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Development of a Context-Based STEAM Learning Approach to Foster Innovative Thinking in Grade 4 Students

Khahnok-on SINNOY [a] and Jirutthitikan PIMVICHAI[b*]

[a]*Anuban paphayom School,Paphayom District,Phatthalung Province 93210 Thailand*
[b]*Institute for Innovative Learning, Mahidol University, Nakhonpathom Province 73170 Thailand*

*Corresponding author: jirutthitikan.pim@mahidol.ac.th

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Abstract: This study aimed to develop a context-based STEAM learning approach designed to foster innovative thinking in Grade 4 students. The researchers reviewed literature on STEAM education, context-based learning (CBL), and innovative thinking, then synthesized the STEAM phases and CBL principles into a six-stage approach called CIRCLE: Connect with the context, Investigate the problem, Represent and plan ideas, Create and test, Learn from testing and improve, and Explain and extend learning. An illustrative lesson on the physical properties of materials shows how Grade 4 students could use the stages to investigate a familiar problem, design and test a solution, and improve it using evidence. CIRCLE provides a proposed approach for lesson design. Its feasibility and effects on students' innovative thinking have not yet been evaluated in a classroom.

Keywords: Context-based STEAM, CIRCLE approach, Grade 4 students, innovative thinking, learning approach

Introduction

Grade 4 students encounter problems in their daily lives that invite them to ask questions, consider different ideas, and find practical solutions. Schools can help students develop these abilities from an early age. Innovative thinking involves generating ideas and considering how they can be improved and used to address a need or problem (Morad et al., 2021a). It is closely related to creative thinking, which includes generating diverse and original ideas and evaluating and improving them (OECD, 2023). In this study, innovative thinking refers to students' ability to identify a problem, propose relevant and original ideas, consider their usefulness, and improve a proposed solution.

STEAM education offers opportunities to develop these skills by connecting science, technology, engineering, the arts, and mathematics in learning activities. Students can use knowledge from more than one subject to investigate a problem, design a solution, create a product, and explain their choices. Research with elementary students suggests that STEAM activities can support aspects of creative thinking, particularly when students design and develop products (Boonchu et al., 2022; Cheng et al., 2022; Keeratichamroen & Phonnong, 2022; Tran et al., 2021). However, STEAM activities differ in how they connect the five disciplines and in what they ask students to learn. Perignat and Katz-Buonincontro (2019) found that studies use different definitions of STEAM and often provide limited evidence of their intended learning outcomes. A STEAM approach aimed at innovative

thinking therefore needs a clear learning process and a clear way to assess students' thinking.

Context-based learning (CBL) can give STEAM activities a meaningful starting point. In this approach, students begin with a situation or problem connected to their experiences. They then learn and use relevant concepts to understand the situation and develop a response. Gilbert (2006) emphasized that an effective context should help students connect the situation with the knowledge they are learning. Bennett et al. (2007) found that context-based approaches were associated with more positive attitudes toward science, while students' understanding of scientific ideas was generally comparable to that achieved through conventional approaches. Although much of this evidence comes from secondary education, it suggests a useful reason to explore meaningful contexts with younger learners.

Bringing STEAM education and CBL together may help Grade 4 students see why they need knowledge from different subjects. A familiar problem can prompt them to investigate, while STEAM can provide ways to design, test, communicate, and improve a solution. For example, students may use scientific observations to understand a problem, mathematics to compare options, engineering to design a product, and the arts to communicate their ideas. In such activities, learning involves more than completing a product. Students also need to explain their decisions and show how their ideas change as they work.

Existing studies provide examples of STEAM activities that support elementary students' creativity (Boonchu et al., 2022; Cheng et al., 2022; Tran et al., 2021). They offer less guidance on how to combine STEAM with CBL specifically to develop innovative thinking among Grade 4 students. This study addresses that need by developing a STEAM learning approach integrated with CBL, with activities that give students opportunities to identify problems, generate ideas, consider their usefulness, and improve solutions.

Research objective

This study aimed to develop a Context-Based STEAM learning approach to foster innovative thinking in Grade 4 students.

Literature Review

STEAM education and integrated learning

STEAM education connects science, technology, engineering, the arts, and mathematics so that students can use knowledge from different subjects to address a shared problem (Riley, 2014). Yakman (2008) described STEAM as a model of integrated education, and Yakman and Lee (2012) discussed its use as a framework for teaching across disciplines. Li et al. (2018) suggested that this integration can create opportunities for creative thinking. The value of STEAM, however, depends on what students do with the connections among subjects. Including all five subjects in a lesson does not, by itself, make the learning meaningful.

Within the proposed approach, the Arts contribute through aesthetic judgment, visual communication, learner expression, and user-centered design. Students exercise aesthetic judgment when they consider how color, shape, texture, and composition influence a solution's appearance and suitability for its context. Visual communication involves organizing images, symbols, and other design features to convey ideas and make a product's purpose or use understandable. Learner expression gives students opportunities to communicate their experiences, preferences, and cultural perspectives through design

choices. User-centered design encourages them to consider intended users' needs and experiences, including comfort, ease of use, and accessibility. These contributions position the Arts as a way of shaping how a solution is experienced, understood, and used.

STEAM activities can be organized in several ways. Jin et al. (2012) developed robotics-based learning content, while Park and Ko (2012) explored the use of educational programming. Both illustrate how a task can bring together knowledge and skills from different fields. Project-based learning offers another approach. In their review, Zayyinah et al. (2022) described how STEAM projects may give students opportunities to investigate problems, design responses, and develop skills relevant to 21st-century learning.

Working in groups may also allow students to share ideas and contribute different strengths. Such benefits depend on how the teacher structures the task and supports participation; they should not be assumed simply because an activity is called STEAM. Perignat and Katz-Buonincontro (2019) found that studies vary in how they define STEAM, integrate its disciplines, and describe the role of the arts. They also found that some intended outcomes, including creativity and problem solving, were not reported clearly. A learning approach should therefore explain how its subjects are connected, what students are expected to learn, and how that learning will be assessed.

Evidence from STEAM learning activities

Studies have examined the effects of STEAM activities on both subject understanding and thinking skills. Liliawati et al. (2018) investigated concept mastery through activities organized around the theme of "Water and Us." Wandari et al. (2018) examined concept mastery and creativity in lessons on light and optics. Among Grade 7 students, Ozkan and Umdu Topsakal (2021) reported improved understanding of force and energy, along with changes in students' misconceptions. These studies show why a STEAM activity should support understanding of the subject matter as well as opportunities to design or create. Their participants and learning topics differ from those of the present study, however, so their results cannot be applied directly to Grade 4 students.

Research with elementary students is more closely related to the present study. Boonchu et al. (2022) developed STEAM science activities in which students designed a zoo and examined their creative thinking. Cheng et al. (2022) studied a project in which students designed musical instruments and assessed their ideas and products. Keeratichamroen and Phonnong (2022) developed STEAM activities for small elementary schools and examined learning achievement and creative thinking. Tran et al. (2021) found improvements in some aspects of elementary students' scientific creativity, although originality did not improve to the same extent as fluency and flexibility. This finding is a reminder that different aspects of thinking should be identified and assessed separately.

The quality of implementation also matters. Armknecht's (2015) case study of an elementary STEAM laboratory school found generally positive stakeholder perceptions, but mixed results for academic achievement. Thus, students' enjoyment of an activity or completion of a product is not enough to show that the intended learning has occurred. Suganda et al. (2021) examined STEAM and environmental learning in relation to creative thinking, offering a further reason to consider problems connected to students' surroundings. Together, these studies support the use of meaningful design tasks while pointing to the need for clear evidence of what students learn through them.

Context-based learning and its connection with STEAM

Context-based learning (CBL) begins with a meaningful situation or problem and uses it to guide the learning of relevant concepts. Gilbert (2006) argued that a context should do more than attract students' attention at the start of a lesson. It should help them connect the situation with the knowledge they learn and the actions they take. Bennett et al. (2007)

found that context-based and science–technology–society approaches were associated with more positive attitudes toward science, while students' understanding of scientific ideas was generally comparable to that achieved through conventional teaching. Because much of the evidence they reviewed involved older students, its relevance to Grade 4 needs to be examined.

CBL and STEAM can play complementary roles in a learning activity. A context can give students a reason to investigate a problem, while STEAM can provide knowledge and methods for developing a response. For example, a problem at school may lead students to make scientific observations, compare measurements, design and test an object, and communicate how it works. To keep the activity context-based, students should return to the original problem when they judge whether their proposed solution is useful. In this study, combining CBL and STEAM is a proposed learning design; its contribution to Grade 4 students' thinking must be examined rather than assumed.

Innovative thinking as the learning outcome

Creative thinking is a central component of innovative thinking, although the two constructs are distinct. The OECD (2023) characterizes creative thinking in terms of generating diverse and original ideas and evaluating and improving them. Morad et al. (2021a) situate these processes within a broader model of innovative thinking that begins with identifying a need or problem and progresses toward developing an outcome with value. Building on this distinction, the present paper defines innovative thinking as *the capacity to identify problems and generate, develop, and refine ideas into useful solutions*. For Grade 4 students, this capacity can be demonstrated through familiar classroom challenges that involve proposing ideas, explaining their usefulness, and improving solutions through testing and feedback.

To make this definition explicit, four interconnected dimensions are proposed: *problem identification*, which involves recognizing a need and relevant constraints; *idea generation*, which involves proposing varied and potentially original approaches; *solution development*, which involves explaining and representing a feasible approach; and *evaluation and improvement*, which involves using evidence from testing or feedback to refine a solution. These dimensions draw on primary-school research connecting innovation with creative ideas, development processes, prototype construction, and iterative improvement (Min et al., 2024; Saetan et al., 2024). Together, they provide a framework for identifying innovative thinking in students' classroom work.

Assessment should capture these dimensions through observable evidence of both thinking processes and their outcomes. Counting ideas alone, for example, would provide limited information about whether students can address a problem, develop a useful response, or improve it. Morad et al. (2021b) developed and examined a measure of educational innovative thinking competencies, highlighting the importance of specifying the competencies to be assessed. For younger learners, these competencies should be translated into tasks and scoring criteria that use familiar language and describe actions students can understand and demonstrate.

We propose that a suitable assessment could involve a short, open-ended science task in which students design a container to slow the melting of an ice cube using a limited selection of classroom materials. Students would identify the problem and constraints, sketch alternative designs, explain their material choices, construct and test a prototype, and propose a justified improvement. This suggested task extends the everyday melting scenario used by Van Hooijdonk et al. (2024), whose assessment considered originality, completeness, and practicality. Individual drawings, brief oral explanations, teacher

observations, test records, and revised designs could provide complementary evidence of the quality of students' solutions and the reasoning underlying their development.

An age-appropriate analytic rubric should be constructed by using the four proposed dimensions, describing how clearly students identify the problem, how varied and original their ideas are, how coherently they explain a feasible solution, and how effectively they use evidence to guide improvement. Allowing responses through drawings, models, and oral explanations would give students several ways to demonstrate their innovative thinking. This combination of process and product assessment is consistent with primary-school research using innovative-thinking rubrics, product assessment, and observation (Ratchakhom, 2024). Research involving Grades 3–4 also distinguishes task-based creative performance from self-reported dispositions and related social behaviors (Guo et al., 2026). Participation, confidence, and cooperation may therefore inform teachers' understanding of the learning context, but should not independently determine innovative thinking scores. Before use as a research instrument, the proposed rubric would require content review, piloting with Grade 4 students, and examination of inter-rater agreement.

STEAM education in Thailand and the focus of this study

Thai elementary studies provide a useful starting point for designing the present approach. Boonchu et al. (2022) showed how a STEAM design task could be used to examine primary students' creative thinking. Keeratichamroen and Phonnong (2022) developed and evaluated STEAM activities in small elementary schools. These studies are more directly relevant to the Thai primary-school context than studies conducted with older students or in other countries. They do not, however, establish how STEAM combined with CBL can foster innovative thinking among Grade 4 students.

The literature therefore points to three connected design requirements. First, a familiar context should give students a clear problem to investigate. Second, STEAM activities should require them to use knowledge from different subjects for a purpose, rather than merely place those subjects side by side. Third, the tasks and assessment should capture how students generate, explain, test, and improve ideas. Guided by these requirements, the present study aimed to develop a STEAM learning approach integrated with CBL to foster innovative thinking skills among Grade 4 students.

Development of the Context-Based STEAM Learning Approach

STEAM education connects knowledge from different subjects through investigation and design, but studies do not prescribe a single sequence of classroom activities (Yakman & Lee, 2012; Perignat & Katz-Buonincontro, 2019). To develop the instructional approach for this study, the researchers drew on engineering design practices and STEAM projects with primary and elementary students (National Research Council, 2012; Boonchu et al., 2022; Cheng et al., 2022). Table 1 summarizes six STEAM phases that can give Grade 4 students opportunities to identify a problem, develop a solution, test it, and improve it.

Table 1. Proposed STEAM learning process for Grade 4 students, synthesized from the literature

Phase	Student activity	Supporting literature
1. Identify a meaningful problem	Observe a familiar school or community situation and state a need or question they can address.	STEAM can connect disciplines around a shared purpose (Yakman, 2008; Yakman & Lee, 2012).
2. Investigate the problem	Gather observations and relevant information; learn the science and mathematics needed to understand the situation.	Investigation and the use of disciplinary knowledge are part of science and engineering practice (National Research Council, 2012).
3. Generate and plan ideas	Suggest more than one solution, discuss how each might work, and draw or describe a design.	Elementary STEAM projects provide opportunities to develop and plan designs (Boonchu et al., 2022; Cheng et al., 2022).
4. Create and test a solution	Make a model, product, or other representation; test it against the original need and record what happens.	Developing and evaluating solutions are part of engineering design and STEAM project work (National Research Council, 2012; Cheng et al., 2022).
5. Improve the solution	Use the test results and feedback to explain changes and revise the design.	Revision is part of engineering design and has been incorporated into elementary STEAM projects (National Research Council, 2012; Cheng et al., 2022).
6. Share and reflect	Present the solution, explain how knowledge from different subjects informed it, and judge how well it addresses the problem.	Project explanations and products provide opportunities to show integrated learning (Yakman & Lee, 2012; Cheng et al., 2022).

Note. The six phases are the present study's synthesis. Lesson plans should make clear what each STEAM discipline contributes where relevant. Including an art activity or decorating a product does not, by itself, show how the arts contributed to understanding or solving the problem (Perignat & Katz-Buonincontro, 2019).

The STEAM phases describe the work students undertake, but they do not specify how a problem becomes meaningful to a particular class. CBL addresses this aspect by connecting learning with a situation students can recognize and by helping them use new knowledge in that situation (Gilbert, 2006; Crawford, 2001). Research on context-based science teaching provides a rationale for this approach, while Pramchoo (2010) and Khwansin (2010) offer examples in science and mathematics (Bennett et al., 2007). Table 2 identifies the CBL principles used to shape the Grade 4 lessons.

Table 2. CBL principles used to design the proposed Grade 4 learning process

CBL design principle	Student activity	Supporting literature
1. Use a meaningful context	Examine a familiar school or community situation that gives the learning task a clear purpose. Return to it throughout the lesson.	A meaningful context helps students connect the situation with the ideas they are learning (Gilbert, 2006). Context-based approaches use situations and applications as starting points for science learning (Bennett et al., 2007).
2. Connect with prior knowledge	Share observations and experiences, and identify what they already know about the situation.	Relating new ideas to students' experiences and existing knowledge is a key contextual teaching strategy (Crawford, 2001; Center for Occupational Research and Development, 1999).
3. Ask questions and investigate	Identify what they need to find out and gather information or evidence. Form a hypothesis when the task calls for one.	A context can give students a reason to explore relevant ideas, while hands-on investigation supports learning through experience (Gilbert, 2006; Crawford, 2001). Pramchoo (2010) provides an example of context-based science activities.
4. Apply knowledge to the situation	Use relevant concepts to develop a response, discuss their choices, and consider whether the response meets the original need.	Applying ideas and learning through discussion are contextual teaching strategies (Crawford, 2001; Center for Occupational Research and Development, 1999). Khwansin (2010) provides an example of context-based mathematics activities.
5. Reflect and transfer	Explain what they learned, evaluate their response to the original situation, and consider where else the knowledge could be useful.	Transferring knowledge to a new situation is a key contextual teaching strategy (Crawford, 2001). Returning to the original context helps students connect their explanations with the situation that prompted their learning (Gilbert, 2006).

Note. These principles guide lesson design and are not five successive stages specified by a single author.

Tables 1 and 2 serve complementary purposes: the STEAM phases organize students' investigation and design work, while the CBL principles keep that work connected to a meaningful situation and its possible applications. The researchers combined them into the six stages shown in Table 3. The stages spell CIRCLE: Connect with the context, Investigate the problem, Represent and plan ideas, Create and test, Learn from testing and improve, and Explain and extend learning.

Table 3. Synthesis of STEAM phases and CBL principles into the CIRCLE stages.

STEAM phase (Table 1)	CBL principle (Table 2)	CIRCLE stages	Student activity	Contribution to innovative thinking
1. Identify a meaningful problem	Use a meaningful context; connect with prior knowledge	**C**onnect with the context	Students examine a familiar school or community situation using photographs, objects, or a short story introduced by the teacher. Guided by questions such as "Who experiences this problem?" and "What	**Problem identification and recognition of value.** Examining a familiar situation helps students notice a difficulty or unmet need and explain why it matters. Discussing who would benefit

STEAM phase (Table 1)	CBL principle (Table 2)	CIRCLE stages	Student activity	Contribution to innovative thinking
			could be improved?", they share experiences in pairs, agree on a meaningful need, and explain their choice. They reflect on what they know and what they need to find out. The teacher uses their explanations and questions to check initial understanding and provide feedback that helps groups clarify the problem.	from a solution encourages them to connect innovation with a useful purpose.
2. Investigate the problem	Ask questions and investigate	**I**nvestigate the problem	Students work in groups to formulate an investigable question and decide what information they need. The teacher provides question starters, models safe observation and simple measurement, and offers recording sheets as needed. Students share responsibilities, collect evidence, and compare observations. They discuss whether their findings support their initial ideas and identify remaining questions. The teacher checks records and listens to discussions, providing brief explanations or prompts to address misconceptions and guide further investigation.	**Problem clarification and evidence-informed thinking.** Asking focused questions and gathering information helps students distinguish assumptions from observations, identify relevant causes and constraints, and define what a useful solution needs to achieve.
3. Generate and plan ideas	Apply knowledge to the situation	**R**epresent and plan ideas	Students first sketch or describe possible solutions individually, then share and combine ideas in groups. Using teacher prompts and a simple checklist, they compare alternatives against the identified need and constraints	**Idea fluency, flexibility, originality, and elaboration.** Generating several possibilities promotes fluency, while exploring different approaches promotes flexibility.

STEAM phase (Table 1)	CBL principle (Table 2)	CIRCLE stages	Student activity	Contribution to innovative thinking
			and justify their selected design. They integrate relevant STEAM knowledge while considering users' needs, aesthetic choices, visual communication, and personal or cultural expression. Groups reflect on whose ideas informed the plan and how feedback could strengthen it. Peer comments and teacher questions help students refine their designs before construction.	Combining STEAM knowledge in new ways encourages originality. Comparing alternatives and drawing or describing a selected design helps students develop an idea into a feasible plan.
4. Create and test a solution	Apply knowledge to the situation	**C**reate and test	Students organize group roles, select available materials, and construct a prototype from their agreed plan, making and explaining adjustments when necessary. The teacher models unfamiliar tool use and supports students in developing a safe, fair test through prompts such as "What will you keep the same?" Students conduct the test, record results through drawings, measurements, or short notes, and discuss unexpected findings. The teacher observes participation, practical decisions, and testing procedures, offering feedback that helps students improve the quality of their evidence.	**Solution development and evaluation of usefulness.** Turning a plan into a testable representation helps students translate ideas into practical action. Testing against the identified need allows them to examine whether the solution works and gather evidence about its strengths and limitations.
5. Improve the solution	Apply knowledge to the situation	**L**earn from testing and improve	Students compare test results with the original need and success criteria, identify strengths and weaknesses, and consider feedback from	**Evaluative thinking, adaptive flexibility, and iterative improvement.** Comparing results with the design goal helps students

STEAM phase (Table 1)	CBL principle (Table 2)	CIRCLE stages	Student activity	Contribution to innovative thinking
			peers acting as users. The teacher supports reflection with prompts such as "What evidence shows this needs changing?" and a simple before-and-after recording sheet. Groups negotiate which changes to make, justify their decisions, revise the prototype, and retest it where feasible. Students assess whether the changes improved the solution, while the teacher reviews their explanations and provides feedback on the connection between evidence and revision.	identify weaknesses. Using evidence and feedback to justify revisions encourages them to reconsider initial choices and improve the solution's usefulness rather than make changes without a clear reason.
6. Share and reflect	Reflect and transfer	**E**xplain and extend learning	Students choose how to present their revised solution through a demonstration, model, poster, or brief oral presentation. With teacher-provided sentence starters or presentation prompts, group members explain their contributions, disciplinary connections, design choices, and evidence of improvement. Classmates ask questions and offer feedback using shared criteria. Students reflect individually on how their thinking changed and propose another situation in which their learning could be applied. The teacher uses presentations, peer feedback, and brief exit responses to assess understanding and identify next steps; students select and explain an adaptation to	**Explanation of value, reflective thinking, and transfer.** Explaining how and why the solution addresses the problem makes its intended value explicit. Reflecting on design decisions helps students recognize effective thinking strategies. Considering another situation encourages them to adapt their knowledge and solution to different needs or constraints.

STEAM phase (Table 1)	CBL principle (Table 2)	CIRCLE stages	Student activity	Contribution to innovative thinking
			a new context or constraint.	

Note. The CIRCLE stages are the instructional sequence proposed in this study. Students may return to earlier stages to investigate further or revise their solutions, and the arts should contribute where relevant across the stages rather than appear as a separate final activity.

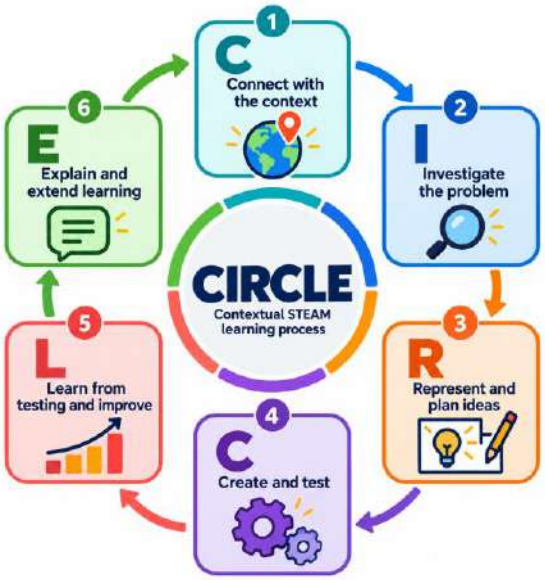


Figure 1 The six CIRCLE stages of the proposed context-based STEAM learning approach.

The following lesson illustrates how the CIRCLE stages as Figure 1 could be used to teach physical properties of materials in Grade 4. A familiar need gives students a reason to compare materials, and the properties they observe inform the design, testing, and revision of a solution. The example also shows how the teacher could gather evidence of individual students' innovative thinking alongside their group work.

Illustrative lesson: Physical Properties of Materials (Grade 4)

In this example, students are asked to design a reusable cover that helps keep a classroom book dry when it is carried outdoors during rain. The teacher may adapt the situation to a need that students have encountered at their own school.

Learning task: Design a reusable cover that helps keep a classroom book dry. Students may examine available materials such as paper, fabric, plastic packaging, and cardboard. The teacher selects safe materials that students can handle and test.

1. Connect with the context

The teacher presents a familiar situation: students sometimes carry classroom books between buildings when it is raining. Students describe what could happen to an uncovered book and share what they already know about materials that absorb or repel water. In groups, they identify the problem: How can we make a cover that helps protect a book from rain? The teacher records their initial ideas without judging them.

2. Investigate the problem

Students examine samples of available materials and ask what they need to know before choosing one. They test properties relevant to the task, such as water resistance and flexibility, using the same simple procedure for each sample. For example, they can place a fixed number of water drops on each material and observe whether water passes through

onto paper beneath it. They record and compare their observations. The teacher helps them use evidence from these tests to explain which properties would make a material suitable for a book cover.

3. Represent and plan ideas

Each group proposes at least two possible cover designs and compares them against the need to keep the book dry while allowing it to be carried and opened. Students draw their chosen design, label the materials, and measure the book to plan an appropriate size. They decide how the cover will fit and how its visual features, such as clear labels or a visible front and back, will help someone use it. The teacher prompts students to explain why they selected each material and design feature.

4. Create and test

Students make a prototype using their plan. They place a substitute object or sheets of scrap paper inside the cover and test it with a small, controlled amount of water; classroom books are kept away from the test. Students check whether water reaches the paper, whether the cover stays in place, and whether the object can still be opened or removed. They record what worked and what did not.

5. Learn from testing and improve

Students compare the test results with the original problem. Each group identifies at least one weakness, suggests a change, and explains why the change may help. They then revise the cover and test it again using the same procedure. The teacher asks students to compare the two results so that their revision is guided by evidence rather than appearance alone.

6. Explain and extend learning

Groups present their revised covers and explain the material properties they considered, how they used measurements, what the test showed, and why they made changes. Classmates ask questions and offer feedback. Students then reflect on what they learned and suggest another situation in which the same material properties might be useful, such as protecting a drawing or keeping supplies dry.

To extend learning, the teacher introduces new design constraints that encourage students to adapt their solutions and draw on other STEAM disciplines. For example, students could redesign the cover so that the protected item can be carried with one hand while the other holds an umbrella, strengthening the connection with engineering through usability and practical problem solving. Limiting the amount of material would require students to apply measurement and mathematical reasoning to plan its efficient use. Students could also integrate the arts by exploring how shape, color, and visual features can improve both the cover's appearance and the clarity of its use.

Assessment: The teacher can examine each student's notes, design sketch, test record, explanation, and reflection for evidence that they identified a need, proposed a relevant idea, justified material choices, evaluated its usefulness, and improved it after testing. Group products can support the assessment, but individual explanations are needed to judge each student's innovative thinking. Notably, this lesson uses the arts in planning and communicating a usable design, rather than adding an art activity after the product is complete. The teacher should adjust the materials and water test to suit what is available at the school.

Discussion

This study brings STEAM education and CBL together in the six-stage CIRCLE approach: Connect with the context, Investigate the problem, Represent and plan ideas, Create and test, Learn from testing and improve, and Explain and extend learning. The

stages give the two approaches connected roles. A familiar situation gives students a reason to learn, while STEAM gives them ways to investigate the situation and develop a response. This design makes the connections among subjects more explicit, addressing the variation in how STEAM integration is described in the literature (Yakman & Lee, 2012; Perignat & Katz-Buonincontro, 2019). It also keeps the context relevant throughout the lesson, consistent with Gilbert's (2006) argument that a context should connect students' actions with the ideas they are learning.

The illustrative lesson on the physical properties of materials shows how this relationship could work in Grade 4. Students consider the practical need for a book cover that protects paper from rain. They examine materials, compare their properties, plan a cover, test a model, and revise it in light of the results. The problem gives a purpose to scientific observations and simple measurements. It also gives students a reason to explain why they chose a material and whether their design meets the original need. Context-based teaching has been associated with more positive attitudes toward science, although much of the evidence concerns older students and does not establish the effect of this particular lesson for Grade 4 students (Bennett et al., 2007).

CIRCLE places particular emphasis on what happens after students suggest an idea. The stages require them to test a proposed solution, consider evidence and feedback, and explain a revision. This emphasis fits Morad et al.'s (2021a) distinction between generating a creative idea and developing an idea into something useful. It also reflects the processes of generating, evaluating, and improving ideas in the OECD's (2023) creative thinking framework. For Grade 4 students, innovative thinking can therefore be examined through actions they can demonstrate: identifying a need, proposing a suitable idea, giving reasons for a design choice, and improving the design after a test. These are intended opportunities within CIRCLE, not outcomes established by the present manuscript.

Elementary STEAM projects offer relevant examples of design tasks and creativity assessment (Boonchu et al., 2022; Cheng et al., 2022; Tran et al., 2021). The proposed approach extends this design focus by asking students to return repeatedly to a familiar problem and judge the usefulness of their response. The arts should contribute to how students develop or communicate an idea—for example, through a drawing that helps them plan the book cover and explain its use. Adding decoration after testing would provide less evidence of how the arts helped students solve the problem. The contribution of each STEAM discipline should therefore be made clear in the lesson plan and in students' explanations (Perignat & Katz-Buonincontro, 2019).

The present manuscript establishes a proposed learning design and shows how it can be translated into one lesson. It does not establish whether the six stages are practical across different topics or whether they improve students' innovative thinking. Those questions require classroom implementation and assessment. In particular, a completed group product alone may conceal differences in what individual students understood or contributed.

Conclusion

This study developed CIRCLE as a six-stage context-based STEAM learning approach for Grade 4 students. The approach starts with a meaningful problem, guides students to investigate and design a response, and asks them to test, improve, and explain their solution. The lesson on the physical properties of materials illustrates how the stages could be used in a science classroom. CIRCLE offers a clear design for creating opportunities to practice innovative thinking; its feasibility and effectiveness remain to be evaluated with Grade 4 students.

Implications

For teaching. Teachers can use CIRCLE to plan lessons around problems that students recognize in their school or community. The problem should remain visible during planning, testing, and revision so that students can judge whether their solution meets a real need. Teachers should identify the knowledge and methods each STEAM discipline contributes, provide materials that children can test safely, and allow time to improve an initial design. The stages can be revisited when new evidence changes students' ideas; they need not be treated as a rigid sequence.

For assessment. Assessment should capture students' thinking across the process, not only the appearance or performance of the final product. Brief individual drawings, explanations, test records, and reflections could show how students identified the problem, used evidence, considered usefulness, and revised an idea. A Grade 4 rubric should describe these actions in clear, age-appropriate terms and be checked for consistency before use. Morad et al.'s (2021b) measurement work supports careful definition of innovative thinking, but its instrument was developed for preservice teachers and should not be applied unchanged to children.

For future research. A first classroom study should examine whether teachers and students can carry out each stage as intended and whether the tasks provide enough time and evidence for meaningful revision. Subsequent research could assess changes in distinct aspects of innovative thinking, examine students' individual contributions during group work, and compare learning across topics or classrooms. Such evidence is needed before concluding that CIRCLE develops innovative thinking skills.

Limitations

This study developed the CIRCLE approach by synthesizing STEAM and CBL literature and illustrating its use in one Grade 4 lesson. The lesson has not been implemented or evaluated in a classroom. Therefore, the study cannot establish whether teachers can use all six stages as intended or whether the approach improves students' innovative thinking. The example also concerns only the physical properties of materials; other topics may require different tasks, materials, or amounts of time. In addition, some of the literature informing the approach involved older students or different learning outcomes, so its findings cannot be assumed to apply directly to Grade 4. Finally, the manuscript does not yet provide a validated, age-appropriate measure of innovative thinking. Classroom trials, feedback from teachers and students, and assessment of individual students' ideas and revisions are needed to examine the approach's feasibility and effect

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