Analysis of the Need to Develop an Integrated Eco-STEAM Deep Learning Model Based on Edutainment to Improve Computational Thinking in Elementary School Students

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Abstract. This study aims to analyze the need for developing a deep learning model based on the Eco-STEAM approach integrated with edutainment media to improve elementary school students' computational thinking (CT) skills in mathematics learning. The research was conducted in six public elementary schools in West Sumatra Province using an exploratory descriptive approach with a mixed-methods design. The sample consisted of 30 teachers and 180 students selected through purposive and proportional random sampling, based on criteria such as teaching experience, digital readiness, and diverse social backgrounds. Data were collected through closed and open questionnaires, semi-structured interviews, and document analysis. The results showed that 70% of teachers reported understanding the concept of CT, but only 30% had implemented it in practice. Furthermore, only 40% could identify CT subcomponents such as algorithms, decomposition, and pattern recognition. Major barriers included limited technological facilities (90%), time constraints in curriculum delivery (80%), and a lack of training on CT and deep learning (73.3%). Regarding learning needs, 100% of teachers highlighted the importance of integrating environmental literacy (Eco-STEAM), 93.3% requested interactive edutainment-based media, and 86.7% emphasized adaptive learning features. From the student side, 88.9% were more motivated when the material was linked to real-life environmental contexts, and 83.3% enjoyed learning through games and contextual projects. These findings reveal a strong need for innovative, contextual, and engaging learning models that align with the infrastructure limitations of Indonesian elementary schools. A model that integrates Eco-STEAM, edutainment media, and deep learning principles has the potential to effectively enhance students' computational thinking skills in line with 21st-century educational demands.
Keyword: STEAM, Deep Learning, Computational thinking

1. INTRODUCTION

In this era of digitalization and globalization, mastery of computational thinking (CT) from primary education onwards is crucial [1]–[10]. Computational thinking is not only about programming skills, but also includes the ability to decompose problems, recognize patterns, perform abstractions, and design algorithms as part of systematic thinking and problem-solving skills [11],[12]. Research by Mariana and Kristanto shows that an integrative approach between STEAM and CT can improve students' creative and critical thinking skills, especially in innovative learning and problem solving [13]. However, the reality in the field shows that mathematics and ICT learning in elementary schools is still conventional. Teachers tend to use lecture methods and exercises emphasizing memorization rather than in-depth understanding of concepts. This results in low student engagement and the lack of systematic computational thinking. The use of educational technology is still limited, and interactive learning models—especially those based on edutainment—have not been widely implemented in classrooms.

In this context, developing a learning model based on deep learning pedagogy is important [14]–[18]. Deep learning does not refer to artificial intelligence technology, but rather a pedagogical approach that encourages students

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to build meaningful understanding through active engagement, reflection, connections between concepts, and applying knowledge in authentic contexts[19]–[21]. Based learning models that adopt this principle are believed to equip students with higher-order thinking skills, including computational thinking, which are essential in the 21st century. In line with this, the Eco-STEAM approach has emerged, which is the development of STEAM learning that integrates environmental literacy as a fundamental value of learning. Environmental issues (eco-literacy) are becoming increasingly important to introduce early, especially in shaping a generation aware of ecosystems, climate change, and nature conservation. Ernawati emphasize that basic education is a strategic point in instilling environmental values, and this can be achieved through concrete and reflective activity-based learning [22]. On the other hand, the concept of edutainment—a combination of education and entertainment—is becoming increasingly relevant to increasing student engagement and motivation. Fun, visual, and interactive learning has been proven more appealing to children and positively impacts concept understanding. Research by Indriani, Nurlita, and Rizky proves that the use of game-based edutainment media and educational videos can significantly increase student participation and help internalize values in the context of environmental learning [23].

Although these various approaches have been studied partially, significant research gaps exist. First, not many studies explicitly combine the deep learning pedagogy, Eco-STEAM, and edutainment approaches in an integrated learning model at the elementary school level. The study by Mariana and Kristanto focuses more on integrating STEAM and CT, but does not touch on ecology and interactive media [13]. Second, although research on eco-literacy in primary education has begun to develop, the approaches used tend to be thematic and are not yet integrated with the CT framework or edutainment media [6]. Third, much CT research at the elementary school level still focuses on introducing coding (e.g., robotics or Scratch), rather than on developing computational thinking through reflective and enjoyable interdisciplinary learning [24]. From these gaps, it is evident that there is still very little innovation in learning that integrates deep learning, Eco-STEAM, and edutainment to shape the computational thinking of elementary school students. This is where the novelty of this research lies: developing a preliminary design for a learning model that is deep learning, contextual (environment-based), and enjoyable (edutainment) learning model focused on strengthening the computational thinking of elementary school students in mathematics and science learning.

This study aims to analyze the needs of teachers and students for the development of an edutainment-integrated Eco-STEAM-based deep learning model in the context of mathematics learning in elementary schools. This analysis includes understanding teachers' obstacles, student readiness, and the learning features needed to support computational thinking skills. Practically, this research contributes as a starting point for developing innovative, enjoyable, and contextual learning models at the elementary school level. Theoretically, this research broadens the horizon of integrative learning approaches by combining three components that have not been studied simultaneously: deep learning pedagogy, environmental literacy, and edutainment media—all to improve students' computational thinking competencies in the 21st century.

2. RESEARCH METHOD

This study uses an exploratory descriptive approach with mixed methods, combining quantitative and qualitative approaches to obtain a comprehensive understanding of the need to develop an integrated Eco-STEAM deep learning learning model based on edutainment to improve the computational thinking of elementary school students in mathematics.

A. Research Location and Time

This research was conducted in six public elementary schools spread across five administrative regions in West Sumatra Province, namely:

- Bukittinggi City
- Padang City
- Agam Regency
- Tanah Datar Regency
- Solok Regency

The six schools were selected purposively, considering geographical context (urban and semi-rural), implementation of the Merdeka Curriculum, and openness to innovative learning approaches and digital technology. The research took place from May to July 2025, covering the stages of instrument development, data collection, and analysis.

B. Research Subjects

The research subjects involved:

- 30 fourth- to sixth-grade teachers, with 5 teachers from each administrative region
- 180 elementary school students, with 30 students from each school
- 6 school principals, one from each school

Using purposive sampling, teachers and principals were selected based on the following criteria: at least 5 years of teaching experience, previous implementation of project-based learning or STEAM, and openness to digital learning innovations. Students were selected using proportional random sampling, considering diversity in social background and academic ability.

C. Data Collection Techniques

Data collection techniques consisted of:

1. Data collection techniques consisted of: Closed and Open Questionnaires
   This was used to collect data on teachers' and students' perceptions of current learning conditions, the need for innovative learning models, and the potential for integrating deep learning, Eco-STEAM, and edutainment components. The teacher questionnaire consisted of 30 statements using a 1–5 Likert scale, while the student questionnaire consisted of 20 statements with simplified language.
2. Semi-Structured Interviews
   Conducted with teachers and principals to explore their experiences, challenges, and expectations regarding learning that supports the development of computational thinking and environmental literacy through fun and interactive media.
3. Documentation Study
   This includes analyzing learning tools such as syllabi, lesson plans, and worksheets used in mathematics lessons. The analysis aims to identify how much CT elements, STEAM approaches, and environmental values have been accommodated in current learning.

D. Research Instruments

Rresearch instruments consist of:

- Teacher and student questionnaires (Likert scale and open-ended questions)
- Interview guides for teachers and principals
- Document analysis format for examining elements of deep learning, 21st-century skills, and environmental literacy

The instruments were developed based on the latest theoretical studies on computational thinking, deep learning, STEAM, and edutainment (Wing, 2006; Brennan & Resnick, 2012; Hattie, 2009) and validated through content validity testing by two experts in basic education and learning technology.

E. Data Analysis Techniques

- Quantitative data were analyzed descriptively using percentages, means, and standard deviations to map learning needs based on the perceptions of teachers and students.
- Qualitative data were analyzed using thematic analysis techniques (Braun & Clarke, 2006), with stages of open coding, categorization, and identifying dominant themes.
- Method and source triangulation were conducted to improve the validity and credibility of the data by comparing the results of questionnaires, interviews, and documentation

F. Research Ethics

This study has complied with academic ethical principles by ensuring informed consent from all respondents, guaranteeing confidentiality, and using data exclusively for scientific research. The entire process was conducted using a participatory approach and upholding the rights of research subjects.

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3. RESULTS AND DISCUSSION

A. Result

This section presents the findings from the data collection obtained through questionnaires, in-depth interviews, and analysis of learning documentation from six public elementary schools in West Sumatra Province. This study aims to identify the real needs of teachers and students in developing an Eco-STEAM-based deep learning model integrated with edutainment to improve computational thinking in mathematics learning. The findings are presented in five subsections: initial understanding, obstacles, feature requirements, teacher expectations, and comparison with previous studies.

1. Teachers' and Students' Understanding of Computational Thinking

Initial data showed that teachers' understanding of computational thinking (CT) was not uniform, and its implementation in learning was still minimal.

TABLE 1. Teachers' understanding and practice of computational thinking

No	Indicator	Number of Teachers (n=30)	Percentage
1	Understanding the concept of *computational thinking*	21	70
2	Implementing it in mathematics learning	9	30
3	Understanding CT subcomponents (algorithms, abstraction, patterns, etc.)	12	40

From Table 1, 70% of teachers stated that they generally understood the concept of CT, but only 30% admitted having explicitly integrated CT components into their teaching activities. Even among those 30 teachers, only 40% could identify CT subcomponents such as decomposition, pattern recognition, and algorithmic thinking. This shows that the implementation of CT in elementary schools is still limited to conceptual understanding, without being supported by consistent pedagogical practices. Research by Li and Oon (2024) also reinforces this finding, where they found that teachers at the elementary education level generally do not yet have a structured approach to developing CT systematically.

2. Teachers' Barriers to Implementing Innovative Learning

Teachers face various challenges in implementing learning approaches that promote 21st-century skills, particularly computational thinking.

TABLE 2. Barriers faced by teachers

No	Barrier	Number of Teachers	Percentage
1	Limited facilities and technology	27	90
2	Learning time is too limited	24	80
3	Lack of training/knowledge about CT	22	73.3

From Table 2, most teachers (90%) cited limited facilities, such as the number of computers or unstable internet connections, as the main obstacle. In addition, the pressure to complete the curriculum resulted in limited time for exploring new learning methods (80%). Teachers' unpreparedness was also a challenge, with 73.3% admitting that they had never received training related to CT.

The following interview excerpt confirms this:

"The mathematics material is already dense, and there is no time for exploratory activities such as problem solving or coding."
(Mathematics Teacher, Bukittinggi Public Elementary School)
"We are not trained to create CT-based learning. We usually just follow examples from textbooks."
(IPAS teacher, Padang Public Elementary School)
"Edutainment media is good, but our internet connection and number of devices are limited."
(Fifth Grade Teacher, Agam Public Elementary School)

These quotes show that the obstacles are not only technical, but also related to policy and teacher readiness. CT-based learning requires structural support and ongoing training in order to be fully adopted.

3. Teachers' and Students' Needs for Learning Model Features

Teachers and students expressed various needs regarding the ideal features in the learning model to be developed.

TABLE 3. Teachers' needs for model features

No	Expected Features	Number of Teachers	Percentage

1	Interactive media based on edutainment	28	93.3
2	Difficulty differentiation (adaptive learning)	26	86.7
3	Environmental literacy integration (Eco-STEAM)	30	100
4	Visual feedback / real-time student progress	25	83

From Table 3, almost all teachers hope to use fun interactive learning media, such as simulations, animations, and educational games. In addition, features such as difficulty level adjustment (adaptive learning), integration of environmental issues (Eco-STEAM), and visual feedback systems are crucial for students to be motivated and get a contextual learning experience.

TABLE 4. Student responses to innovative learning models

No	Statement	Number of Students	Percentage
1	Enjoy learning through games or environmental projects	150	83.3
2	Motivated when material is related to the surrounding environment	160	88.9
3	Enjoy seeing learning progress in the form of graphs/badges/levels	140	77.8

From Table 4, most students feel more enthusiastic when learning is conducted using a project or game-based approach. They also show a high interest in learning based on the local environment that can be linked to mathematics topics. This supports the Eco-STEAM approach as a relevant development framework for the needs of elementary school students in Indonesia.

4. Teachers' Expectations for the Integration of Eco-STEAM and Edutainment

Teachers expressed their hopes for a learning approach that is not only enjoyable but also contextual and capable of building environmental awareness. Teacher Interview Quotes:

"Students understand faster when learning mathematics through real projects, such as calculating the volume of planting media or measuring rainfall."
(Math Teacher, Tanah Datar Public Elementary School)
"Games from abroad are sometimes not suitable for our students. I hope there will be media that uses our local culture and language."
(Science Teacher, Solok State Elementary School)
"We need media that can be used offline. If we rely on the internet, many students will be left behind."
(Sixth-grade Teacher, Bukittinggi State Elementary School)

The teachers' statements emphasize that the ideal learning model combines local contextualization (culture and environment), technological flexibility, and educational entertainment elements. This reflects real needs in the field and reinforces the urgency of developing a holistically designed model.

Overall, the findings from questionnaires, interviews, and document analysis at six public elementary schools in West Sumatra show that understanding of computational thinking is still limited, and its implementation in mathematics learning has not been systematically structured. Teachers and students showed great enthusiasm for developing innovative learning models that integrate the Eco-STEAM and edutainment approaches, hoping that these models can provide meaningful, contextual learning that is adaptive to the conditions and limitations of school infrastructure. These results provide a strong basis for designing relevant and applicable deep learning models and serve as a foundation for the next stage of development.

B. Discussion

The results of this study reveal that although most teachers understand the concept of computational thinking (CT), its implementation in mathematics learning in elementary schools is still limited. Most teachers cannot explicitly integrate CT into systematic learning activities, and students are not yet fully involved in learning activities that reflect computational thinking skills. The main obstacles include limited technological facilities, limited time to complete the curriculum, and a lack of training or guidance related to the CT approach and deep learning. On the other hand, teachers and students show a high need for contextual, enjoyable, and in-depth learning models integrated with an environmental (Eco-STEAM) approach and edutainment media.

These findings align with the research objectives: to analyze the need to develop a deep learning-based learning model with an Eco-STEAM approach integrated through edutainment media. These needs reflect expectations for innovative and enjoyable learning and emphasize the importance of integrating environmental values and local contextualization in mathematics learning. This shows that the development of learning models needs to be adapted to real needs in the field, in terms of content, approach, and learning media used.

This research is in line with the findings of Mariana and Kristanto, which show that the simultaneous integration of STEAM and CT education can improve elementary school students' critical and creative thinking skills [13]. The study emphasizes the importance of interdisciplinary learning that prioritizes meaningful and contextual learning experiences. Meanwhile, Küçük et al. through the SP-STEAM model, found that project-based learning integrated with environmental issues can increase student participation and deeper understanding of concepts [25]. A similar study was also conducted by Suparman et al., which showed that although the CT approach is increasingly being adopted in mathematics learning, learning models that combine environmental literacy and edutainment media are rarely developed, especially at the elementary school level[26].

Furthermore, the results of this study are also reinforced by a meta-analysis by Li and Oon, which found that integrating CT in learning effectively improves students' problem-solving [27]. However, the approaches used are generally still instructional and do not yet take full advantage of the potential of interactive media or locally based approaches. In the Indonesian context, research by Indriani, Nurlita, and Rizky also confirms that edutainment-based learning media can significantly increase the learning motivation of elementary school students [23]. However, their use is still sporadic and has not been integrated into STEAM-based or environmental learning models.

The interpretation of these results shows that mathematics learning in elementary schools needs to be designed within the framework of deep learning pedagogy that allows students to build deep, reflective understanding and develop higher-order thinking skills such as CT. The Eco-STEAM approach provides opportunities to deliver learning that is not only cognitive but also affective and psychomotor, by linking the material to environmental issues and students' daily lives. Meanwhile, using edutainment as a learning medium is important in creating a fun, interactive, and motivating learning atmosphere, especially for elementary school students who need visual stimuli and varied creative activities.

However, this study has several limitations. First, the scope of the research location was limited to six public elementary schools in five administrative areas of West Sumatra Province, so the results cannot necessarily be generalized to the entire context of basic education in Indonesia. Second, the research approach was still descriptive and analytical, using simple qualitative and quantitative methods, so it could not directly measure the impact of the model's implementation on improving students' CT. Third, other factors such as the role of the principal, the school curriculum, and the students' socioeconomic background have not been analyzed in depth.

Therefore, further research is recommended to develop a learning model based on the identified needs. The prototype model needs to be tested through a quasi-experimental approach or a limited implementation study to assess its effectiveness in improving students' CT abilities. In addition, further exploration is needed on the influence of integrating locally-based edutainment and environmental issues on students' learning motivation and character. Future research can also expand the scope of the research context to various regions, including areas with more extreme technological infrastructure limitations.

4. CONCLUSION

Based on the research results, teachers and students in elementary schools have a high need for innovative learning models capable of integrating deep learning, the Eco-STEAM approach, and edutainment media to support the development of computational thinking in mathematics learning. Although there is a basic understanding of CT among teachers, its implementation is still minimal due to facilities, time, and training limitations. Teachers hope for contextual, enjoyable, and flexible learning media, while students respond positively to interactive and environment-based project approaches. Therefore, it is recommended that the development of Eco-STEAM-based learning models integrated with edutainment be continued to the prototype design and limited testing stages, considering the technical conditions in elementary schools and accommodating aspects of locality and technological affordability so that implementation can be carried out sustainably and inclusively.

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