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ORIGINAL

Hybrid Learning Microsite Project STEAMER: Computational Thinking and Creative Thinking Abilities of Prospective Elementary School Teachers

Proyecto de micrositio de aprendizaje híbrido STEAMER: pensamiento computacional y habilidades de pensamiento creativo de futuros maestros de escuela primaria

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ABSTRACT

Introduction: prospective teachers' computational and creative thinking skills show quite low results because classroom learning is less innovative. This requires the use of innovative models. This study was conducted to determine the effectiveness of the Hybrid Learning Microsite Project STEAMER in improving prospective elementary school teachers' Computational and Creative Thinking Skills.
Method: the study subjects were prospective elementary school teachers from 10 Educational Personnel Education Institutions in six provinces. This method of study used a mixed approach. Data were collected through tests, interviews, and observations. Data were analyzed quantitatively and qualitatively. Quantitative data were analyzed using Multivariate statistics, SEM LISREL 8.80, while Miles and Huberman data analysis techniques were used to analyze qualitative data.
Results: this study shown that the average post-test score in the experimental class increased by 69.95 and in the control class by 55.65. This study concludes that the application of the learning model has implications for the variables of creative and computational thinking abilities by 29,6 % and 10,6 %.
Conclusions: the implementation of the STEAMER Hybrid Learning Project has influenced students' computational and creative thinking abilities through a series of model stages, such as reflection, conducting research, finding strategies, implementing design results, and communicating the results of the developed project.

Keywords: Computational; Creative; Science; Elementary School.

RESUMEN

Introducción: las habilidades de pensamiento computacional y creativo de los futuros maestros muestran resultados bastante bajos porque el aprendizaje en el aula es menos innovador. Esto requiere el uso de modelos innovadores. Este estudio se realizó para determinar la eficacia del Proyecto STEAMER del Micrositio de Aprendizaje Híbrido para mejorar las habilidades de pensamiento computacional y creativo de los futuros maestros de escuela primaria.
Método: los sujetos del estudio fueron futuros maestros de escuela primaria de 10 instituciones de educación laboral en seis provincias. Este método de investigación utiliza un enfoque mixto. Los datos se recopilaron

mediante pruebas, entrevistas y observaciones. Los datos se analizaron cuantitativa y cualitativamente. Los datos cuantitativos se analizaron utilizando estadísticas multivariadas, SEM LISREL 8.80, mientras que las técnicas de análisis de datos de Miles y Huberman se utilizaron para analizar los datos cualitativos.
Resultados: este estudio muestra que la puntuación media del post-test en la clase experimental aumentó en 69,95 y en la clase de control en 55,65. Este estudio concluye que la aplicación del modelo de aprendizaje tiene implicaciones en las variables de habilidades de pensamiento creativo y computacional en un 29,6 % y un 10,6 %.
Conclusiones: la implementación del Proyecto de Aprendizaje Híbrido STEAMER ha influido en las habilidades de pensamiento computacional y pensamiento creativo de los estudiantes a través de una serie de etapas modelo, como reflexión, realización de investigaciones, búsqueda de estrategias, implementación de resultados de diseño y comunicación de los resultados de los proyectos desarrollados.

Palabras clave: Computacional; Creativo; Ciencia; Escuela Primaria.

INTRODUCTION

Currently, in the era of Industrial Revolution 5.0, individuals need to master Computational and Creative Thinking Skills. Computational Thinking Skills is a systematic and structured way of thinking that is useful for solving contextual problems in real-life.[1,2] Computational thinking skills adopt the concept of systematic, analytical,[3] abstract, algorithmic,[3,4,5,6] open thinking[7,8] and logical computer thinking.[9] This ability can be trained in students so that they can improve their academic abilities.[10] Computational thinking skills have several indicators, namely abstraction, algorithmic thinking, decomposition, and pattern recognition.[9] Another ability that students currently need to have is creative thinking skills.

Creative Thinking Skills is the ability to develop a new method or idea in the form of a solution to overcome a problem.[11,12,13] Creative thinking skills are identical to the ability to create new ideas, through the process of breaking down, refining, analyzing, and evaluating ideas in producing solutions accompanied by four characteristics including fluency, flexibility, originality, and elaboration.[14,15,16,17,18] Creative thinking skills facilitate a person to formulate new ideas. A person's creative thinking skills can develop with practice to hone these skills.[19,20,21,22]

Computational and creative thinking skills are crucial to improving prospective teachers in Indonesia, especially prospective elementary school teachers. This is because prospective elementary school teachers are prospective elementary school teachers who play a necessary role in strengthening the foundations of elementary school students' thinking patterns. However, the study of the first year showed that the computational and creative thinking skills abilities of prospective elementary school teachers from 8 Educational Personnel Education Institutions (EPEI) in Indonesia still tend to be low.

Based on publications by researchers in the first year show that prospective elementary school teachers in general have not been able to develop the ability to determine problem patterns in computational thinking skills to develop original ideas in creative thinking skills.[23] This is also propped by the study which states that prospective teachers in Indonesia still tend to lack mastery of computational and creative thinking skills.[24,25,26,27] This problem is caused by learning and assignments that do not train analytical and creative thinking as well as using less varied media in learning.[28] This problem does not only occur in first-year research subjects, but education quality problems also occur in several regions in Indonesia.[29]

Based on this, appropriate learning is needed to overcome the problem of low Computational and creative thinking skills of prospective elementary school teachers in Indonesia. One model that shall be used to repair prospective teachers' computational and creative thinking skills is the integration of project-based learning and STEAM models or STEAM projects and reflection.[30,31,32,33] The Project-based learning model can increase student creativity, student involvement,[34] student abilities,[35,36] critical thinking, more meaningful learning.[37] The STEAM model can develop students' creativity, critical thinking, computational thinking skills, real-world problem-solving skills, imagination, and collaboration capabilities.[38,39,40,41,42,43,44,45,46] It is also very important for prospective teachers to be trained in reflection activities in learning. This is to train prospective teachers to think reflectively and critically.[47,48] Critical thinking skills are also influenced by digital literacy skills.

The model that shall be used to train computational and creative thinking skills is the Hybrid Learning Microsite Project STEAMER. This hybrid learning model integrates the Project-based learning model, STEAM approach, and reflection using microsite media.[49] Practically, in implementing the model, prospective teachers are given a project to construct a solution using microsite media that integrates STEAM and reflection. Hybrid learning Microsite Project STEAMER is based on the theory of constructivism where a person's knowledge will be constructed through their environment and experiences.[50] This model is implemented in a hybrid

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manner consisting of learning using Learning Management System SPADA (asynchronous) and online and offline asynchronous.[51] Hybrid learning is equipped with multimedia which reason students to be more enthusiastic about learning.[23,52,53] Apart from the theoretical basis, This model is also based on other theories in learning. The model design is briefly displayed in figure 1.

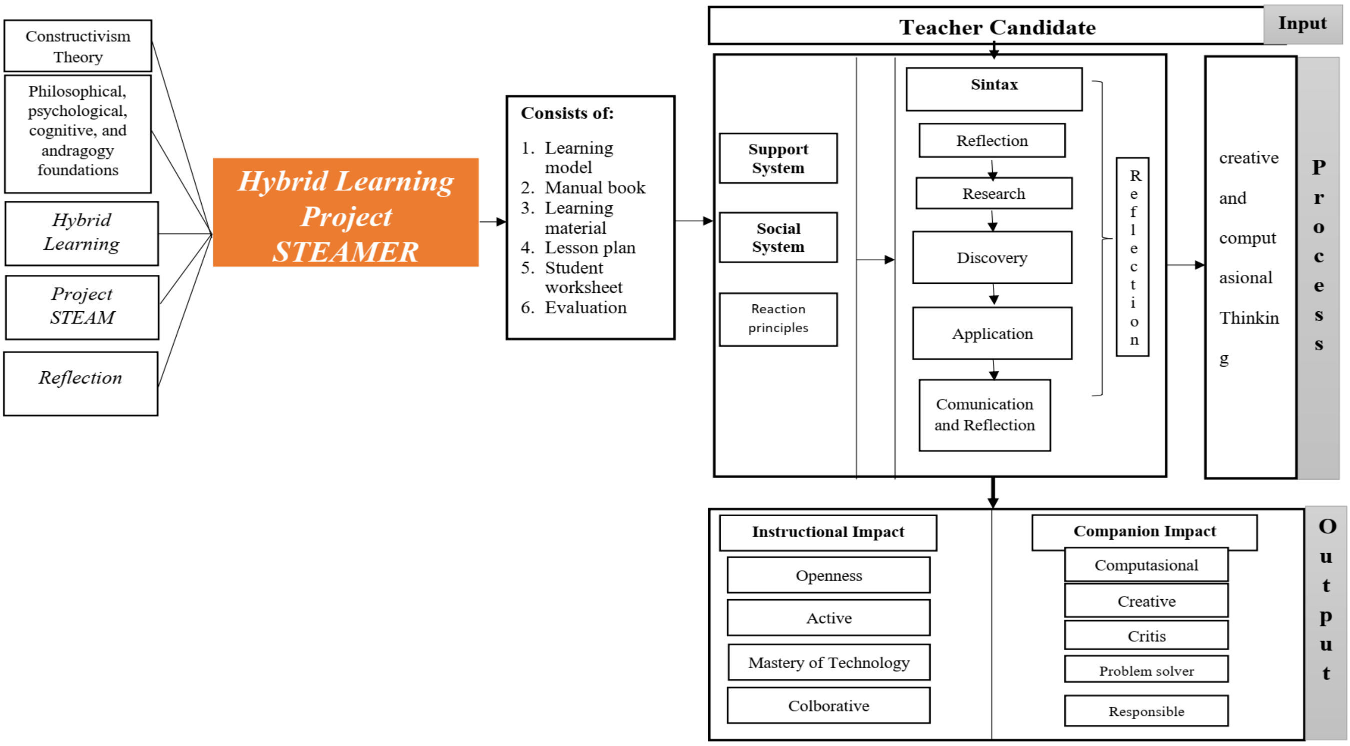

Figure 1. Design of the STEAMER project microsite learning model

In detail the learning steps are shown in figure 2.

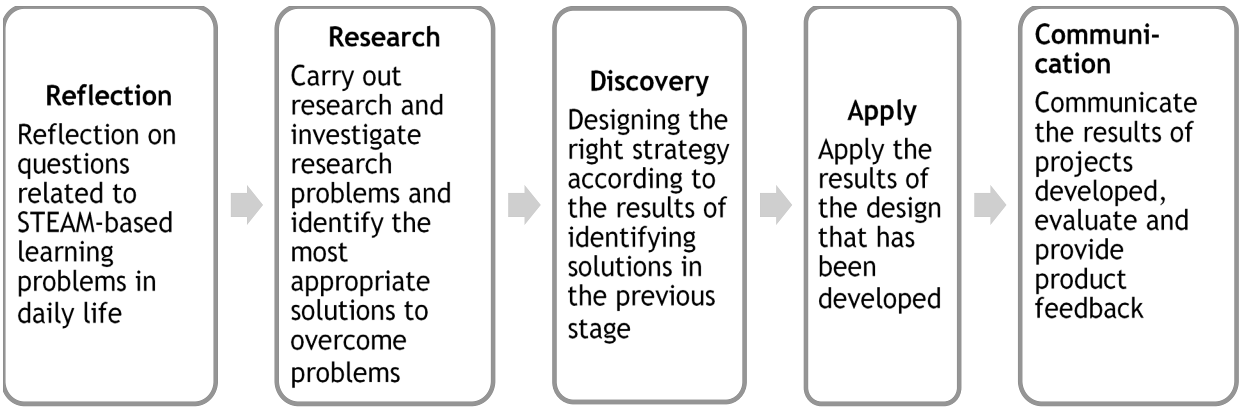

Figure 2. Syntax of the hybrid learning microsite project STEAMER

The implementation of Hybrid learning which integrates project-based learning models, STEAM and reflection as well as the use of microsite media has never been implemented. Existing research has mostly centered on the application of the STEAM Project model and the use of microsites.[39,54,55,56,57,58,59,60,61] However, there has been no implementation of the STEAM Project model which integrates reflection in learning to improve Computational and Creative Thinking Skills. Reflection really needs to be trained on prospective teachers to be more reflective and critical. The novelty of the research is also strengthened by the distribution of research related to the STEAM Project, microsite, and computational and creative thinking skills if the bibliometric analysis of the distribution map of previous research results is displayed in figure 3.

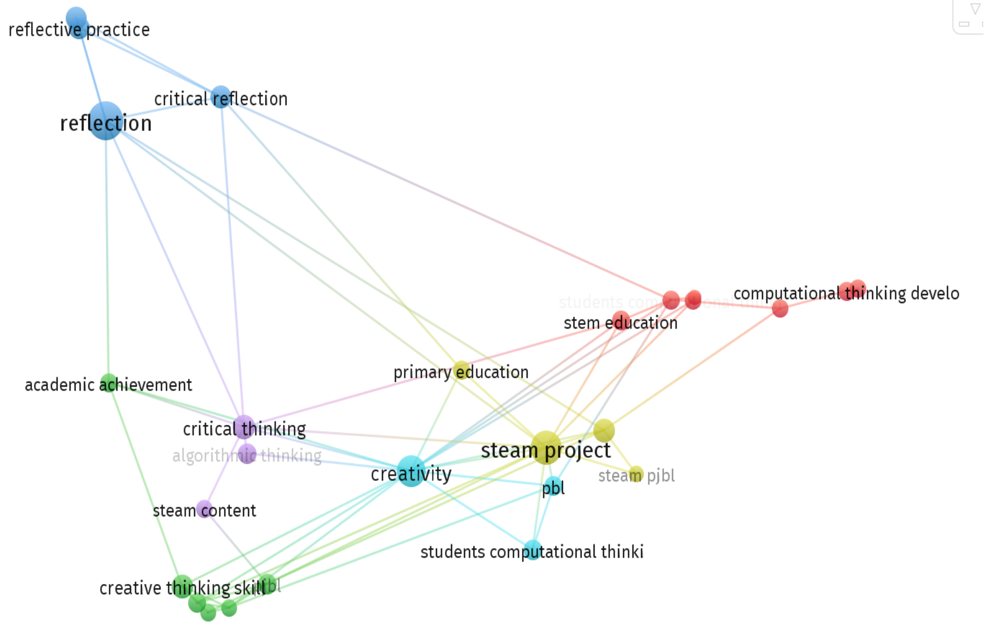

Figure 3. Results of bibliometric analysis of previous research mapping

Figure 3 informs that the implementation of STEAM Project learning has been carried out, but integration with reflection and the use of microsites to improve Computational and Creative Thinking Skills has never been implemented. So, this study goals to determine the effectiveness of the implementation of the hybrid learning microsite project STEAMER in increasing the computational and creative thinking skills of prospective elementary school teachers.

METHOD

This study is an experimental study with a pretest-posttest non-equivalent control group design. The study subjects were samples of Educational Personnel Education Institution (EPEI) Universitas PGRI Yogyakarta, Universitas Sebelas Maret, Universitas PGRI Kanjuruhan Malang, Universitas Muhammadiyah Sidoarjo, Universitas Muhammadiyah Magelang, Universitas Islam Negeri Antasari Banjarmasin, Universitas Pattimura Maluku, Universitas Muhammadiyah Kupang, Universitas Trunojoyo Madura, and Universitas Tribhuwana Tungga Dewi. The number of research subjects was 300 prospective elementary school teachers. The instruments used were observation sheets and interviews regarding the practice of the learning model, as well as computational and creative thinking skills measurement tests. The computational and creative thinking skills test grid is shown in table 1.

Table 1. Perspective instrument guidelines on computational dan creative thinking skills

No		Indicators
Computational Thinking Skills		
1	Abstraction	Identify general patterns regarding the similarities/differences in available problem findings
		Draw conclusions on problem solving patterns
2	Algorythmic thinking	Identify problem solving procedures
3	Decomposition	Identify data on the issues raised
		Identify data on questions that are in line with the issues raised
4	Patternn recognition	Knowing the characteristics of problem solving
Creative Thinking Skills		
1	Fluency	Offering a variety of problem solving fluently
2	Flexibility	Delivering varied ideas and having points of view from various perspectives in problem solving
3	Originality	Having new and original ideas
4	Elaboration	Packaging existing ideas in new forms

Source: [62,63]

The data analysis technique uses Multivariate statistical analysis SEM (Structural Equation Modeling) technique using LISREL 8.80 with RMSEA criteria ≤ 0,08, CFI ≥ 0,95, NFI ≥ 0,90, RMR ≤ 0,05 and t value > 1,96. Next, the application of the learning model was analyzed qualitatively using Miles and Huberman's qualitative data analysis technique which consists of data collection, data reduction, data collection, and conclusions.

RESULTS AND DISCUSSION

The description of the learning implementation refers to the stages of the Project STEAMER microsite learning model which consists of:

Reflection, 2 main problems are presented for students to reflect on. Next, students reflect by determining the differences between the two problems and then look for problem patterns. Based on the differences and similarities in the problems that have been analyzed, the problem patterns of the two problems can then be looked for so that the root of the problem in two different learning situations can be identified. From this activity, students can analyze in more detail the problem to be analyzed and find the root of the problem in two situations.

The study findings display that some students are quite detailed in analyzing the similarities and differences between the two problems, but some are still lacking. In determining learning patterns, students have been able to determine existing problem patterns from both learning problems. This matter pattern is used to train students to determine patterns of learning problems that will later be encountered in the field. From the pattern of problems, the root of the learning problems that occur will be known. In research, students are trained to determine solutions to these problems by exploring and observing theories or research results to develop the most appropriate solutions. The solution developed was not just one design but was asked to develop two designs. This is done with the hope that students can develop alternative solutions to overcome a problem. So don't stick to just one solution.

Based on the alternative solutions chosen, they are then analyzed based on theory regarding the strengths and weaknesses of the chosen solutions. In-depth analysis can train students to determine the most appropriate choice that suits the existing problem. This study known that from this stage students can determine more deeply and critically analyze the solutions that have been developed. At this stage students are quite enthusiastic about the work, students have several alternative solutions so students need to choose the most suitable design. Alternative solutions enable students to construct the skill to consider more creatively and more openly.

In the third stage, the discovery stage, students determine a learning model that they feel is most appropriate. The selected solution is then explored in more depth and students are trained to integrate STEAM in their design. It is hoped that STEAM integration can train students to develop solutions not only from one point of view but linking them with studies in other fields such as technology, engineering, art, and mathematics. Students are asked to describe the learning plan that will be developed in detail. This study display that students have been able to develop and integrate STEAM in learning and try to describe the results of their development in more detail. At this stage, students experienced a little difficulty in integrating STEAM at the first meeting, but at the second and subsequent meetings, students found it easier to integrate STEAM in learning.

At the application stage, students apply the learning model that has been developed by carrying out simulations in class and try to upload and compile the material that has been developed into the microsite. At this stage, students are involved in determining the advantages and limitations of the solutions offered after being demonstrated. The results of the study inform that students can determine the advantages and limitations of the solutions offered and students have been able to master the microsite to be further developed in the form of a website. Students are also able to improve the results of the learning simulation so that it is better.

Then, communication and reflection this stage, students consider together on the solutions that have been developed and discuss improvements that will be developed with students in other groups. The following is a student worksheet at the communication and reflection stage. Students can share and discuss the shortcomings of the solutions they have chosen and put them into practice to produce a final product that best suits the existing problem.

Implementation of activities in the control class refers to the implementation of problem-based learning which consists of. First is problem orientation. At this stage students are trained to analyze science learning problem material in elementary school. The following is an example of material analysis of science learning problems in elementary school. Students observe the questions given by the lecturer. Students make individual observations. Second, organizing learning. At the organizing learning stage, students carry out problem analysis together in one group to analyze the causes of the problem. In practice, in the control class, the discussion was quite warm between the participants in the lecture. Several analyses were put forward by students. Discussions take place openly between students. Students exchange ideas to find the causes of the problems that have been determined. The following is a picture of the discussion in the control class.

Third, independent investigation. The study of analysis has been provided, a more in-depth discussion is then held to overcome the problem together. The preparation of the solution is based on the material in the elementary science learning development course. The solutions developed are related to the development of models, media, teaching materials, and learning tools that are suitable to overcome these problems. The preparation of solutions is based on theory and research articles. So students carry out exploration first before

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formulating specific solutions. From the work that has been carried out by students, students have developed analyses and solutions, some of which are still less detailed and not yet based on a complete theory, but some are complete. Based on this, instructions are needed to develop solutions that are based on a complete theory of research results, because the instructions for use still do not ask to develop a theory of research results.

Fourth, developing and presenting solutions. At the developing and presenting solution stage, students compile and describe the solution being developed. The results of the student worksheet show that students are quite capable of designing solutions that are tailored to the problems experienced in learning. The solutions developed also vary according to the understanding and references that students have read. Next, the results of the student worksheet are presented to get meaningful input from other groups.

Fifth, the stages of analyzing and evaluating the implementation of learning results from student discussions are carried out. During the implementation of the control class, it can be seen that students can make learning activities well and can formulate product improvements following input from the discussion results. Added to the results of interviews and observation results are several points that need to be considered in implementation in the control class. These include: 1) students in the control class feel comfortable and are quite familiar with the steps of the model being developed, 2) the time required is quite short, 3) students feel more challenged compared to the implementation of learning carried out with presentations, and 4) More complete instructions are needed so that the quality of student work is even better. The study displays that students have been able to construct products based on the model used in the control class, namely the PBL model. However, several shortcomings during the implementation of the model are: 1) the model developed does not train students' reflection skills, 2) the model does not lead to the ability to analyze and develop learning solutions based on theory, and 3) the model is quite capable of training students to think more critically.

The results of observations of prospective elementary school teachers' computational and creative thinking abilities during learning are shown as follows in table 2.

Table 2. Observation results of computational ability and creative thinking

No	Indicator	Sub Indicator	Description
Computational Thinking Skills			
1	Abstraction	Identify general patterns regarding the similarities/ differences in available problem findings	In determining the similarities and differences in problems, students determine the advantages and disadvantages of the teacher's way of teaching, then differentiate the context of their activities and determine the similarities in the problems faced by the teacher.
		Draw conclusions on problem solving patterns	Students can determine problem patterns according to the context of the problem equations raised. Students determine problem patterns from concluding the similarities of the problems presented. This stage is carried out at the reflection stage
2	Algorithmic thinking	Identify problem solving procedures	Students develop problem-structuring steps based on the discovery stage, students make in-depth observations and determine solutions from references such as journals and books. In the previous stage, students develop alternative solutions and determine the most appropriate solution. The choice of solution is based on the characteristics of the problem that the student has encountered. Students also integrate STEAM in learning so that learning takes into account more multidiscipline
3	Decomposition	Identify data on the issues raised	Identification skills for students are carried out at the beginning of learning at the reflection stage, at the reflection stage identification of information from the problem presented is carried out.
		Identify data on questions that are in line with the issues raised	This ability is developed at the reflection stage, where students reflect on the problem being asked and then break it down into simpler problems.
4	Pattern recognition	Knowing the characteristics of problem solving	The introduction of solution patterns is carried out at the research stage. At the research stage, students determine alternative solutions to the problem being developed. Based on the existing alternative solutions, students determine the pattern of the resulting solutions and choose the most appropriate solution to overcome the learning problem.
Creative Thinking Skills			
1	fluency	Offering a variety of problem solving fluently	Fluency abilities are developed at the stage of developing alternative ideas for solutions to problems presented to students at the research stage.
2	flexibility	Delivering varied ideas and having points of view from various perspectives in problem solving	This ability is produced at each step of the research since the determination of the idea of a solution to the problem faced through interviews and others. The results of the exploration obtained that students can produce various alternative solutions to problems from different points of view.

3	Originality	Having new and original ideas	Students still have a little difficulty in developing this ability. Not many students can develop original ideas because students focus more on existing theories, but several student groups try to develop original products.
4	Elaboration	Packaging existing ideas in new forms	The skill to fertilize and construct a product is developed at the discovery stage where students integrate STEAM in learning so that there is development in the product produced.

Based on this, the research was carried out on 300 research samples from 10 Educational Personnel Education Institution. The study of the pretest and posttest are shown in figure 4.

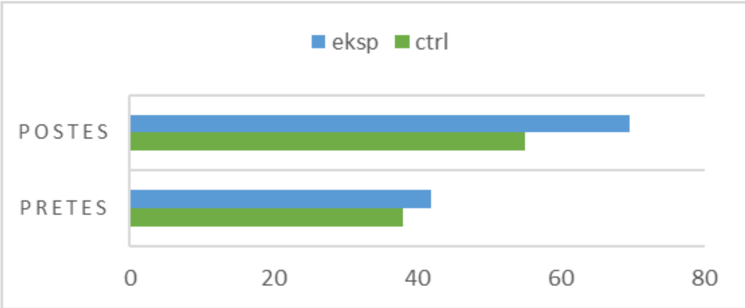

Figure 4. Comparison of pretest and posttest for experimental class and control class

Figure 4 can be seen that the pretest and posttest scores of students in the experimental and control classes have increased, but if we observe the scores in the experimental class, the increase has been more significant compared to the increase in the control class. It can be seen that the average pretest score in the experimental class was 42,66 and in the control class was 38,5. Meanwhile, in the post-test in the experimental class and control class, there was an upgrade to 69,95 in the experimental class and in the control class the average score was 55,65. Based on the pretest and posttest learning analysis data, analysis was carried out using SEM as shown in figure 5.

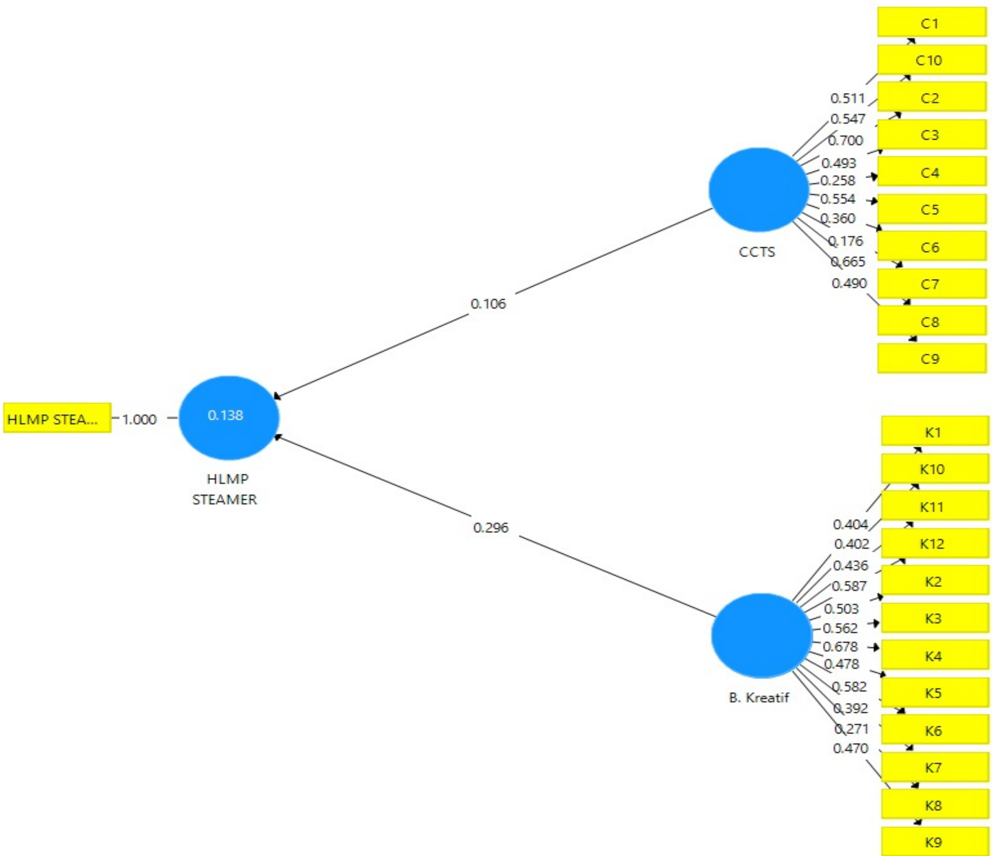

Figure 5. Analysis of Pretest and Posttest Model Data Using SEM MPLS

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Based on figure 5, it is known that the utilization of the learning model has implications for the creative and computational thinking ability variables of 29,6 % and 10,6 %. In accordance with the indicators for each variable. The study of the analysis show that there is an upgrade in computational thinking and creative thinking abilities in the experimental class compared to the control class. This is because the experimental class trains several activity points, including carrying out research using the Project STEAMER microsite learning model, which is able to: 1) train students to develop more critical thinking skills, 2) train them to construct alternative solutions to a problem, 3) Train students to determine problem patterns, 4) train students to think more openly towards other scientific disciplines, 5) reflect and consider more deeply in solving learning problems, 6) train students to determine solutions based on theory and research results. However, there are weaknesses, including that there are still several activity steps that can be made more concise, such as steps 4 and 5 so that learning can be shorter and more practical for students. In general, in training critical, computational and creative thinking skills, the learning model has trained the expected thinking patterns.

In implementing the model in the control class, it was found that: 1) it could improve critical thinking skills, 2) the time required was quite short, 3) students felt more challenged compared to implementing learning carried out with presentations, 4) the model used was practical and easy to understand. However, in its implementation there are still shortcomings, namely the need for more complete instructions so that the quality of student work is better, the model developed does not train students' reflection skills, the model does not lead to the ability to analyze in depth and develop alternative learning solutions so that students are less able to think more openly. of the solutions developed. So students often think that one problem can be solved with one solution. This makes students less creative and less able to develop learning that is more open to other alternative solutions. In addition, computational thinking abilities have not been sufficiently developed in this model.

Hybrid Learning Project STEAMER is a learning model that has been developed by [64]. This model is an integration of project-based learning models, STEAM and reflection. Project-based learning has benefits and can improve a person's computational thinking skills increasing student involvement, student abilities, student understanding, critical thinking, meaningful learning, and improving learning outcomes for students.[31,32,33,35,65,66] STEAM learning can develop students' creativity and skills in solving problems,[44] develop critical thinking skills,[38] and imaginatively,[45] reflection can update thinking skills, solving problems, creative and evaluative thinking,[67] Thinking computational.[47,68] The Project STEAM Learning Model has several benefits: 1) Active and Involved Learning, 2) Increasing students' understanding and skills through direct experience, 3) 21st Century Skills Development, 4) Expanding students' insight into various scientific disciplines and preparing them for the future diverse, 5) Increasing motivation, 6) Developing problem-solving abilities, 7) Increasing students' independence and self-confidence in facing problems, and 8) Developing knowledge, skills, and interests in various scientific disciplines.

Based on research that has been conducted, the STEAMER hybrid learning project can train students' computational thinking and creative thinking skills. The uniqueness of the hybrid learning project STEAMER stage compared to other models is in the reflection stage where students determine the pattern of problems presented so that students can recognize the characteristics and context of the problems presented. This can develop students' abilities to apply it in everyday life so that prospective teachers can see problem patterns first by carrying out in-depth analysis. The next stage is the discovery stage, at this stage the results of the analysis that have been obtained are developed as alternative solutions. Often some models only develop one forecasting solution. In this model, attention is paid to developing solutions to problems so that students are not fixated and closed off to other solutions. This stage trains students' creative and computational thinking skills. Computational thinking skills can be updated by applying STEAM models such as problem-solving-based learning.[69,70,71] The development of this ability can be optimized utilizing training in concept illustration and integration of computational thinking in each discipline.[72,73,74,75]

At the reflection stage, students formulate problem-solving patterns. The patterns are analyzed in depth according to their characteristics. Through this stage, students can think abstractly and decompose, especially in determining the similarities and differences of information regarding problem solving. The next stage is research. Students explore alternative problem solving by recognizing problem-solving patterns. They are more open in determining alternative problem-solving patterns. This stage also optimizes all indicators of creative thinking skills. The next stage is discovery. Optimization of the discovery stage is determined based on the process of decomposing problem-solving procedures and developing elaborative thinking skills towards problem solving. The development of learning solutions is able to develop creative and more open thinking abilities.[76] Regular practice activities can train the ability to develop flexibility in creative thinking.[77,78] Being open to new experiences and perspectives will result in more original and innovative ideas.[79,80,81]

CONCLUSIONS

The conclusion of this study is that the implementation of the Hybrid Learning Project STEAMER has influenced students' computational thinking and creative thinking skills through a series of model stages, such as reflection, research implementation, strategy discovery, application of design results, and communication of the results of the developed project. Students show changes in abilities, such as being trained to think critically, being able to solve problems, being able to find problem patterns, thinking openly, and being able to reflect on the problems faced. The application of this learning has opened up new originality related to innovative learning models so that teachers can adopt them in learning. These findings can also be a reference material for policy makers to establish regulations for the use of innovative learning methods at the madrasah level. For future researchers, it is recommended to conduct thinking development training in learning that can train individual thinking skills to be better. In addition, the development of similar learning models can be carried out by future researchers.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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