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The development of creative problem solving of grade 10 students using inquiry-based learning with creative problem solving processes

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ABSTRACT

The science learning required to promote students' thinking and problem-solving. This research focuses on enhancing the creative problem-solving abilities of Mathayomsuksa 4 students through the integration of inquiry-based learning (IBL) and creative problem-solving (CPS) processes. A group of 23 students from a secondary school in Thailand participated in the study. Research tools included lesson plans based on IBL and CPS methodologies, a creative problem-solving assessment, and a learning achievement test. Statistical analysis, employing measures such as mean, standard deviation, and percentage, was conducted to evaluate the outcomes. The findings indicate significant improvement in students' creative problem-solving abilities, with scores rising from 34.48% in the first cycle to 60.87% in the second cycle and to 86.96 in the final cycle. The results also highlight a steady increase in students' academic performance across the 3 cycles, suggesting that the combined use of IBL and CPS effectively supports students' intellectual growth and innovative thinking. These results demonstrate the potential of this integrated approach in fostering creativity and problem-solving skills, particularly in science-related subjects. To maximize the benefits of this educational strategy, it is crucial for teachers to gain a solid understanding of how to design and implement IBL and CPS based activities effectively. Such preparation will enable educators to create dynamic, student-centered learning environments that encourage exploration, critical thinking, and innovative solutions to complex problems.

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1. INTRODUCTION

In the 21st century, the ability to solve problems creatively has emerged as a crucial skill for individuals to navigate academic and real-world challenges (Jedaman et al., 2023). Creative problem solving (CPS) is essential for fostering adaptability, innovation, and critical thinking in an era characterized by rapid technological advancements and complex societal issues (There, 2010). Inquiry-based learning (IBL) has been recognized as a powerful educational approach to nurture these skills by emphasizing active student engagement, critical inquiry, and collaborative exploration (Hmelo-Silver et al., 2007). IBL differs from traditional instructional methods by allowing students to take ownership of their learning through curiosity-driven investigations and meaningful problem-solving activities (Sreejun & Chatwattana, 2023).

Adolescents in Grade 10 or garde 10 sttudents in Thailand represent a pivotal stage of intellectual development. According to educational psychology, students at this stage are in the formal operational phase, characterized by their ability to think abstractly, reason logically, and tackle complex problems (Inhelder & Piaget, 2013). However, despite their cognitive readiness, there remains a significant gap in nurturing creativity within this age group. A study by Baer & Garrett (2010) found that conventional classroom practices often fail to provide opportunities for students to develop creative problem-solving skills due to the emphasis on rote learning and standardized testing.

The Thai education system has acknowledged the importance of equipping students with 21st-century skills, such as creativity, critical thinking, and collaboration. The National Education Plan of Thailand (2017-2036) emphasizes the need to prepare students for an interconnected and competitive global society. Nevertheless, achieving these goals has proven challenging due to persistent barriers, including limited teacher training in innovative pedagogies and a predominant focus on test-oriented instruction (Office of the Education Council, 2018). As a result, many Thai students lack the capacity to apply creative thinking to real-world problems, as indicated by their performance in global assessments like the Programme for International Student Assessment (OECD, 2019).

This research aims to address these challenges by integrating inquiry-based learning with the creative problem solving process to develop a blended instructional model tailored to grade 10 students. The CPS process, as conceptualized by Parnes (1967), Osborn (1963) provide a structured methodology for generating, refining, and implementing creative solutions. When combined with IBL, this approach fosters a dynamic learning environment where students can actively engage in constructing knowledge while honing their creativity and critical thinking abilities (Setyosari et al., 2023). Recent research has demonstrated that combining CPS with inquiry-based strategies significantly enhances students' abilities to approach problems innovatively and collaboratively (Kolodner et al., 2003; Renzulli et al., 2021).

By designing and implementing a curriculum based on this integrated framework, this study seeks to evaluate its impact on the development of CPS skills among grade 10 students. Specifically, it investigates how such an approach can enhance students' ability to generate novel ideas (Plailek et al., 2023), critically evaluate multiple perspectives, and apply innovative solutions to academic and real-life contexts. The findings are expected to contribute valuable insights to educational practices aimed at fostering creativity and problem-solving in Thailand and beyond (Güven & Alpaslan, 2022).

2. METHOD

This study employed action research to develop and implement lesson plans integrating inquiry-based learning with creative problem-solving processes. The research was conducted systematically. The tools used in this study included:

1. Lesson plans: Nine IBL-CPS lesson plans focusing on the topic of projectile motion, with a total instructional time of 14 hours. The lesson plans were designed following the principles of inquiry-based instruction, which emphasize student-centered learning, hands-on exploration, and active engagement in problem-solving (Hmelo-Silver et al., 2007).

2. Creative problem-solving ability test: A researcher-developed situational open-ended test consisting of three sets, each containing three scenarios. Each scenario included five sub-questions based on computational thinking components, totaling 75 points per set. The first set was administered after the first action cycle, the second set after the second cycle, and the third set after the third cycle. The tests had an item-objective

congruence value of 1.00. creative problem-solving was assessed based on established frameworks, emphasizing divergent thinking, fluency, flexibility, originality, and elaboration (Treffinger et al., 2013).

3. Student interview form: A semi-structured interview form was used to gather qualitative data from students after completing each action cycle of the IBL-CPS lesson plans. Semi-structured interviews allow for in-depth exploration of student perceptions and experiences, making them an effective tool in educational research (Kvale & Brinkmann, 2015).

The research followed the action research framework proposed by Kemmis & McTaggart (2000), which consists of 4 stages: planning, acting, observing, and reflecting. The study was conducted over three action cycles, with each cycle carried out as follows:

Action Cycle 1: Lesson plans 1-3 were implemented with Mathayomsuksa 4 students over five hours. During the sessions, the researcher observed and recorded student learning behaviors using observation sheets. After completing lesson plan 3, students were assessed using the first CPS test. The scores were analyzed to calculate the mean and percentage, which were then compared to the 70% benchmark. Reflection data were used to refine instructional activities for the next cycle. Students scoring below 70% were identified as the target group for additional interventions, while those scoring above 70% continued to the next cycle. Inquiry-based learning has been shown to improve students' engagement and conceptual understanding in science-related subjects (Pedaste et al., 2015).

Action Cycle 2: Lesson plans 4-6 were conducted with the same students over four hours. Observations were recorded, and students completed the second CPS test after lesson plan 6. Test results were analyzed for averages and percentages, compared to the 70% benchmark, and used to adjust the lesson plans for the next cycle. Students who failed to meet the 70% benchmark received targeted interventions, while those who passed moved forward to the subsequent cycle. Research suggests that iterative learning cycles help reinforce problem-solving skills and deepen students' understanding of scientific concepts (Kolodner et al., 2003).

Action Cycle 3: Lesson plans 7-9 were implemented over five hours. Observation data were collected as in previous cycles, and students completed the third CPS test after lesson plan 9. The scores were analyzed and compared against the 70% benchmark. The final results were summarized to evaluate overall student progress and the effectiveness of the intervention. Previous studies have found that combining IBL with CPS fosters higher-order thinking skills and encourages students to take an active role in their learning process (Renzulli et al., 2021).

Data were analysis through quantitative and qualitative.

1. Quantitative analysis: CPS abilities were assessed based on five components, adapted from Osborn (1963) and Parnes (1967): 1) Fact finding: identifying relevant information, 2) problem finding: pinpointing the core issues, 3) idea finding: generating innovative ideas, 4) solution finding: developing feasible solutions, and 5) acceptance finding: refining and presenting solutions for practical use (Treffinger & Isaksen, 2005).

Scores were analyzed using mean, standard deviation, and percentage. Each student's performance was compared against the 70% benchmark. The percentage of students meeting or failing to meet the benchmark was calculated for each cycle. The importance of these skills has been highlighted in research showing that structured CPS training enhances students' ability to generate and apply creative solutions (Puccio et al., 2011).

2. Qualitative analysis: Data from observation sheets and student interviews were analyzed byusing inductive reasoning to identify patterns and derive insights. These findings informed adjustments to the instructional approach for subsequent cycles. Qualitative analysis provides a deeper understanding of students' learning experiences and challenges, which can guide improvements in instructional design (Creswell & Poth, 2018).

3. RESULT AND DISCUSSION

This study evaluated the improvement of students' creative problem-solving abilities through three learning cycles using inquiry-based learning with creative problem-solving processes. The finding in Table 1 illustrates students' gradual improvement in 5 key components of CPS. While Figures 1 and 2 visualize the progression in scores and the increasing number of students meeting the 70% benchmark in problem-solving.

Table 1 The detail of participants' creative problem-solving abilities test scores in 3 learning cycles

Learning cycle	Components of creative problem-solving abilities					Overall (75)
	Fact finding (15)	Problem finding (15)	Idea finding (15)	Solution finding (15)	Acceptance finding (15)	
1	11.26 (75.07%)	10.61 (70.72%)	9.57 (63.77%)	10.13 (67.54%)	9.52 (63.48%)	51.09 (68.12%)
2	11.38 (75.90%)	11.00 (73.33%)	10.62 (70.77%)	9.77 (65.13%)	9.92 (66.15%)	52.69 (70.26%)
3	11.89 (79.26%)	11.11 (74.07%)	10.89 (72.60%)	10.67 (71.11%)	11.00 (73.33%)	55.56 (74.07%)

According to the findings shown in Table 1, the participants exhibited a steady improvement in their creative problem-solving skills across the three learning cycles. Across all components—fact discovery, issue identification, idea generation, solution development, and acceptance evaluation—there was a progressive improvement in scores and % performance from cycle 1 to cycle 3. The fact-finding component consistently demonstrated superior performance throughout all cycles, increasing from 75.07% to 79.26%. The greatest significant improvement was seen in the acceptance finding, which rose from 63.48% in the first cycle to 73.33% in the third. All other components—problem identification, idea generation, and solution formulation—exhibited rising trends, suggesting that students improved their creative problem-solving skills over time. The three learning cycles significantly improved participants' creative problem-solving abilities across all assessed dimensions. This demonstrates the beneficial effect of iterative learning methodologies on cultivating higher-order thinking abilities.

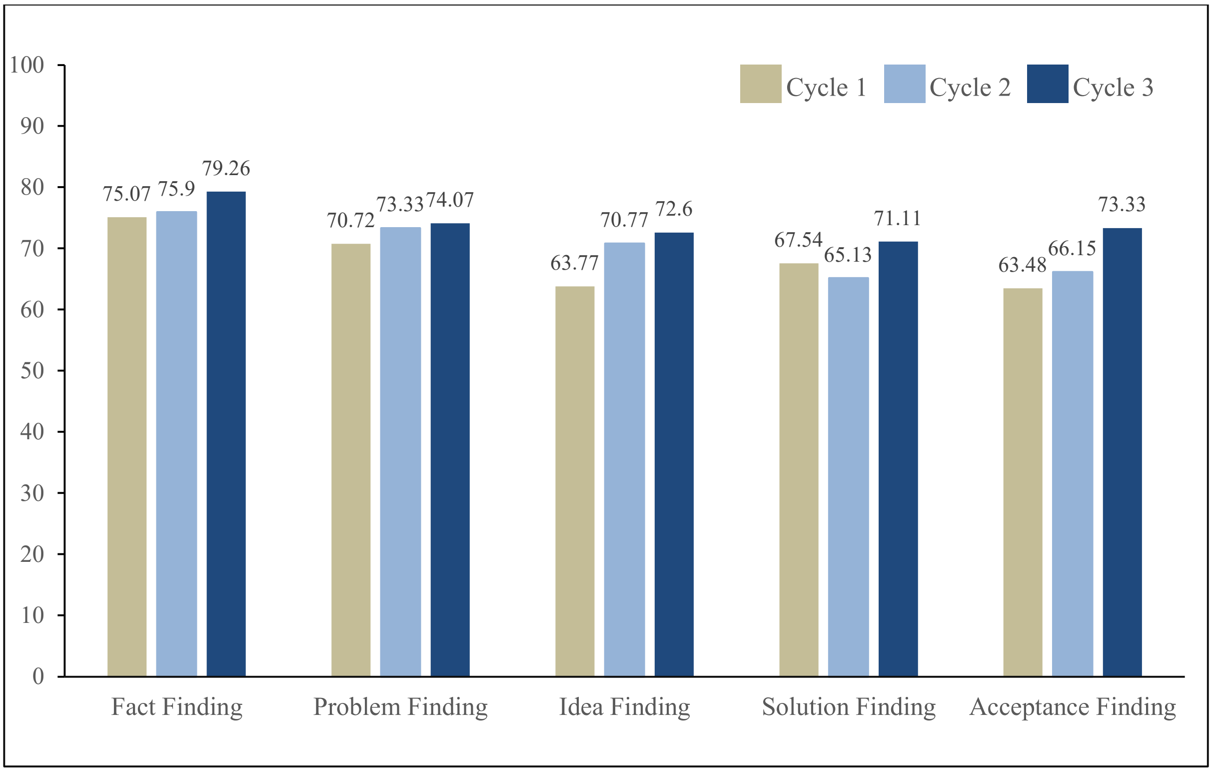

Figure 1 Average score for each factor of creative problem-solving abilities

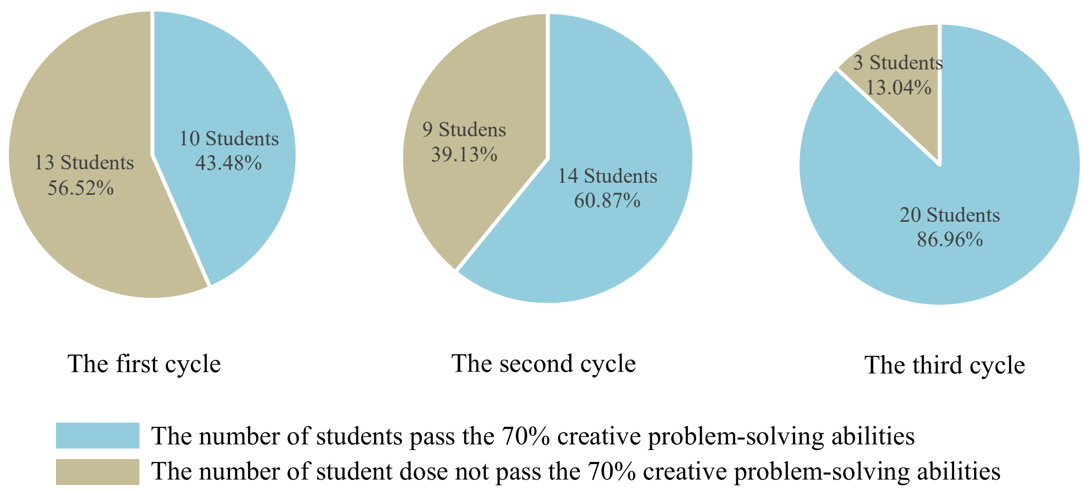

Figure 2 Summary of the learning cycles

Figure 2 illustrates the increasing number of students who achieved the 70% benchmark in CPS abilities, In cycle 1, 10 students (43.48%) passed, while 13 students (56.52%) scored below the threshold. In cycle 2, The number of students passing increased to 14 (60.87%), reducing the number of those below the benchmark to 9 (39.13%). In cycle 3, A significant majority-20 students (86.96%)-met the benchmark, leaving only 3 students (13.04%) below the threshold.

Fact Finding

Fact finding refers to students' ability to gather and analyze relevant information when solving a problem. The results show continuous improvement, with an average score of 11.26 (75.07%) in Cycle 1, increasing to 11.38 (75.90%) in Cycle 2, and reaching 11.89 (79.26%) in Cycle 3. This suggests that as students progressed through the cycles, they became more skilled at identifying critical information, a fundamental aspect of inquiry-based learning (Hmelo-Silver et al., 2007).

Problem Finding

Problem finding involves identifying the core issue within a given scenario. The students' scores improved from 10.61 (70.72%) in Cycle 1 to 11.00 (73.33%) in Cycle 2 and 11.11 (74.07%) in Cycle 3. This indicates that students developed stronger analytical skills in breaking down problems systematically, which aligns with previous findings emphasizing that structured inquiry-based activities enhance students' ability to recognize underlying problems (Puccio et al., 2011).

Idea Finding

The ability to generate creative ideas also showed a steady improvement. The students' scores increased from 9.57 (63.77%) in Cycle 1 to 10.62 (70.77%) in Cycle 2, reaching 10.89 (72.60%) in Cycle 3. This result suggests that students became more comfortable with brainstorming alternative solutions. Structured Creative Problem-Solving (CPS) techniques provided students with tools to develop innovative thinking, supporting the argument that repeated engagement in problem-solving fosters divergent thinking skills (Renzulli et al., 2021).

Solution Finding

Solution finding, which measures students' ability to propose effective solutions, fluctuated slightly throughout the learning cycles. The scores were 10.13 (67.54%) in Cycle 1, decreased to 9.77 (65.13%) in Cycle 2, and later improved to 10.67 (71.11%) in Cycle 3. The slight dip in the second cycle suggests that while students generated more ideas, they initially struggled to refine them into practical solutions. However, the structured support provided in Cycle 3 helped students develop stronger problem-solving strategies, consistent with findings that iterative learning cycles enhance solution refinement (Kolodner et al., 2003).

Acceptance Finding

Acceptance finding assesses how well students can evaluate and refine their solutions. The improvement across the cycles, from 9.52 (63.48%) in Cycle 1 to 9.92 (66.15%) in Cycle 2 and 11.00 (73.33%) in Cycle 3, suggests that students became more confident in assessing the feasibility of their solutions. This result is consistent with prior research, which highlights that structured reflection enhances students’ ability to critically evaluate their solutions (Treffinger et al., 2013).

This progressive increase in students meeting the benchmark supports the claim that IBL with CPS significantly enhances problem-solving abilities over time. The findings align with prior research emphasizing the effectiveness of iterative learning cycles in reinforcing critical and creative thinking (Wilson et al., 2021; Duanphol et al., 2024). The results of this study indicate that processes significantly improved students' problem-solving abilities across three learning cycles. This section discusses key findings in relation to existing literature, possible explanations for observed trends, and implications for future instructional design.

One of the most evident trends in the findings was the steady improvement in Fact Finding and Problem Finding scores. These two components are essential cognitive skills in problem-solving (Caswell & LaBrie, 2017), requiring students to identify relevant information and define core issues effectively. Fact finding scores increased from 75.07% in Cycle 1 to 79.26% in Cycle 3, while problem finding scores improved from 70.72% to 74.07%. this trend aligns with previous research indicating that inquiry-based learning fosters deeper conceptual understanding by promoting active engagement with information sources and critical analysis (Hmelo-Silver et al., 2007). The gradual increase suggests that as students progressed through the cycles, they became more proficient at extracting key details, identifying patterns, and distinguishing relevant from irrelevant information, which are fundamental skills in scientific reasoning (Puccio et al., 2010).

Moreover, the incremental nature of the improvement supports the theory that scaffolded inquiry learning helps students develop analytical abilities over time (Prince et al., 2020). During the initial cycle, students may have struggled with unfamiliar problem-solving strategies. However, repeated exposure to inquiry-based tasks allowed them to refine their information-seeking behaviors, leading to more effective problem identification in later cycles. A key implication of this finding is that educators should incorporate structured inquiry-based activities over multiple learning cycles rather than relying on one-time problem-solving exercises. This approach enables students to gradually internalize cognitive strategies necessary for effective problem-solving.

While the results demonstrated steady growth in most CPS components, there was a notable decline in Solution Finding scores from Cycle 1 (67.54%) to Cycle 2 (65.13%) before rebounding in Cycle 3 (71.11%). This dip suggests that while students were generating more ideas in later cycles, they initially struggled to refine those ideas into viable solutions. This trend aligns with research indicating that creative problem-solving requires multiple iterations, where students first generate a diverse range of ideas before filtering and refining them into actionable solutions (Meyer & Norman, 2020). The slight decrease in Cycle 2 may reflect a stage where students were experimenting with different approaches but had not yet developed effective strategies for evaluating feasibility.

Another potential explanation for this pattern is that solution finding involves higher-order cognitive skills, including synthesis, evaluation, and decision-making (Treffinger et al., 2013). While students showed improvements in fact finding and problem finding, it is possible that they required additional scaffolding to transition from idea generation to structured implementation (Cropley, 2006; Wu & Hsieh, 2006; Teseo, 2019). By integrating these strategies, instructors can better support students in bridging the gap between idea generation and practical solution development (Chen & Chang, 2021).

A major finding in this study was the significant increase in students meeting the 70% benchmark in creative problem-solving abilities over the three learning cycles. The percentage of students achieving this threshold rose from 43.48% in Cycle 1 to 86.96% in Cycle 3, demonstrating the effectiveness of iterative learning experiences. This result supports constructivist learning theories, which emphasize that problem-solving abilities develop through repeated exposure to challenges, opportunities for reflection, and iterative refinement of cognitive strategies (Wilson et al., 2021). The increase in student achievement aligns with studies indicating that multiple cycles of inquiry-based instruction lead to deeper learning compared to one-time interventions (Kolodner et al., 2020).

One possible explanation for this pattern is that students benefited from cumulative learning experiences in which knowledge and skills acquired in earlier cycles built the foundation for more complex problem-solving tasks in later cycles. This aligns with the Zone of Proximal Development (ZPD) theory proposed by Vygotsky (1978), which suggests that students learn best when tasks are progressively challenging yet scaffolded. Furthermore, Figure 2 illustrates that by Cycle 3, only 13.04% of students remained below the benchmark, suggesting that even students who initially struggled eventually showed significant improvement. This finding reinforces the importance of persistence and repeated exposure in developing creative problem-solving competencies (Laisema & Wannapiroon, 2014ว Kanphukiew & Nuangchalerm, 2024).

A practical implication of this finding is that educators should implement multi-cycle learning experiences rather than single-session problem-solving tasks. Providing scaffolding, progressive challenges over time ensures that students have ample opportunities to practice, reflect, and refine their cognitive strategies. The success of iterative learning cycles highlights the need for frequent self-reflection and feedback loops to reinforce learning. Integrating student journals, collaborative discussions, and instructor feedback can significantly enhance students' ability to refine their cognitive processes.

4. CONCLUSION

The findings of this study demonstrate that inquiry-based learning combined with creative problem-solving processes effectively enhances students' creative problem-solving abilities over multiple learning cycles. The increase in student performance over three cycles supports the view that problem-solving is best developed through iterative, scaffolded experiences rather than isolated instructional sessions. The observed challenges in Solution Finding highlight the need for structured frameworks and instructional supports to help students bridge the gap between idea generation and solution refinement. Additionally, the substantial increase in the number of students meeting the 70% benchmark reinforces the importance of long-term, iterative exposure to problem-solving tasks.

Future research should explore, the role of collaborative learning in CPS development, the impact of digital tools on enhancing creative thinking and problem-solving strategies, and longitudinal studies examining how CPS skills evolve beyond classroom settings. These findings contribute to the growing body of literature emphasizing the importance of inquiry-based, student-centered pedagogies in preparing learners for real-world problem-solving challenges.

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