

Computational Thinking and Scientific Modules: Effectiveness on Students' Cognitive Learning Outcomes and Critical Thinking Skills

Silvia Yuni Safitri, Suharno*, Ahmad Fauzi

Physics Education Study Program, Faculty of Teacher Training and Education, Sebelas Maret University, Ir. Sutami No. 36A Street, Jebres, Surakarta, Central Java, 57126, Indonesia

*Corresponding Author Email : suharno_71@staff.uns.ac.id

Article's Info

Received: 22 Mei 2023

Accepted: 4 Februari 2024

Published: 30 Mei 2024

DOI:

<https://doi.org/10.20961/jmpf.v14i1.86266>

How to Cite : Safitri, S.Y., Suharno, Fauzi, A. (2024). Computational thinking and scientific modules: Effectiveness on students' cognitive learning outcomes and critical thinking skills. *Jurnal Materi dan Pembelajaran Fisika*, 14(1), 9-19

Abstract. The purpose of the research is to find out whether or not 1) there were different effects using learning modules with Computational Thinking (CT) and scientific approaches, 2) different effects on students' critical thinking ability in the high and low categories, 3) interaction between the effects using learning modules with CT and scientific approaches in the level of students' critical thinking ability on cognitive learning outcomes in temperature and heat subject. This research method was quasi-experimental with a quantitative approach. The design used a non-equivalent post-test-only control group design and a 2x2 factorial design pattern. The population was students of XI MIPA SMA Negeri 1 Kartasura in the academic year of 2021/2022. The sample was chosen using a cluster random sampling technique. Two classes were used as the samples: 36 students of XI MIPA 2 as the first experiment class and 36 students of XI MIPA 4 as the second experiment class—the data collecting technique used documentation, test, and questionnaire techniques. Data were analyzed using non-parametric test statistics, and the method was the Mann-Whitney test. The conclusions of the research results are: 1) there are no effects of using learning modules with CT and scientific approaches on cognitive learning outcomes, 2) there are no effects on student's critical thinking ability in the high and low categories towards cognitive learning outcomes, 3) there is no interaction between the effects of using learning modules and students' critical thinking ability on cognitive learning outcomes in temperature and heat subject. This study shows the effectiveness of applying learning modules with CT and scientific approaches to students' critical thinking skills on cognitive learning outcomes on Temperature and Heat material.

Keywords: Cognitive learning outcomes; computational thinking; critical thinking; learning modules; scientific

This open access article is distributed under a CC-BY License



INTRODUCTION

Learning outcomes are to be understood and applied after successfully completing a learning process (European Commission, 2009). Learning outcomes are indicators of the success of academic programs (Mahajan & Singh, 2017), which include cognitive, affective, and psychomotor aspects (Rusman, 2013; Tabun et al., 2019). Based on the Trends in International Mathematics and Science Study (TIMSS), Indonesian students' average physics learning outcomes in the cognitive aspect still

need to be higher and tend to decline (Swandi et al., 2018). Internal and external factors are involved in realizing maximum learning outcomes. Internal factors refer to students's health, mental, intellectual, and motivation. External factors lead to outside students: the environment, friends, society, family, media, facilities, infrastructure, and teachers (Jufrida et al., 2019). Both factors affect the learning process and students' learning abilities.

Critical thinking skills are part of the internal factors that influence students in building knowledge and become a demand for competence in the 21st century (Crenshaw et al., 2011 dalam Uribe-Enciso et al., 2017). The application of critical thinking in the classroom makes students likely to broaden their perspectives on global views and improve their ability to make decisions in learning and life (Murawski, 2014). Critical thinking skills positively impact student learning achievement (Taghva et al., 2014; Malawi & Tristiari, 2016; Fatmawati et al., 2019). Students with high critical thinking skills have a better understanding of physical science (Dewi et al., 2019). The same thing occurs in the science literacy skills of students with higher critical thinking skills (Rahayuni, 2016). The ability to think critically also has a positive impact on student learning outcomes, which is an indicator of the success of the academic process (Mulyanto et al., 2018; Miharja et al., 2019; Subiyantari et al., 2019; Dharma et al., 2020; Andayani et al., 2020). However, another study found that critical thinking skills did not affect student learning outcomes (Tabun et al., 2019). Based on the positive impact of critical thinking skills on learning outcomes, teachers can use students' critical thinking skills as a reference for providing learning and influencing students, especially learning outcomes during the learning process.

In the external factor, the supporting factor for the success of student learning outcomes is the learning media. The low quality of students' physics learning outcomes may be caused by learning media that have yet to be able to motivate students to learn physics (Amin et al., 2017). Modules are learning media often implemented by students in the learning process (Degeng et al., 2021). The development and use of modules in classroom learning also positively affect learning outcomes (Istuningsih et al., 2018). Based on the book *Audio-Visual Methods in Teaching*, Dale (1969) categorizes learning experiences from concrete to abstract levels called the cone of experience. According to this classification, learning media that present demonstrations will help students remember up to 50% of the material while learning media that practice the material directly (contextual) will help students remember 70% of the material. Several studies have developed modules that can provide demonstrations and direct students to experience contextual learning experiences that affect student learning achievement. From the classification of learning experiences, learning modules that contain demonstrations and practices can positively impact student learning outcomes.

Implementing Curriculum 2013 in the learning process requires a scientific approach that allows students to obtain concepts through activities and phenomena to improve student learning outcomes (Setyawan et al., 2017). Several studies have shown that the application of scientific learning in the classroom has a positive impact on the completeness of cognitive learning outcomes (Putri et al., 2019; Murtini, 2018). However, applying the 2013 curriculum with a scientific approach has not been maximized (Amin et al., 2017).

Minister Nadime Makarim recently added Compassion and CT competencies to the curriculum. Several Asia Pacific countries such as Korea, Taiwan, Hong Kong, and China have reformed the education curriculum (K-12) to adopt CT (So et al., 2020). CT is one of the 21st-century digital skills (Haseski et al., 2018), in addition to creativity, critical thinking, collaboration, and communication (van Laar et al., 2020), essential to adapt to technological and economic developments in the 21st century. In the industrial era 5.0, technology has become part of human life and changed the order from human-centered to technology-based. Human resources must be prepared early to solve problems (Dinata et al., 2021). Therefore, in the 5.0 era, the role of CT is very important as a technique in solving problems.

The use of CT in education was first studied by Papert in 1980 and promoted by Wing in 2006. According to Wing, CT is an essential skill for both the present and the future and is as vital as reading, writing, and basic arithmetic (Mohaghegh & McCauley, 2016). Yadav and Berges (2019) argued that CT is an essential universal skill in school learning to be added as an analytical ability for every student. CT is a skill that highly benefits many disciplines, not just computer science and technology (Mohaghegh & McCauley, 2016). CT must be implemented in education, especially in science classes,

to provide a realistic view of science and prepare students for future careers (Weintrop et al., 2016 dalam Naingalis, 2021). One of the branches of science that is the focus is physics.

Several studies have examined CT-based physics learning. Kawuri et al. (2019) implemented learning with the CT approach, which showed an increase in students' critical thinking skills. Dwyer et al. (2014) conducted CT-based learning experiments accompanied by simulations during the learning process, and Hutchins and Biswas (2020) combined CT and STEM (Science, Technology, Engineering, and Mathematics). In addition, a physics learning module based on computational thinking (CT) has been developed on liner motion material by (Khasyyatillah & Osman, 2019) and on temperature and heat material by Naingalis (2021). Meanwhile, Lapawi and Husnin (2020) implemented a CT-based learning module, effectively improving students' science learning achievement. From the various positive impacts of the application of CT, there are still few learning practices or studies on CT learning in Indonesia (Ansori, 2020); thus, the role of CT research in education in Indonesia can add scientific references.

Based on the background description of the importance of (CT) in facing the 5.0 era and the development of CT-based modules, which are external factors in influencing cognitive learning outcomes in terms of the influence of internal factors, namely critical thinking skills. The scientific-based module was compared because scientific learning must be applied in the 2013 curriculum. It has been widely developed and researched for its effect on students' cognitive aspects. The temperature and heat material was chosen because it contains daily life events, and this learning can be applied to the surrounding tools and materials.

This study aims to determine whether there are differences in the cognitive learning outcomes of Physics class XI students on temperature and heat material between the use of CT and Scientific modules, between the level of critical thinking ability with high and low categories, as well as the interaction of modules and critical thinking ability on cognitive learning outcomes of Physics students.

METHOD

This kind of research is a quasi-experiment with a quantitative approach. The characteristic of quasi-experimental research is that the determination of the class experimental (class I) and control class (experimental class II) must be done randomly (random) (Isnawan et al., 2020). The research design used was a non-equivalent post-test-only control group design and a 2x2 factorial design model as a data analysis design. The factorial design allows for moderating variables to influence the independent variable on the dependent variable (Jakni, 2016).

The population used is class XI MIPA students at SMA Negeri 1 Kartasura in the 2021/2022 academic year. The sampling technique is Cluster Random Sampling, which is a cluster-based sampling method where each cluster can contain elements with different characteristics (heterogeneity) (Jakni, 2016). The samples used were 36 students of XI MIPA 2 class as experimental class I and 36 students of XI MIPA 4 as experimental class II. IBM SPSS Statistics 23 was used for normality and homogeneity tests to determine whether the initial conditions of the two samples were the same based on the data of the Final Semester Assessment scores. Table 1 shows the results of the normality test.

Table 1. Student Initial Normality Test Results

Class	Sig. ($\alpha = 0,05$)	Normality
Experimental I	0,096	Normal
Experimental II	0,061	Normal

There are three variables: namely, the independent variable is the use of Physics modules with a CT approach and a scientific approach, the moderating variable is the level of students' critical thinking skills, and the dependent variable is the student's cognitive learning outcomes in Physics for temperature and heat material.

Data on students' critical thinking skills were obtained from answers to a 10-item questionnaire containing five indicators of critical thinking skills according to Enis: Basic Clarification, Basic

Decision, Inference, Advance Clarification, and Supposition and Integration. The scoring technique for each item uses a Likert scale of 1 to 4.

Microsoft Excel was used to analyze the critical thinking ability questionnaire instrument testing. The questionnaire was analyzed both qualitatively content and quantitatively in the form of validity and reliability of the instrument. The content validity analysis technique was carried out using Aiken's V content validity coefficient (Bashoor & Supahar, 2018) and reliability testing using Cronbach's Alpha test (Yusup, 2018).

Data on students' cognitive learning outcomes were obtained from tests using 20 objective questions with five alternative temperature and heat material answers. The cognitive test assessment instrument was analyzed qualitatively and quantitatively. Expert lecturers assessed qualitative analysis to assess whether the test was relevant to the grid. Quantitative analysis includes test reliability, distractor effectiveness, differentiability, and difficulty level of questions with the help of the ANBUSO program. The prerequisite analysis, normality, and homogeneity tests were conducted before hypothesis testing. Table 2 shows The results of the normality test.

Table 2. Normality Test Results of Students' Cognitive Ability

Class	Sig. ($\alpha = 0,05$)	Normality
Experimental I	0,000	Not Normal
Experimental II	0,063	Normal

The prerequisite test results do not satisfy the assumptions of parametric analysis, so nonparametric statistics are used, namely the Mann-Whitney test, with the assistance of Ms. Excel. Mann-Whitney test statistics are obtained from the calculation of the equation (Silaban et al., 2014).

$$U = n_1n_2 + \frac{n_i(n_i + 1)}{2} - R_i \quad [1]$$

Description:

n_1 = number of elements in the experimental class I

n_2 = number of elements in the experimental class II

U = value of Mann-Whitney test statistic

R_i = number of ranks in class i

n_i = number of elements in sample i

If n_1 or n_2 , or both are greater than or equal to 20, the normal curve with the mean (E (U)) approach is used.

$$E(U) = \frac{n_1n_2}{2} \quad [2]$$

The normal distribution value (Z) is calculated by the formula:

$$Z = \frac{U - E(U)}{SD} \quad [3]$$

RESULT AND DISCUSSION

RESULTS

The Use of CT and Scientific Modules on Cognitive Learning Outcomes

The following is data on the relationship between computational thinking and scientific modules on cognitive learning outcomes. Table 3 shows that the use of modules with CT and scientific approaches has no difference in the effect on cognitive learning outcomes of grade XI students on temperature and heat material.

Table 3. Mann-Whitney Test Results on The Use of Learning Modules

Modules	Z _{count}	Z _{table} ($\alpha = 0,05$)	Sig. ($\alpha = 0,05$)	Conclusion
CT and Scientific Modules	0,65	1,96	0,512	H _{0A} accepted

Table 4 shows that the difference in mean scores is not statistically significant. Hence, the conclusion is that students' cognitive learning outcomes using CT-based and scientific learning modules are similar.

Table 4. Data on Cognitive Ability of Experimental Class I and II

Class	Number of Students	Cognitive Ability		
		Average	Lowest	Highest
Experimental I	36	67,78	50	95
Experimental II	36	66,67	30	90

Critical Thinking Ability on Cognitive Learning Outcomes

The following is data on students' cognitive learning outcomes regarding their critical thinking ability. Students' critical thinking skills collected from a questionnaire with 10 items. The critical thinking ability of high and low group physics was categorized using the average score. Table 5 shows data on the critical thinking skills of experimental classes I and II.

Table 5. Data Description of Critical Thinking Ability

Class	Average	Number of Students	
		High	Low
Experimental I	26,97	14	22
Experimental II	28,28	21	15

Each indicator of critical thinking ability has a total percentage of the questionnaire results presented in Table 6.

Table 6. Percentage Analysis of Each Critical Thinking Ability Indicator

Indicator	Experimental I	Experimental II
Basic Clarification	48,13%	51,87%
Basic Decision	48,84%	51,16%
Inference	49,47%	50,53%
Advance Clarification	49,73%	50,27%
Supposition and Integration	47,97%	52,03%

Table 7 shows differences in the cognitive learning outcomes of grade XI students on temperature and heat between high and low critical thinking abilities.

Table 7. Mann-Whitney Test Results for Learning Module and Critical Thinking Ability Level

Critical Thinking Ability	Z _{count}	Z _{table} ($\alpha = 0,05$)	Sig. ($\alpha = 0,05$)	Conclusion
	0,36	1,96	0,715	H _{0B} accepted

Table 8 shows that students with high critical thinking skills score better than those with low critical thinking skills, but not significantly.

Table 8. Average and Total Average of Students' Cognitive Ability in Physics

Module	Critical Thinking Ability (B)		
	High (B ₁)	Low (B ₂)	Total
CT (A ₁)	68,57	67,27	135,84
Scientific (A ₂)	67,38	65,67	133,05
Total	135,95	132,94	
Average	67,98	66,47	

Interaction Between The Usage of Module and Critical Thinking Ability on Cognitive Learning Outcome

The following is data on the relationship between the usage of module and critical thinking ability on cognitive learning outcome. Table 9 shows that using CT learning modules produces the same cognitive learning outcomes between students with high and low critical thinking skills. In contrast, using scientific learning modules produces different cognitive learning outcomes in students with high and low levels of critical thinking skills.

Table 9. Mann-Whitney test results of the two modules on the level of students' critical thinking skills

Critical Thinking	Module	Z _{count}	Z _{table}	Sig.	Conclusion
H_{0B1} vs H_{0B2}	CT	0,63	1,96	0,532	H_0 accepted
	Scientific	0,31	1,96	0,776	H_0 accepted

The Mann-Whitney test results on the level of students' critical thinking ability towards the use of modules shows in Table 10.

Table 10. Mann-Whitney Test Results on The Level of Students' Critical Thinking Ability Towards The Use of Modules

Module	Critical Thinking	Z _{count}	Z _{table}	Sig.	Conclusion
H_{0A1} vs H_{0A2}	High	0,14	1,96	0,907	H_0 accepted
	Low	0,88	1,96	0,385	H_0 accepted

Based on the level of critical thinking skills shown in Table 10, it can be interpreted that students with high and low critical thinking skills produce the same cognitive learning outcomes when using CT and scientific learning modules, so it can be concluded that there is no interaction between the use of learning modules and critical thinking skills in physics on students' cognitive learning outcomes in temperature and heat materials.

DISCUSSION

The Use of CT and Scientific Modules on Cognitive Learning Outcomes

CT is a new method of problem-solving. CT is not limited to generating solutions performed by computers but can be applied to solve problems in life activities. CT has four foundations that become the foundation of problem-solving, namely decomposition, algorithm, pattern recognition, and abstraction. The CT module in this study contains components or stages of Determine Problem, Decomposition, Pattern Recognition, Algorithm, Simulation, Abstraction, and Generalization.

In the cone of experience classification by Edgar Dale, learning media that presents demonstrations will help students remember the material by up to 50%, while practicing the material helps students remember the material by up to 70% directly (Dale, 1969). The CT module contains the algorithm and simulation stages directly, while the sigil scientific module contains a demonstration of the material. Based on the cone of experience, learning with CT is supposed to be better than learning with scientific modules. However, the results of the data analysis show that there is no difference in influence between the use of the two modules.

According to the book Computational Thinking for Teacher Professional Education course book (Kemendikburistek, 2022), Barefoot Computing (2020) explains that the formation of CT thinking habits cannot be briefly formed but need to be trained continuously through a tinkering approach, practicing creating something (creating), trying to find the root of the problem and correcting the error (debugging), working together (collaborating), and having a persevering attitude.

Physics learning with the CT approach is similar to learning with a scientific approach. There is an extension of steps in learning with the CT approach (Sengupta et al., 2013, including Rinaldi, 2020). The extension of these steps lies in making the appropriate problem-solving stages, namely algorithms. Scientific-based learning students train to observe, formulate problems, explore, analyze data, and generalize. Rinaldi (2020) suggests that if students experience difficulties in learning with a scientific approach, they will also experience the same thing in the learning process with the CT approach. There

are challenges in implementing the CT approach in the classroom. There are several challenges, such as developing algorithms and automation.

Based on research by Suyanto (2018), applying the scientific approach in the Indonesian curriculum is still classified as moderate and not optimal. Similar research results by Nenotaek et al. (2019) found that teachers face difficulties implementing learning with a scientific approach. Based on the research results conducted in Kupang city, several regions in Indonesia, such as Jambi, Surakarta, Semarang, and other regions, have not been optimal in implementing the scientific approach in the learning process. The Covid-19 outbreak has caused the learning process to be online, impacting the application of the scientific approach that has not been effective and run optimally (Solikha et al., 2022). The online learning process can cause students to be less familiar with scientific learning because one of the determinants of learning success is the teacher (Arini, 2020), and student learning performance depends on how science is taught at school (OECD, 2018 in Bigozzi et al., 2018).

Critical Thinking Ability on Cognitive Learning Outcomes

Critical thinking encourages students to evaluate or investigate the logic, evidence, and assumptions that form the basis of other people's thinking. It is also a higher-level thinking ability. Students who think critically will think clearly and rationally and be open to evidence and facts in the material that students read, hear or see. With critical thinking, there is an active question-and-answer process and curiosity to understand the statement so that it can clarify the material obtained. Therefore, critical thinking skills have a significant impact on student learning outcomes.

Critical thinking skills make students think freely and openly about statements, arguments, or phenomena used to analyze and make decisions. In training, the critical thinking process can be done through activities related to aspects or indicators related to critical thinking. According to Ennis (in Tabun et al., 2019), indicators in critical thinking are being able to provide basic clarification, make decisions by considering the validity of various sources, conclude an event, define a term, and be able to reason, and then integrate it in a problem. From this description, critical thinking skills are essential in science learning, especially physics, so students can apply scientific concepts and be responsible in their decisions.

Critical thinking skills play an essential role and positively impact student learning outcomes. This statement aligns with the research of Dewi et al. (2019), who found that students with critical thinking skills better understand physics, as evidenced by their interest and enthusiasm for learning. Halpern defines using cognitive skills or developing strategies to improve planned results as critical thinking (Moore, 2007). Contrary to the results of this study, research conducted by Tabun (2019) on junior high school students on wave material showed that there was no difference in the influence between critical thinking ability and learning outcomes in cognitive aspects because there were other factors, such as the environment and learning experience.

Dweck (2021) states that assessment at one time is only marginally helpful in understanding a person's ability. The results that show the same effect of critical thinking skills in each category can be influenced by invalid data collection. The questionnaire only provides a brief and in-depth description of the factors that influence social desires in students responding to the questionnaire (Patten, 2017). Students may give answers according to what society considers right and good.

Critical thinking is an ability students can acquire in short-term memory. Questioning, criticizing, and arguing are important classroom activities that encourage critical thinking and improve science teaching and learning. In addition, discussion activities and case studies about science facts through books or movies can be critical to students, and connecting science topics with real-life problems can support students in developing critical thinking skills (Kazmi, 2017). These activities are expected to improve students' critical thinking skills.

Interaction Between The Usage of Module and Critical Thinking Ability on Cognitive Learning Outcome

Both learning modules produced the same outcomes in high and low critical thinking ability categories. The key to CT learning lies in abstraction. CT is often associated with problem-solving, where some of the main points that are part of the problem-solving process are formulating the problem in a way that is possible with tools such as computers or others, organizing and analyzing data logically,

and representing the data represented through abstraction. The thought process in formulating problems into solutions can be represented as computational steps and algorithms. In contrast, the scientific approach involves exploring nature, which leads to asking questions, making discoveries, and testing these discoveries to seek new understanding (Hutchins & Biswas, 2020).

Table 6 shows that by learning using different module approaches, better scores are consistently acquired by students with high critical thinking skills than those with low critical thinking skills. Learning modules with CT and scientific approaches with high and low critical thinking skills influence students' cognitive learning outcomes. These results are similar to research (Fauzi et al., 2022), which shows that there is no interaction between critical thinking ability as a moderating variable that can have a positive or negative impact on the relationship between the learning module (independent variable) and learning outcomes (dependent variable). There is no difference in the effect between critical thinking ability and cognitive aspect learning outcomes, which can occur due to other factors such as the environment and learning experience (Tabun et al., 2019).

Cognitive learning outcomes that are not influenced by the use of both modules or critical thinking skills can be caused by the impact of learning loss. Recalling that the learning process using CT and Scientific learning modules or this research was conducted during the transition period between online and offline learning allows students to be affected by learning loss. Learning loss can be defined as a condition where students lose knowledge and skills either in general or specifically or academic setbacks due to certain conditions, such as prolonged absence of the educational process. Learning loss can occur when there is limited interaction between teachers and students, between students and other students, and other reasons, such as learning time, loss of focus on students, and students' lack of ability to absorb material. Limited interaction and time in the learning process occurred due to the COVID-19 pandemic. As the spread of the COVID-19 virus subsided, a transition period occurred, where learning that was carried out online for approximately two years slowly changed to offline or face-to-face learning. This condition allows for learning loss in students due to a lack of interaction with teachers or other students (Hanafiah et al., 2022). (Kaffenberger, 2021) predicted that a three-month school closure could result in as much learning loss for students as a year of missed learning when schools reopen.

CONCLUSION

The conclusions of the research results are, first, the cognitive learning outcomes of Physics class XI students on temperature and heat material do not have significant differences between the use of CT and scientific modules. Second, high and low critical thinking ability showed no significant difference in cognitive learning outcomes. Third, there is no interaction between the effect of learning module usage (CT and scientific) and students' critical thinking ability on cognitive learning outcomes of grade XI students in temperature and heat. The research process should consider field conditions and students' readiness to accept new things, such as CT. Data on students' critical thinking skills can be strengthened by data from other sources such as observation, interviews, or tests, not limited to questionnaires. This statement can strengthen the research results about the effect of critical thinking skills on cognitive learning outcomes, where, based on previous research, the ability to think critically has a good influence on student learning outcomes.

REFERENCES

- Amin, B. D., Haris, A., & Swandi. (2017). Implementation of hypermedia-based physics learning tools to improve science process skills. *Proceeding International Seminar on Science Education*, 3, 175-182.
- Andayani, S., Muchtar, H., Yufiarti, & Susanto, E. (2020). Critical thinking profile and learning outcomes of prospective teachers regarding gender differences. *Journal of Physics: Conference Series*, 1567(4).
- Ansori, M. (2020). Computational thinking in problem-solving. *Dirasah: Journal of Islamic Education Science and Management Studies*, 3(1), 111-126.

- Arini, W. (2020). Implementation of scientific approach in physics learning. *Thabiea: Journal of Natural Science Teaching*, 3(2), 151.
- Bashoor, K., & Supahar. (2018). Validity and reliability of STEM-based physics lesson science literacy performance assessment instrument. *Journal of Educational Research and Evaluation*, 22(2), 219-230.
- Bigozzi, L., Tarchi, C., Fiorentini, C., Falsini, P., & Stefanelli, F. (2018). The effect of teaching approach on students' conceptual learning in physics. *Frontiers in Psychology*, 9, 1-14.
- Dale, E. (1969). *Audio-Visual Methods in Teaching 3rd Edition* (Holt (ed.)). Rinehart & Winston.
- Degeng, M. D. K., Prihatmoko, Y., & Hemilia, F. (2021). Application of the redundancy principle in digital modules for teaching material development courses. *Proceedings of the International Conference on Information and Education*, 609, 73-78.
- Dewi, A. C., Hapidin, H., & Akbar, Z. (2019). The effect of learning models and critical thinking skills on physics science understanding. *Journal of Obsession: Journal of Early Childhood Education*, 3(1), 18.
- Dharma, B. A., Tasrikah, N., & Churiyah, M. (2020). The effectiveness of problem-based learning (PBL) on learning outcomes through critical thinking skills. *Journal of Administrare*, 7(2), 235.
- Dinata, Y. M., Tjahjono, L. M., & Engel, M. M. (2021). Computational thinking mini-series for Ciputra Education Foundation school teachers. *Journal of Education and Community Service*, 4(2), 194-200.
- Dweck, C. S. (2021). *Mindset* (Translation). READ.
- Dwyer, H. A., Boe, B., Hill, C., Franklin, D., & Harlow, D. (2014). Computational thinking for physics: programming models of physics phenomena in elementary school. *Physics Education Research Conference*, 133-136.
- European Commission. (2009). *ECTS user guide*. Luxembourg: Office for Official Publications of the European Communities.
- Fatmawati, A., Zubaidah, S., Mahanal, S., & Sutopo. (2019). Critical thinking, creative thinking, and learning achievement: how they are related. *Journal of Physics: Conference Series*, 1417(1).
- Fauzi, A., Zahroh, S. H., & Ekawati, E. Y. (2022). The effect of using modules with a scientific approach and modules with a scientific approach regarding students' critical thinking skills on cognitive abilities in temperature and heat transfer materials. *Widyagogik: Journal of School Education and Learning*, 10(1), 234-248.
- Hanafiah, H., Sauri, R. S., Mulyadi, D., & Arifudin, O. (2022). Overcoming the Impact of Learning Loss in Improving Learning Quality in Senior High Schools. *Scientific Journal of Education Sciences*, 5(6), 1816-1823. <https://doi.org/10.54371/jiip.v5i6.642>
- Haseski, H. I., Ilic, U., & Tugtekin, U. (2018). Defining new 21st century skills-computational thinking: concepts and trends. *International Education Studies*, 11(4), 29.
- Hutchins, N., & Biswas, G. (2020). C2STEM: a system for synergistic learning of physics and computational thinking. *Journal of Science Education and Technology*, 29(1).
- Isnawan, M. G., Nahdlatul, U., & Mataram, W. (2020). *Quasi-Experiment*. Lombok: Nashir Al-Kutub Indonesia.
- Istuningsih, W., Baedhowi, B., & Sangka, K. B. (2018). Effectiveness of scientific approach using e-module based on learning cycle 7E to improve student learning outcomes. *International Journal of Educational Research Review*, 3(3), 75-85.
- Jakni. (2016). *Experimental research methodology in education*. Bandung: Alfabeta.
- Jufrida, J., Basuki, F. R., Kurniawan, W., Pangestu, M. D., & Fitaloka, O. (2019). Science literacy and science learning achievement in junior high school. *International Journal of Educational Evaluation and Research*, 8(4), 630-636.
- Kaffenberger, M. (2021). Modeling the long-term learning impact of COVID-19 learning shocks: Actions to (more than) mitigate losses. *International Journal of Educational Development*, 81 (October, 2020), 102326. <https://doi.org/10.1016/j.ijedudev.2020.102326>
- Kawuri, K. R., Budiharti, R., & Fauzi, A. (2019). Application of computational thinking to improve students' critical thinking skills in class X MIA 9 SMA Negeri 1 Surakarta on the material of effort and energy. *Journal of Physics Materials and Learning*, 9(2), 116-121.

-
- Kazmi, Y. (2017). The role of critical thinking in Islam. *Hamdard Islamicus*, 8(20), 159-173.
- Kemendikbudristek. (2022). *Computational thinking elective courses*. Ministry of Education and Culture of the Republic of Indonesia.
- Khasyyatillah, I., & Osman, K. (2019). Development of CT-S learning module on the topic of straight motion to train computational thinking skills. *Journal of Education Science*, 3(3), 270-280.
- Lapawi, N., & Husnin, H. (2020). Effect of computational thinking module on achievement in science computational thinking module on achievement in science. *Science Education International*, 31(2), 164-171.
- Mahajan, M., & Singh, M. K. S. (2017). Importance and benefits of learning outcomes. *IOSR Journal of Humanities and Social Sciences*, 22(3), 65-67.
- Malawi, I., & Tristiar, A. (2016). the effect of concentration and critical thinking skills on social studies learning achievement of fifth-grade students of Manisrejo I Elementary School, Magetan Regency. *Premiere Educandum: Journal of Basic Education and Learning*, 3(2), 118-131.
- Miharja, F. J., Hindun, I., & Fauzi, A. (2019). Critical thinking, metacognitive skills, and cognitive learning outcomes: a correlation study on genetics. *Biosphere: Journal of Biology Education*, 12(2), 135-143.
- Mohaghegh, D. M., & McCauley, M. (2016). Computational thinking: 21st century skills. *International Journal of Computer Science and Information Technology (IJCSIT)*, 7(3), 1524-1530.
- Moore, D. T. (2007). *Critical thinking and intelligence analysis*. Washington: National Defense Intelligence College
- Mulyanto, H., Gunarhadi, G., & Indriayu, M. (2018). The effect of problem-based learning model on students' mathematics learning outcomes regarding critical thinking skills. *Journal of Educational Research Review*, 3(2), 37-45.
- Murawski, L. M. (2014). Critical thinking in the classroom and beyond. *Journal of Learning in Higher Education*, 10(1), 25-30.
- Murtini, W. (2018). International Journal of active learning the effectiveness of scientific approaches to improve student learning outcomes. *International Journal of Active Learning (IJAL)*, 3(2), 86-91.
- Nenotaek, B., Sujadi, I., & Subanti, S. (2019). Difficulties in implementing the scientific approach in mathematics learning. *Journal of Educational Research Review*, 4(4), 624-636.
- Patten, M. L. (2017). *Questionnaire research: A practical guide*. In Questionnaire Research. Routledge. <https://doi.org/10.4324/9781315265858-5>
- Putri, M. M. A., Sinulingga, P., & Hartanto, T. J. (2019). Implementing scientific learning in high school physics learning on elasticity and Hooke's law. *Vidya Karya*, 34(1), 15.
- Rahayuni, G. (2016). The relationship between critical thinking skills and science literacy in integrated science learning with PBM and STM models. *Journal of Science Research and Learning*, 2(2), 131.
- Rinaldi, R. G. (2020). *Application of computational thinking approach in physics learning on parabolic motion material (case study at SMA Negeri 3 Surakarta)*. Sebelas Maret University.
- Setyawan, D. N., Sarwanto, S., & Aminah, N. S. (2017). Development of scientific-based learning on rotational dynamics and equilibrium of rigid bodies to improve high school students' critical thinking and verbal communication skills. *Journal of Physics Learning Research*, 8(1), 14-25.
- Silaban, B., Tarigan, G., & Siagian, P. (2014). The application of Mann-Whitney was used to determine whether there is a difference in the achievement index of students who come from Medan City and those outside Medan City. *Saintia Mathematics*, 2(2), 173-187.
- So, H. J., Jong, M. S. Y., & Liu, C. C. (2020). Computational thinking education in the Asian Pacific region. *Asia-Pacific Education Researcher*, 29(1), 1-8.
- Solikha, W. K., Martini, & Purnomo, A. B. (2022). Analysis of implementing the scientific approach in science learning during the pandemic. *Pensa E-Journal: Science Education*, 10(1), 142-149.
- Subiyantari, A. R., Muslim, S., & Rahmadyanti, E. (2019). The effectiveness of the jigsaw-type cooperative learning model in the primary building construction subject on student learning outcomes regarding critical thinking skills. *Journal of Education and Vocational*, 1(7), 691-696.
-

- Suyanto, S. (2018). Implementation of the scientific approach through 5M in the revised 2013 curriculum in Indonesia. *Cakrawala Pendidikan*, 37(1), 22-29.
- Swandi, A., Amin, B. D., & Muin, F. (2018). Learning 21st-century physics in high school through interactive computer simulation to improve student achievement. *International Conference on Mathematics and Science Education*, 3(1), 130-135.
- Tabun, Y. F., Sunarno, W., & Sukarmin. (2019). The effectiveness of critical thinking skills on learning outcomes at Stella Maris Catholic Junior High School Biudukfoho, Indonesia. *International Journal of Educational Research Review*, 4(4), 593-601.
- Taghva, F., Rezaei, N., Ghaderi, J., & Taghva, R. (2014). Studying the relationship between critical thinking skills and students' educational achievement (Eghlid University as a case study). *International Letters of Social and Humanistic Sciences*, 25, 18–25.
- Uribe-Enciso, O. L., Uribe-Enciso, D. S., & Vargas-Daza, M. D. P. (2017). Pensamiento crítico y su importancia en la educación: algunas reflexiones. *Rastros Rostros*, 19(34), 78-88.
- van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). Determinants of 21st century and 21st century digital skills for workers: a systematic literature review. *SAGE Open*, 10(1).
- Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for math and science classrooms. *Journal of Science Education and Technology*, 25(1), 127-147.
- Yadav, A., & Berges, M. (2019). Computer science pedagogical content knowledge: characterizing teacher performance. *ACM Transactions on Computing Education*, 19(3).
- Yusup, F. (2018). Test the validity and reliability of quantitative research instruments. *Tarbiyah Journal: Educational Scientific Journal*. 7(1), 17–23