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STEAMER Hybrid Learning Project for Creative and Computational Thinking: Perspectives from Elementary School Teacher Candidates

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Abstract: The computing and creative skills of students in Indonesia are still low since the government has not focused on student creativity and computational empowerment programs. This research aims to develop a science, technology, engineering, art, mathematics, and reflection (STEAMER) hybrid learning project model for teachers' creative and computational thinking abilities, as well as analyze elementary school teacher candidates' perceptions of the use of STEAMER hybrid learning model to improve teachers' creative and computational thinking abilities. This research is development research with an analysis, design, development, implementation, and evaluation (ADDIE) model. The instruments used in this study were questionnaires and interviews with experts, lecturers, and elementary school teacher candidates. The research was conducted at eight universities in Indonesia with a total sample of 100 elementary school teacher candidates. Through quantitative and qualitative data analysis, the research results have developed the STEAMER hybrid learning project model based on learning theory, syntax, social systems, support systems, and the instructional impact of learning models. The results of the validation show that the developed learning model is feasible in terms of model, material, media, and language experts. The model is suitable for elementary school teacher education. Furthermore, based on the perceptions of the teacher candidates, it is stated that the STEAMER hybrid learning project can develop the ability of the teacher candidates to think creatively and computationally.

Keywords: *Creative, computational thinking, STEAMER hybrid learning.*

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Introduction

Computational and creative thinking skills are essential for solving complex problems in the 21st century. Computational thinking skills are a way of thinking analytically, and mathematically that is used in solving problems and allows designing and evaluating complex systems in the real world (Mulyanto et al., 2020; Wing, 2006) with the primary concepts of computer science (Selby & Woollard, 2013). Computational thinking skills are skills that lead to thinking abstractly and algorithmically (Jacob & Warschauer, 2018), and logically (Hunsaker, 2018; Wing, 2017), to solve complicated problems (Palts & Pedaste, 2020), and to improve academic abilities (Kert et al., 2020). In addition to computational thinking skills, currently, the focus of the empowerment program of the Indonesian Government is creative thinking skills. Creative thinking skills are the skills to create something in a new and unique way or idea, resulting in a unique solution to a problem (Moeller et al., 2013; Román-González et al., 2018) with the indicators consisting of fluency, flexibility, originality, and elaboration (Lefrançois, 1999).

Computational thinking skills and creative thinking skills (CCTS) are important to develop university students in Indonesia. However, based on a previous study, show that students in Indonesia have not fully mastered computational and creative thinking skills and tend to show low levels of computational and creative thinking skills (Harmini et al., 2020; Julianti et al., 2022; Rosali & Suryadi, 2021; Yuntawati et al., 2021). In terms of the level of students' creative thinking skills, for instance, research has also been carried out by (Budi & Izzati, 2021; Purba et al., 2017; Yulvinamaesari & Tenriawaru, 2017) which states that students' creative thinking skills still have not reached the target.

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One of the solutions that can be developed to overcome the issues among elementary teacher candidates is the use of a hybrid learning project based on Science, Technology, Engineering, Art, Mathematics, and Reflection (STEAMER). This model integrates STEAMER and project-based learning models. STEAMER Hybrid learning project is a project-based learning model that has the advantage of being able to increase students' CCTS (Azmi & Ummah, 2021; Nurhopipah et al., 2021; Shin et al., 2021; Yang et al., 2020). STEAMER Hybrid learning project is the development of hybrid learning, project-based learning, and integrating STEAM and reflection (Sigit et al., 2022). In implementing this model, teacher candidates are given a project to construct a solution. In practice, learning is carried out in a hybrid learning. The learning tools used, i.e., lesson plans, worksheets, e-modules, learning videos, and evaluations, are integrated into the learning management system and the project for elementary teacher candidates is to develop a learning project.

Hybrid learning is a merger of e-learning and private methods (Bustamante et al., 2022). The implementation of such hybrid learning develops four quadrants of blended learning (Chaeruman, 2017; Kintu et al., 2017). The advantages of hybrid learning are to provide more effective learning (Fauzan & Arifin, 2017) and attractive (Nashir & Laili, 2021), raise self-regulation, raise critical thinking skills (Aristika et al., 2021), reduce alienation (El-Gayar & Dennis, 2005), increase learning outcomes (Khader, 2016; Vonti & Rahmah, 2019), self-efficacy (Fitriyana et al., 2021), student motivation and achievement (Islam et al., 2018), and facilitate online learning assessment (Susiani et al., 2021).

STEAMER project is a learning approach that merges STEAM-based learning and reflection. STEAM project is the merger of project-based learning (PjBL) and STEAM learning models. The PjBL model is the process of integrating everyday problems by providing challenges for students to solve problems in groups (Goodman & Stivers, 2010). The application of a project-based learning model increases student engagement (Almulla, 2020), student abilities (Baptist et al., 2020), student understanding (Hudiananingsih et al., 2019), critical thinking skills (Issa & Khataibeh, 2021), and meaningful learning (Hsbollah & Hassan, 2022), and improves student's learning outcomes (Maksum & Purwanto, 2022). In addition, STEAM learning is trusted to maximize all the capabilities needed in the 21st century (Tabiin, 2019; Wilson & Hawkins, 2019). STEAM learning has positive impacts on learning (Becker & Park, 2011). STEAM is needed in learning since it can increase interest, and motivation, and provide a meaningful learning experience (Rukayah et al., 2022). STEAM develops innovation, a learning paradigm that follows real life helps students build self-concept (Zubaidah, 2019), and increases mastery of concepts (Liliwati et al., 2018). The application of the STEAM approach encourages prospective elementary school teachers to actualize systematic and sustainable procedures regarding objects related to human needs.

The last concept in STEAMER learning is reflection as a form of thinking to solve practical problems by looking back at the experiences that have been carried out or experienced and formulating solutions to the experiences (Zeichner & Liston, 2014). Reflection is used to explore understanding, stimulate open thinking regarding problems to be developed further with new actions (Love et al., 2018), develop self-awareness (Walker, 2006), and improve the quality of the learning process (Buchholz et al., 2013). Reflection may develop critical thinking, problem-solving, creative, and evaluative skills (Schön, 2017). Reflection can develop thinking, problem-solving, creative thinking (Razdorskaya, 2015), computational thinking (Sondakh, 2019), evaluative skills, and computational thinking skills (Azmi & Ummah, 2021; Nguyen et al., 2020; Nurhopipah et al., 2021; Shin et al., 2021).

As explained above, the STEAMER-Based Hybrid Learning Project is very necessary in the field of education. The basic thing is to look at the advantages of using the STEAMER-Based Hybrid Learning Project, such as triggering increased student interest, motivation, and learning experience. In STEAMER-Based Hybrid Learning Project learning, students are often involved so that their cognitive understanding and skills develop. The outcomes produced through this learning are in line with the development of 21st-century education. One important aspect of the 21st-century learning approach is the emphasis on 21st-century skills (including problem-solving, critical thinking, collaboration, communication, creativity, and technological literacy) (Thornhill-Miller et al., 2023). In 21st-century learning, students will be heavily involved in collaborative project learning, online research, digital simulations, and problem-based learning.

21st-century learning is very relevant to the learning process with the STEAMER-Based Hybrid Learning Project. As proposed by the Korean Ministry of Education, Science, and Technology (MEST) regarding the STEAM model in learning, the STEAMER-based Hybrid Learning Project takes a broad view of the performing arts, creativity, problem-solving, research, and aesthetic perspectives in everyday life (Sousa & Pilecki, 2013). Research in the STEAM field is growing exponentially. Choi et al. (2017) examine its perceptions and practices and suggest that STEAM Education is necessary and important. STEM education is accepted as one of the largest educational movements in recent years and contains three instructional approaches: multidisciplinary, interdisciplinary, and transdisciplinary (Kukushkin & Churlyaeva, 2012).

STEAM education is based on a constructivist approach and places students at the center of learning. In the constructivist approach, individuals construct knowledge, as opposed to behaviorism and cognitivism, that rules and knowledge are acquired. This approach enables 'different ways of understanding and knowing and dealing with the world, as a way of expanding the science and Engineering toolbox. The STEAMER-based Hybrid Learning Project supports preparing students to join the workforce by educating them to become adaptive on-the-job learners, rather than simply asking them to acquire rigid knowledge.

In this study, the design was carried out both synchronously and asynchronously by integrating the STEAM project learning model and reflection as well as which is rarely used in learning. There have not been many studies discussing the STEAM project, including research (Adriyawati et al., 2020; Montés et al., 2023; Putri & Pitria, 2022; Suryaningsih, 2021) and not many have integrated reflective learning. Some studies on reflective learning have been carried out (Aprilia, 2016; Widiansyah, 2021), yet the impact of the integration of the STEAM project learning model and the development of reflective learning in hybrid learning has not been discussed in a specific manner. Based on the previous rationale, the goal of this study is to build a hybrid learning model based on the STEAMER project to improve the computational and creative thinking skills of elementary school teacher candidates and to find out their perceptions of them.

Methodology

Development research using the ADDIE model was used in this research. According to Dick et al. (2004), the ADDIE development model is a model involving five development stages including analysis, design, development or production, implementation, and evaluations. It uses an ADDIE design since the developed product is a learning model, not software engineering so the ADDIE design is suitable for product development.

The study involved elementary school teacher candidates in three provinces in Indonesia and the samples were eight public and private universities (N=100 participants). The characteristics of the research participants were determined based on the following criteria: (a) the students are taking elementary school teacher education study programs; (b) students are taking science education courses at elementary school; and (c) students are in state and private universities. This is a multi-year study in which the first year focuses on the development of the STEAMER hybrid learning project, validates tests (material, languages, models, and learning media), and examines the perspectives of the teacher candidates on creative and computational thinking abilities). The study framework in this study is displayed in Figure 1.

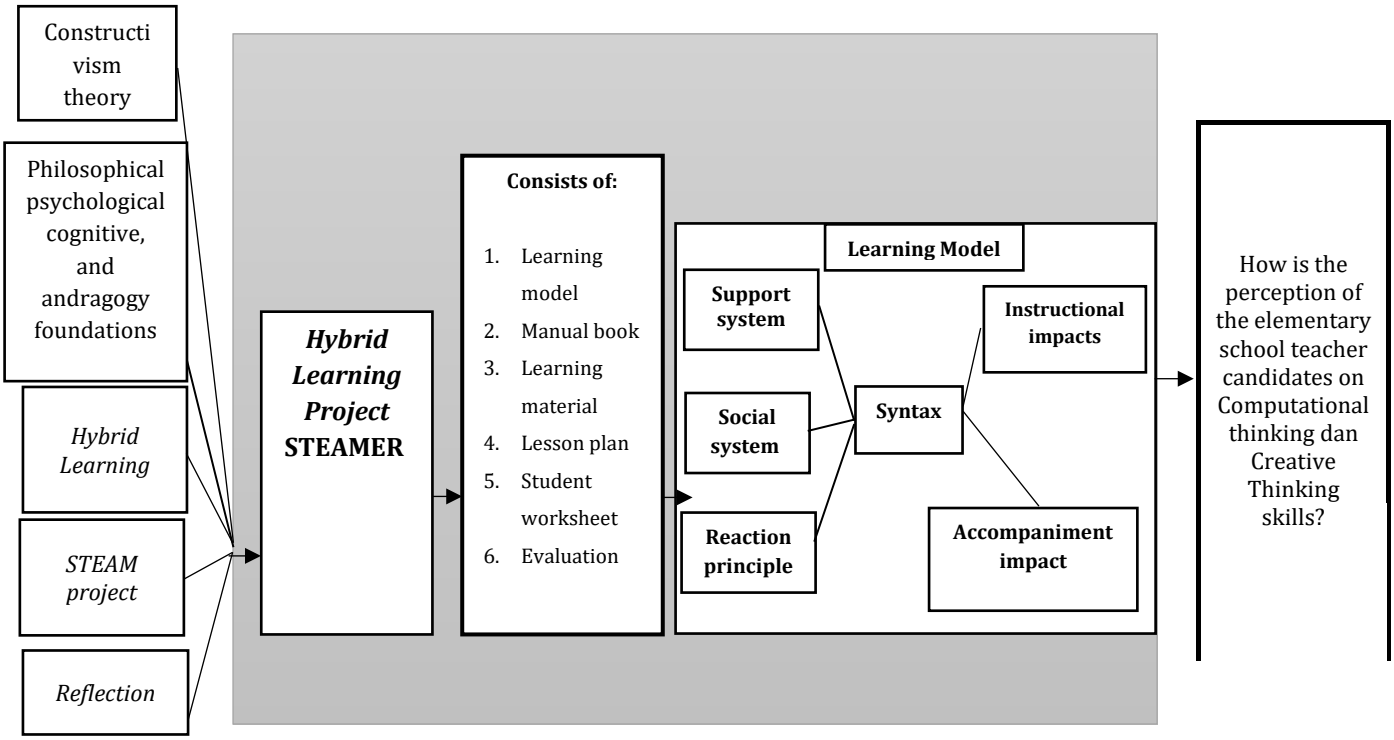

Figure 1. Research Framework

The research procedures consist of (a) analysis which was carried out by analyzing the initial skill of the elementary school teacher candidates and the application of learning; (b) at this stage, learning instruments were developed consisting of lesson plans, learning media, student worksheets, and evaluation instruments to know the learning outcomes; (c) at the development stage, construct validation was carried out on the model, materials, media, and language experts; (d) during the implementation stage, a survey of perspectives from the elementary school teacher candidates on the model that has been developed; and (e) the evaluation was carried out by conducting evaluations based on perspectives, suggestions, and input from research subjects. According to the evaluation, the final product was developed which was utilized for large-scale trials in the following year. The research stage is shown in Figure 2.

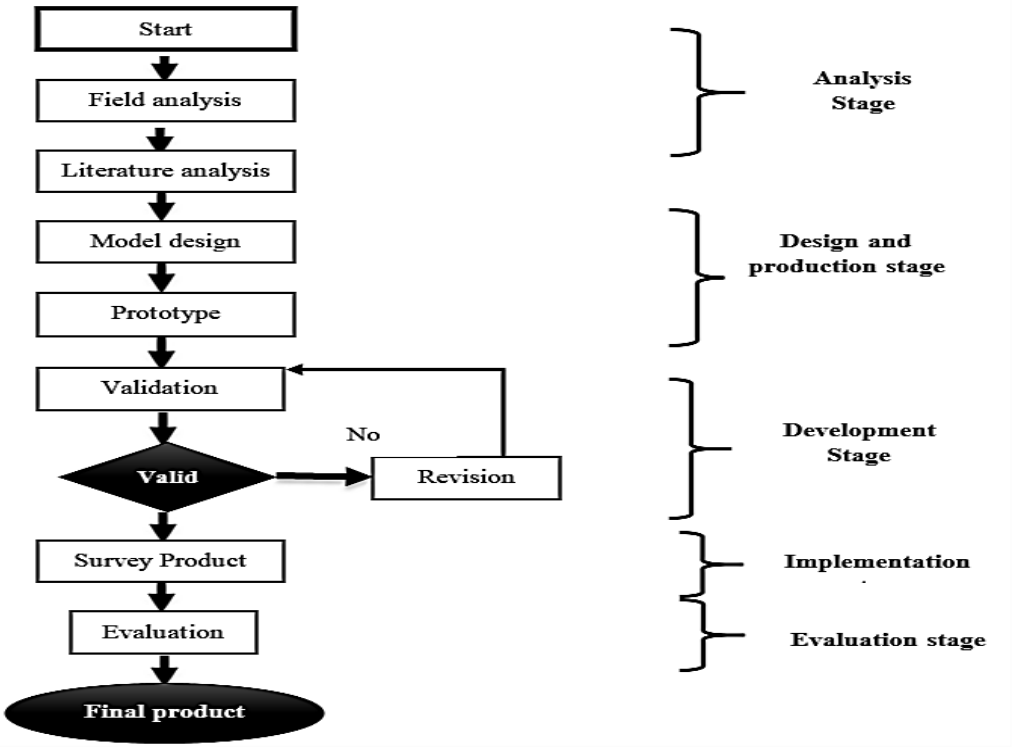

Figure 2. Research Procedures

In this research, data collection techniques were carried out using questionnaires. The questionnaire contains statements with a focus on the model developed and the views of prospective elementary school teachers on project learning. The questionnaire was used to test the feasibility of the model being developed and a questionnaire to see the perspective of the elementary school teacher candidates on the project learning model being developed. The questionnaire was prepared based on the STEAMER-based hybrid learning project indicators, computational thinking skills indicators, and creative thinking skills indicators. In preparing the questionnaire, the Likert scale was determined as a division into categories with details of strongly agree (SA) with a value of 4, agree (A) with a value of 3, disagree (D) with a value of 2, and strongly disagree (SD) with a value of 1.

During the research process, the questionnaire was tested for suitability to ensure it could be used as a data collection tool. Questionnaire testing considers several assessment criteria, such as aspects of the learning model, material/content, language, and media. Questionnaire testing also involves experts (Lecturers who are experts in media, evaluation, and language). The involvement of experts is useful for checking the instrument from the aspects of the learning model, material/content, language, and media. The guidelines of the model feasibility test instrument and the questionnaire are displayed (see Table 1).

Table 1. Validity Test Model and Learning Instruments Being Developed

Aspects	**Learning model Indicators**
Learning models	Theory
	Syntax
	Social system
	Supporting system
	Reaction principles
	Instructional impact
	Complementary impact
Materials	Scope
	Accuracy
	Recentness
	Compliance with laws and regulations

Table 1. Continued

Aspects	Learning model Indicators
Language	Relevance with student development
	Communicativeness
	Dialogic and interactive
	Brevity
	Coherence and cohesion of logical thinking
	Relevance with standard Indonesian language
	Consistency in the use of symbols
Media	Usability
	Presentation design
	Consistency with the learning objectives
	Feedback and Adaptation
	Motivation
	Accessibility
	Compliance with the standard

Table 2. Perspective Instrument Guidelines on Computational Thinking Skills (Csizmadia et al., 2015)

No	Computational Thinking Skills	Indicators
1	Abstraction	Can mention similarities/differences according to the problem
		Can conclude from the patterns found according to the problem
2	Algorithmic thinking	Can mention procedures for preparing solutions to problems
3	Decomposition	Can identify information from problems
		Can identify the information requested according to the problem
4	Pattern recognition	Can recognize characteristics to solve problems to find a solution

Table 3. Perspective Instrument Guidelines on Creative Thinking Skills (Akpur, 2020; Kartikasari et al., 2022)

No	Creative Thinking Skills	Indicators
1	Fluency	Express several ideas, strategies, suggestions, answers, problem-solving, questions smoothly
2	Flexibility	Create various ideas, answers, questions, perceive problems from other points of view, and appear for alternative solutions to other problems
3	Originality	Put forward new and original alternative solutions
4	Elaboration	Develop new ideas and products

Apart from questionnaires, interview techniques are also used to collect data. In interviews, interview guidelines are used to guide the course of the interview. Interview techniques were carried out to collect qualitative data about prospective teachers' perspectives on the use of the STEAMER-based hybrid learning project. The interview instrument contains question sentences. The instrument was also tested for content validity by experts. Things to look at include the validity of the interview language/sentences and the content of the interview question sentences (to test the suitability of the questions to the research topic). The results of expert validation prove that the interview instrument is suitable for use in terms of language and content to collect data.

The data were analyzed quantitatively and qualitatively, and the data were in the form of numbers calculated by cumulating and comparing them to obtain a feasibility percentage. Quantitative data analysis was carried out by calculating content validity by experts regarding the learning model developed (STEAMER-based hybrid learning project). Testing is limited to using an equation regarding the percentage of product suitability. The feasibility analysis used the following equation:

$$\text{Feasibility percentage (\%)} = \frac{score\ obtained}{score\ expected} \times 100\%$$

The results of the calculation were converted based on the Table 4:

Table 4. Feasibility Percentage

Achievement Percentage	Feasibility classification
76% - 100%	Very feasible
51% - 75%	Feasible
26% - 50%	Moderate
0 – 25%	Not feasible

Meanwhile, qualitative data analysis was carried out using the interactive analysis method (referring to Miles & Huberman's theory). The data analysis process includes data reduction, data presentation, and drawing conclusions (Miles et al., 2013). Data reduction is carried out by selecting important data that is still related to the research topic and discarding data that is less relevant. Data presentation is carried out by changing raw data into data presented in the form of narratives, tables, or images. Conclusions are drawn by looking for common threads (conclusions) related to the focus of this research. Qualitative data analysis was accustomed to knowing the perspectives of the elementary school teacher candidates on the use of the STEAMER hybrid learning project on computational and creative thinking skills.

Findings/Results

Development of STEAMER-Based Hybrid Learning Project on Computational Thinking Skills and Creative Thinking Skills

Study activities started from the analysis stage. Based on the analysis, it was known that the computational thinking skills and creative thinking skills of the elementary school teacher candidates in the Science Education courses were considered low. Learning methods in the classroom were carried out through students' presentations and group discussions; the class was not regularly encouraged to have project-based learning methods, in particular the use of the STEAM approach in learning. The study at the analysis stage was accustomed as the basis for the development of the hybrid learning project STEAMER. The study of the model design was developed into several outputs which are shown in Table 5.

Table 5. Design of STEAMER Hybrid Learning Project

Names	Descriptions
Theoretical bases	The STEAMER hybrid learning project model is taken from constructivism theory, philosophical, psychological, cognitive, and andragogical foundations
Learning model books	Contains theory, syntax models, reaction principles, social and support systems as well as instructional and supporting impacts.
Lesson plan	Consists of instructions in every meeting. The instructions integrate the stages of the hybrid learning project STEAMER model
Learning materials	The learning materials being developed are materials of Science Education for elementary school levels.
Student's worksheet	Designed for elementary school teacher candidates to develop computational and creative thinking skills. It refers to the steps of the hybrid learning project STEAMER.
Assessment	To quantify the computational and creative thinking skills of the elementary school teachers' candidates after using the model.

The model book has described the design of the learning model being developed. The design results are shown in Figure 3.

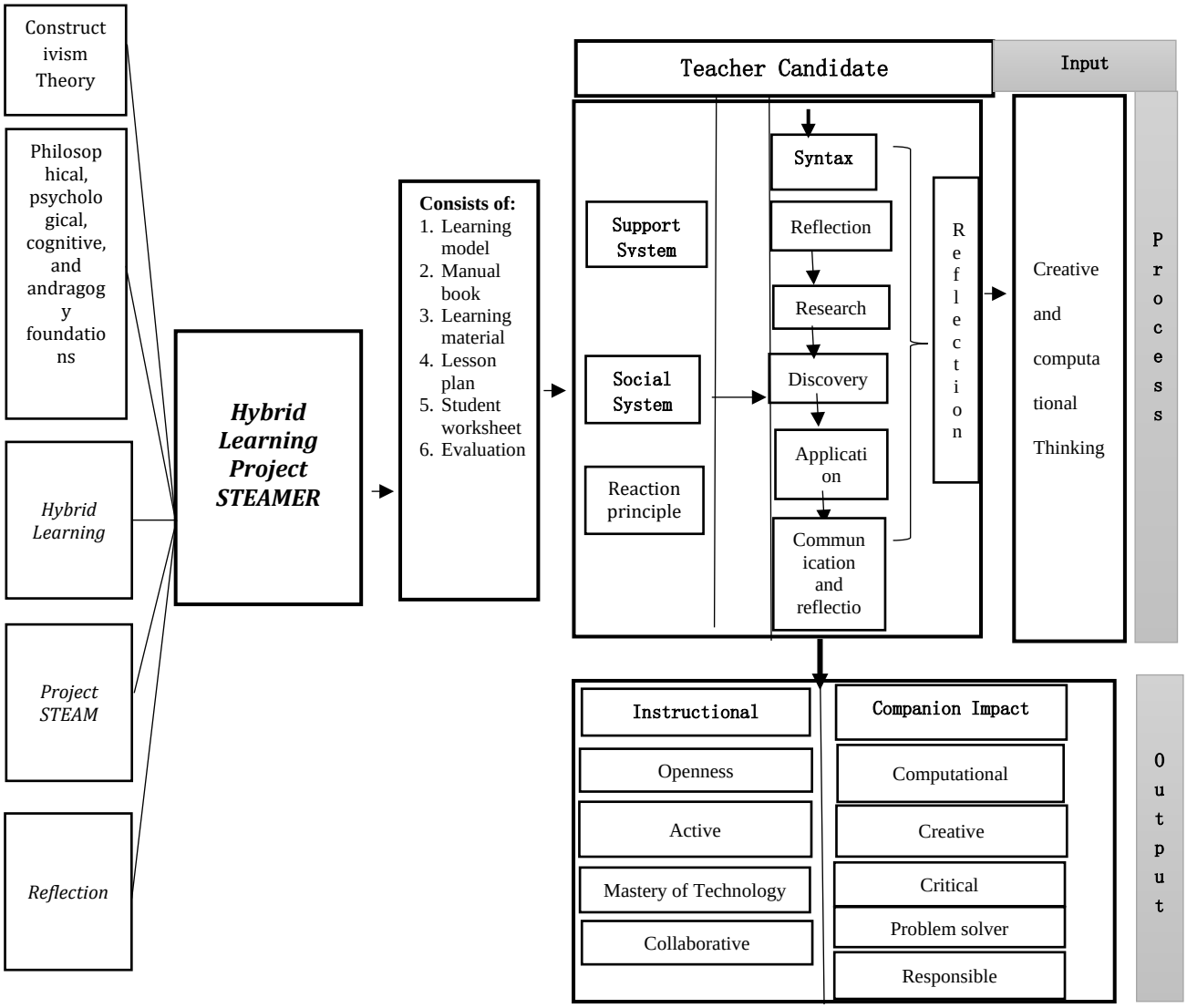

Figure 3. Hypothetic Model of STEAMER Hybrid Learning Project

Based on the design shown in Figure 3, the STEAMER-based hybrid learning project was developed based on constructivism theory and four basic principles of Pancasila education, hybrid learning, and the integration of reflection. This model combined synchronous and asynchronous learning through the merger of project-based learning models and STEAMER. This model illustrated that a person learns starting from constructing his thoughts on the environment and experiences.

The stages of the STEAMER hybrid learning project model begin with reflection. (a) Initially, an elementary school teacher candidate is accustomed to problems regarding elementary school science. The STEAM problem-based approach should refer to multidisciplinary perspectives. Reflection is carried out to analyze the causes of problems that occur based on STEAM. (b) The second stage is the research. Teacher candidates conduct research and investigate research problems that are formulated by linking STEAM. Prospective teachers are encouraged to develop several alternative solutions so that they know the strengths and weaknesses of the offered solutions. (c) The third stage is discovery. Prospective teachers plan strategies according to the results of previous identification. (d) The fourth stage is implementation. Prospective teachers implement the results of their work according to the initial plan and reflect on learning activities. (e) Communication and reflection is the fifth stage. Students convey project results and solutions, as well as talk about the learning process.

The implementation of a social system is openness, responsibility, and collaboration. The principles of openness and collaboration are needed during learning activities, in particular during discussion activities. The principle of openness is also essential during reflection. During discussion activities, teacher candidates should be able to have openness to

accept opinions from their peers. The principle of responsibility should be owned in carrying out the developed problem project.

The support system in this model consists of learning instruments in the form of lesson plans, syllabi, teaching materials, learning model manuals, worksheets, assessment rubrics, and learning design development worksheets. In the STEAMER project device, hybrid learning tools and adequate network quality are needed. In addition to its implementation, relevance, multidisciplinary, and up-to-date learning resources are needed. In detail, the three reaction principles of the model are providing challenges related to learning problems, providing guidance and feedback, and exploring alternative solutions to problems by integrating STEAMER as well as showing points of evaluation on the learning process.

The implementation of the learning that has been done, is expected to have instructional and accompanying impacts on the learning model. The instructional impact is that the teacher candidates can openly accept opinions from other friends. The next instructional impact is the increasing engagement, increasing mastery of technology, and ability to collaborate shown by the teacher candidates. Furthermore, the accompanying impacts of the model include responsible, creative, critical, computational thinking, problem-solving, and divergent thinking, as well as other scientific disciplines. This capability is trained with a series of project activities from the implementation of the model that has been accomplished.

The outputs of the implementation of the learning model that has been developed are then subjected to content validity by the experts. The outputs of the content validation test are shown in Figure 4.

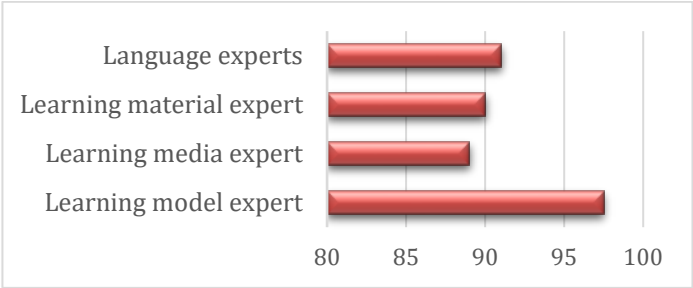

Figure 4. Results of Expert Validation

From Figure 4, it was gained the score from the learning model expert was 97.5% which was categorized as very feasible. In terms of other aspects, the scores given by the expert were 92%, and learning material experts and linguists scored respectively 90% and 91%. From these results, it can be concluded that the learning model is categorized as very feasible. However, there are also suggestions and feedback from the experts, especially the learning model experts who explained that the development should be based on strong knowledge and taxonomies; it is necessary to study various taxonomies, and the placement of reflections needs to be considered in designing learning. Based on the media validator, it is explained that the learning media used are quite varied, but it is necessary to consider the usefulness of the media and the effectiveness of the used media; it is necessary to sort out the learning media that are efficiently used in education. Furthermore, suggestions from the language validator are that there are still sentences that need to be examined again, especially adjustments with the level of language used according to the characteristics of the student levels. The validation from the material expert explained that the material being developed was still incomplete in-depth, so explanations, examples, and analogies related to the concept of Science Education for elementary schools still needed to be added. Suggestions and feedback from the experts are used as the basis for improvement of the learning model.

Perceptions of Prospective Elementary School Teachers on the Use of Development of STEAMER-Based Hybrid Learning Project

A survey involving the teacher candidates was attempted to view the perspectives toward the learning model that had been developed about improving computational and creative thinking skills. The study of the perceptions of the teacher candidates is shown in Figure 5.

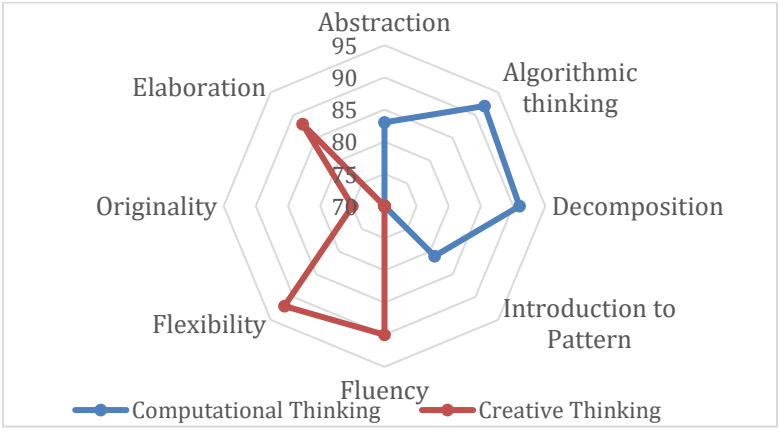

Figure 5. Perception of The Elementary School Candidate Teacher Towards This Model

Data on the perceptions of the teacher candidates show that the model can increase the computational thinking and creative thinking skills of the teachers. In detail, 82% of the teacher candidates perceive that the developed learning model can improve abstraction skills, 92% can use algorithmic thinking, 91% can develop decomposition skills, and 81% can do pattern recognition of solutions against the problems. In terms of creative thinking skills, 90% of the teacher candidates can develop fluency skills, 92% can develop flexibility skills, 75% can develop originality skills, and 88% can develop elaboration skills.

This was corroborated by the inquiry from the teacher candidates during the interview:

> "[...] *the ability to determine the pattern of a problem and the pattern of a lesson plan is quite difficult to develop because the instructions of the learning model developed don't train this. And it's not yet practical (abstract*)."

In terms of the ability to think creatively, it was known that the learning model being developed is considered insufficient to accommodate the ability to compile original ideas and solutions. The stance is indicated by the lower percentage of affirmation by the teachers (75%). One teacher candidate stated:

> "*In my opinion, the ability of students to come up with original ideas is less to be trained using this model because they are mostly taken from the Internet, which is ubiquitous and makes students unable to develop their originality. It would be nice if the worksheet emphasized originality. So, the students are able to determine their originality compared to pre-existing models."*

However, there are suggestions and feedback for the development of the model, along with his presentation according to the lecturer (HDA):

> "*In my opinion, this model is good and can develop students' computational and creative thinking skills because we're trained to reflect on the problems and formulate solutions to the learning problems. However, there are a few things that need to be added, namely in the manual which should be more specific and practical to use for anyone who wants to apply it." (HDA).*

From the data, it can be concluded that the computational thinking and creative thinking skills have been well-accommodated using the developed learning model. However, two indicators gained under 85% of the participants, namely the ability of abstraction and pattern recognition and the indicator of developing original ideas.

Discussion

Development of STEAMER-Based Hybrid Learning Project on The Computational Thinking Skills and Creative Thinking Skills

The STEAMER-based hybrid learning project was developed based on constructivism theory and the four foundations of Pancasila education. The philosophical foundation refers to Pancasila (the Indonesian state philosophy). Pancasila views human knowledge as obtained through faith/belief, thinking, empirical experience, appreciation, morals, knowledge, health, capability, independence, creativity, democracy, and responsibility. The implementation of the STEAMER hybrid learning project model develops the potential of students in all aspects through developing attitudes, skills, and cognitive abilities of students to enhance the development of science, technology, and art to face world work and the dynamics of global developments.

Furthermore, by developing models according to cognitive foundations, the STEAMER-based hybrid learning project model can maximize students' cognitive development. The increase in students' cognitive abilities is caused by the development of the syntax. This step is the output of development through the merger of project-based and STEAMER-based learning models. The research findings produce five steps, namely reflection, research, discovery, application, communication, and reflection. At the reflection stage, prospective elementary school teachers face problems according

to the material (Science Education in Elementary Schools). Providing problems at the beginning of lectures requires students to find solutions to existing problems. The aim of giving problems at the beginning of learning is that the students know the benefits of the material being studied in real life and they are motivated to complete it (Alam, 2020).

Then, at the research stage, prospective teachers must investigate the problem and connect it with STEAM. The inquiry process in learning helps students with critical and creative thinking skills (Wale & Bishaw, 2020; Wannapiroon & Pimdee, 2022). At the discovery stage, prospective teachers must design appropriate strategies. In designing strategies, prospective teachers must look at the strengths and weaknesses of the chosen strategy. This is a consideration so that the choices are following the initial plans and problems. At the application stage, prospective teachers apply the results of their work according to the initial plan. At the communication and reflection stage, prospective teachers communicate the outputs of the developed projects and the outputs of the proposed solutions. Communication and reflection are the stages of presenting the obtained results. Communication can go hand in hand with reflection. Good communication can provide positive reflection.

Then, based on psychosocial development, the participants are known for a period of intimacy and isolation (Slavin, 2020). At this time, it requires intimacy/closeness with people who are in their social environment. Based on this characteristic, the development of the model learning should include activities to accommodate group-based instructions to create closeness and engagement among the students which is expected to reduce feelings of isolation/withdrawal from the environment (their peers).

Furthermore, this study uses the basis of andragogy as the target of this learning model is university students (adult learners). Based on andragogy, it is explained that learning for adults as part of teacher education is expected to produce a learning community that respects each other; the material is practical and can be applied in everyday reality (Knowles et al., 2020; Remenick & Goralnik, 2019; Yusri, 2013). Based on this situation, the model implements learning by creating a learning community, connecting with needs in work, practice, and accordance with the characteristics of the research subject.

The STEAMER hybrid learning project is a learning model that is believed to develop creative and computational thinking skills. Computational thinking skills are developed through problems raised at the beginning of the learning model that stimulate students' thinking skills to analyze and identify the problems (decomposition I) and to determine the pattern of the problems given to drive the conclusions based on the problem (abstraction). Furthermore, the problems that have been understood are used as the basis for developing solutions in the form of learning designs. In designing the learning, the teacher candidates are anticipated to determine the given learning steps (algorithmic thinking). Final of the activity, the teacher candidates determine the patterns and characteristics of problem-solving that have been developed compared to their peers (recognition of problem-solving patterns). This activity can refer to aspects of computational thinking that have been described previously.

Creative thinking skills are developed from the process of developing learning projects that integrate STEAM. The elementary school teacher candidates will be more creative in finding solutions to the learning problems based on various multidisciplines (different perspectives). Apart from these problems, they also can generate various new ideas and propose alternative approaches to overcome existing learning problems. The PJBL learning model is believed to increase student engagement (Almulla, 2020), student abilities (Baptist et al., 2020), understanding (Hudiananingsih et al., 2019), critical thinking (Issa & Khataibeh, 2021), meaningful learning and improve student learning outcomes (Hsbollah & Hassan, 2022), while STEAM learning in specific can develop student creativity, problem-solving skills, critical thinking, and imagination (Katz-Buonincontro, 2018; Tabiin, 2019; Wilson & Hawkins et al., 2019; Zayyinah et al., 2022). Reflection can improve thinking skills, problem-solving, creativity, and evaluative thinking (Santrock, 2011).

Perceptions of Prospective Elementary School Teachers on the Use of Development of STEAMER-Based Hybrid Learning Project

The study outputs display that computational thinking and creative thinking skills have been accommodated well using the developed learning model, however, indicators of abstraction and pattern recognition abilities as well as indicators of developing original ideas only obtain results below 85%. These findings are reasonable since elementary school teachers' candidates consider the STEAMER-based hybrid learning model to be practical and interesting, especially in the use of microsites and learning videos. This reason is in line with the benefits of using video. Learning videos assist students in learning (Skukauskaitė & Girdzijauskienė, 2021), understanding learning material, and supporting learning (Richards et al., 2021). Learning videos can improve the quality of learning, increase interest and attention, student learning achievement, and improve concept mastery (Gaston & Havard, 2019; Murwaningsih et al., 2023).

The application of the hybrid learning model has been demonstrated to be able to generate good perceptions from prospective teachers. The theory of the hybrid learning concept is defined as active learning that is student-centered and being able to understand existing concepts (Anzari et al., 2021). This model combines various technological media to solve problems in learning. Students have more freedom to study the material when using the hybrid learning model. Using a variety of technological media is a strategy that many students are interested in. Previous findings concluded that students gave positive perceptions of online lectures with technology-based media (Chamdani et al., 2022). The outputs

of this study are also in tune with previous findings which state that the STEAM-based Hybrid PBL learning model is able to maximize students' conceptual understanding with moderate results (Chusna & Yoto, 2023). This means that the use of the model has been implemented well so that the obtained results are also good.

Apart from that, prospective teachers also think that the STEAMER-based hybrid model is able to maximize their creativity naturally. These findings are consistent with the advantages of the STEAMER approach. It has the advantage of enabling students to solve problems and have the ability to think broadly. Apart from that, judging from the syntax, the STEAMER approach has systematic and comprehensive steps, such as asking questions (science), formulating answers (science & mathematics), applying case studies (engineering & technology), motivating questions (science), asking questions (questions and answers & science), awards (art), and reporting (art) (Domenici, 2022; Kummanee et al., 2020). Each of these steps accommodates students or prospective teachers to be more creative and computational. In previous research, the problem-based hybrid learning model with the STEAM approach was applied in two groups of classes, namely classes with high-ranking of student participation and classes with low levels of student participation (Utomo et al., 2023). The use of STEAM is an innovative learning method that integrates five scientific principles to solve learning problems. In addition, previous surveys also show that giving positive responses about STEAM and considering it as a new thing that is beneficial to the student experience (Susiani et al., 2020).

The findings showed that indicators of abstraction and pattern recognition abilities as well as indicators of original idea development obtained results below 85%. Meanwhile, indicators of algorithmic thinking and decomposition on computational thinking skills, as well as indicators of fluency, flexibility, and elaboration on creative thinking skills obtained adequate results above 85%. The differences in results are due to the level of difficulty in achieving indicators of abstraction ability, pattern recognition, and developing original ideas. These three indicators are difficult to achieve. In accordance with the theory of abstraction and generalization abilities, Doleck et al. (2017) explain that these two abilities have different definitions. Abstraction is related to making meaning from data that has been found and its implications, while generalization is a precise and responsive effort to solve problems, whether similar or not. Judging from the definition, in achieving abstraction and generalization abilities, students must be able to use fast methods by selecting and connecting several pieces of information correctly. This method has not been implemented optimally by students due to the limited information that they have. The level of speed that must be used is also an obstacle in this indicator which is not optimal since the studied material is quite extensive and must go through a gradual practicum process.

Then, looking at the definition of pattern recognition, Csizmadia et al. (2015) explain that pattern recognition is the skill of identifying, recognizing, and developing patterns, relationships, and strategies used to understand large data and strengthen abstraction ideas. From this definition, it is implied that pattern recognition requires students to recognize and develop patterns, relationships, or similarities to understand the information and used strategies. Therefore, students can generate patterns as a system of equations since each equation has a relationship between one and the others. The process considered difficult is when students have to develop connections between patterns so that the obtained results are not optimal.

On the other hand, in the aspect of creative thinking skills, the originality indicator is the indicator with the lowest results compared to other indicators. This is appropriate for the definition of originality, namely the ability to create original and unique ideas. In creating ideas, someone needs inspiration which cannot just appear. Creating new ideas takes time and different conditions than simply continuing ideas that are already available. This finding is also in line with previous findings that the originality indicator is the lowest indicator obtained by students in learning (Murwaningsih & Fauziah, 2022).

Conclusion

The research findings conclude two main points. First, the STEAMER hybrid learning project model has been constructed based on constructivism theory, philosophical foundation, cognitive, psychosocial, and andragogy. The development of this model combines synchronous and asynchronous learning through project learning and STEAMER with stages of presenting problems about elementary school science, research investigations, discovery, implementation, as well as communication and reflection. Second, the results of surveys and interviews show that the learning model can develop the computational and creative thinking abilities of the students as teacher candidates. In addition, the learning model is considered practical and interesting because it is equipped with a variety of learning media.

Recommendation

Future researchers should develop learning models that include group-based instruction activities to create closeness and involvement among students which is expected to reduce feelings of isolation/withdrawal from the environment (peers). In designing learning, prospective teachers are also intended to determine the learning steps given (algorithmic thinking). Prospective teachers must also determine the problem-solving patterns and characteristics that have been developed compared to their colleagues (recognition of problem-solving patterns).

Limitations

There are two indicators that have not been optimally achieved, namely the abstraction indicator and pattern recognition on the variable computational thinking ability. In the creative thinking variable, the indicator that has not been achieved is originality. This variable gets a low score because habituation to the learning model has not appeared.

Ethics Statements

The studies involving human participants were reviewed and approved by the Universitas PGRI Kanjuruhan Malang. The participants provided their written informed consent to participate in this study.

Conflict of Interest

"Conflict of interest in this research includes a conflict between financial gain, meticulous completion and reporting of this research study".

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Authorship Contribution Statement

Kumala: Writing, Analysis, Conceptualization. Yasa: Writing, Analysis. Salimi: Supervision. Sueb: Editing/ reviewing.

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