

Application of the hybrid learning project STEAMER in science courses for prospective elementary school teachers: Computational thinking and creative thinking

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Abstract This research aims to describe the application of the STEAMER hybrid learning project in training computational and creative thinking skills of prospective elementary school teacher students. The research used was classroom action research. The research subjects were 176 students at PGRI Kanjuruhan University, Malang. The instruments used consisted of observation sheets, test sheets, and interview guidelines. Analysis of the research data was carried out quantitative and descriptive qualitative analysis. The research results show that the application of the STEAMER hybrid learning project consists of the learning syntax Reflection, Research, Discovery, Application, Communication and Reflection. The results of the learning implementation show an increase in computational thinking abilities and creative thinking abilities in cycle I and cycle II through the application of the Hybrid Learning Project STEAMER learning model. Presenting problems and determining solutions in learning can develop computational thinking and creative thinking skills.

Keywords: computational thinking skills, creative thinking skills, hybrid learning, project STEAMER, science learning

1. Introduction

In the 5.0 era, the focus of the education sector is currently developing students' thinking abilities. One of them is the ability to think computationally and creatively. Computational thinking skills are the ability to formulate, analyze and solve complex problems using computer working principles (Chen et al., 2022; Vourletsis & Politis, 2022) through the reasoning process and the ability to work together to produce effective learning solutions. This ability is the ability to develop solutions or solve problems, design and evaluate systems (Mulyanto et al., 2020; Wing, 2017) of a complex problem by managing information and identifying problems that have been presented through a process of abstraction, iteration and recursion (Lemay et al., 2021). Computational thinking skills can influence students' abilities and learning outcomes (Lemay et al., 2021). Computational thinking skills can be developed through training activities (Mulyanto et al., 2020) so that individuals can train abstract, algorithmic (Berland & Lee, 2011; Dierbach et al., 2011; Perković et al., 2010) and logical thinking abilities (Selby, 2013; Wing, 2010, 2017); complex problem solving; open (Noraini & Hazrati, 2016; Yadav et al., 2011); structured (Yasin, 2020); and academic abilities (Durak & Saritepeci, 2017).

Computational thinking skills involve 4 steps (Wing, 2010): (a) decomposition, which involves problem solving by simplifying complex problems into small parts that are easy to understand; (b) pattern recognition, namely the stage that aims to identify similarities in the causes of problems that arise; (c) abstraction, which focuses on identifying important information in the problem; and (d) algorithms, namely, designing the stages in solving a problem. This ability needs to be trained and owned by students. Computational thinking skills are skills that describe increased attention to designing computational solutions for problem solving, algorithmic thinking, abstract thinking, pattern recognition, logical reasoning, and coding through the stages of decomposition, pattern recognition, abstraction, and algorithms obtained from observation data, interviews, and tests (Angeli & Giannakos, 2020). However, referring to the research results (Kumala et al., 2023) shown in Figure 1.

Based on Figure 1, the results of the computational thinking skills of prospective elementary school teacher students are based on each sub indicator of computational thinking skills. It is known that elementary school teachers' ability scores on the abstraction indicator consist of stating general patterns of similarities and differences in a problem at 91.4%, focusing on information at 70.6%, drawing conclusions at 53.11% and drawing conclusions at 38.3% and stating that the algorithm

indicator was 72.28%. The decomposition indicator which consisted of the sub indicator for identification of known information, obtained a value of 50.2% and identifying the problem was asked about a value of 29.7%. Based on the results of previous research, compared with those of other indicators, the computational thinking skills of prospective elementary school teacher students at eight educational universities in Indonesia on average obtain quite high scores on abstraction and algorithm indicators, while decomposition and pattern exploration indicators still obtain low scores.

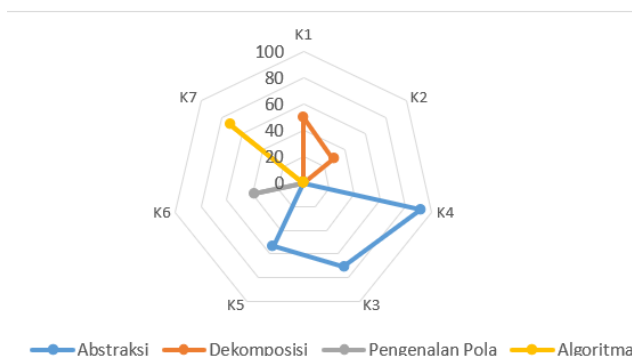


Figure 1 Results of the analysis of prospective elementary school teachers' computational thinking abilities.

Apart from Computational Thinking Skills, currently, the Indonesian government's focus on empowerment is Creative Thinking Skills. Creative thinking is the ability to think of new, unusual ways or ideas, giving birth to a unique solution to a problem (McGregor, 2007; Santrock, 2011; Sternberg, 2003), creating valuable new ideas, elaborating on an idea, refining ideas, analyzing, and evaluating the ideas developed (Moeller et al., 2013), and producing new ideas that are original and innovative (Chen et al., 2022; Eragamreddy, 2015; Sitorus & Masrayati, 2016).

Creative thinking skills have four indicators, namely, fluency, flexibility, originality, and elaboration (Habibi et al., 2020; Wijayati et al., 2019; Yustina et al., 2022). This indicator is useful for measuring a person's creative thinking skills in a certain context. The ability to think creatively can increase a person's ability to innovate and formulate new ideas and solutions that have never been thought of before (Csikszentmihalyi & Wolfe, 2014). Like computational thinking abilities, creative thinking abilities are also important for improving a person's ability to produce solutions in everyday life and to be able to develop a better life with solutions and innovative ideas. Creative thinking is a person's ability to find unique and newest ideas, create valuable ideas, analyze and evaluate ideas, and develop ideas in an original and innovative way, especially in solving a problem which is characterized by fluency, flexibility, originality and elaboration (Fauziah et al., 2020; Santrock, 2011; Sternberg, 2003). The results of the research conducted by (Arnelia & Hardiyanti, 2023), are shown in Figure 2.

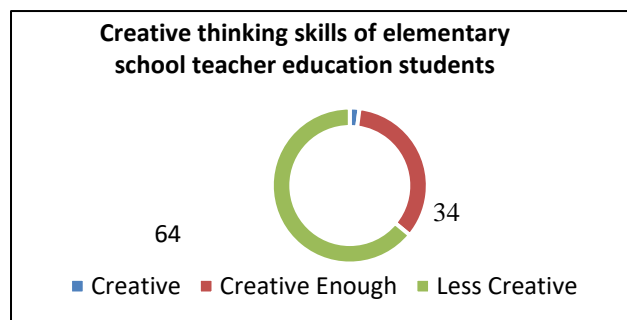


Figure 2 Creative Thinking Ability of Prospective Elementary School Teacher Students.

Figure 2 shows that 2% of the students were in the creative thinking category. This indicates that the student has met the indicators of fluency, flexibility and originality. Approximately 34% of the participants fell into the creative category; they met the fluency and flexibility indicators. Moreover, 64% of the students fell into the less creative category, indicating that they met only the fluency indicators. Based on the data that have been developed, prospective elementary school teachers still lack the ability to perform computational thinking and creative thinking. Training is needed to develop this thinking ability. Creative thinking abilities can be developed through skills training (Dilekci & Halit, 2023; Putra, 2022; Putri et al., 2019). One way to develop students' thinking abilities is by providing open-ended questions related to problems in everyday life (Damayanti & Sumardi, 2018). Open-ended questions are used to determine students' critical, creative and analytical thinking abilities (Kartikasari et al., 2022; Molita & Masriyah, 2023).

One lesson that can be developed to overcome this problem is the hybrid learning project STEAMER learning model. The hybrid learning project STEAMER is a learning model that was previously developed by (Kumala et al., 2023). This model is a combination of project-based learning models and STEAMER (Science, Technology, Engineering, Art, Mathematics and



Reflection). Project STEAMER is an integration of the project-based learning model. Project-based learning has the advantage of improving a person's Computational Thinking Skills (Azmi & Ummah, 2021; Yang et al., 2020); increasing student engagement and ability (Azizah et al., 2023); understanding students (Hudiananingsih et al., 2019); engaging in critical thinking (Muhdhar et al., 2021) and meaningful learning (Çelik et al., 2018); and improving student learning outcomes (Nurbavliyev et al., 2020). The implementation of STEAM-based learning can develop students' creativity, real-world problem solving skills (Katz-Buonincontro, 2018), critical thinking skills (Tabiin, 2020), imagination (Miller et al., 2019), and reflection can develop thinking skills, solve problems, creative and evaluative thinking (Donald, 1983; Razdorskaya, 2015), computational thinking (Nguyen et al., 2020; Sondakh, 2019), and diverse understanding and have positive perceptions in learning fine arts (Susiani et al., 2020). The concept of the STEAMER hybrid learning project learning model is shown in Figure 3.

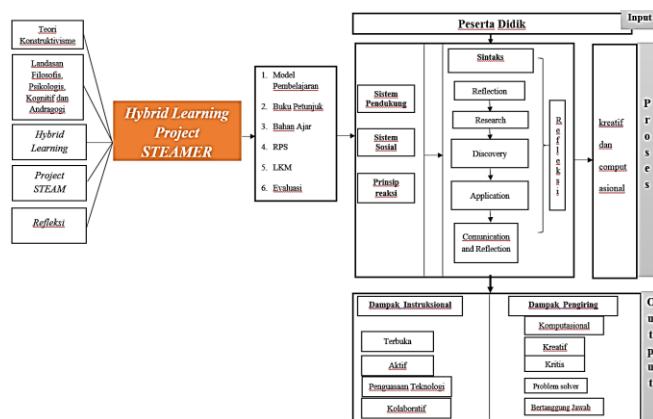


Figure 3 Hypothetical hybrid learning project STEAMER model.

Hybrid learning is a combination of e-learning and face-to-face learning (Jeffrey et al., 2014). The advantages of hybrid learning include increased self-regulation, increased critical thinking skills (Kintu et al., 2017), effectiveness and attractiveness in learning (Nashir & Laili, 2021), reduced isolation (El-Gayar, 2005), increased learning outcomes (Islam et al., 2018; Saleh & Khader, 2016), and self-efficacy (Fitriyana et al., 2021). As previous researchers found, the use of online learning platforms in elementary schools reached a significant value or more than 75% in each aspect (aspects of preparation, implementation, processing and utilization) (Susiani et al., 2021). In brief, the implementation of the model is carried out by means of prospective teachers being given a project to develop a solution. The learning model tools consist of learning models, manuals, teaching materials, an RPS, an LKM and learning evaluation. In its implementation, the learning model develops a support system, social system, reaction principles and learning model syntax.

The STEAMER hybrid learning project learning model refers to constructivism theory and is based on philosophical, psychological, cognitive and andragogy foundations; hybrid learning, and the integration of reflection in learning. The hybrid learning project STEAMER is based on Piaget's constructivism theory, which explains that a person learns based on the construction of his thoughts on the environment and experience (Zimmerman, 1990).

The syntax of the STEAMER hybrid learning project learning model begins with the following steps: 1). Reflection. At this stage, prospective elementary school teachers are given two problems with learning science in elementary school. At this reflection stage, prospective elementary school teachers develop essential questions about the causes of the problem and determine the pattern of problems that have occurred. Based on the analysis of problem patterns, problem solutions have been developed. 2). At this stage, students conduct research and investigate research problems by developing two alternative solutions that are most appropriate for overcoming existing problems. Alternative solutions are analyzed for the advantages and disadvantages of the solutions that have been developed. 3) The third stage is discovery. At this stage, students choose and design strategies according to the results of identifying solutions in the previous stage. Students determine the reasons for choosing the solution developed; 4). The fourth stage is application. At this stage, students apply the results of their work in accordance with the plans that have been developed and reflect on their learning of the solutions that have been created so that prospective elementary school teachers can understand the advantages and disadvantages of the solutions that have been developed by them. The results of the reflection are used to improve the design that has been developed. 5). The fifth stage is communication and reflection. At this stage, students communicate and reflect on the results of the projects that have been developed and the results of the solutions that have been implemented; additionally, lecturers and peers evaluate and provide feedback on the results of the products that students have developed.

This research aimed to apply the STEAMER hybrid learning project learning model to determine its effectiveness in training prospective elementary school teachers on computational thinking and creative thinking skills. Previous research related to STEAM projects, including (Anzari et al., 2021; Domenici, 2022; Sigit et al., 2022; Zayyah et al., 2022), has been conducted. This research was limited by its retrospective nature before testing the model on a large scale.



2. Materials and Methods

This research is classroom action research conducted on 159 UNIKAMA elementary school teacher candidates. Action research is research of any practice undertaken by those involved in that practice, with the primary aim of encouraging continuous reflection and making improvements (Napitupulu, 2021). The stages of research implementation refer to the Kemmis and Taggart stages shown in the figure. The implementation of the research consisted of three stages: 1) planning. At the planning stage, learning planning was carried out by developing learning tools and conditions for the implementation of the STEAMER microsite project hybrid learning model; 2) acting and observing. At this stage, the learning model was implemented according to the planning stage; and 3) reflecting. At the reflection stage, reflection is carried out on the results of implementing the learning model. If cycle I is still not implemented well, continue with cycle 2 and so on. The implementation of the research is shown in Figure 4.

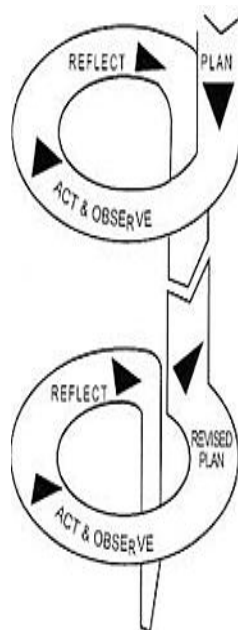


Figure 4 Modified Kemmis and Taggart flow stages.

The data collection techniques used were observation, interviews and tests. The instruments used in this research consisted of model implementation observation sheets and interview guidelines related to the implementation of the STEAMER hybrid learning project learning model as well as computational ability and creative thinking ability observation sheets and creative thinking and computational thinking tests. The grid of the observation sheets for computational abilities and creative thinking abilities is shown in Tables 1 and 2.

Table 1 The grid of the observation sheet for computational abilities.

Computational thinking skills	Indicators
Abstraction	Being able to mention the general pattern of similarities/differences found in the given problem Being able to draw conclusions from the patterns found in the given problem
Algorithmic thinking	Being able to mention the steps used to construct a solution to the given problem
Decomposition	Being able to identify the information from the problems given Being able to identify the information asked of the problems given.
Pattern recognition	Being able to recognize patterns or characteristics that are the same/different in solving a given problem in order to build a solution

Table 2 Grid of the observation sheet for creative thinking abilities.

Creative thinking skills	Indicators
Fluency	Proposing lots of ideas/strategies/suggestions, lots of answers, lots of problem solving, lots of questions fluently
Flexibility	Generating ideas, answers or questions that vary and being able to see a problem from different perspectives and look for many different alternatives
Originality	Finding a new and genuine alternative solution
Elaboration	Developing new ideas and products

The validity of the data in this research was assessed via triangulation techniques. Triangulation is an approach taken by researchers to find more perspectives related to the data found (Pandey & Pandey, 2021). Triangulation is also used to check the validity of the data. Triangulation includes triangulation of methods and data sources. Data source triangulation is an approach that is often used to check the validity of data from various sources ranging from data sources obtained directly such as interviews and observations, to those obtained indirectly such as documents and archives. In method triangulation, researchers use various methods to check the completeness of the data and ensure that the data is valid.

The research results were analyzed qualitatively using Miles and Huberman's analysis stages, which consisted of data collection, data reduction, data display and conclusion (Miles et al., 2014). The statistical test used in this research is descriptive statistics. Descriptive statistics are used to analyze data by describing or illustrating the data that has been collected as it is without the intention of making general conclusions or generalizations. Descriptive statistics provide a description of data seen from the average value, standard deviation, minimum value and maximum value.

3. Results

The implementation of the research begins with planning the research by developing learning tools consisting of an RPS, student worksheets and evaluation. The research results show that the learning model consists of the learning syntax Reflection, Research, Discovery, Application, Communication and Reflection. The learning model is implemented in two cycles. A description of the implementation of the learning model is shown in Table 3.

Table 3 Description of the implementation of the learning model.

No	Stage	Description
1	Reflection	This stage is carried out to reflect the problems that have been presented. Students reflect by asking questions related to STEAM, analyzing similarities and differences and looking for patterns in the two problems presented. From these problem patterns, students are expected to be able to provide the best solution. Reflection questions are developed on previously prepared worksheets. When carrying out the reflection stage in cycle I, students still experienced confusion in determining the pattern of these two problems. Students also experienced little difficulty in reflecting and developing questions that cause problems based on STEAM. Therefore, in cycle II, students are given convenience in the form of trigger questions reflecting based on the STEAM concept. In cycle II, students were able to determine the pattern of the problems presented, and students were able to reflect based on STEAM.
2	Research	At the research stage, students conduct experiments by conducting literature reviews to determine two approaches to addressing this problem. From these two approaches, students carry out in-depth studies and determine the similarities and differences in the approaches developed. Students determine the advantages and disadvantages of the model that has been developed. Based on the results of these studies, students can determine alternative learning models that are most appropriate for overcoming existing problems. The ability to determine the advantages and disadvantages of a model makes it easier for students to determine the characteristics of the model being developed. In cycle I, this research stage also integrates STEAM. However, students experienced difficulties for example, in cycle II, STEAM integration was included in the discovery stage rather than in the research stage. The implementation of the stages in cycles I and II shows that students do not experience difficulties exploring alternative solutions being developed.
3	Discovery	At the discovery stage, students choose the best learning model to overcome the problems that have been presented. Model selection requires students to be able to provide reasons for using the chosen learning model. The model selection results were developed by integrating STEAM. In the implementation of cycle I, students had difficulty determining the best model because they still did not understand the characteristics of the model chosen at the research stage; most students wrote only from theoretical studies, but this was not understood well enough by students. However, in cycle II, students were able to determine the best solution and were able to integrate STEAM into learning solutions.
4	Application	At this stage, students apply the learning model. The model implementation application is adapted to the material in cycle I and cycle II. The implementation of the learning model material is carried out by simulating it in class; for the learning device material, it is performed by presenting the results in class. As a result of the presentation, students learn the advantages and disadvantages of the product that has been developed. Therefore, students can determine improvement points for the products that have been developed.
5	Communication and reflection	At the communication and reflection stage, students hold discussions and ask questions about the products developed by the students. Students provide each other with suggestions and input from the activities they have carried out. Suggestions and input are the basis for determining the use of learning products. In cycles I and II, students did not experience many obstacles during this stage.

The implementation of activities is carried out using hybrid learning. The implementation of hybrid learning was carried out in cycle one and cycle two in six PGSD parallel classes at PGRI Kanjuruhan University, Malang. The implementation of hybrid learning at the beginning of cycle I experienced many obstacles because the signal and students' readiness to carry out learning were still incomplete. There are still many shortcomings in its implementation. In cycle I, meeting II was



conducted offline by students and their respective lecturers. In cycle II, hybrid learning was carried out again, and the learning was implemented better.

Furthermore, based on the results of implementation in cycles I and II, students' computational thinking abilities after implementing the hybrid learning project STEAMER model based on the results of observation and documentation analysis are shown in Table 4 and 5.

Table 4 Computational ability observation results.

Computational Thinking Skills			
No	Indicator	Sub indicator	Description of action research
1	Abstraction	able to mention general patterns of similarities/differences found in the problems given. able to draw conclusions from patterns found in the given problem.	In the first cycle of the first meeting, students experienced difficulty in determining the differences and similarities in the problems. In cycle I, the second meeting and cycle II, it was shown that students were able to show the similarities and differences of the problems that had been found. In the first cycle, there were still difficulties, and many students did not complete the survey because they were still confused and answered as best they could. After adding work instructions, the students were ultimately able to determine the pattern of problems found based on the context of the similarities in the problems raised. In cycle II, this ability has emerged well.
2	Algorithmic thinking	able to mention the steps used to develop a solution to the given problem.	In cycle I and cycle II, students are able to develop the ability to solve a problem through steps, and students develop from existing references. At this stage, students generally do not experience difficulties.
3	Decomposition	able to identify known information from the given problem. able to identify the information requested from the problem given.	In cycle I, students still experienced difficulties with this thinking ability because they were not accustomed to describing information to identify the problems being developed. In cycle II, students were able to follow and were able to identify information about the problems that had been given. The ability to identify the information being asked about is quite difficult for students to develop. In cycle I and cycle II, guidance is still needed in identifying problems. Specifically, in the context of this research learning problems adapted to STEAM were identified.
4	Pattern recognition	able to recognize similar/different patterns or characteristics in solving given problems in order to build a solution.	At this stage, students are able to determine the characteristics of the solution used to solve the problem. Students practice this ability with the help of fairly complete learning resources so that the effectiveness and characteristics of the solutions developed are in accordance with theory.

Table 5 Computational ability and creative thinking results.

Creative Thinking Skills			
No	Indicator	Sub indicator	Description of action research
1	Fluency	sparked lots of ideas/methods/suggestions, lots of answers, lots of problem solving.	In cycle I and cycle II, the worksheets developed by students were able to develop fluency abilities, demonstrated by developing ideas in the form of alternative solutions to problems presented to students.
2	Flexibility	Generate varied ideas, answers or questions, can see a problem from different points of view, look for many different alternatives.	This ability is characterized by generating ideas in the form of alternative solutions at the research stage. Ideas for alternative solutions were obtained from several sources, for example from theory and the results of exploratory interviews with teachers. The results of exploration can develop the ability to see several problems from several points of view and produce various alternative solutions that can be used to overcome the problems that have been presented. Students' flexibility abilities in cycle I were still not optimal, whereas in cycle II students were able to do it well.
3	Originality	Giving birth to a new way.	This ability in cycle I and cycle II students still have difficulty producing ideas that are new and different from existing ones, students are more focused on existing references. Improvements are needed to the worksheets developed to be able to train students in generating new ways or ideas to overcome existing problems.
4	Elaboration	Enrich and develop an idea or product.	This ability can be exercised by students in terms of developing ideas and products, but in terms of enriching in cycle I and cycle II, students still have difficulty in enriching product development. Students are not able to get out of their comfort zone or do more creative things to generate ideas.



The results of the interviews showed that the implementation of the learning model according to the observers and students revealed several things that could be understood, including that in terms of implementation, at the beginning of the first cycle, the first meeting felt that they were still not ready to implement hybrid learning; the steps were quite confusing and took a long time. However, in the second cycle, the students began to enjoy the implementation of learning and felt that the model steps made students more critical and creative in solving problems that had been presented to students. In accordance with the results of interviews with the following two students, in the NM, "This model was quite complicated at the beginning because we were not used to looking for problem patterns, and we were asked to develop alternative solutions. Usually, we are only asked to develop assignments by compiling solutions without considering alternative solutions and responding to a more practical educational problem." The same thing was said by RT, who explained that "at the beginning of implementing the model, I was still confused and felt that the model steps were too long, but after the second to fourth meeting, I became clearer and I became more confident in developing a solution to a problem. The implementation of hybrid learning in the first stage is still limited because the sound is intermittent, the lecturer's explanations are unclear, and there is a lack of concentration during the activity.

In addition, interviews with ADY observers revealed that the implementation of the model went quite well and was able to improve students' computational, critical and creative thinking abilities. However, students experienced problems in cycle I because they were not accustomed to developing the STEAMER hybrid learning project; thus, students had difficulty understanding the tasks on the worksheet being developed. "The implementation of hybrid learning also experienced quite a few obstacles in the first meeting. However, in the second cycle, students seemed more enthusiastic and felt capable of working on the worksheet that had been determined."

According to the MNH, several weaknesses are explained as follows: "1) Worksheets need to be made shorter by preparing instructions that make it easier for students to carry out learning; 2) In the STEM integration worksheet in cycle I, it is still not appropriate and is quite burdensome for students because of the alternative solutions developed. Everything must be STEAM-based even though all of these alternative solutions are not used. In cycle II, STEAM integration was appropriate at the research stage. 3) Alternative solutions were explored for solution development. In cycle I, there was no exploration of alternative solutions from several sources. In cycle II, this point was added. This approach allows students to think about using many points of view. 4) In implementing learning, additional emphasis is needed so that students can develop results or products that are original, high quality and practical. Apart from that, what needs to be noted is that implementing hybrid learning truly requires student commitment and readiness in learning."

The increase in students' computational thinking and creative thinking skills according to the results of the student worksheet work and tests in cycle I and cycle II are shown in the picture.

Figure 5 shows that computational thinking abilities develop abstraction abilities (determining similarities and differences, as well as problem patterns) by 65% in cycle I and 88% in cycle II. The algorithms' thinking ability is shown by a percentage of 60% in cycle I and 86% in cycle II; their decomposition ability is 62% in cycle I and 82% in cycle II; and their pattern recognition ability in solving problems is 55% in cycle I and 80% in cycle II. The ability to think creatively is shown by the fluency indicator in cycle I (70%) and in cycle II (85%), the flexibility indicator in cycle I (65%). in cycle II (80%), the originality indicator in cycle I (60%) and in cycle II (75%), and the elaboration indicator in cycle I (60%) and in cycle II (78%). There is an increase in every indicator of creative thinking and computational thinking abilities.

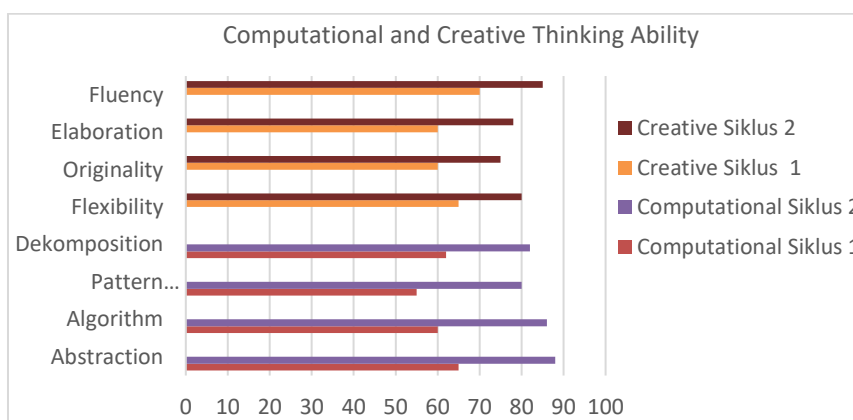


Figure 5 Results of the computational and creative thinking abilities of prospective elementary school teacher students.

Based on the implementation of learning, the following conclusions were drawn: (1) The implementation of learning runs well and smoothly according to the existing model steps, but activities need to be condensed; (2) Implementation of hybrid learning requires increased preparation and equipment. Student readiness and commitment are required when carrying out hybrid learning; (3) Some LKs need improvement, namely, the need for a summary of activities, the need for alternative solutions so that they are not subjective, the need for additional exploration to develop alternative solutions, and

the need for emphasis on producing original products; and (4) computational thinking abilities that have emerged several times in cycle I and especially in cycle II. The results of the observations show that students do not experience many obstacles, especially in terms of computational thinking abilities. Based on the results of the students' computational thinking ability tests, improvements were shown in all aspects in cycles I and II, and (5) Students' creative thinking abilities are still lacking, especially in terms of the ability to produce original ideas and enrich ideas. The ability to think creatively increased in all aspects in cycles I and II.

4. Discussion

Based on the implementation of the hybrid learning model, the STEAMER project can train students in computational thinking and creative thinking skills. There is an increase from cycle I to cycle II in both computational thinking and creative thinking abilities. Increasing computational thinking and creative thinking skills are based on learning model steps that involve developing analytical thinking skills for solving problems and developing innovative solutions that are open and link various scientific disciplines through the use of STEAM. The STEAMER Hybrid Learning Project Development Model can increase responsibility creativity, critical thinking skills, computational thinking, and problem solving, as well as thinking more broadly and being open to other scientific disciplines. This ability is trained through project activities following the implementation of the model. This activity can develop critical thinking, be responsible for overcoming the problems faced through a multidisciplinary approach (Kumala et al., 2023). This research is in line with previous research which shows that the STEAM approach is an effective teaching method for improving computational thinking skills (Bedar & Al-Shboul, 2020). Other relevant findings show that student learning outcomes increased significantly regarding computing skills after using the STEAM approach (Phadung et al., 2021). Also, other research has found that the integrative STEAM-CT learning process can improve students' critical attitudes and creative thinking skills (Mariana & Kristanto, 2023).

Computational thinking is the ability to formulate problems following computer work systems through the process of analyzing, representing data, identifying and implementing solutions from several alternative solutions that have been developed (ISTE et al., 2011). Problem-solving abilities in learning are fundamental (Azizah et al., 2023). For this reason, learning is more directed at understanding observation and problem-solving activities. In implementing the learning model, computational thinking skills are developed through several activities, including reflection. At the reflection stage, students are asked to analyze the problems presented, after which they determine the pattern to be developed. The results of the problem pattern analysis are used to determine in depth the characteristics of the chosen problem. This ability can develop aspects of computational thinking in terms of abstraction and decomposition thinking, where a person is able to determine similarities and differences, identify known information and draw conclusions about the problem patterns being developed. In line with these findings, through STEAM learning, students gain computational thinking skills (Conde et al., 2019). STEAM projects also facilitate problem-solving activities that use physical devices. This finding is in accordance with this research which produced data that there was a significant increase in CT literacy in each indicator of computational thinking, namely computational artifacts, decomposition, abstraction, algorithms, communication and collaboration, computing and society, and evaluation (Juškevičienė et al., 2021).

In the research stage, students explore alternative solutions. At this stage, students can develop the ability to recognize the chosen solution pattern. The discovery stage can develop algorithmic thinking skills to state the steps in solving problems based on the results of selecting alternative solutions that have been developed. Based on these findings, the learning model used can improve students' computational abilities. Computational thinking skills can be improved using the STEAM model (Çiftçi & Topçu, 2022; Sen et al., 2021) problem solving-based learning (Latifah et al., 2022). The research found also obtained similar results to previous findings. In previous findings, the results showed that the discovery model was effective in using computational thinking skills because the discovery model provided more diverse learning resources (Sulistiyo & Wijaya, 2020). Other relevant findings show the positive influence of a STEM content Inquiry based scenario on the dimensions of computational thinking (Psycharis & Kotzampasaki, 2019). The development of computational thinking can be carried out through several scenarios (Barr et al., 2011), which consist of concept illustrations, the integration of computational thinking skills in all scientific disciplines, and the application of learning in the classroom and other environments. Familiarization with computational thinking skills trains students to apply computational thinking skills. Computing skills also have an impact on student performance results in learning at school (Saad, 2020).

Apart from computing, there is the ability to think creatively. Creative thinking skills are developed at several stages of the model used. In the research model step, students explore the development of solutions to the problems being developed. In this stage, fluency and flexibility develop, and students are able to explore their creative thinking abilities to find and see solutions from various points of view. In the next stage, the students are able to develop originality and elaboration skills so that they can give birth to new methods and develop ideas from alternative solutions. It can be concluded that developing learning solutions from developed learning problems can develop students' creative thinking abilities. This finding is in line with previous research which shows that the application of problem-based learning methods can improve students' critical and creative thinking abilities by carrying out appropriate analyzes and being able to provide alternative solutions (Nurkhin & Pramusinto, 2020). Other research data also finds that STEAM integration provides

opportunities for students to engage in learning and develop creative thinking skills, especially in the problem-solving stage (Rahmawati et al., 2019).

Developing learning solutions can lead to the development of creative and more open thinking abilities (Chumsukon, 2021; Leasa et al., 2021; Wijayati et al., 2019). These abilities can be developed and improved through habituation (Hoffmann & Russ, 2016), practice and experience (Henriksen, 2016). Regular practice activities can increase flexibility in creative thinking (Samura, 2019). For example, through practice and openness to new experiences and perspectives, more original and innovative ideas result (Caniëls et al., 2014; Matraeva et al., 2020; Patricio et al., 2020). One of the stages of developing creative thinking skills is through training in generating initial ideas, detailing the framework, and identifying concrete steps used to develop ideas (Leasa et al., 2021; Wijayati et al., 2019). The results of this research are in line with previous research which produced data that students obtained better grades and obtained higher scientific creativity scores after taking STEAM-based courses (Tran et al., 2021). Furthermore, the results of this study imply that a STEAM approach can help students maintain or continue their scientific creativity. On the same hand, STEM project-based learning has had a good impact on increasing teachers' creative thinking (Poonsin & Jansoon, 2021). Project-based integrated STEM can be implemented as an alternative learning strategy.

5. Conclusions

The implementation of the hybrid learning microsite project STEAMER learning model consists of the steps of reflection, research, and implementation which can improve computational thinking abilities and creative thinking abilities. The results of implementing the STEAMER hybrid learning microsite project learning model showed that students' computational thinking abilities started to improve their computational thinking and creative thinking abilities. The development of computational thinking abilities is developed through model steps in the syntax of reflection, research and discovery, and the development of creative thinking abilities is developed through the stages of the learning model in the syntax of research, discovery, communication and reflection. Presenting problems and developing solutions for students can improve their analytical, critical and creative abilities.

The findings of this research present data about maximizing computational thinking abilities and creative thinking through the hybrid learning microsite project STEAMER learning model. From the results obtained, the STEAMER hybrid learning microsite project learning model has developed these two capabilities at once. These findings can be a basis for teachers in determining models that want to maximize computational thinking and creative thinking abilities, or other similar abilities. Teachers can use the STEAMER project microsite hybrid learning model. The results of this research can also be used as discussion material for teachers if they want to disseminate concepts and findings in maximizing learning simultaneously in educational units. Using the correct steps in the hybrid learning microsite project STEAMER learning model can be a guide to successful learning for students to improve students' computing skills or creative thinking. This research can provide meaningful and critical input into STEAM learning practices and student experiences. Apart from that, the findings of this research can be developed more widely through development research or experimental research to test the effectiveness of the hybrid learning microsite project STEAMER learning model on computational thinking and creative thinking abilities.

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Ethical considerations

Not applicable.

Conflict of interest

The authors declare no conflicts of interest.

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