



A Proposal of a Method to Promote Creativity Based on Computational Thinking Using Modified Problem-posing

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ABSTRACT

The development of creativity and computational thinking (CT) has been emphasized in education through various studies and research. In activities such as problem-based learning (PBL), students are required to set and solve problems independently. However, it is often difficult for them to discover problems independently, and for teachers to evaluate them appropriately. This study focused on activities where students created problems, that is, problem-posing and examined methods for demonstrating creativity based on CT. Using this method, students were asked to modify and improve the original problem based on CT. The advantages of this method are that it encourages students to understand the structure of the problem, allows them to create entirely new problems, and helps teachers evaluate their work properly.

Keywords: Problem-posing, Creativity, Computational thinking, Classroom, Problem-based learning

INTRODUCTION

In the digital age of the 21st century, where advanced information technology is accelerating, it has been pointed out that it is essential to acquire creativity, computational thinking, and more.

Computational thinking (CT) is the process of organizing and expressing problems in a form that computers can solve [1]. Google for Education specifies abstraction, algorithm design, decomposition, and pattern recognition as psychological processes, and automation, data representation, and pattern generalization as visible results, and that these are related to problem-solving using computers [2]. The International Society for Technology in Education (ISTE) and the Computer Science Teachers Association (CSTA) also provide an operational definition of CT [3]. Therefore, it is essential to foster creativity based on CT. This study included Wing's definition of CT [1] since it has been used by many studies [4].

There has been much research on creativity. Guilford states there is convergent and divergent thinking and that latter is essential for creativity [5]. Csikszentmihalyi defines creativity (with small c) as creativity in a very personal sphere, demonstrated in one's personal life and space, enriching one's life even if others do not recognize the result, and Creativity (with capital C) as creativity in the public sphere; even if the starting point is the individual, it brings about reforms in culture, the structure of things, and the way of life. It is something that people expect and seek from society – and that society expects and demands from people [6]. Onda defines creativity as the ability to ideate or create something new and valuable, and the personality traits that underlie it (i.e., creative personality), and emphasizes that since creative self-realization values novelty in each

child, it is fundamental to school education. Although several studies define creativity, it actually has two contexts: “what is new to the world?” and “what is new to the individual?” Educationally, it is essential to create something new for an individual and connect it to creating something new in the world [7]. Since I considered the development of creativity in each subject, this study found creativity as “the ability of learners to understand the limits of a given problem and go beyond those limits.”

To foster creativity through school education, students are often made to set their tasks and solve them. Problem-based learning (PBL) is one such method; it promotes students’ learning of concepts and principles by allowing them to explore and learn from complex real-world problems rather than having teachers directly teach facts and ideas [8]. Kwon et al. [9] and Chamberlin and Moon [10] pointed out that PBL effectively fosters students’ creativity and is therefore vital for activities that encourage creativity. In addition, to develop the skills to find and solve problems independently, PBL must focus on discovering problems (i.e., problem-posing) and problem-solving.

However, a lot of research on PBL has focused on problem-solving activities; practical ways to help students discover problems on their own have yet to be fully explored. Therefore, this study focused on problem-posing. Freire states that problem-posing education fosters the ability to take a critical look at the world we live in and helps us to see the world not as a fixed reality but as a reality in the process of change [11]. There have been several studies on problem-posing, especially in the field of science, where hypotheses are formulated and experiments are conducted based on the theory of abduction. Abduction is a concept proposed by Peirce; it refers to logical reasoning to derive a hypothesis that can best explain an individual event. It has been pointed out that problem-posing is related to understanding the structure of problems, which incites creativity; therefore, problem-posing activities can be expected to foster basic creativity skills.

However, there are several issues that need to be addressed. For example, it is difficult for novice learners to find a new topic. In this study, I proposed a method for promoting creativity based on CT. It involves “modified problem-posing” in a classroom. In the following section, the proposed method is introduced.

This study builds on our previous conceptual work on modified problem-posing in relation to computational thinking [12]. While the earlier study focused on conceptual clarification, the present paper emphasizes concrete representations and examples that support instructional implementation in classroom settings.

MATERIALS AND METHODS

In this section, I propose a method for fostering creativity through school education based on CT. There are two types of creativity: creativity in solving and discovering problems. Activities that allow students to think of problems freely are convenient for those who can think of problems on their own but need to learn how to set them up. It can be challenging to understand how to set up the task and can be difficult for the teacher to evaluate. Meanwhile, activities that require students to choose a wholly fixed task or several tasks may not be sufficient to foster their creativity. Therefore, it is necessary to develop activities to solve these problems.

However, it is often difficult for students who have never created a problem to solve it by themselves before setting up a task. In other words, proposing a method that enables such students to create problems is necessary.

Polya states that changing the problem and creating a new problem is essential for understanding and solving problems [13]. Wallas stated that transforming the problem effectively develops creativity [14]. Therefore, to foster creativity at school-level education, creating questions by transforming problems is necessary.

RESULTS AND DISCUSSION

In this study, I propose the “modified problem-posing” method, where students modify and improve the problems presented by the teacher in advance. The goal is to have students create new problems for themselves by modifying the problems based on CT.

This methodology may be regarded as a CT in modified problem-posing. For example, the relationship between modified problem-posing and CT is shown in Table 1.

Table 1. Instructional interpretation of computational thinking through modified problem-posing

CT Concepts	Examples of activity
Decomposition	Identifying which components of the problem structure or procedure can be independently modified during exploration.
Abstraction	Focusing on essential rules or patterns while temporarily ignoring numerical details that are not relevant to the modification task.
Algorithmic thinking	Tracing and reasoning about the step-by-step consequences of modified rules within an iterative procedure.
Generalization	Examining whether a modification applied to one case can be extended to a broader set of initial values or conditions.

In this context, computational thinking is not treated as an abstract cognitive ability but as a set of observable practices emerging through learners’ interactions with modified problems. The Table 1 highlights how specific modification activities can be interpreted as instructional opportunities to foster different aspects of CT.

Example of Modified Problem-posing

In this section, I have provided an example of problem-posing using a modification. To make the structure of the problem easier to understand, I have used the Collatz conjecture as a problem that does not require prior knowledge. It is a well-known problem in mathematics.

To illustrate how modified problem-posing can be introduced in a well-structured manner, we employ the Collatz conjecture as a base problem.

Rather than emphasizing the mathematical conjecture itself, this study focuses on the procedural structure that allows learners to identify and manipulate rule-based transitions.

In this problem, learners repeatedly apply simple transformation rules depending on the parity of a given number.

From an instructional perspective, this iterative process provides a clear opportunity

for learners to observe how local rule modifications influence the global behavior of the system.

To make modified problem-posing easier to understand, the problem as an activity diagram of a unified modeling language (UML) is used, as shown in Figure 2 [12].

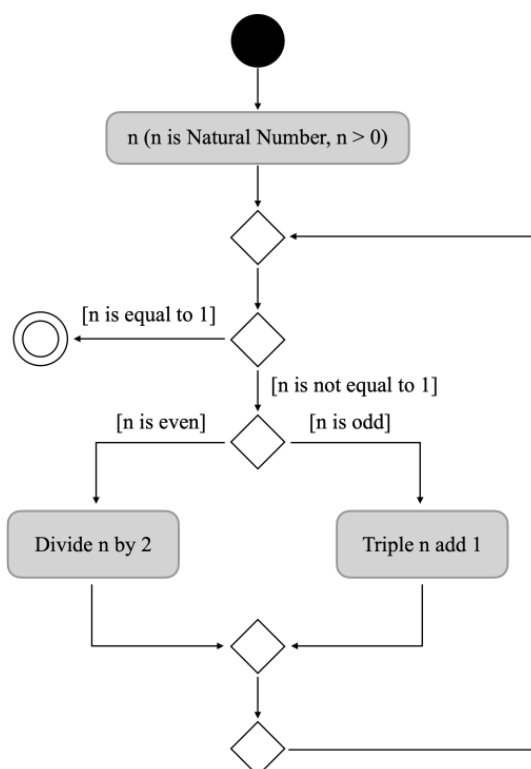


Figure 2. The activity diagram of Collatz conjecture [12]

If the learner can divide the problem (decomposition) and understand the game's flow (algorithmic thinking), the learner can draw the structure of the problem, as shown in Figure 2. In addition, modification focusing on a part or balance of the whole is possible. Examples of the modifications are shown in Table 2.

Table 2. Examples of Modification

Type of modification	Description	Instructional focus
Initial value	Changing constraints on starting values	Noticing the role of initial conditions
Rule condition	Altering the condition for branching	Understanding conditional structures
Transformation rule	Modifying the numerical operation	Exploring algorithmic consequences

These modifications are not intended to generate new mathematical problems but to make the structure of the original problem more explicit to learners. By systematically altering specific components, students can explore which parts of the procedure are essential and which are adjustable, thereby supporting reflective engagement with algorithmic structures.

To modify the problem while focusing on the parts, it is necessary to understand the structure of the problem. It is also possible for students to explain the reason for the modification. In addition, it can make students think about the overall effect when a

specific part is changed.

In this way, modified problem-posing can deepen the understanding of the tasks used in existing education. In PBL using problem-posing with modification, many students are expected to create new problems that are new to them and use their own creativity based on CT.

CONCLUSION

In this paper, I proposed modified problem-posing as a method to foster creativity based on CT. The procedure is explained, it shows that students can create new problems and teachers can guide and evaluate them. In the future, it will be necessary to study the effect of using this method and evaluate the impact of the modification on academic performance and creativity. Further, it will be necessary to study the effects of using this method and quantitatively evaluate the relationship between the deformed parts, academic ability, and creativity.

NOTE

Part of the conceptual ideas underlying this study was explored in an earlier conference manuscript on creativity evaluation using well-structured problems [15], which was not formally published. The present paper reorganizes and reframes these ideas for instructional use in classroom settings.

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