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# NOVEL APPROACH IN ENHANCING SCIENCE EDUCATION THROUGH PROBLEM-BASED CREATIVE LEARNING AND DELPHI EVALUATION

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**ABSTRACT**

This research aims to optimize the problem-based creative learning model to enhance higher-order thinking skills in natural science learning. The research used the Delphi method, which involved seven experts in education from various disciplines contributing to a cycle of Delphi. The Delphi cycle consisted of two cycles, and data analysis involved using the Aiken V. The first round of the Delphi panel was given open-ended questions. The second round of Delphi panels were presented with a close-ended question and asked to respond using a five-point Likert scale. The assessment given by the expert forum in the second round included aspects of the learning model characteristics: (1) syntax, (2) social system, (3) principles of reaction, (4) support system, and (5) learning effects. The Delphi study results highlighted agreement on the characteristics of the problem-based creative learning model, which included (1) syntax, (2) social system, (3) principles of reaction, (4) support system, and (5) the impact of learning. The research findings highlight the potential of problem-based creative learning as an innovative learning model in natural science learning, emphasizing its effectiveness in improving aspects of analysis, evaluation, and creation as part of HOTS. The study contributes a learning model framework for educators to strengthen natural science education and cultivate insightful and adaptive students in the 21st century.



Keywords: problem-based creative learning; pedagogy; higher-order thinking skills; learning framework; student engagement

## INTRODUCTION

Problem-based learning (PBL) is a well-established model commonly utilized in natural science education. PBL emphasizes students' active engagement in solving real-world problems. It requires critical and analytical thinking and cooperative effort (Hursen, 2021; Liu & Pásztor, 2022; Loyens et al., 2023; Cossu et al., 2024; Sastra Negara et al., 2024). PBL immerses students in complex situations where they are prompted by their investigation methods, lines of inquiry, research, and exploration to invent solutions independently (Lonergan et al., 2022; Sebatana & Dudu, 2022; Suradika et al., 2023). This model not only helps students understand natural science knowledge but also develops essential abilities such as critique, communication, and collaboration (Chang et al., 2022; Boye & Agyei, 2023; Kholid et al., 2023; Sharma et al., 2023; Yan et al., 2023; Khoiri et al., 2023).

Meta-analyses indicate that the use of PBL has increased across various educational levels due to its ability to bridge the gap between theory and practice, its alignment with real-world competencies, and its motivational impact on students (Nantha et al., 2022; Anggraeni et al., 2023; Arruzza et al., 2023; Loyens et al., 2023; Cossu

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et al., 2024; Ishartono et al., 2024). However, the extent to which PBL triggers HOTS, particularly creativity, analysis, evaluation, and new solution formulation in natural science learning is still an ongoing exploration (Hodam et al., 2022; Sebatana & Dudu, 2022; Susantini et al., 2022; Zhang et al., 2022; Rusnilawati et al., 2023; Şendağ et al., 2023; Ngatono et al., 2024).

Implementing PBL in natural science teaching poses challenges, including the transition from conventional models to PBL and the readiness of teachers and students for this shift (Bosica et al., 2021; Roca, 2022; Sebatana & Dudu, 2022; Rusnilawati et al., 2023; Affandy et al., 2024). Success in PBL also hinges on teachers' abilities to design engaging problems, organize discussions, and guide students toward solutions (Zotou et al., 2020; Hugerat et al., 2021; Sajidan et al., 2022; Ulfatun et al., 2023; Cossu et al., 2024). Additionally, the availability of learning resources and institutional support are critical factors (Anggraeni et al., 2023; Loyens et al., 2023; Cossu et al., 2024; Setiawan et al., 2024).

Moreover, natural science education requires students to learn abstract and complicated concepts that they find difficult to understand and apply in real-world situations (Potkonjak et al., 2016; McColgan et al., 2017; Karpudewan et al., 2023; Lai, 2023; Luo & Jiang, 2023; Siming & Abraha, 2023). One promising approach to the challenges has been creative pedagogy, which has been shown to encourage students and broader thinking in problem-solving (Siew et al., 2015; Ashwin, 2019; Lund & Cyvin, 2022; Zhang et al., 2022; Zhao & Wang, 2024). The integration of PBL with creative elements has rarely been investigated (Lin, 2014; Chang et al., 2022; Han & Abdrahim, 2023; Hews et al., 2023; Hidajat, 2023; Liu et al., 2023) and thus, we have little understanding of how it can facilitate HOTS, spur innovation, or resolve barriers in PBL.

There is a lack of study that can develop enough understanding regarding integrating PBL with creative pedagogy to accelerate learning in natural science. The proposed Problem-Based Creative Learning (PBCL) model aims to enhance students' HOTS and prepare them to solve real-world problems effectively by building on the structured problem-solving approach of PBL and the innovative components of creative pedagogy. Natural science education, in which the PBCL model stimulates analytical and critical thinking, evaluative skills, and innovative perspectives that improve learning outcomes.

## METHODS

A Delphi approach is a design utilizing an expert panel conducted in at least two interconnected rounds, with each round dependent on the answers collected during the proceeding round. However, no specific criteria define the characteristics of the "experts," the most appropriate panel size, or even the criteria used for the selection of the panelists (Ye et al., 2022; Kosman et al., 2024; Laupichler et al., 2023). A Delphi study can be said to be most often used to collect data from experts in a particular study area to obtain a consensus, in this case, to provide empirical validation of the assertion that the PBCL model improves natural science learning outcomes and that this improvement is more significant in HOTS.

Several factors explain why the Delphi method is well suited to this research. First, the iterative rounds of the Delphi method give space for these experts to evolve their opinions and reach consensus, which is crucial in supporting the robustness and relevance of the model. Second, the Delphi method's flexibility in incorporating diverse opinions from experts and synthesizing them into a coherent framework makes it suitable for this research as we aim to optimize the PBCL model for HOTS enhancement.

The Delphi method has been successfully implemented in previous studies to validate complex constructs, including an artificial intelligence test (Laupichler et al., 2023), core competencies in clinical nursing education in China (Ye et al., 2022), and the development of assessment in higher education (Kosman et al., 2024). These precedents demonstrate its suitability for tasks requiring agreement among experts on complex and abstract issues, such as verification of the PBCL model. Figure 1 shows the research method.

A Delphi study group of seven members was assembled with meticulous attention to detail, ensuring a comprehensive range of in-depth expertise. The expert forum involved in the Delphi study consisted of seven experts, including the educational science expert (n=1), who brings a deep understanding of the learning process, pedagogy, and educational theories, which are essential for ensuring that the PBCL model aligns with sound educational principles. Natural science education experts (n=4), given that the PBCL model focuses on natural science learning, were selected from this field. Their specific perspectives on science in the education curriculum, methods of teaching science, and challenges in science education are critical for the model's relevance and applicability. The Natural Science Education Research and Evaluation Expert (n=1) provides an in-depth analysis of the effectiveness of learning methods, offering insights into how the PBCL model can be evaluated and validated. The physics expert (n=1) involved included knowledge of physics concepts and their teaching, helping to ensure that the model included appropriate, correct scientific information.

The allocation specifically focused on natural science, given that the PBCL model directly relates to improving natural science learning. By bringing in several natural science education experts, the presence of different science education subfields and pedagogical approaches promotes a more comprehensive and robust model.

Regarding geographical representation, those present at the expert forum were from several regions in Java and Kalimantan. It had a geographical mix to ensure a range of perspectives based on local experiences and the challenges faced by different education systems on those continents. However, this included six experts from Java and only one expert from Kalimantan, which may not fully reflect Indonesia's geographical diversity. This is acknowledged as a limitation of the study, as the involved experts may not reflect the full spectrum of educational contexts across the country. Future studies should aim to include a more geographically diverse panel to enhance the generalizability of the findings.

The combined expertise and the limited geographical distribution of the expert panel were assets in the Delphi study process, ensuring that the information obtained included a broad and holistic view of the issues studied, albeit within the constraint of the geographical limitation. Table 1 presents detailed information on the characteristics of the expert panel.

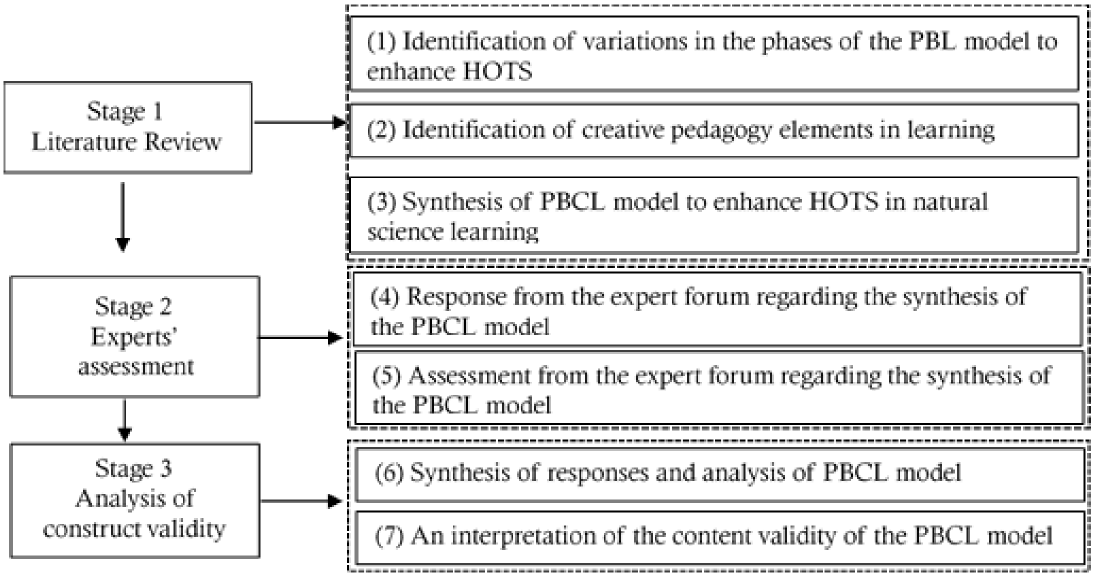


**Figure 1.** Research Method

## The Delphi Process

### Round 1

The first round of the Delphi panel was given open-ended questions, for example, on the syntax aspect: (1) According to an expert's view, have the syntax aspects in the PBCL model been able to achieve the objective of enhancing HOTS in the learning of natural sciences?; (2) How does an expert see the role of syntax in determining the success of the integration between PBL and creative pedagogy in achieving the objective of HOTS-oriented learning in the natural sciences?; (3) What does an expert think about the role of a more flexible syntax in developing a learning model that integrates PBL and creative pedagogy to promote the development of HOTS in natural sciences learning? The expert forum had the opportunity to provide feedback and additional comments related to the PBCL framework.

The results of the first round of Delphi panel discussions were then synthesized into a PBCL model consisting of syntax, social system, reaction principles, support system, and learning effects proposed and formulated under Bloom's taxonomy (Anderson et al., 2001). The questions for the first round were based on reviewing relevant literature, while the questions for each subsequent round were derived from the previous responses. Additionally, since our objective was to reach a consensus on the PBCL model, we used statistical analysis to assess the expert forum responses, and the responses from round 1 were analyzed qualitatively (Creswell, 2012).

**Round 2**

The second round of Delphi panels were presented with a close-ended question and asked to respond using a five-point Likert scale: 1 = not applicable, 2 = less applicable, 3 = moderately applicable, 4 = applicable, 5 = highly applicable. The assessment given by the expert forum in the second round included aspects of the learning model characteristics proposed by Joyce et al. (2009), consisting of (1) syntax, (2) social system, (3) principles of reaction, (4) support system, and (5) learning effects. The expert forum was also asked to provide comments and suggestions on the PBCL model that had been developed if the expert forum considered the framework incomplete. The expert forum assessment data was analyzed and displayed in a validation table that displays the consensus of expert forum responses based on a Likert scale of 1-5.

**Table 1.** General Background of Expert and Practice in Science

| Panel Participants | Position | Expertise | Experience Years |
|---|---|---|---|
| Expert 1: Universitas Negeri Yogyakarta | Professor | Science Education | 31- 40 year |
| Expert 2: Universitas Negeri Yogyakarta | Professor | Evaluation in Science Education | 31- 40 year |
| Expert 3: Universitas Sunan Kalijaga | Associate Professor | Science Education | 21- 30 year |
| Expert 4: Universitas Palangka Raya | Associate Professor | Science Education | 31- 40 year |
| Expert 5: Universitas Sebelas Maret | Professor | Educational science | 31- 40 year |
| Expert 6: Universitas Sebelas Maret | Professor | Physics | 10- 20 year |
| Expert 7: Universitas Sebelas Maret | Associate Professor | Science Education | 31- 40 year |

Responses from the expert forum in round 1 were obtained from open-ended questions, which were analyzed qualitatively. The expert forum responses through open-ended questions were then synthesized to obtain an initial description of the characteristics of the PBCL model. Whereas in round 2, the responses were obtained from a questionnaire that employed a 5-category Likert scale. Round 2 data were analyzed using the content validity coefficient using the Aiken V (Aiken, 1980) to obtain consensus on the Delphi results. The Aiken V statistical equation is applied , with  = $r - lo$; $n$ = raters; $lo$ = minimum validity assessment number; $c$ = highest validity assessment number; $r$ = the number given by the panel of experts.

## RESULTS AND DISCUSSION

The conceptual framework of the PBCL model was developed by integrating creative pedagogy into the PBL model. The creative pedagogy employed to minimize the disadvantages of the PBL model in facilitating HOTS adopts the framework proposed by (Lin, 2014). The rationale for adopting the creative pedagogy framework is as follows: first, the proposed framework is more holistic, which includes creative learning factors, including creative teaching, teaching for creativity, and creative learning process. Amabile et al. (1996) explain that the three elements of creative pedagogy are interrelated, which makes it resonant when each element complements the other. Second, the concept of science on vibration and wave material in life and creative pedagogy is based on the same thing: imagination. The imagination is not limited to educators or learners, but both because science is built from the results of processing the imagination. There is imagination in managing teaching (Lin, 2011; Chung et al., 2020), and imagination in solving problems creatively (Bollen et al., 2017; Malthouse et al., 2022). Finally, experimental activities in building an understanding of vibration and wave concepts in life may provide a more democratic and flexible relationship between teachers and students. Therefore, the role of the teacher in the classroom is no longer as an authority figure but as a facilitator and learning partner for students. Students also take part in the process of forming an understanding of the knowledge gained through experiments.

**Results of Delphi Round I**

The results of the first round provided the experts' opinions on various aspects of the integration between PBL and creative pedagogy in the context of natural science learning. The results of round 1 provided the basis for formulating a PBCL model to develop learning processes that focus on students' HOTS. The responses of the expert forum in Delphi round 1 are presented in Table 2.

Table 2 summarizes the important aspects assessed and evaluated by the expert forum in the first round of Delphi. The responses provided by the expert forum became the basis for improving, adding, and deleting some elements that were considered insubstantial within the framework of the PBCL model. The evaluation from the experts provides a broad and in-depth view of the effectiveness, meaningfulness, and relevance of the elements contained in the PBCL model, thus allowing for better refinement to formulate a more robust and substantial learning model in supporting students' HOTS in science learning.

**Table 2.** Overview of Expert Responses in Round

| Aspect | Expert Response |
|---|---|
| Syntax | There is a need to integrate a divergent thinking approach that encourages students to develop creative ideas, leading them to a structured solution (convergence).<br>There is a need to employ continuous formative evaluation to maximize the effectiveness of the PBCL model in improving HOTS in natural science learning. |
| Social system | The development of more structured group work with clear roles and responsibilities for each group member<br>Guidance is needed to provide constructive feedback and support students' social development in HOTS-oriented learning. |
| Principles of reaction | It is necessary to use a variety of learning approaches in the PBCL model, such as group discussions, collaborative projects, or interactive technology, to facilitate the exploration and understanding of natural science concepts. |
| Support system | Provide adequate technological infrastructure in the learning environment, including easy access to devices such as computers or tablets and stable internet access to support online learning or access to interactive learning resources. |
| Learning effects | It is necessary to use comprehensive measurement methods to evaluate the impact of the HOTS in the PBCL model. Measurement methods may include tests, classroom observations, student portfolios, and interviews to understand the effects of learning thoroughly.<br>A more active role of formative evaluation in the PBCL model. Facilitate continuous and structured feedback for students to enhance the learning process. |

**Results of Delphi Round II**

The results of the expert forum responses based on round 1 obtained general characteristics of the PBCL model, including syntax, social system, reaction principles, support system, and learning effects. The results of the synthesis of the PBCL model in round 1 were then submitted back to the expert forum for judgment. The purpose of the judgment was to validate the characteristics of the PBCL model in round 2. The summary of the judgment results in round 2 is represented in Table 3.

**Table 3.** Summary of Expert Judgment

| Aspect | Aiken's V Index | V Table | Interpretation |
|---|---|---|---|
| Syntax | 0,804 | 0,75 | Valid |
| Social system | 0,857 | 0,75 | Valid |
| Principles of reaction | 0,857 | 0,75 | Valid |
| Support system | 0,821 | 0,75 | Valid |
| Learning effects | 0,839 | 0,75 | Valid |

The evaluation of the aspects that constituted the PBCL model demonstrated positive results based on the Aiken index in round 2. The syntax aspect of the PBCL model obtained an Aiken index value of 0.804 (>0.75), indicating a high level of agreement among the seven experts who assessed this aspect, exceeding the established threshold (>0.75) for substantial agreement. Meanwhile, the evaluation of the social system, principles of reaction, support system, and learning effects of the PBCL model reflected a significant level of agreement with Aiken's indices of 0.857, 0.857, 0.821, and 0.839, respectively, all of which exceeded the threshold. The assessment provided by seven experts in the second round of Delphi provided strong validation of various aspects of the PBCL model, confirming the success in formulating a relevant learning framework to support the enhancement of students' HOTS in natural science learning.

**Implementation in Classroom**

The PBCL model was implemented in junior high school on vibrations and waves in everyday life. The following is a detailed explanation of each stage in the implementation.

*Syntax 1 – Presentation of the problem*

The first of the syntax, the presentation of the problem, aims to orient students to the problem and motivate them to use higher-order thinking skills: analysis and evaluation. The teacher introduces vibrations and waves and their relevance in everyday life, such as music, communication technology, or natural phenomena. The teacher uses creative teaching techniques to attract students' attention, such as showing interesting videos, live demonstrations, or inspirational stories. Following the introduction, students are invited to discuss in groups examples of vibration and wave phenomena that they know and identify the problems that cause them.

*Syntax 2 – Creative problem identification*

The second syntax, creative problem identification, aims to help students identify problems using analytical skills. Each group identifies a problem related to vibrations and waves that they consider essential. During the creative problem identification syntax, students are encouraged to use teaching creativity techniques, such as brainstorming and mind mapping, to explore various possible problems. Furthermore, students list the analytical questions they must ask to understand the identified problem more.

*Syntax 3 – Creative Exploration*

The third syntax is creative exploration, and the main objective is to develop students' ability to create solutions through independent and group investigations. Students conduct investigations independently and in groups to find relevant information and data regarding vibrations and waves. Based on this, they use various sources such as textbooks, the internet, simple experiments, and expert interviews. The teacher encourages students to think creatively using role-playing, simulation, or practical experiments. Students collect and analyze the data obtained, then compile a provisional report on their findings.

*Syntax 4 – Creative solution and sharing*

Creative solution and sharing aims to develop creative solutions and present the results, enhancing students' creative skills. Each group creates a creative solution to the problem they have identified based on the data and analysis that has been done. The teacher facilitates by providing constructive feedback and suggestions. Students then present their solutions in front of the class, using creative presentation techniques such as videos or demonstrations of experimental results. Each group is encouraged to demonstrate the creative thinking process during solution development. Other students provide feedback and discuss the presentations, identifying strengths and weaknesses in the proposed solutions.

*Syntax 5 – Reflection and evaluation*

Reflection and evaluation aims to evaluate the problem-solving process and the resulting solutions and reflect on the learning that has taken place. The teacher and students assess the problem-solving process, from identification to the resulting solution. Students use the prepared evaluation rubric to evaluate their performance and that of other groups. Students then write personal reflections on what they have learned, how they contributed, and what they can improve. Each group has a reflective discussion about their teamwork, the effectiveness of their solution, and the creative process they went through. At the end, students formulate an action plan to deepen their understanding.

The evaluation provided by the expert forum in Rounds 1 and 2 using the Delphi technique resulted in the final framework of the PBCL model. The PBCL model framework has undergone a series of evaluations involving various expert insights and thoughts. The primary purpose of the PBCL model framework is to provide educational practitioners with a better understanding of the implementation of the learning phases contained in the PBCL model. The results of the evaluation provided by the expert forum in Rounds 1 and 2, using the Delphi technique, successfully obtained the contribution of the PBCL model to HOTS. The effectiveness of the PBCL model in enhancing HOTS theory begins with the divergent thinking process in solving, finding solutions, and proposing solutions to problems. The divergent thinking process is facilitated in the second stage of the PBCL model, where students actively identify problems creatively through various learning resources.

The PBCL model as a form of problem-based inquiry model is consistent with the research findings (Hou et al., 2023; Miroshnik et al., 2023; Xie, 2023) in their studies, each of which suggests a relationship between divergent thinking activities and natural science concepts and in-depth concept understanding. Problem-based inquiry-oriented learning provides many alternative answers to solve the problem (Aibin et al., 2023; Da'as, 2023). Effective learning in the PBCL model is encouraged by several things, such as 1) student activities complemented by reflection and efforts to achieve understanding (Chang et al., 2022; Liu & Pásztor, ; Hidajat, 2023), 2) collaboration between students for learning (Grajzel et al., 2023; Hews et al., 2023; Kao et al., 2023), 3) responsibility for learning (Cilliers et al., 2022; Stefaniak, 2021), 4) metacognitive (Boye & Agyei, 2023; Feng et al., 2023). The PBCL model accommodates all four requirements. Effective learning in the PBCL model is also designed for cooperation and collaboration between students in groups to solve problems, and group participants are responsible. The Delphi study provides legitimacy for each stage in the PBCL model to contribute to the theoretical improvement of students' HOTS.

The first syntax is the presentation of the problem in the PBCL model. Also, the expert judgment of presenting the problem syntax will help provide a better understanding of the problem and require students to analyze and evaluate all relevant information. The study results favor expert judgment (Bosica et al., 2021; Cossu et al., 2024), indicating that the problem presented in learning can trigger critical thinking, and students can discern and resolve complex problems (Anggraeni et al., 2023; Cossu et al., 2024). Reading the problem syntax in a new type of question makes the learning process more exciting and challenging while helping students learn to read questions deeply to understand better the ideas they need to read and the associated context. The presentation of the problem syntax theoretical constructs is in line with previous researches that build stimulating learning environments for students to actively engage in solving problems (Loyens et al., 2023; Cossu et al., 2024), consider solutions that can be given from several different perspectives and creative solutions (Anggraeni et al., 2023; Cevikbas & Kaiser, 2023) offers students the opportunity to not just focus on problem recognition (Nantha et al., 2022; Zhang et al., 2022; Arruzza et al., 2023) but also encourages students' critical and creative ability in solving the problem (Arruzza et al., 2023; Loyens et al., 2023).

The second syntax is creative problem identification. Expert judgments highlighted that the creative problem identification syntax improves students' skills in identifying problems creatively, expanding the capacity to elaborate and understand the core of complex problems. Expert judgment is consistent with previous research (Hodam et al., 2022; Toker & Akbay, 2022) that creative problem identification encourages students to explore multiple perspectives (Sebatana & Dudu, 2022; Zhang et al., 2022) and innovative solutions (Yang et al., 2022; Karpudewan et al., 2023; Lai, 2023). The assessment from a creative problem identification expert is designed to make the problem identification process more dynamic and creative. Students are not only organized to understand the context of the problem but also encouraged to identify the problem creatively, involving analytical thinking. The theoretical construct of creative problem identification syntax is consistent with Liu et al. (2023) and Siming and Abraha (2023) that creating a learning environment that encourages students to view problems from multiple perspectives can develop excellent analytical skills. The creative problem identification syntax focuses on the organization of understanding and encourages students to create creative solutions and hone analytical skills simultaneously.

The third syntax is creative exploration. The results of the expert forum evaluation confirmed that this syntax provides opportunities for students to experiment creatively to find solutions to the problems encountered. The expert forum evaluation results follow research findings that exploring solution options that have not been considered before requires creative exploration activities (Stolk et al., 2021; Chang et al., 2022; Gatchev et al., 2022). Furthermore, creative exploration activities can develop students' ability to design innovative approaches to problem-solving (Hews et al., 2023; Lee et al., 2023; Liu et al., 2023). The creative exploration syntax aims to achieve aspects of HOTS, especially creating by utilizing PBL principles, encouraging students to conduct independent and group investigations in creative learning. The theoretical construct of creative exploration syntax is in line with the results of previous research (Roca, 2022; Yan et al., 2023) that exploratory learning activities are not only provided with the flexibility to explore concepts independently or collaboratively but also encouraged to discover unique and creative solutions. Karpudewan et al. (2023), Lai (2023), and Luo and Jiang (2023) described that the exploration process not only strengthens students' ability to analyze information but also stimulates the ability to create new ideas.

The fourth syntax is creative solution and sharing. The expert judgment highlights that the creative solution and sharing syntax encourages students to not only find solutions but also to consider and communicate those solutions in a creative and structured way. The expert judgment is consistent with Hews et al. (2023) and Yao et al. (2023) that learning activities that encourage students to not only find solutions but also to consider and communicate those solutions creatively and structured involve collaborative processes. Collaborative processes can expand students' inventive skills (He et al., 2023; Loyens et al., 2023; Maor et al., 2023), engage students to design original ideas and communicate those concepts clearly and effectively to others (Cirkony, 2023; Li et al., 2023; Maor et al., 2023), consistent with the principles of Bloom's revised taxonomy (Anderson et al., 2001). With the creative solution and sharing syntax, students are encouraged to develop creative solutions to the problem at hand and share their ideas with peers. The theoretical construct of creative solution and sharing syntax is consistent with Karpudewan et al. (2023) and Siming and Abraha (2023) that developing problem solutions accompanied by sharing activities encourages a dynamic learning process, where students can explore innovative ideas. Students are tested in formulating effective solutions and their ability to convey ideas creatively and persuasively to their peers (Chang et al., 2022; Han & Abdrahim, 2023). Lai (2023) explained that large group peer-sharing activities provide opportunities for students to develop as problem solvers and individuals who can convey new ideas effectively.

The fifth syntax is reflection and evaluation. The expert judgment highlighted that the reflection and evaluation syntax allows students to provide opportunities to evaluate their work and develop reflective and evaluative skills that are essential in learning. The expert judgment aligns with Hartmann et al. (2023), Liu et al. (2023), and Maor et al. (2023) that deep introspection of the learning experience is an essential step for any individual or group. Reflection and evaluation activities are carried out by critically analyzing each stage, successes, and failures during the learning process (Toker & Akbay, 2022; Yang et al., 2022; Lefebvre et al., 2023). The reflection process helps to understand what has worked and what needs to be improved and to look for new opportunities and strategies that could improve the efficiency and effectiveness of learning (Yang et al., 2022; Choi et al., 2023). In the reflection and evaluation syntax, students are asked to reflect on the learning process and evaluate the solutions that have been produced critically. The theoretical construct of creative exploration syntax is consistent with Hidajat (2023) and Liu et al. (2023). Reflection on the learning process invites students to assess the proposed solution's success critically, detail the advantages and disadvantages, and consider alternative solutions.

## CONCLUSION

The PBCL model derived through a Delphi process with input from domain experts yields important findings. The expert evaluation report indicates that there has been a high level of agreement and consistency among experts towards the framework of the PBCL model. It juxtaposes the salient tenets of the PBL model and creative pedagogy to build a scaffold to support learning the natural sciences and HOTS. In detail, the attributes of learning models that are known include syntax, social system, reaction principle, support system, and the consequences of learning, which are to be applied in learning science. The evaluation results provide valuable insights for educational practitioners in designing learning that focuses on students' HOTS, creativity, and problem-solving. The study concludes that the PBCL model becomes a cornerstone of learning innovation, orienting students' comprehensive development in natural sciences. The study's implications provide renewed optimism in enhancing learning effectiveness as the PBCL model is proven to encourage HOTS, which is essential for holistic student development. However, given that these findings are based on a literature study and expert evaluation, further research is recommended to evaluate the effectiveness of the PBCL model in fostering HOTS from students' perspectives. Future studies should include empirical testing and student feedback to validate and refine the model.

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