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Implementation of Science Module Based on Microcontroller to Improve Students' Computational Thinking Skills in Earth Science Course

Mustofa[1*], Joko Waluyo[1], Yushardi[1], Zainur Rasyid Ridlo[1]

[1]Department of Science Education, Faculty of Education, University of Jember, Indonesia.

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Corresponding Author:
Mustofa
mr.tofa30@gmail.com

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Abstract: The aim of this research is to explore the computational thinking skills using Microcontroller under implementation of science module. Computational thinking is not only an investment in computer science, but can be applied across disciplines as a step towards solving higher-order thinking problems. Improving computational thinking skills helps students to adapt to the digital age of the 21st century. To improve these skills, a tool or media is needed, such as a learning module, that can guide students in performing activities in this area. This module contains student activity using microcontrollers as a tool for collecting data. The analysis data include practicality and effectiveness of the science module. The method used was a group pre-post test as learning assessment and use practicality observation sheet, student pretest - posttest and student response questionnaire. The results of this study are the practicality of 92% which is declared very practical, and the effectiveness of 0.78 obtained from the n-gain analysis which means it is quite effective, the p-value of paired sample t-test is less than the threshold of 0.05 which indicates a significant increase in students' computational thinking skills and direct student experience in connecting sensors related to technological applications applied in the world of agriculture and get a positive response with a score of 72% with a good category. From the results of the analysis obtained, it can be concluded that the implementation of the module can improve students' computational thinking skills.

Keywords: Computational thinking; Microcontroller; Science module

Introduction

Education is an important component in determining the quality of human resources in both developed and developing countries (Akbar et al., 2024). Technological advances in education provide opportunities for educational institutions to further adapt to improve the quality of learning (Angraini et al., 2022). The development of educational technology, including learning media infrastructure and the advancement of various disciplines, as well as the mastery of information technology and learning innovation techniques must be implemented in the world of education (Qibtiyah & Sukarmin, 2022). To navigate the Industrial Revolution 4.0 and create a generation capable of surviving and competing, several preparatory steps are necessary, including the development of innovative learning systems, adaptive policy adjustments, and the preparation of responsive, adaptive, and competent human resources to face these changes (Mustofa et al., 2023).

One crucial skill that supports the rapid development of information technology is computational thinking (Barr et al., 2011). Computational thinking is a way to find solutions to problems from input data by using an algorithm as well as applying techniques used by software in writing programs (Cahdriyana & Richardo, 2020).

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Computational thinking is a structured approach to problem-solving that involves breaking down complex problems into smaller, more manageable parts and applying algorithmic processes to find solutions (Anistyasari, 2020). It draws from concepts used in software programming but extends beyond computer science, making it applicable to a wide range of disciplines (Csizmadia et al., 2015). This conceptualization is closely linked to the concepts and practices of Computer Science (CS) — that is, thinking like a computer scientist — which has been proposed as an intellectual framework for thinking (Dilber et al., 2009). Caeli & Yadav (2020) offer historical perspectives on CT and highlight how current initiatives can inspire students to engage with and learn CS. Computational thinking redirects attention from programming and coding lessons to areas such as problem-solving across different disciplines through the use of coding or other CT skills (Basu et al., 2020). According to Fitriani et al. (2021) today, computational thought concepts are the subject of much discussion in educational research. Recognizing the significance of computational skills, which encompass related terms like information technology and digital skills, numerous articles address the challenges of teaching programming in education (Fülöp et al., 2022). A range of both digital and non-digital games has been utilized to engage learners in computational thinking practices and computer programming (Asbell-Clark et al., 2021). Although it is widely recognized in the literature that computational thinking (CT) encompasses various skills, such as problem decomposition (breaking complex problems into simpler ones), algorithm development (creating step-by-step solutions), and abstraction, there is still limited evidence regarding the challenges and issues one must consider when designing effective learning experiences for CT competencies (Angeli & Diannakos, 2020).

This method consists of several key components, which is, decomposition is breaking down a complex problem into smaller, more understandable sub-problems (Palts & Pedaste, 2020). This makes it easier to tackle each part individually before integrating them into a complete solution (Saad, 2020). Pattern recognition is identifying similarities or trends in problems, which helps in predicting outcomes and applying previously learned solutions to new situations (Yadav et al., 2017). Abstraction is filtering out unnecessary details to focus on the essential elements of a problem, making it more efficient to process information (Sa'adah et al., 2023). Ridlo et al. (2021) further emphasize that computational thinking can train students to analyze, identify, and develop solutions to problems.

In recent years, many countries have introduced the concept of Computational Thinking (CT) into compulsory education as part of general curriculum reform efforts (Kampylis et al., 2023). However, in Indonesia, the introduction of computational thinking skills is still limited because lack of self-reliance learn can also cause a lack of decision-making ability (Nuraini et al., 2023). Computational thinking (CT) is highly relevant and important in science learning because it enhances problem-solving abilities, analytical skills, and the capacity to work with complex data. The Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) has conducted an internal study revealing constraints in the implementation of computational thinking learning (Ridlo et al., 2021). A survey conducted by Zulfaniar et al. (2024) found that conventional teaching models are still frequently used, causing students to feel bored and drowsy during lessons.

An alternative approach to enhancing students' computational thinking in earth sciences is through the use of microcontroller-assisted modules as teaching materials. The use of microcontroller-based learning media has been tested by Manalu in Husada et al. (2020), demonstrating that microcontroller learning media can be adapted to meet students' needs, helping them master the material more effectively. Similarly, Morton in Husada et al. (2020), in his study titled "A Student Constructed Microprocessor Development Board for Teaching Microcontrollers," found that students were more engaged and interested when assembling and programming circuits themselves, as they felt a sense of ownership over their work.

Field observations indicate that the low level of computational thinking among students is due to lecturers relying on limited references without developing their own teaching materials to support learning activities (Yayuk, 2019). Learning using interactive multimedia-based teaching materials can improve students' CT abilities, this is certainly new because so far research that links the application of interactive multimedia, in this case using quizizz as a tool in completing practice questions from algebraic structure material to improve computational thinking skills has not been found (Angraini et al., 2022). Additionally, the lack of engaging learning media, such as interactive modules, has hindered students' computational thinking development. Therefore, developing teaching materials is essential for improving students' computational thinking skills. In the 21st century, technological advancements are accelerating, making computational thinking crucial for both students and learners (Tabesh, 2017). Computational thinking involves understanding problems, reasoning through them, and developing automated solutions (Ramadhani

& Yahfizham, 2024). This development aims to meet students' needs in facing 21st-century challenges and enhance the quality of higher education learning in line with the rapid advancement of educational technology. Most research on computational thinking focuses on computer science or mathematics. This study has a different focus. This study offers a new approach by using microcontrollers in learning earth science, which is rarely done in previous research.

Method

Research Design

This research conducted one group pretest-posttest. Serves as a robust framework for assessing the practicality and effectiveness of an implementation of a science module based on a microcontroller by establishing students' pretest score measurements prior to its implementation and comparing them with students' posttest score after learning used science module. This research will measure practicality and effectiveness of implementation of science module and its impact on improving students' computational thinking skills.

The practicality of the module was carried out by observing the implementation of learning by three observers in each meeting through the practicality observation sheet, this sheet employed questionnaires using Likert scale 1-4 will be filled by observers and the scores obtained will be aligned with category following in the Table 1.

The effectiveness of the module was carried out within two analyses, they are N-gain score and students' response questionnaires. Students will do the tests pretest and posttest, the test scores will then be analyzed using the N-gain score so that it can be seen how much improvement of implementation of the module. The N-gain value can be determined using the following calculation formula according to Hake (1998) and its score will be aligned following Table 2. Additionally, the student response questionnaire to gain students' feedback after they learn used module based on microcontroller and its activities inside and to measure the effectiveness of implementation. The student response questionnaire will be analyzed using a Likert scale 1-4 and the scores obtained will be aligned with the same category as practicality score following the Table 1 below. All the formula to measure practicality and effectiveness of this research given in formulas below.
Practicality calculation formula:

$$KP = \frac{A}{N} \times 100\% \quad (1)$$

Description:
KP = Practicality score
A= Result score
N= Maximum score

Calculation formula for student response questionnaire:

$$P = \frac{S}{N} \times 100\% \quad (2)$$

Description:
P = Effectiveness score
S = Results score
N = Maximum scores

Table 1. Category of practicality score

Score (%)	Criteria
80 < P ≤ 100	Very good
60 < P ≤ 80	Good
40 < P ≤ 60	Pretty good
25 < P ≤ 40	Not good

(Murniati et al., 2023)

Calculation of formula N-gain

$$< g >= \frac{(Xpost) - (Xpre)}{Xmax - (Xpre)} \quad (3)$$

Description:
<g> = Average of N-gain score
Xpre = Average posttest score
Xpost = Average pretest score
Xmax = Maximum score

Table 2. Category of N-gain

Range Score	Criteria
0.7 ≤ gain ≤ 1	High
0.3 ≤ gain < 0.7	Moderate
0 ≤ gain < 0.3	Low

(Hake, 1998)

Population and Sample

The research was located in the Bachelor of Science Education study program, Faculty of Teacher Training and Education, University of Jember with the research time during the odd semester of the 2024/2025 academic year. Research participants were 3rd semester students of the Bachelor of Science Education study program with 33 students in total. This class uses one group pretest – the posttest was presented in Table 3.

Table 3. One group pretest - posttest

Pretest	Treatment	Posttest
O1	X	O2

Description:
O1 = Pretest
X = Implementation of the use of module
O2 = Posttest

Data Collection Tools

There are three data analyzed in this research, first practicality observation sheet to measure how the module that has been developed can improve computational thinking skill and this sheet used questionnaire is filled by three observers per meeting. The practicality observation sheet filled by three observers aims to find out how the implementation of module in the classroom works and practice to improve students' computational thinking skill. This sheet uses likert 1-4 from very poor until very good.

The second is a student's test using pretest and posttest. Either pretest and posttest obtained with several indicators of computational thinking skill, namely abstraction, generalization, decomposition, algorithms, and debugging. The test is implemented in the form of a pretest before students use the product and a posttest is given after students use the product. The test serves to determine the extent to which the module can improve students' computational thinking skill, later the scores will be analyzed using N-gain score and paired t-test. Test results are useful as data to determine the effectiveness of the implementation of the module itself.

Additionally, the third is students' response questionnaires to measure how students feedback after using the science module and to measure effectiveness of implementation of the module. This questionnaire is filled after the posttest and all of the meetings are over. Students respond using questionnaires with likert scale 1-4 from very poor until very good.

Data Analysis

This study examines three key aspects: the N-gain score, practicality score, and effectiveness score. The N-gain score is calculated by analyzing students' pretest and posttest results. The practicality score is determined using the practicality observation sheet completed by observers, while the effectiveness score is assessed through student response questionnaires. The research was conducted at 3rd semester students of the Bachelor of Science Education study program with 33 students in total.

The paired sample t-test was used with Jamovi software to compare the means of two measurements taken from the same group of individuals under different conditions. This method effectively minimizes individual variability since measurements are taken from the same group. In this research, the paired t-test analyzed the pretest and posttest scores to evaluate whether the module significantly improved their computational thinking skills. It then determines whether the average difference is statistically significant. A significance level of 0.05 was set for the analysis. If the p-value obtained from the test is less than or equal to 0.05, it indicates a statistically significant difference between pretest and posttest scores.

Result and Discussion

In the implementation stage, field trials of products, namely modules, are conducted to measure the effectiveness and practicality in learning. The product was tested in learning for five sessions. The trial was carried out only once, because through the trial, the researcher had obtained the results or an overview of the students' shortcomings. The results of the product practicality analysis are measured through assessment activities carried out during learning, such as the usefulness of the implementation of activities in the module and the readability of the module, which when described in student activities are in the following table.

Table 4. Module practicality test results

Aspects observed	Meeting to 1	2	3	4	5	Average (%)	Category
Introduction	100	85	89	96	96	93	Very practical
Core	93	98	91	89	100	94	Very practical
Closing	96	89	85	85	85	88	Very practical
Average presentation (%)							92
Score criteria							Very practical

The practicality of the microcontroller-assisted module is shown by the implementation of the learning process using the microcontroller-assisted module which will be measured based on the learning implementation sheet by three observers. When viewed based on Table 4, the implementation of learning in five meetings obtained an average percentage value of 92%. Based on this percentage value, it can be interpreted that learning by applying microcontroller-assisted modules is included in the practical category when implemented. In accordance with the criteria for the level of practicality of learning implementation stated by Nesri & Kristanto (2020) that microcontroller-assisted modules can be said to be very practical if they obtain a percentage of learning implementation in the range of 80–100%. This statement is also reinforced by the research of Masruhah et al. (2022) that the average percentage of implementation using the module is very practical to use with a score of 87%. The implementation of learning using the microcontroller-assisted module teaching materials, students are quite enthusiastic and play an active role when learning takes place. Students are not considered to have difficulties in using microcontroller-assisted modules. However, there are some obstacles in the implementation of learning using the module, namely there are some students who are a little unclear about the questions given in some of the activities in the module because each question is inserted with computational thinking indicators, besides that there are some students who are a little difficult in assembling the sensors they will use to complete the project together because they did not enter the previous meeting.

Table 5. Module effectiveness test results

Component	Class B		N-gain	Category
	Pretest	Posttest		
Total Students	33			
Lowest Score	12	72	0.78	High
Highest Score	50	94		

Based on Table 5, it can be seen that the students' n-gain value is 0.78, which is in the high category. These results indicate an increase in students' computational thinking skills after using a microcontroller-based module on the topic of Earth's Past Directions, determining the age of rocks, atmosphere, and microclimate parameters. The test consisted of ten items, with each item consisting of five computational thinking indicators (abstraction, generalization, decomposition, algorithm, and debugging). In addition, validity data were also analyzed based on each indicator.

Table 6. Results of N-gain analysis of computational thinking indicators

Indicator computational thinking	Average pretest	Average pos-test	N-gain	Category
Abstraction	3.97	8.70	0.78	High
Generalization	4.85	9.18	0.84	High
Decomposition	3.73	7.85	0.66	Medium
Algorithms	0.48	8.97	0.89	High
Debugging	0.79	8.28	0.81	High

Table 6 shows the results of the analysis of each indicator of students' computational thinking, students' ability to recognize patterns to formulate problems (decomposition) is still relatively low because students still have difficulty in gathering information and connecting the problems given. This is in line with the results of research by Litia et al. (2023) the generalization indicator (pattern recognition) obtained the lowest average percentage compared to other computational thinking indicators, namely 74%. Meanwhile, what has a very significant increase is the algorithm indicator because students can design problem steps after fully going directly to the field to see the surrounding conditions and learn in advance about programming that is organized and logical to solve the problems given. In line with the statement Selby (2014), computational thinking promotes analytical and algorithmic skills necessary for problem solving. Logical thinking is closely related to problem solving, because computational thinking, whose thinking comes from computer science, is an important problem-solving skill that learners will need in the era of the Industrial Revolution 4.0 (Cahdriyana & Richardo, 2020).

However, it is not uncommon for some students to still be confused about how to do the pre- and post-test computational thinking questions. This happens because students have never been presented with questions that include indicators of computational thinking skills. The result of the n-gain analysis is 0.78, where according to Hake (1998), the N-gain is said to be high if it exceeds 0.70, which means that the students' computational thinking skills have increased. Based on Figure 1 all of N-gain scores show good value, except indicator of decomposition shows N-gain 0.66 in medium category. According to Mustofa et al. (2023), the use of modules in learning helps students to better understand the material independently and the effectiveness of the teaching and learning process can be known through test results that meet the learning objectives.

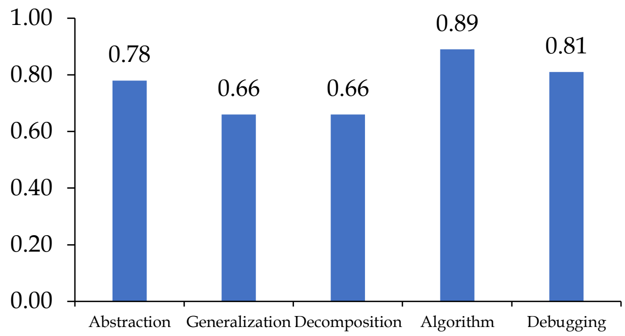

Figure 1. N-gain score of each indicator of computational thinking skills

Paired Samples T-Test

			statistic	df	p	Mean difference	SE difference		Effect Size
A	B	Student's t	−26.2	32.0	< .001	−52.4	2.00	Cohen's d	−4.56

Note. H_a $\mu_{Measure\ 1\ -\ Measure\ 2} \neq 0$

Figure 2. Results of paired t – test

The next analysis of students' test uses paired sample t-test with Jamovi software shown in Figure 2 above. A paired sample t-test was employed to ascertain whether a notable distinction existed between the pretest and posttest scores in regard to the utilization of the learning module (Anazifa & Djukri, 2017). The table shows a p value < 0.001, which is much smaller than the threshold of 0.05, which strongly indicates that the implementation of the science module has a significant and substantial positive impact on improving students' computational thinking skills. This result is not coincidental, but is supported by a valid comparison between pretest and posttest scores, which consistently show significant improvements. Thus, it can be concluded that the changes that occur are the result of effective interventions, not just coincidence factors or other variables.

Table 7. Student response questionnaire analysis results

Assessment indicators	Percentage (%)	Category
Attraction	85	Very good
Material	71	Good
Language	60	Good
Average Score	72	Good

Effectiveness is also seen from the students' responses to the microcontroller-based modules. In Table 5, the results of the analysis of the student response questionnaire include 3 indicators consisting of 5 items of interest indicators, 3 items of material indicators, and 3 items of language indicators. The analysis of students' responses is useful for measuring students' comments after using a microcontroller-based module. The results of the analysis of the questionnaire answers filled out by 33 students after using the microcontroller-based module showed that the average percentage of achievement was 72%, which is included in the good criteria. This is also supported by the research of Tukan et al. (2020), which suggests that the results of student response questionnaires in the good category show that modules are classified as effective teaching materials in attracting student interest in learning. This figure was obtained after analyzing various aspects that were measured, such as understanding concepts, application of technical skills, and the level of student satisfaction with the material provided. Thus, it can be concluded that most students showed a positive response to this module, although there is still room for improvement in certain aspects. According to Pradhana (2020) and Murniati et al. (2023), the acquisition of high scores in the student response questionnaire is an indicator that the teaching materials used have a high appeal to students. The effectiveness of the product is described based on the improvement of students' computational thinking as measured by computational thinking tests in the form of tests. A more in-depth analysis by Wahab et al. (2021) is in line with the results of this study, which has resulted in the conclusion that computational thinking (CT) has become more general and interdisciplinary, which seems to drive progress in STEM education. However, further research is needed, especially regarding its long-term effects.

Similar research has been conducted where the development of a module specifically for use in fifth grade science T&L, to enhance science content knowledge and CT skills, has been validated in content and can be used as a reference by science teachers to diversify their teaching strategies in enhancing systematic thinking skills among children in an active and collaborative learning environment (Mensan et al., 2020). A wider body of evidence on CT pedagogy, assessment, and teacher professional development in computing education is also explored in a study by (Bocconi et al. (2022). The findings from the review suggest that the debate on CT definitions has reached a plateau, with current discussions primarily centered around key CT concepts, including abstraction, algorithmic thinking, automation, decomposition, debugging, and generalization (Wing, 2006). Cateté et al. (2020) argue that effective professional development equips teachers with the skills needed to teach computer science and address the needs of diverse student groups, including those with varying ethnicities, socioeconomic backgrounds, and genders.

A similar study by Waterman et al. (2020) that aimed to integrate computational thinking (CT) with core elementary content areas showed positive outcomes. Students shared ideas reflecting a deeper understanding of both CT and subjects like science or mathematics. Teachers expressed interest in continuing the initiative, and most project participants indicated they had either explored or planned to explore further opportunities to incorporate CT into their future lessons.

Conclusion

The microcontroller-based module is feasible to be used as a learning medium in earth science courses, with a practicality and effectiveness value of 92% and 0.78, respectively. The advantages of the microcontroller-based module as a learning medium lie in the students' experience of directly connecting sensors related to technological applications applied in the world of agriculture and receiving a positive response with a value of 72% in the good category. It is hoped that future research can focus on integrating computational thinking with subjects such as literature, social science or art to explore how these skills can be applied outside the STEM field. This could help to identify new ways to promote creativity and critical thinking through computational concepts.

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Conceptualization, formal analysis, M., J.W., Z.R.R., and Y.; methodology, funding acquisition, M., J.W., and Y.; software, writing—review and editing, supervision, project administration, M. and Z.R.R.; validation, Z.R.R., Y., and J.W.; resources, M. and J.W.; data curation, M., Z.R.R., and J.W.;

writing— original draft preparation, M. all authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interests regarding this manuscript.

References

Akbar, R. B. W., Fadhilah, R., & Hadiarti, D. (2024). Development of Augmented Reality-Based Modules for Chemistry Bonding Materials at Taman Mulia Pontianak High School. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10109-10115. https://doi.org/10.29303/jppipa.v10i12.8507

Anazifa, R. D., & Djukri, D. (2017). Project-Based Learning and Problem-Based Learning: Are They Effective to Improve Student's Thinking Skills? *Jurnal Pendidikan IPA Indonesia*, *6*(2), 346. https://doi.org/10.15294/jpii.v6i2.1110

Angeli, C., & Giannakos, M. (2020). Computational Thinking Education: Issues and Challenges. *Computers in Human Behavior*, *105*, 106185. https://doi.org/10.1016/j.chb.2019.106185

Angraini, L. M., Arcat, A., & Sohibun, S. (2022). Pengaruh Bahan Ajar Berbasis Multimedia Interaktif Terhadap Kemampuan Computational Thinking Matematis Mahasiswa. *JNPM (Jurnal Nasional Pendidikan Matematika)*, *6*(2), 370-383. https://doi.org/10.33603/jnpm.v6i2.6937

Anistyasari,Y. (2020). Strategi Pembelajaran untuk Meningkatkan Keterampilan Pemrograman dan Berpikir Komputasi. *JVTE: Journal of Vocational and Technical Education*, *2*(8), 37-44. http://dx.doi.org/10.26740/jvte.v2n2.p37-44

Asbell-Clarke, J., Rowe, E., Almeda, V., Edwards, T., Bardar, E., Gasca, S., Baker, R. S., & Scruggs, R. (2021). The Development of Students' Computational Thinking Practices in Elementary- and Middle-School Classes Using the Learning Game, Zoombinis. *Computers in Human Behavior*, *115*, 1–14. https://doi.org/10.1016/j.chb.2020.106587

Barr, D., Harrison, J., & Conery, L. (2011). Computational Thinking: A Digital Age Skill for Everyone. *Learning & Leading with Technology*, 38(6), 20-23. https://doi.org/10.5220/0006367001660170

Basu, S., Rutstein, D., Shear, L., & Xu, Y. (2020). A Principled Approach to Designing a Computational Thinking Practices Assessment for Early Grades. *Proceedings of the 51st ACM Technical Symposium on Computer Science Education* (pp. 912- 918). Association for Computing Machinery. https://doi.org/10.1145/3328778.3366849

Bocconi, S., Chioccariello, A., Kampylis, P., Dagienė, V., Wastiau, P., Engelhardt, K., Earp, J., Horvath, M. A., Jasutė, E., Malagoli, C., Masiulionytė-Dagienė, V., & Stupurienė, G. (2022). *Reviewing Computational Thinking in Compulsory Education*. Publications Office of the European Union. https://doi.org/10.2760/126955

Caeli, E. N., & Yadav, A. (2020). Unplugged Approaches to Computational Thinking: A Historical Perspective. *TechTrends*, *64*(1), 29–36. https://doi.org/10.1007/s11528-019-00410-5

Cahdriyana, R. A., & Richardo, R. (2020). Berpikir Komputasi dalam Pembelajaran Matematika. *Literasi: Jurnal Ilmu Pendidikan*, *11*(1), 50-56. https://doi.org/10.21927/literasi.2020.11(1).50-56

Cateté, V., Alvarez, L., Isvik, A., Milliken, A., Hill, M., & Barnes, T. (2020). Aligning Theory and Practice in Teacher Professional Development for Computer Science. *Proceedings of the 20th Koli Calling International Conference on Computing Education Research*, 1–11. Association for Computing Machinery. https://doi.org/10.1145/3428029.3428560

Csizmadia, A., Curzon, P., Dorling, M., Humphreys, S., Ng, T., Selby, C., & Woollard, J. (2015). Computational Thinking a Guide for Teachers. *Computing at School*, 1-18. Retrieved from http://eprints.soton.ac.uk/id/eprint/424545

Dilber, R., Ibrahim, K., & Bahattin, D. (2009). High School Students' Understanding of Projectile Motion Concepts. *Educational Research and Evaluation*, *15*(3), 203-222. https://doi.org/10.1080/13803610902899101

Fitriani, W., Suwarjo, S., & Wangid, M. N. (2021). Berpikir Kritis dan Komputasi: Analisis Kebutuhan Media Pembelajaran di SekolahDasar. *Jurnal Pendidikan Sains Indonesia*, *9*(2), 234-242. https://doi.org/10.24815/jpsi.v9i2.19040

Fülöp, M. T., Udvaros, J., Gubán, Á., & Sándor, Á. (2022). Development of Computational Thinking Using Microcontrollers Integrated into OOP (Object-Oriented Programming). *Sustainability*, *14*(12), 7218. https://doi.org/10.3390/su14127218

Hake, R. R. (1998). Interactive-Engagement Versus Traditional Methods: A Six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses. *American Journal of Physics*, 66(1), 64–74. https://doi.org/10.1119/1.18809

Husada, S. P., Taufina, T., & Zikri, A. (2020). Pengembangan Bahan Ajar Pembelajaran Tematik dengan Menggunakan Metode Visual Storytelling di Sekolah Dasar. *Jurnal Basicedu*, 4(2), 419–425. https://doi.org/10.31004/basicedu.v4i2.373

Kampylis, P., Dagienė, V., Bocconi, S., Chioccariello, A., Engelhardt, K., Stupurienė, G., Masiulionytė-Dagienė, V., Jasutė, E., Malagoli, C., Horvath, M., & Earp, J. (2023). Integrating Computational Thinking into Primary and Lower Secondary Education. *Educational Technology & Society*, *26*(2), 99-117. https://doi.org/10.30191/ETS.202304_26(2).0008

Litia, N., Sinaga, B., & Mulyono, M. (2023). Profil Berpikir Komputasi Siswa dengan Menggunakan Model Pembelajaran Problem Based Learning (PBL) Ditinjau dari Gaya Belajar di SMA N 1 Langsa. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 7(2), 1508–1518. https://doi.org/10.31004/cendekia.v7i2.2270

Masruhah, G. D., Rusdianto, R., & Wahyuni, S. (2022). Pengembangan e-LKPD Berbasis Inkuiri Terbimbing untuk Meningkatkan Keterampilan Proses Sains Siswa SMP. *SAP (Susunan Artikel Pendidikan)*, *7*(1), 169-177. https://doi.org/10.30998/sap.v7i1.12935

Mensan, T., Osman, K., & Majid, N. A. A. (2020). Development and Validation of Unplugged Activity of Computational Thinking in Science Module to Integrate Computational Thinking in Primary Science Education. *Science Education International*, *31*(2), 142-149. https://doi.org/10.33828/sei.v31.i2.2

Murniati, M. E., Alex, H., & Maryani, M. (2023). Respon Siswa Terhadap Media Pembelajaran Articulate Storyline 3 dengan Pendekatan STEM pada Materi Gerak Parabola. *Compton: Jurnal Ilmiah Pendidikan Fisika*, *9*(2), 152–160. https://doi.org/10.30738/cjipf.v9i2.14440

Mustofa, M., Putra, P. D. A., & Ridlo, Z. R. (2023). Pengembangan Flipbook Modul Berbasis Engineering Design Process (EDP) untuk Meningkatkan Literasi Sains Siswa SMP dalam Pembelajaran IPA. *Tarbiyah Wa Ta'lim: Jurnal Penelitian Pendidikan dan Pembelajaran*, *10*(2), 81-91. https://doi.org/10.21093/twt.v10i2.5841

Nesri, F. D. P., & Kristanto, Y. D. (2020). Pengembangan Modul Ajar Berbantuan Teknologi untuk Mengembangkan Kecakapan Abad 21 Siswa. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *9*(3), 480-492. https://doi.org/10.24127/ajpm.v9i3.2925

Nuraini, F., Agustiani, N., & Mulyanti, Y. (2023). Analisis Kemampuan Berpikir Komputasi Ditinjau dari Kemandirian Belajar Siswa Kelas X SMK. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *7*(3), 3067-3082. https://doi.org/10.31004/cendekia.v7i3.262

Palts, T., & Pedaste, M. (2020). A Model for Developing Computational Thinking Skills. *Informatics in Education*, *19*(1), 113–128. https://doi.org/10.15388/infedu.2020.06

Pradhana, C. (2020). Efek Percepatan Gravitasi pada Gerak Parabola. *Jurnal Teknologi Terapan: G-Tech*, *2*(2), 140–144. https://doi.org/10.33379/gtech.v2i2.334

Qibtiyah, M., & Sukarmin, S. (2022). Development of Augmented Reality-Based Interactive "Element Card" Media on Electron Configuration Submaterial According to Niels Bohr. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram*, *10*(2), 252-261. https://doi.org/10.33394/j-ps.v10i2.4916

Ramadhani, S. H., & Yahfizham, Y. (2024). Systematic Literature Review: Analisis Pemecahan Masalah Matematika Mahasiswa dan Siswa dengan Berpikir Komputasional. *Pendekar: Jurnal Pendidikan Berkarakter*, *2*(3), 75-81. https://doi.org/10.51903/pendekar.v2i3.730

Ridlo, Z. R., Afafa, L., Bahri, S., & Kamila, I. S. (2021). The Effectiveness of Research-Based Learning Model of Teaching Integrated with Computer Simulation in Astronomy Course in Improving Student Computational Thinking Skills. *Journal of Physics: Conference Series*, *1839*(1), 012027. https://doi.org/10.1088/17426596/1839/1/012027

Sa'adah, U., Faridah, S. N., Ichwan, M., Nurwiani, N., & Tristanti, L. B. (2023). Pengaruh Model Pembelajaran Discovery Learning Menggunakan Pendekatan STEAM (Science, Technology, Enginering, Art, Mathematic) Terhadap Kemampuan Berpikir Komputasi Siswa. *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah di Bidang Pendidikan Matematika*, *9*(1), 62–75. https://doi.org/10.29407/jmen.v9i1.19391

Saad, A. (2020). Students' Computational Thinking Skill Through Cooperative Learning Based on Hands-on, Inquiry-Based, and Student-Centric Learning Approaches. *Universal Journal of Educational Research*, *8*(1), 290–296. https://doi.org/10.13189/ujer.2020.080135

Selby, C. C. (2014). *How Can the Teaching of Programming be Used to Enhance Computational Thinking Skills?* (Doctoral Dissertation). University of Southampton Southampton UK. Retrieved from http://eprints.soton.ac.uk/id/eprint/366256

Tabesh, Y. (2017). Computational Thinking: A 21st Century Skill. *Olympiads in Informatics*, *11*(Special Issue), 65–70. https://doi.org/10.15388/ioi.2017.special.10

Tukan, M. B., Komisia, F., Leba, M. A. U., & Amtonis, J. S. (2020). Pengembangan Lembar Kerja Peserta Didik (LKPD) Praktikum Kimia Berbasis Lingkungan pada Materi Laju Reaksi. *Jurnal Koulutus*, 3(1), 108-119. Retrieved from https://ejournal.kahuripan.ac.id/index.php/koulutus/article/view/324

Wahab, N. A., Talib, O., Razali, F., & Kamarudin, N. (2021). The Big Why of Implementing Computational Thinking in STEM Education: A Systematic Literature Review. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, *6*(3), 272-289. https://doi.org/10.47405/mjssh.v6i3.706

Waterman, K. P., Goldsmith, L., & Pasquale, M. (2020). Integrating Computational Thinking into Elementary Science Curriculum: An Examination of Activities that Support Students' Computational Thinking in the Service of Disciplinary Learning. *Journal of Science Education and Technology*, *29*(1), 53-64. https://doi.org/10.1007/s10956-019-09801-y

Wing, J. (2006). Computational Thinking. *Communications of the ACM*, *49*(3), 33-35. https://doi.org/10.1145/1118178.1118215

Yadav, A., Stephenson, C., & Hong, H. (2017). Computational Thinking for Teacher Education. *Communications of the ACM*, *60*(4), 55–62. https://doi.org/10.1145/2994591

Yayuk, E. (2019). Pengembangan Bahan Ajar Pembelajaran Matematika untuk Mahasiswa PGSD Semester 6. *Scholaria: Jurnal Pendidikan dan Kebudayaan*, *9*(2), 172-182. https://doi.org/10.24246/j.js.2019.v9.i2.p172-182

Zulfaniar, Z., Arsyad, M., & Palloan, P. (2024). Development of Physics Teaching Materials Based on SETS (Science, Environment, Technology, and Society) to Improve Student Creativity. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10102–10108. https://doi.org/10.29303/jppipa.v10i12.8774