valuable ideas in solving problems (Dwikoranto et al., 2021).

Creative products include the results of creative thinking that are seen as something new (Muflikhun & Setyarsih, 2022). Creative products do not have to be an object, but can be an idea or written work; they do not have to be new, but can be the result of combining, changing, or adding existing ideas. Creative products will continue to develop with a supporting creative system (Dwikoranto et al., 2020). The creative system that supports this study is a problem-solving-based essay instrument. A system is said to be if the device has clear, systematic, and meaningful procedures (Asim et al., 2021). With the existence of a system, individuals and creative products, a creative environment is created that can encourage the development of a person's potential to drive creative behavior (Sukawi et al., 2021). Students feel safe sharing unusual ideas with others and are encouraged to take risks in an autonomy-based learning environment. In this setting, students are given the freedom to choose and convey their own creative ideas through problem-solving solutions.

Students who have high initial skills tend to achieve higher final skill scores compared to those with low initial skills, as shown in the pre-test and post-test achievement data in Figure 3. However, there are also students with low initial skills who achieve high scores on the final measurement, indicating that the learning has a significant impact (Mulyadi et al., 2020). The increase in the average score of the question indicator is a result of learning achievement using the assessment instrument (Susetyarini & Fauzi, 2020).

The first factor that influences the improvement of students' learning outcomes in terms of creative thinking skills and problem-solving is students' motivation (Suryanto et al., 2020). Motivation does not only come from within the students themselves; one of the external motivations that can trigger the development of learning outcomes is the use of appropriate learning tools or models (Safitri et al., 2023; Vivilia & Prahani, 2024). In this case, the use of problem-solving essays as a teaching tool can increase students' motivation. The existence of syntax or stages in problem-solving provides procedural knowledge to students, so that they become accustomed to solving problems.

Another factor that influences students' answers is their developing cognitive abilities. Developing cognitive abilities is triggered by the stimulus of using problem-solving-based essay instruments (Zarrabi & Bozorgian, 2020). This stimulus can be obtained because the content, construction, and visuals of the problem-solving-based essay instrument are found to be interesting by students. Students' interest in the visuals and construction of the instrument triggers an increase in their cognitive abilities as the process of delivering knowledge unfolds (Shofiyah et al., 2024). This cognitive improvement affects the skills that are to be developed, such as creative thinking and problem-solving skills. However, because each individual has their own way or style of learning, their learning outcomes will also not be the same (Ratnaningsih, 2017). It must be considered how the process of delivering knowledge or learning objectives in the future will be to avoid learning outcomes that have too big a difference.

Previously, it was evident from the presented results that Cre-ASI in PBL (Problem-Based Learning) has been developed with valid, practical, and effective outcomes. The problem-based learning model emphasizes the process of organizing students around a problem, guiding them to learn, and facilitating individual and group investigations, as well as developing and presenting results, and analyzing and completing the problem-solving process (Stepien, 1993; Gallagher, 2015; Dwikoranto et al., 2023). With the PBL model, students can solve problems and

trigger skills for discovery and elaboration (Handoyo et al., 2021). This supports the increase in creativity indicators. The improvement in creative thinking skills in this study was due to the evaluation of the use of Cre-ASI in the PBL learning model. However, several evaluations are very important to review empirically. Evaluation is crucial in the development of products or teaching tools, as it enables the continuous development process to be carried out properly (Rafner et al., 2022). When viewed in terms of the products that have been produced, the Cre-ASI instrument that has been developed is still based on conventional output, utilizing existing technology. Although conventional instruments have advantages in direct observation, the future use of advanced technology may involve producing more competent products with alternative costs, time, and efficiency in the materials used (Rifsih & Zainul, 2024).

Furthermore, the results of student tests were reviewed in terms of the indicators of creative thinking and problem-solving skills. Evaluation must be emphasized, even though there is a correlation between creative thinking and previous problem-solving. However, it is not advisable to be too focused or fanatical on a single indicator or specific value (Nasution et al., 2024). As shown in the results of the relationship between the two indicators, although the indicators are generally related, several indicators exhibit a low level of relationship. This influence occurs because the construct used in the instrument does not always ensure that the relationship between the two indicators is appropriate. The alternative is to conduct a limited study using the instrument to demonstrate that the two indicators (problem-solving and creative thinking) have a strong relationship (Puccio et al., 2020).

Another advantage lies in the 21st-century skills integrated into the Cre-ASI instrument, which supports more profound and transformative learning. In line with transformative learning theory, Cre-ASI encourages learners to reflect on their learning experiences, construct new meanings, and transform their thinking through solving real-world problems that spark creativity (Desmet & Roberts, 2022; Holdo, 2023). This aligns with modern pedagogical frameworks such as the OECD Learning Compass 2030, which emphasizes the importance of developing cognitive, socio-emotional, and value competencies through future-oriented learning (Taguma, 2024). By facilitating fluency, flexibility, originality, and elaboration in problem-solving contexts, Cre-ASI creates a learning environment that is autonomous, collaborative, and oriented toward developing self-potential to face the complex challenges of the 21st century (Samaniego et al., 2024; Ekayana, 2025).

The results of the Cre-ASI evaluation also provide important implications for learning in science education, particularly physics. The use of the Cre-ASI in PBL has been shown to improve students' creative thinking skills, which are integral to the higher-level science learning process. Implementing instruments tailored to 21st-century needs is part of today's ideal learning environment. These findings emphasize that physics learning is not only oriented toward mastering concepts but also toward developing students' thinking skills in formulating, planning, and evaluating solutions to problems (Isra & Mufit, 2023; Lintangesukmanjaya et al., 2024). Thus, Cre-ASI can be viewed as an assessment instrument that encourages change and growth in learning from cognitive, social, and affective perspectives, aligning with the primary goal of science learning: to develop students who are creative, reflective, and adaptable to the challenges of the 21st century.

The contribution to understanding the learning process with the help of Cre-ASI is a form of implication of the results of the Cre-ASI product development. As seen from the findings on the relationship between indicators of creative thinking and problem-solving in problem-based learning, the results of this study demonstrate how students construct knowledge, develop thinking strategies, and foster learning motivation. This shows that Cre-ASI is not only an evaluation tool, but also a pedagogical tool that reflects changes and growth in learning. Thus, the substance in the development of Cre-ASI emphasizes both theoretical and empirical aspects of the science learning process in physics classes.

Based on the analysis of Cre-ASI's strengths, particularly in its constructs and content relevant to PBL, creative thinking, and problem-solving skills, the Cre-ASI model has the potential to be adapted for use in STEM or STEAM disciplines and cross-cultural settings. The STEAM learning approach is particularly well-suited because it integrates creativity, problem-solving, and cross-disciplinary exploration (Fajriati et al., 2025; Ntsobi & Costa, 2024). Although STEM encompasses the development of scientific and technological thinking, STEAM —the combination of science, technology, engineering, art, and mathematics — requires students not only to think logically but also to express ideas in original and innovative ways (Fang, 2025). This also has the potential to lead to high-quality educational

media that is appropriate and supports SDG 4, and can be integrated into multidisciplinary disciplines such as ethnoscience, culture, and the environment. Cre-ASI supports STEAM through creative thinking indicators, such as fluency, flexibility, originality, and elaboration, which align with the problem-solving stages. This instrument encourages students to develop solutions that are not only technically sound but also creative and visually or narratively meaningful, thus enriching the learning process in STEAM (Samaniego et al., 2024) and forming a learning experience that is deep, reflective, and relevant to the challenges of the 21st century.

Based on all of this, it is also important to address potential biases in assessing creativity, particularly cultural biases that often arise in evaluating the dimension of originality. Perceptions of "unique" or "novel" ideas are often influenced by dominant cultural norms, which can overlook the diverse ways of thinking of students from diverse backgrounds. Therefore, the future development of instruments like Cre-ASI needs to consider the use of tools capable of ensuring objectivity in the assessment process. Maximizing 21st-century technologies such as AI (Artificial Intelligence) can help provide more consistent, bias-free analysis and support the iterative updating of assessment instruments to remain relevant, adaptive, and inclusive of student diversity across various learning contexts (Banerjee & Bhat, 2025). This represents a significant breakthrough in creating quality education in line with the Sustainable Development Goals.

CONCLUSION

The results of the study indicate that Cre-ASI has met the criteria of validity, practicality, and effectiveness. The developed instrument yielded a highly valid category, and it was assessed as practical according to educational product development standards. In addition, the results of the PBL (Problem-Based Learning) model application test showed an N-Gain score in the medium category, indicating an increase in students' creative thinking skills. Further analysis revealed a positive correlation between indicators of problem-solving skills and creative thinking skills; students with low problem-solving skills tend to exhibit lower creativity. The integration of PBL and Cre-ASI has been shown to encourage knowledge construction, thinking strategies, learning motivation, and the development of students' cognitive abilities. This confirms that physics learning is not only focused on mastering concepts, but also on developing creativity and problem-solving skills. In the future, the development of Cre-ASI can be directed at utilizing advanced technology to increase efficiency of time, costs, and resources, so that the resulting product is more competent. This research makes an innovative contribution and can serve as a benchmark for the development of assessment instruments in the future.

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