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Students' Creative Thinking Stages in Inquiry-Based Learning: A Mixed-Methods Study of Elementary School Students in Indonesia

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ABSTRACT

Background: Creative thinking skills significantly affect the learning process's success. Improving higher-order thinking skills requires wise consideration of learning techniques and a commitment to an active and learner-centered learning environment. **Objectives**: The objective of this research is to explore the creative process of children when playing games using coding skills**. Design:** This study employed a mixed-methods approach to data collection, combining semi-structured and comparison methods. **Setting and Participants**: The research sample consisted of 20 five-grade students (twelve boys and eight girls) from SD Negeri 149 Tokinjong, Sinjai Regency. **Data collection and analysis**: Descriptive statistics and the N-Gain test were used to analyse participants' creative thinking pre- and post-test scores. Interview analysis was performed through data reduction, data display, and conclusion drawing and verification. **Results**: The results showed that IBL has the potential to improve elementary school students' creative thinking skills with a mean score of 77.25. Besides, participants engaged in a cyclical thinking phase between the preparation and imagination phases. The two cognitive tasks distinguished the cyclical thinking process are information collection and information examination. This process was repeated until participants decided that no more viable alternatives. **Conclusions**: The implementation of inquiry-based learning has the potential to improve elementary school students' creative thinking skills; participants engaged in a cyclical thinking phase between the preparation and imagination stages.

Keywords: creative thinking stages; inquiry-based learning; imagination;

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RESUMO

Contexto: Habilidades de pensamento criativo afetam significativamente o sucesso do processo de aprendizagem. Melhorar as habilidades de pensamento de ordem superior requer uma consideração sábia das técnicas de aprendizagem e um compromisso com um ambiente de aprendizagem ativo e centrado no aluno. **Objetivos**: O objetivo desta pesquisa é explorar o processo criativo de crianças ao jogar jogos usando habilidades de codificação. **Design**: Este estudo empregou uma abordagem de métodos mistos para coleta de dados, combinando métodos semiestruturados e de comparação. **Ambiente e participantes**: A amostra da pesquisa consistiu em 20 alunos de cinco séries (doze meninos e oito meninas) de SD Negeri 149 Tokinjong, Sinjai Regency. **Coleta e análise de dados**: Estatísticas descritivas e o teste N-Gain foram usados para analisar as pontuações pré e pós-teste de pensamento criativo dos participantes. A análise da entrevista foi realizada por meio de redução de dados, exibição de dados e desenho e verificação de conclusões. **Resultados**: Os resultados mostraram que o IBL tem potencial para melhorar as habilidades de pensamento criativo dos alunos do ensino fundamental com uma pontuação média de 77,25. Além disso, os participantes se envolveram em uma fase de pensamento cíclico entre as fases de preparação e imaginação. As duas tarefas cognitivas que distinguem o processo de pensamento cíclico são a coleta de informações e o exame de informações. Esse processo foi repetido até que os participantes decidissem que não havia mais alternativas viáveis. **Conclusões**: A implementação da aprendizagem baseada em investigação tem o potencial de melhorar as habilidades de pensamento criativo dos alunos do ensino fundamental; os participantes se envolveram em uma fase de pensamento cíclico entre os estágios de preparação e imaginação.

Palavras-chave: estágios de pensamento criativo; aprendizagem baseada na investigação; imaginação.

INTRODUCTION

In his book “The Art of Thought”, Wallas (1926) introduced four creativity stages: preparation, incubation, illumination, and verification. However, in the 1950s, (1953) developed creativity into seven stages: orientation, preparation, analysis, ideation, incubation, synthesis, and evaluation. Osborn’s theory refined Wallas’ modification of creativity. Osborn divided the preparation stages into 3 parts, namely: preparation, analysis, and ideation, which are fractions of the preparation stage raised by Wallas. The three sections developed by Osborn have the same meaning and purpose as Wallas’ view of the preparation stage. Osborn classified illumination into the incubation stage, even though, according to Wallas, the two stages of the creative thinking process are different. In addition, Osborn put the synthesis stage between the incubation and evaluation stages.

Mace & Ward (2002) have generated a creative thinking model of four stages or processes. *First*, students try to understand the concept of creativity. *Then*, students develop ideas by rearranging their creative ideas, identifying and developing them according to their feelings, and evaluating them by asking questions and making metaphors and analogies. *Third*, students realize these ideas by changing the form of these ideas into physical ideas. *Fourth*, students finalize the creative product. Students evaluate their creative products by selecting and determining the best. This process occurs by guessing and checking, meaning students will change and discard the wrong products and display the correct ones.

Taylor (2017) argues that the creative process involves transforming individuals and their environment through multiple stages, namely exposure, pre-divergence, conversion, pass-divergence, and expression. Exposure refers to individual openness and individual sensitivity to the environment. It is also related to the ability to assimilate and accommodate information and classify (homogenization), differentiate, and integrate that information. The pre-divergence stage is characterized by the natural interaction of data, reflex incubation, and induction. This stage allows an individual to gain a lot of experience. The conversion stage is marked by a new awareness (insight) or perceptual transaction. Conversion is also known as the "Eureka" phase or reformulating phase by reversing. Lateral thinking, analogies, and metaphors can occur when new ideas appear or appear suddenly (flash of new ideas). In the pass-divergence phase, individuals form a new idea through deduction, inference, verification, or extrapolation. Finally, at the expression stage, individuals implement and communicate creative ideas.

On the other hand, according to Cheung et al., (2008), some Americans can think outside the box to find creative ideas without going through the stages of the thought process, which people in general do not usually do. Meanwhile, Wallas, Osborn, Mace, and Taylor found nothing "unusual." Rahayuningsih inserts an imagination stage as the first step for students to find something new or unusual. The creative process involving imagination was first introduced by Plsek (1996). However, then researchers developed indicators of the creative process proposed by Plsek by taking into account the characteristics and social environment of the students.

This statement implies that the social environment dramatically influences a person's role in managing information to develop creative ideas.

In the context of learning at school, the social environment that can affect student creativity involves teachers or peers with a higher level of knowledge or competence. On the other hand, Piaget's theory focuses on students' prior knowledge to create ideas and reduce the influence of the social environment (Schunk, 2012).

According to Hill Jr et al., (2004), students' information acquisition can be influenced by internal and external factors. Internal factors include initial knowledge obtained through previous learning or spontaneous knowledge obtained through experiences (Sitorus, 2016). Both prior knowledge and spontaneous knowledge come from students' cognitive abilities. Meanwhile, external factors are factors outside students that influence their information acquisition, such as teachers, peers, or other references. These factors were initially defined by Wallas, Osborn, Wace, and Taylor in their research.

Dyer et al., (2011) revealed that two-thirds of a person's creative abilities are obtained through education, the remaining third comes from genetics. Conversely, a third of intelligence is obtained from education and two-thirds from genetics. Furthermore (Craft, 2001) suggests that education can influence creativity. Weisberg, (2006) further argues that a person needs to undergo special training in the knowledge acquisition phase before generating creative ideas. After continuous practice, a person has a greater chance of creating significant creative ideas (Ruseffendi, 2006). Based on this description, it is evident that students' creative thinking abilities are greatly influenced by the learning methods applied at the student's educational level.

Creative thinking skills significantly affect the learning process's success. Improving higher-order thinking skills requires wise consideration of learning techniques and a commitment to an active and learner-centered learning environment (Limbach & Waugh, 2010). This opinion is in accordance with our assumption that higher-order thinking can only be developed if students are allowed to actively synthesize information in such a way as to complement and expand existing understanding.

Innovative learning allows students to build experiences and skills in their way. Innovative learning emphasizes process and results and can improve students' creative thinking skills. Various examples of innovative learning models include instruction-based, problem-based, project-based, collaborative, and cooperative learning models with various approaches, such as scientific and contextual approaches. One of the innovative learning models that can help improve students' creative thinking skills in solving mathematical problems is Inquiry-Based Learning (IBL).

Inquiry-Based Learning (IBL) is perfect for improving creative and innovative thinking skills. Inquiry-Based Learning is based on the thoughts of John Dewey, an American education expert, who said that the learning, development, and growth of human beings would be optimal when faced with real and substantive problems to solve. Dewey believes curriculum and learning should be based on integrative community-based tasks and activities and engage learners in pragmatic social actions that bring tangible benefits to the world. Inquiry emphasizes that schools play the best role possible in facilitating self-development. Therefore, inquiry-based learning is student-centered, determining that students actively participate in their learning. Inquiry involves a search-surprise element, and this trait makes it highly motivating for students. All must learn no pool of knowledge and skills. The learning process is seen as something as important as the outcome.

Inquiry assumes that the school is doing its best to facilitate self-development. Meanwhile, in Inquiry-Based Learning (IBL), the teacher acts as a facilitator who challenges students and assists students in identifying questions from problems, and guides the inquiry to be carried out. Students carry out IBL in seven steps or learning syntax, namely: 1) formulating problems; 2) determining temporary answers or better known as hypotheses; 3) seeking information, retrieving data and facts needed to answer the hypotheses; 4) conducting experiments; 5) interpreting data to answer research questions; 6) presenting the results of the inquiry to peers and teachers and providing feedback by way of discussion; and 7) reflecting on the results of the discussion and evaluating the results of the investigation (Niesche & Haase, 2012).

The discovery process occurs when students formulate hypotheses and test them by conducting experiments (Pedaste et al., 2012). IBL is an educational strategy in which students follow methods and practices by experimenting to build knowledge (Keselman, 2003). During the independent learning process, students conduct experiments to investigate the relationship between one independent variable and one dependent variable (Wilhelm & Beishuizen, 2003). IBL emphasizes students' active participation and responsibility in discovering new knowledge (De Jong & Van Joolingen, 1998).

Based on the experts' opinions above, it can be concluded that IBL contains a series of learning activities that optimally involve all students' abilities to seek and investigate information in a systematic, logical, analytical, and critical manner. Students can formulate their findings in learning activities and develop a confident attitude toward what is discovered in the inquiry process. It is essential to trace children's creative process because it can be used as a reference for developing children's creative thinking in the future as a provision for competence in the world of work in modern times. The current study aimed to reveal elementary students' creative thinking skills and explore their creative thinking processes in solving mathematical problems after implementing inquiry-based learning. This study was conducted in *SD Negeri 149* Tokinjong, Sinjai Regency. The stages of creative thinking used in this study refer to those suggested by Rahayuningsih et al., (2021), which consist of preparation, imagination, development, and action. Students' creative thinking skills are identified when students demonstrate the ability to solve problems by meeting the indicators of flexible thinking (cognitive flexibility) (Rahayuningsih et al., 2020).

Research Questions

1. Do students' mathematical creative thinking skills improve after implementing Inquiry-Based Learning?
2. What creative thinking processes do students go through when implementing Inquiry-Based Learning?

METHODOLOGY

The present study aimed to reveal elementary school students' creative thinking skills profile and explore their creative thinking processes in solving mathematical problems after implementing Inquiry-Based Learning. This study was conducted at the public elementary school (SDN) number 149 Tokinjong, Sinjai. The increase in students' creative thinking skills was observed in their scores after implementing Inquiry-Based Learning (IBL). This study used quantitative descriptive methods for data collection and data analysis. Students' creative thinking processes were evaluated from the participants' behavior, reflecting their mental activity in solving mathematical problems. Students' behavior was explored based on their written work and through in-depth interviews. According to Creswell, (2017), this method is identified as exploratory with a qualitative approach. Based on the explanations above, we concluded that this study employed a mixed-methods approach to data collection, combining semi-structured and comparison methods (Sharma & Gigras, 2017). Meanwhile, data analysis utilized the explanatory strategy, where quantitative data analysis preceded qualitative data analysis (Creswell, 2017).

The research population comprised all five-grade students from SD Negeri 149 Tokinjong, Sinjai Regency. The sample consisted of 20 students (twelve boys and eight girls). Descriptive statistics and the N-Gain test were used to analyze the comparison between students' creative thinking test scores before and after implementing Inquiry-Based Learning (IBL). The analysis table contained the distribution frequency of students' scores, mean ($\overline{X}$), median (Me), mode (Mo), standard deviation (S), and variance (S^2).

Students' creative thinking score was categorized based on the guidelines for minimum achievement criteria used in SD Negeri 149 Tokinjong, where the minimum passing score was 75. Students' score was classified based on five criteria in creative thinking: very poor, poor, medium, high, and very high. Table 1 shows the criteria for students' creative thinking evaluation.

Table 1

Criteria for students' creative thinking assessment. (Arikunto, 2019)

Score Interval	Category
0 – 41	very poor
42 – 58	poor
59 – 74	medium
75 – 89	high
90 – 100	very high

Table 2 presents students' minimum achievement criteria in mathematics at SD Negeri 149 Tokinjong, where score under 75 was considered to be failing the course.

Table 2

Minimum Achievement Criteria. (Arikunto, 2019)

Score	Criteria
< 75	Fail
≥ 75	Pass

A gain test was run to investigate the increase in students' creative thinking scores in solving mathematical problems after receiving treatment, i.e. Inquiry-Based learning. The data were obtained from students' post-test and pretest scores. The gain score was calculated using the following formula:

$$g = \text{post-test score} - \text{pretest score}$$

The N-Gain data were gathered by comparing the participants' post-test and pretest scores, including the difference between the ideal and highest pretest scores. Besides informing the increase in students' creative thinking scores, these data also provided information on students' achievement in creative thinking. The n-gain score was determined using the following formula (Figure 1).

Figure 1

The n-gain score. (Arikunto, 2019)

$$\text{N-Gain} = \frac{postest\ score - pretest\ score}{\text{SMI} - pretest\ score}$$

Table 3 shows the criteria for interpreting the n-gain analysis result.

Table 3

N-Gain score criteria.(Arikunto, 2019)

N-Gain Score	Criteria
N-gain ≥ 0.7	High
0.3 ≤ N-gain < 0.7	Medium
N-gain < 0.3	Low

The results of the students' problem-solving tasks were analyzed based on the task instructions and the answer key, considering the indicators of cognitive flexibility. Cognitive flexibility occurs when students can solve mathematical problems in different or unusual ways that have never been encountered before (Rahayuningsih, 2021). The results of the interviews were analyzed in several stages: (1) data reduction, (2) data presentation, which included data classification and data identification, and (3) conclusion drawing and conclusion verification. Persistent observation was carried out to maintain the data credibility. During the observation, we were at school observing student activities in "sufficient" time at school. We also held discussions with fellow researchers for data triangulation and validation. In other words, we triangulated the data sources and research methods.

Table 4

Creative thinking processes. (Plsek, 1996)

No	Creative thinking process	Definition	Code
1	Preparation	Observing and thoroughly analyzing how something works or fails	Pre
2	Imagination	Creating a series of concepts in memory to generate new ideas	Ima
3	Development	Constructing ideas and implementing them in problem-solving	Peg
4	Action	Implementing ideas and testing the solutions	Aks

RESULTS AND ANALISES

The results of the quantitative data analysis

Participants' creative thinking skills were described using descriptive statistics. Students' creative thinking pretest and post-test scores were classified into five categories: very high, high, fair, poor, and very poor.

Students' Mathematical Creative Thinking Skills Before Implementing Inquiry-Based Learning

Initial data on students' creative thinking skills in solving mathematical problems were collected using a pretest. Table 5 shows the descriptive statistical analysis results on participants' pretest scores.

Table 5

Description of students' mathematical creative thinking skills before implementing Inquiry-Based Learning.

Statistics	Statistical Score
Sample size	20
Ideal score	100
Highest score	64
Lowest score	18
Range	46
Mean	46.90
Variance	147.989
Standard deviation	12.165
Median	49.5
Mode	39,49,56

Table 5 shows that before implementing Inquiry-based learning, participants in this study obtained a mean score of 46.90 with a standard deviation of 12.165. The highest pretest score achieved by the students was 64 out of 100, while the lowest was 18 with the lowest possible score of 0. The difference (range) between the highest and lowest scores was 46. The median was 49.5, indicating that 50% of the students scored above 49.5 and the remaining 50% scored below 49.5. The modes or the numbers that often occurred in the dataset were 39,49,56. Students' pretest scores were then categorized into five mathematical creative thinking skills categories. Table 6 presents the pretest score frequency, percentage, and category distribution.

Table 6

Percentage of students' creative thinking scores before implementing Inquiry-Based Learning.

Score Interval	Frequency	Percentage (%)	Category
0 – 41	6	30	very poor
42 – 58	11	55	poor

59 – 74	3	15	fair
75 – 89	0	0	high
90 – 100	0	0	very high
Total	20	100	

According to Table 6, three students achieved medium scores, eleven obtained poor scores, and six got very poor scores on the creative thinking pretest. Based on Table 5 and Table 6, it was concluded that before implementing Inquiry-Based Learning, participants performed poorly on the creative thinking test.

Students' Mathematical Creative Thinking Skills After Implementing Inquiry-Based Learning

Table 7 shows the results of the descriptive statistical analysis on participants' posttest scores following the implementation of Inquiry-Based Learning.

Table 7

Description of students' mathematical creative thinking skills in mathematics after implementing Inquiry-Based Learning

Statistics	Statistical Score
Sample size	20
Ideal score	100
Highest score	89
Lowest score	34
Range	55
Mean	77.25
Variance	128.303
Standard deviation	11.327

Median	79.50
Mode	75,76,78,80,81,82,85

Table 7 indicates that after implementing Inquiry-Based Learning, participants in this study obtained a mean score of 77.25 with a standard deviation of 11.327. The highest pretest score achieved by the students was 89 with the highest possible score of 100, while the lowest was 34 with the lowest possible score of 0. The difference (range) between the highest and lowest scores was 55. The median was 79.5, indicating that 50% of the students scored above 79.5 and the remaining 50% scored below 79.5. The modes or the numbers that often occurred in the dataset were 75,76,78,80,81,82,85. Students' post-test scores were then categorized into five categories of mathematical creative thinking skills. Table 8 summarizes the distribution of post-test score frequency, percentage, and category.

Table 8

Percentage of students' creative thinking scores after implementing Inquiry-Based Learning

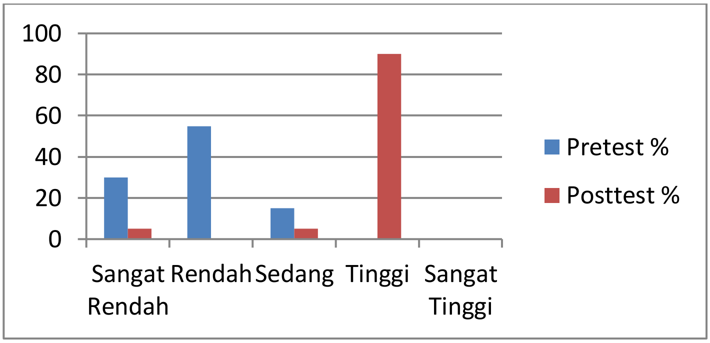
Score Interval	Frequency	Percentage (%)	Category
0 – 41	1	5	very poor
42 – 58	0	0	poor
59 – 74	1	5	fair
75 – 89	18	90	high
90 – 100	0	0	very high

Total	20	100

According to Table 8, one student achieved a medium score and eighteen obtained high scores on the post-test. Based on Table 7 and Table 8, it was concluded that after implementing Inquiry-Based Learning, participants' creative thinking scores increased significantly, from "poor" to "high" category. Figure 2 summarizes the difference between participants' pretest and post-test scores.

Figure 2

Percentage of students' pretest and post-test scores.



Students' mathematical creative thinking skills based on the minimum achievement criteria (KKM)

Table 9 presents students' mathematical creative thinking skills after implementing Inquiry-based learning.

Table 9

Percentage of students' achievement in mathematical creative thinking skills

Score	Category	Frequency 20	Percentage	Remarks
< 75	Fail	2	10 %	Effective

≥ 75	Pass	18	90 %

Table 9 suggests that, after implementing Inquiry-Based Learning, 90% of the students completed the minimum achievement criteria of mathematical creative thinking. This result exceeded the class completeness expectation of 85%. Before implementing IBL, students' creative thinking mean score was rated as poor (46.90) and did not fulfill the minimum achievement criteria at SD Negeri 149 Tokinjong. Meanwhile, after implementing IBL, students' creative thinking mean score was categorized high (77.25), even above the minimum achievement criteria at SD Negeri 149 Tokinjong, which is 75.

These data indicated that participants' mean score increased drastically from the pretest to posttest, with a medium gain score of 0.57 ($0.3 \leq g < 0.7$). In similar fashion, Amtiningsih et al., (2016) found an increase in students' creative thinking skills from "poor" in pre-cycle to "fair" in cycle I. The research evaluation showed that integrating guided inquiry and brainstorming into the classroom effectively improved students' creative thinking skills. Factors affecting students' creative thinking skills include a good learning climate, motivation and intelligence. Putra et al., (2016) also concluded that guided-inquiry learning can enhance the creative thinking skills of the eleventh graders from SMA Negeri Colomadu Karanganyar, where the students demonstrated a 40.3% increase in creative thinking (19.8% from pre-cycle to cycle I, and 20.5% from cycle I to cycle II).

The results of the qualitative data analysis

From 18 students participating in this study, we selected six students to be further observed and interviewed based on the following considerations: (1) the student could communicate ideas clearly or, in other words, had strong communication skills; (2) the student was willing to participate in the further investigation; (3) the student was willing to do an interview.

Students could digest the given problem at the preparation stage, but it took them a while to understand it. They had to read the question repeatedly to comprehend the problem. Some students were occasionally silent and seemed to ponder the problem. One participant stared at the question paper while biting the pen's tip. Before we asked the question, the student appeared relaxed, but he kept looking in front of him and around him, indicating that he was yet to grasp the problem. This finding is supported by the following interview excerpt.

Figure 4

Interview Excerpt (1)

Interviewer	*Can you tell me why you looked nervous first time reading the question?*
Participant	*I was nervous because I thought I could not answer the question.*
Interviewer	*Why did you think that way?*
Participant	*The question is unfamiliar to me. It was difficult to solve.*

Figure 4 indicates that the participant was not familiar with the question. Thus, it took a while for him to read and try to understand the problem. After reading it repeatedly, he could finally describe what was asked by the question, suggesting his ability to comprehend the problem. After the participant explained what was known and what was asked by the problem, he tried to determine the area or side length of the figure, indicating that he could find the gap within the problem. The student looked serious solving the problem, trying to create other two-dimensional figures from the given one. He did this activity repeatedly until he gave up finding the solution. Figure 4 confirms this finding.

Figure 5

Interview Excerpt (2)

Interviewer	*Is this problem difficult to solve?*
Participant	*I could not find information on the area or side length of the figure.*
Interviewer	*How did you solve the problem?*
Participant	*I think I need to think it over*

In the *imagination* phase, a participant tried to generate new two-dimensional figures, although it took a lot of effort and time. The participant admitted he used a guess-and-check strategy to solve the problem. Therefore, he spent much time trying to create new shapes while holding his head with his two hands. He mumbled his answer while looking ahead. Figure 6 contains an excerpt from the student's interview.

Figure 6

Interview Excerpt (3)

Interviewer	*You appeared desperate when you held your head like that. What were you feeling? Could you please explain it to me?*
Participant	*Hahaha, I had no idea that it would be so difficult.*
Interviewer	*You said you had no idea that it would be so difficult? What were you thinking earlier?*
Participant	*I was imagining that I could create new two-dimensional figures, such as a square or a parallelogram. But, when I tried, I found out that it was not that easy.*

Figure 7 shows that the student faced a difficulty when constructing his ideas although he had imagined what he could do with the original shape. Ideas that come to mind are still in the form of fantasy (imagination) and take a long time to be realized. When students attempted to construct what was in their heads, they always failed. However, they were working hard to discover the most appropriate solution.

Figure 7

Interview Excerpt (4)

Interviewer	*Can you find other two-dimensional figures?*
Participant	*I have been focusing on that figure for a while, while searching how to form other two-dimensional figures.*
Interviewer	*The original figure. What do you call it?*
Participant	*It is not what I wanted. The pattern is messy.*

After experimenting with several two-dimensional shapes, the student appeared to use a new technique to tackle the problem: redrawing a different two-dimensional shape. However, this method could not help him locate a new two-dimensional shape. The learner then went through a phase in which he felt he had reached a dead end and began to give up. The student repeated the process until he believed he was no longer able to tackle the problem using the same technique. This process took a long time.

In the *development* phase, the student recalled a similar problem he had solved previously. He then devised a fresh plan to create a square from the given shape. The development of this new thought marked the beginning of the birth of his creativity. Finally, he was able to recognize the area of the two-dimensional shape in the problem.

Before deciding on an outcome, students must evaluate concepts. The *evaluation* phase is marked by the students' ability to describe the reasons for choosing the problem-solving strategy, which in this case is to form a distinct pattern to generate a new two-dimensional figure. Participants in this study made errors in calculating the area of a known form, but they were able to analyze their own solutions and figure out where they went wrong. Even if the participants made mistakes while trying to solve the problem, their evaluation abilities were evident when they outlined their solution. Participants went over the problem-solving result by contemplating the written solution, checking the question, and changing the answer to the question. As a result, we discovered numerous scribbles on the participants' answer sheets. Some participants, in fact, used more than one answer sheet. Figure 8 shows an extract from a participant's interview about the evaluation phase.

Figure 8

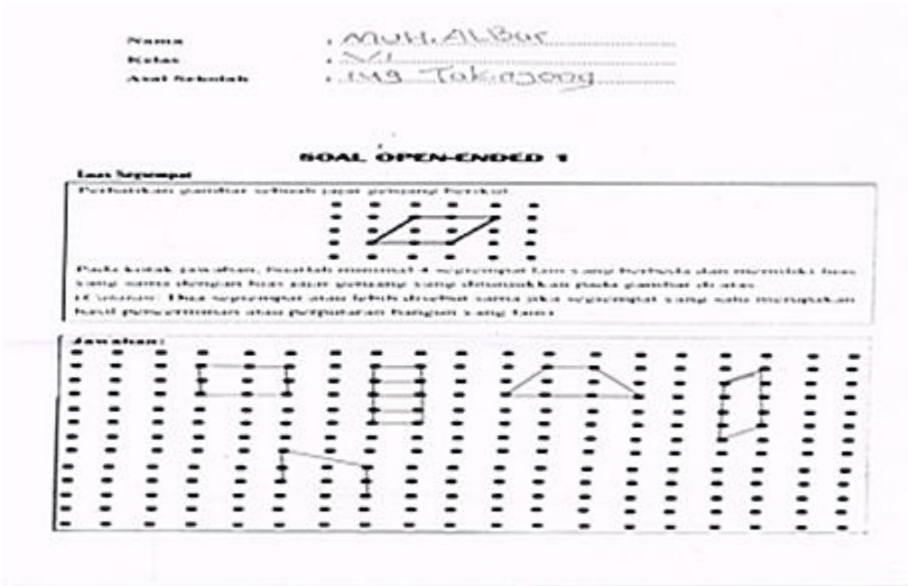
Interview Excerpt (5)

Interviewer	*What two-dimensional figures have you created?*
Participant	*a square, a trapezium, a rectangle*
Interviewer	*Why do you claim that the area of all three figures is the same?*
Participant	*Because the number of dots is the same*
Interviewer	*Look at the third figure you created; how many dots are involved?*
Participant	*Hmm there are eight dots.*
Interviewer	*Does that mean the third figure is incorrect?*
Participant	*Not the dots…but the figures have the same number of small squares.*

Interviewer	*Show me the small squares.*
Participant	*(Draw a square by connecting the dots)*

Figure 9

Student Answer Sheet



The *action* phase is distinguished by examining the implementation of the problem-solving ideas or methods. During this phase, students attempted to explain the same approach to uncover further answers or develop ideas received during the previous development phase. Furthermore, participants were able to use the same method to get a different response, re-describe the solution, and re-check the answer's accuracy. Students could identify some two-dimensional shapes with the same area during the action stage, such as a rectangle, a parallelogram, a trapezium, and a square. Students could also describe how to find the area of a known shape by counting the number of dots. Figures 8 and 9 depict student answer sheets. Figure 10 contains an excerpt from a participant's interview about the action phase.

Figure 10

Student Answer Sheet

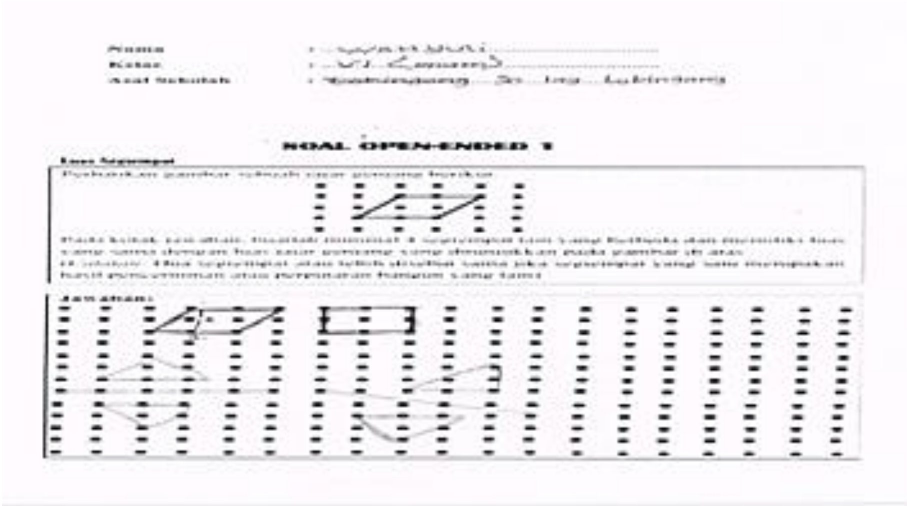


Figure 11

Interview Excerpt (6)

Interviewer	*What is asked by the question?*
Participant	*shapes with four sides that have the same area*
Interviewer	*What will you do first?*
Participant	*determine the area of each figure*
Interviewer	*What figures have you created?*
Participant	*a square and a parallelogram*
Interviewer	*look at the two-dimensional figures you have created. Do they have four sides?*
Participant	*Yes, they do*
Interviewer	*Do they have the same area?*
Participant	*Yes, they do*
Participant	*(shy) I forgot the formula*

Interviewer	*(pointing at the picture) What is this?*
Participant	*It's the triangle's reflection*
Interviewer	*Well, if the parallelogram is drawn like this (drawing), what is the reflection?*
Participant	*(drawing the correct reflection)*

Table 11 summarizes the creative thinking processes of students from SD Negeri 149 Tokinjong in solving mathematical problems.

Table 11

Participants' Creative Thinking Processes in Solving Mathematical Problems

Creative Thinking Processes			
Preparation	**Imagination**	**Development**	**Action**
Observation • Reads the question repeatedly. • Collects information. ***Analysis*** • Analyzes ideas. • Seeks for the solution. • Links the information with existing schemes. • Selects and determines mathematical concepts, characteristic s, and principles.	***Generation*** - Students try to build conjecture ideas by interweaving/a ssociating relevant knowledge with problems in TPMO. - Students think hard to build assumptions or hypotheses by tweaking the tangram for a long time. ***Harvesting*** - Students carry out the thinking process by	***Enhancement*** • Students find key ideas to solve the problem. • Students suddenly find the key idea to solve the problem. • Students remember the same problems that have been encountered before. • Students find new ideas, namely sketching new two-dimensional shapes as a first step to forming a whole new two-dimensional shape.	***Implementation*** The implementation phase is characterized by a smooth problem-solving process. At this stage, students are able to solve problems by finding four categories of answers to question no. 1 and three answer categories for question no. 3. ***Living with It*** In the *living with it* phase, students evaluate or test the ideas that have been found in the development phase. The living with up phase is

Cyclical Thinking • Saturated thinking - Collects information in the form of mathematical concepts, characteristics, principles, and problems by recalling knowledge existing in the long-term memory. - Analyzes ideas, determining knowledge relevant to the problem and interprets the relationship between the knowledge and the problem-solving goal.	implementing the guess and check strategy (testing assumptions) by making arbitrary two-dimensional shapes, marking, and finding difficulties in answering the problem. **Cyclical Thinking** - Students carry out a cyclical thinking process to generate new ideas to solve the problem. Students construct assumptions by associating relevant knowledge with the problem and implementing a guess and check strategy (testing the assumptions). This process is repeated several times, until students decide that there is no other correct idea to solve	• Students use the new shape pattern to solve the problem. • Students revisit previous experiences as the new strategy to solve the problem. • Students use the new strategy to solve the problem. ***Evaluation*** • Students evaluate the problem-solving idea before deciding on the final solution. The evaluation phase is marked by the ability to describe the reasons for choosing the problem-solving strategy, which in this case is to form a distinct pattern to generate a new two-dimensional figure. • Students make errors in calculating the area of a known form but can analyze their own solutions and identify the errors.	characterized by the ability of students to reexamine the answer obtained and conclude the results smoothly. When testing the answer, students ask the following questions: a) is the answer in accordance with the question? b) is the answer rational? and c) is the algorithm correct?

• Determines the initial step to solving the problem.	the problem. After failing to apply the guess and check strategy to find different answers, students think of other ways.	

According to data analysis, the participants went through the thinking processes identified by Plsek, (1996) including preparation, imagination, development, and action. There were, however, distinctions in the phases that each person had to go through. Research shows that students' creative thinking process in solving mathematical problems are separated into two primary phases: observation and analysis. According to Plsek, (1996), creative thinking begins with observation of the environment around oneself, followed by an in-depth investigation of how things operate and fail.

In the observation phase, participants paid close attention to problems by reading questions repeatedly, marking information to understand the interrelationships between quantitative information, collecting various information in the form of mathematical concepts, properties, and questions that have been encountered before by recalling knowledge stored in their long-term memory. In the observation phase, some students needed a lot of time to understand the information mentioned in the questions. However, other students experienced other mental activities in the observation phase, namely reading problems that were considered easy and then connecting prior experiences to dealing with more difficult questions. These students then collected various information in the form of mathematical concepts from everyday life experiences, described what was understood using their own language and provided examples of experiences they had encountered before. Therefore, these students did not need a long time to enter the next phase.

The analysis phase is distinguished by a mental action performed by participants, which is developing new ideas through examining concepts derived from information clearly mentioned in the questions. That is, participants analyzed the relationships between the information presented and the goals to be attained and determined that the information in the problems was insufficient to address these problems. (Plsek, 1996) explains that there are numerous specific ways that can be used to establish these associations, such as analogies, branching out from a given thought, utilizing a random word, classic brainstorming, and so on.

The participants' preparation stage corresponds to the findings of Sriraman & Hwa Lee, (2011) which concluded that during the preparation stage, a scientist (1) reads literature; (2) communicates problems with mathematicians in the domain of mathematics; (3) tries various heuristics; (4) uses a backwards, guessing approach; and (5) looks for links between reading results and natural phenomena. Sriraman & Hwa Lee, (2011) imply that the mental processes passed by participants in this study were those of scientists who encountered dead ends in solving an issue. This viewpoint is founded on the notion that a scientist's efforts to gather knowledge to solve a problem include reading literature, communicating problems with mathematicians in the field of mathematics, and looking for correlations between reading and natural phenomena. If the problem at hand is well understood, scientists will undertake initial attempts to address the problem and will likely fail in their attempts.

The preceding viewpoint is supported by the phases for solving mathematical issues outlined by (Polya, 1978), which are as follows: analyzing the problem, establishing a strategy to solve the problem, applying the strategy, and reviewing the problem-solving process. Both (Sriraman, 2004) and Polya believe that a scientist takes efforts to find the best technique or develop ideas to address an issue. A scientist has therefore passed problem orientation and problem understanding. The distinction between the two research findings is the approach followed by a scientist in acquiring facts or information about the topic. Participants in this study gathered information by recalling their learning experiences, whereas scientists in Sriraman, (2004) obtained information by reading literature, communicating with mathematicians in the domain of mathematics, and looking for links between reading materials and natural phenomena. According to Plsek, (2000) the preparation stage entails one's ability to make observations in order to see more creative ideas that can be used to solve a problem. Furthermore, Plsek, (2000) explains that creative thinking preparation must include one's ability to notice the natural environment, sounds, smells, words of people around them, store images, and rearrange these things with imagination.

During the analysis phase, scientists generate ideas and strategies that are broader in scope than those developed by the participants in this study. This variation can be explained by the characteristics of the research subjects as well as the nature of the problems they experience. The subjects of this study were students with a basic level of creative thinking. Meanwhile, Sriraman, (2004) involved scientists with a complex level of creative thinking and who have written many mathematical research articles. The substance of the problem presented in this study was an open-ended problem, whereas Sriraman, (2004) studied the discovery or creation of mathematical concepts by scientists. However, both the scientists and research subjects made observations and analyzed problems by constructing ideas.

The *analysis* phase entails breaking the material down into small pieces and determining the relationship between each piece and the overall structure (Plsek, 2000). Cognitive processes such as distinguishing, organizing, and attributing information are included in the analysis process. Analysis includes determining what information is relevant and important (distinguishing), determining how to organize the information (organizing), and determining the purpose of the information (attributing). For example, students can identify information explicitly stated in the problem, interpret the linkages between the information presented and the goals to be reached, and determine that the information in the problem is insufficient to solve the problem, necessitating a development phase. During the analysis phase, students should associate problem situations with prior knowledge of arithmetic, algebra, geometry, rational numbers, integers, and fractions, as well as knowledge gained outside of school, such as everyday life experiences, habits, and environmental circumstances.

During the analysis phase, research participants associated various situations/information/problems. Some students were more prone to identify issues with mathematical principles they had learnt, while others preferred to associate same problems with common life situations. Each participant employed a variety of symbols or representations when thinking. Concept is a symbolic structure that describes the properties of an object or event in general (Wallace et al., 2011). For example, when participants first read the question, they instantly considered the area, length, width, and perimeter of the object they perceived. An individual can differentiate two-dimensional figures from non-two-dimensional figures using this approach. Concept knowledge can be obtained in three ways: through mental ideas, experience, and intuition (Wallace et al., 2011).

Participants experience different processes when finding the initial ideas to solve a problem. Some students used a guess and check strategy, whereas others looked for initial ideas to solve a problem spontaneously. Guess and check is a strategy that allowed the participants to find knowledge by acting first. Guess and check is a strategy of estimating and verifying the validity of a solution to a problem (Levin, 2008).

According to the findings of this study, the participants passed through a new phase between preparation and imagination. This phase passed quickly and was barely perceptible in the minds of the individuals. After further investigation, it was discovered that the thought process that happened between the preparation and imagination stages is cyclical thinking. Cyclical thinking includes gathering information in the form of mathematical concepts, properties, and problems by recalling knowledge stored in long-term memory; analyzing ideas and determining knowledge that is relevant to the problem at hand and interpreting the relationships between knowledge and the goals to be achieved. The cyclical thinking process was repeated until the participants decided that there was no other solution to the problem. Tall, (1991) mentioned that the mental activity occurring in the early stages of problem-solving is to seek coherence between learning experiences and the difficulties encountered, which is consistent with our study. At the early stages of problem-solving, participants lacked a fixed awareness in solving the problem at hand and instead relied on practical strategies or practical applications of mathematical rules and procedures. Besides, participants attempted to establish a relationship between facts clearly mentioned in the questions, and when they failed, they tried to devise new techniques to tackle these challenges.

Because student behavior during the imagination phase is difficult to discern, we must conduct interviews. According to the findings of the interviews, the imagination phase is distinguished by the appearance of negative behavior such as despair, worry, doubt, quiet, and the cessation of problem-solving actions. The imagination process is characterized by the presence of two thinking stages, namely the *generation* phase and the *harvesting* phase. Participants attempted to construct ideas during the generation phase by interweaving or linking relevant knowledge with the problems encountered. During this stage, some students appeared to be working hard to construct assumptions or hypotheses by sketching new two-dimensional figures, whilst others appeared to construct ideas by associating these problems with relevant everyday experiences. Students in the latter group looked calmer when constructing assumptions or hypotheses, attempting to create various constructs in a short period of time. With the early steps established on their imagination, some students seemed to be doubtful and despondent. Then they connected each problem to their basic knowledge, which they gained through learning experiences or regular life experiences. The subconscious generates a person's conceptions and thoughts, which are subsequently tested by the conscious sense to determine if the concept should be accepted or rejected (Rodionov, 2013). In fact, only a small portion of a person’s unconscious processes are remembered. The ability to remember is determined by how frequently a person pays attention to ideas that come in his/her subconscious. McFarland et al., (2017) explain that subconscious mentality in the form of creativity and intuition influences a progress.

Despite the fact that some participants were depressed throughout the imagination phase, this procedure suggested that they were entering a productive imagination thinking stage. Wellner, (2022) claims that one can generate ideas through imagination. There are two types of imagination: passive imagination (daydreaming or dreams) and reproductive imagination (scientific imagination). Furthermore, Wellner, (2022) emphasizes that a person’s ability to change prior experiences supports reproductive imagination. People with reproductive imagination are always curious about everything around them, and they want to own and implement all their ideas. Reproductive imagination is also known as creative imagination. New discoveries are typically produced through creative imagination in the form of objects, concepts, or models. According to Ladd & Troop-Gordon, (2003), the process of imagination becomes extremely productive when it is influenced by doubt, courage, interest, earnestness, temporary surrender, relaxation/rest, writing, confusion, pressure, and having goals. This remark demonstrates that the imagination process that students went through in this study is a reproductive imagination process, i.e., one that results in unique or uncommon yet logical discoveries.

In the harvesting phase, participants performed thinking by applying the guess and check strategy. At this stage, participants 1) created a random pattern; 2) marked the pattern to easily create a new one; 3) found a gap to answer the question. In creative thinking, harvesting refers to the process of gathering and assessing ideas. Plsek, (1996) contends that in order to strike a balance between assumptions (satisficing) and early decision making (premature judgment), one needs to gather prior knowledge and improve ideas before moving to the evaluation stage. This statement is consistent with the study’s findings, which show that pupils went through the harvesting phase before producing new ideas during the imagination phase. Participants used the guess and check technique to solve problems, then constructed random patterns and uncovered gaps in the questions throughout this phase.

Furthermore, participants underwent the *evaluation* phase before determining the solutions to the problems. In this case, students were engaged in a cyclical thinking process, characterized by the recurring thinking processes. Students performed a circular thinking process to address the problems found in this phase. During this phase, participants constructed hypotheses/ideas by interweaving/associating knowledge relevant to the problems. They then employed the guess and check strategy to solving the problems. This process was repeated until participants concluded that there was no other method to solve the problems. After failing to find a new answer by guess-and-check, students considered another option. However, they remained clueless about the solutions.

The *development* phase is marked by the event that participants suddenly discovered a key idea that led them to a problem solution. Participants attempted to recall previous encounters with similar questions. They then could create new two-dimensional shapes. After the participants had gone through the imagination stage, the idea suddenly arrived. Before deciding on the outcomes, the participants made efforts to increase (enhancement) and assess (evaluation) thoughts to see if they were reasonable and rational. Creative ideas are worthless unless they are put into action (Plsek, 1996). Plsek further revealed that to start the development stage, one must choose some of the most promising ideas to work on. These ideas are selected and enhanced by asking: Does it make sense to develop the idea? If yes, how will it be developed? who and what should be involved? what hurdles will be encountered? Is it feasible?

According to Sriraman, (2009), Ervynck describes mathematical creativity in three stages. The first stage (Stage 0) is known as the preliminary technical stage. Individuals at this stage use mathematical rules and techniques to solve mathematical issues in a technical and practical manner (trying out solutions). The second stage (Stage 1) is referred to as the algorithmic activity stage. Individuals are already applying mathematical strategies to solve issues at this stage, such as operations, calculations, and manipulations. The third stage (Phase 2) is referred to as creative activity (conceptual and constructive). At this point, the individual has made a non-algorithmic decision, which means that while considering how to solve a problem, the individual no longer performs conventional mathematical operations, but instead takes general steps that aid the individual in addressing the problem.

The findings of this study, especially those refer to the development phase, are in line with the findings of Ervynck, where participants performed the algorithmic activity stage. Individuals are already able to apply mathematical approaches to solve problems at this stage, such as operations, calculations, and manipulation. However, the participants in this study had not done computing operations during the development stage. Instead, they developed patterns and used measuring aids to begin the manipulation process in solving a mathematical problem. In other words, the participants discovered the starting steps for producing concepts that were realized at the action stage. This process is referred to as the illumination stage by Sriraman, (2009). However, according to Hadamard, the creative process does not end at that point because the fourth and final stage is the stage where individuals express problem-solving results through language or writing.

The *action* phase in this study was distinguished by a procedure in which participants attempted to describe and develop the concepts discovered in the development stage, then incorporated these ideas in previously discovered responses (answers discovered through “guess and check”) to obtain more complicated answers. Students also double-checked the responses for accuracy. According to Plsek (1996), the action phase includes the implementation and “living with it” phases. Plsek contends that during the action phase, one must adequately select how to use or implement the concepts gained. Participants in this study were able to apply ideas and re-evaluate the final solution in the action phase. Thus, the participants in this study proceeded through Plsek’s postulated stages of creative thinking, including preparation, imagination, development, and action.

This study also discovered that students used logical reasoning, metacognition, divergent thinking, intuitive thinking, and critical thinking when solving mathematical problems. Divergent thinking was used by participants when solving problems, obtaining pertinent information, formulating assumptions, and developing ideas. Metacognition occurred when participants became aware of their failure to solve problems. When making educated guesses and reasoning rationally, intuition was used. When seeking for coherence between questions, participants also relied on their intuition. Finally, participants were engaged in critical thinking when analyzing responses or problem-solving strategies.

The findings of this study indicate that participants employed divergent thinking to solve problems. Similarly, Althuizen et al., (2010) and Sternberg & Lubart, (1996) presented a psychometric technique to measure a larger group's creative capacities, such as famous artists or imaginative scientists. The psychometric approach in question is a test to assess a person’s creative thinking, or ability to think divergently. According to this definition, creative thinking is also known as divergent thinking. Divergent thinking assessments, such as the Guilford’s Alternate Uses Test, can potentially predict creative ability (Althuizen et al., 2010; Plucker et al., 2004;Runco, 2007). In addition, Cropley (in Haylock, 1997) describes creativity as a sort of thinking or mental function that is sometimes referred to as divergent thinking. Furthermore, Pehkonen (1997) considers creative thinking to be a combination of logical and divergent thinking based on conscious intuition. Pehkonen further suggests that creative thinking is a combination of rational and divergent thinking that results in something unique. In mathematics, anything new is an indicator of creative thinking.

According to Siswono (2016), there are two schools of thought about the relationship between creative and critical thinking. One view considers creative thinking to be intuitive, as opposed to critical (analytical) thinking, which is based on logic, while the other considers creative thinking to be a combination of analytical and intuitive thinking. Intuitive thinking refers to reasoning based on instincts or spontaneous impulses (insights) rather than broad facts. This assertion is consistent with the current study's findings that elementary school pupils use both critical and intuitive thinking when solving mathematical problems.

Participants' critical thinking skills in solving mathematical problems can be seen from how they evaluated answers or strategies used in solving the problems. This finding is consistent with the viewpoint of Brahler et al., (2002) who state that critical thinking helps individuals organize the processes involved in mental activity such as problem solving, decision making, persuasion, examining assumptions, and scientific discoveries. Critical thinking includes the ability to reason systematically and analyze the quality of one's and other people's thinking in a methodical manner.

Metacognition in this study occurred when participants realized that they could not find steps to solve the problems. Recognizing this, the participants conducted an evaluation by amending the incorrect responses, describing the processes for completion, and deciding on the right settlement approach. This finding is consistent with those of Wilson & Clarke, (2004) who found that the metacognitive behaviors involved in solving a problem are awareness, evaluation, and regulation. Metacognitive skills help to retain one's *awareness* of the problem-solving process, as well as what has been done, what needs to be done, and what might be done to attain specific learning or problem-solving goals. When *evaluating* a problem solution, the right strategy is examined and revised. Metacognitive skills also include the ability to *regulate* information about how and why to apply problem-solving procedures and define goals to optimize cognitive resources. In mathematics, the sactual problem-solving activity occurs only when the problem is non-routine. Several cognitive and metacognitive processes are involved in solving non-routine mathematical problems (Kantowski, 1977).

CONCLUSIONS

The implementation of inquiry-based learning has the potential to improve elementary school students' creative thinking skills, indicated by the mean score achieved by the experimental group which is 77.25. The score indicates that after applying inquiry-based learning, students' mathematical creative thinking was higher than the Minimum Achievement Criteria (*KKM*).

When thinking creatively, participants in this study went through a preparation stage that included observation, analysis, and cyclical thinking. Then they went through the imagination stage, which included the generation, harvesting, and cyclical thinking phases. Participants in the development stage went through the enhancement and evaluation phases. Finally, participants experienced the action stage, which included the implementation and stop/finish phases (living with it).

According to the results of this study, participants engaged in a cyclical thinking phase between the preparation and imagination stages. Participants used cyclical thinking to generate fresh ideas to address problems. Two cognitive tasks distinguish the cyclical thinking process. First, participants gathered information in the form of mathematical concepts, qualities, and problems by recalling knowledge stored in long-term memory. Second, participants examined ideas and determined information in the form of knowledge that is important to the problem at hand, as well as assess the relationship between knowledge and the goals to be reached. This process was repeated until the participants decided that no alternative solution would work.

AUTHORS' CONTRIBUTIONS STATEMENTS

S.R. conceived the idea of the research presented. S.R. collected the data. The three authors S.R., K., and M.N. actively participated in the development of the theory, methodology, data organisation and analysis, discussion of results and approval of the final version of the work

DATA AVAILABILITY STATEMENT

The data supporting the results of this investigation will be made available by the correspondent S.R., upon reasonable request.

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