JIPF (JURNAL ILMU PENDIDIKAN FISIKA)
p-ISSN: 2477-5959 | e-ISSN: 2477-8451 *Vol. 8 No. 1, January 2023, Page 1-9*

This work is licensed under
a Creative Commons Attribution-NonCommercial 4.0 International License.

Problem-Solving and Computational Thinking Practices: Lesson Learned from The Implementation of ExPRession Model

Natalya Limbong [1], Kartini Herlina [2*)], Hervin Maulina [3], Abdurrahman [4]
Universitas Lampung, Indonesia[1,2,3,4]
***Corresponding email: kkartini.herlina@gmail.com**

Received: January 5th, 2022. Revised: May 12th, 2022. Accepted: August 1st, 2022

Keywords :
Problem-Solving Ability; Computational Thinking Ability; Well-Structure Physics Problem; ExPRession Learning Model

ABSTRACT
Computational thinking ability is one of today's problem-solving methods that can be applied in physics learning. However, it is not yet known by most teachers so it has not been applied optimally in learning activities. This study aims to identify students' problem-solving and computational thinking abilities in solving well-structure physics problems. The subject of this study was the eleven grade majoring in natural science of SMAN 1 Bangunrejo. This type of research is descriptive research. The data used to analyze the students' problem-solving and computational thinking abilities were obtained from the essay test. Based on the results of descriptive analysis, it can be concluded that there is a relationship between students' problem-solving abilities and students' computational thinking abilities. In making a useful description, abstraction and decomposition abilities are needed, while to determine the physics approach and specific application of physics, generalization abiliy are needed. In solving mathematical procedures, algorithm ability are needed and to find out logical progressions, debugging ability are needed.

INTRODUCTION

Educational institutions have an important role in equipping students to master the various skills needed in 21st-century life. The skills that must be mastered by students in this century include critical thinking and problem-solving, communication and collaboration, creativity and innovation [1]. Computational thinking is an approach to solving-problems that can be applied across subjects [2]. This explains that computational thinking is an important part of problem-solving skills. The 21st-century learning makes computational thinking skills the main subject of learning because it is increasingly being recognized as a fundamental or basic competency today [3]. This confirms that computational thinking is one of the competencies that must be trained in today's learning. However, computing thinking is not widely known by teachers. Based on the results of a preliminary study through interviews with three physics teachers at one of the public high schools in the Bangunrejo regency, it is known that teachers do not understand computational thinking so they assume that the physics learning activities that have taken place so far have not involved computational thinking skills in solving problems.

Wing assumes that computational thinking is a basic skill for everyone, not only for computer scientists where computational thinking does not mean humans think like computers but rather a human way of thinking based on concepts that combine mathematical thinking and technical thinking to be able to understand problems and find problem-solving ideas [4]. Based on these characteristics, it can be understood that computational thinking is a basic ability for everyone to understand the problem so as to obtain the right problem solution. The application of computational thinking can be interpreted as an expression of mental activity in formulating problems and expressing solutions [5]. Computational thinking is a mental activity for problem abstraction in finding automatic solutions [6]. Based on the expert's statement above, it can be said that computational thinking is a problem-solving process involving mental activity and abstraction processes.

Computational thinking is closely related to problem-solving and information processing. The relationship between these three components showed a high degree of similarity. In computational thinking, students demonstrate the ability to identify problems, break them down into workable steps, build patterns that are considered important, form possible solutions and present understandable solutions [7]. In other words, in problem solving, computational thinking skills are needed to process information in finding solutions. So it is suspected that learning activities that involve computational thinking skills will help students process information in understanding problems and finding appropriate solutions. Logical thinking and ability to analyze information needed in problem-solving can be improved through application of computational thinking [8] [9]. Problem-solving in this study is defined as a process or series of activities carried out by students to find logical solutions to well-structured physics problems. The solution to solving a problem contains four phases of completion, namely understanding the problem, planning a solution, solving the problem according to the plan and re-checking all the steps that have been done [10].

A better way to practice problem-solving abilities in students is through inductive teaching, one of which is problem-based learning [10]. The ExPRession learning model is a problem-based hypothetical learning model designed for the purpose of building mental models and problem-solving abilities. The application of the ExPRession learning model which consists of orientation, expression, investigation, evaluation, and generalization stages, will train students to have the ability to understand problems, plan solutions, and solve numerical problems using useful descriptions, physics approaches, specific application of physics, mathematical procedures, and logical progressions [11]. Thus, the application of the ExPRession model can facilitate the formation of students' mental models through the depiction of physics concepts into various external representations that have an impact on better problem-solving abilities.

The application of multiple external representations can provide complementary information when each representation in the system contains several different information [12]. The second advantage of using multiple external representations is that it can limit the interpretation of a representation. When two representations are presented simultaneously, the interpretation of the first representation that is still confusing can be limited by the second, which is more specific. In addition, multiple representations support the construction of deeper understanding when students integrate information from multiple external representations in achieving understanding that would be difficult to achieve with just one representation.

Based on the preliminary description, the purpose of this study is to find out how the influence of computational thinking on the problem-solving ability of well-structured physics problem using the ExPRession learning model. The difference between this research and other studies is that it compares Doctor problem solving with Angeli's computational thinking through the application of the ExPRession learning model. While previous research was conducted by Maharani who compared Polya problem-solving with Angeli computational thinking. Polya problem-solving ability has 4 indicators of problem solving ability, namely understand the problem, devising a plan, carrying out the plan, and looking back [13]. Different from the Doctor problem solving which has 5 indicators of problem solving ability, namely useful description, physics approach, specific aplication of physics, mathematical procedures, and logical progression [14].

METHOD

The subject of this research was the eleven grade majoring in natural science of SMAN 1 Bangunrejo. This study used the descriptive qualitative method as presented in Figure 1.

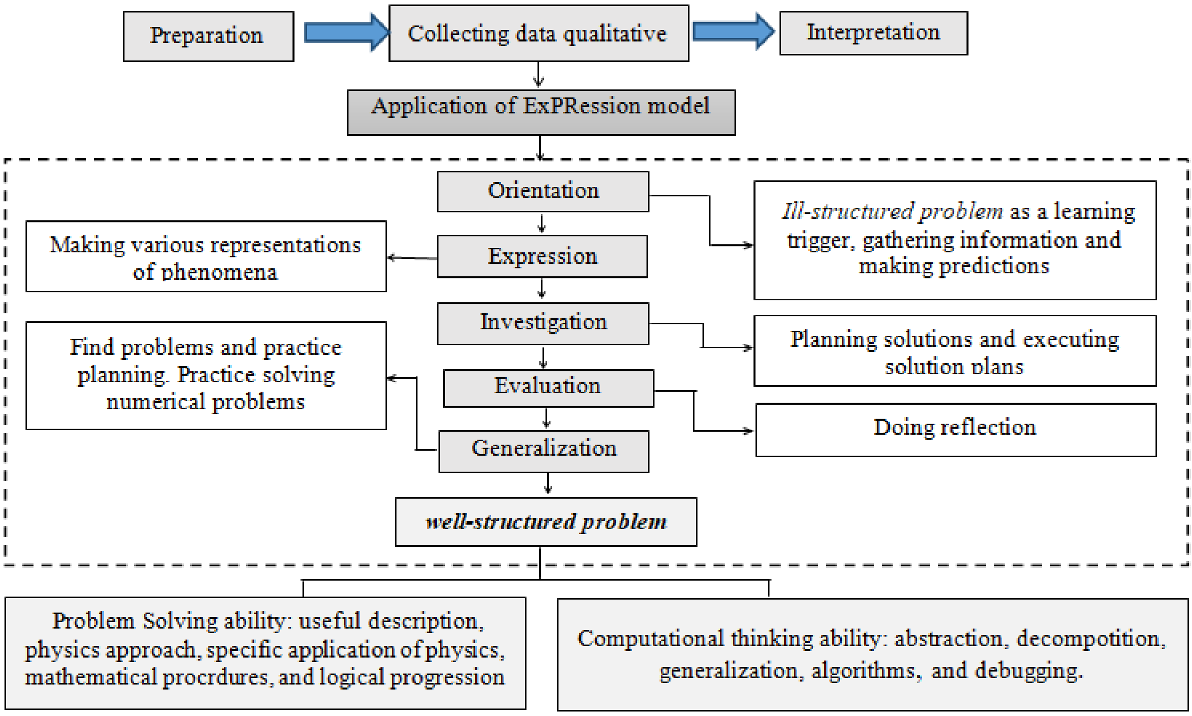

***Fig 1**. Research methodology*

The data on this study were obtained from test result about dynamic fluid material. The questions tested are in the form of national exam questions so that validity and reliability tests were not carried out. The collected data is then processed using a scoring technique. The scoring rubric used was adapted by measuring the problem-solving process observed from the solution to each problem as shown in Table 1 below.

Table 1. Assessment Rubric

Problem solving steps	Description	Score
Useful description	The pictures and data presented are useful, appropriate, and complete	5
	The pictures and data presented are useful and complete but contain a few errors	4
	Some of the pictures and data presented are useless, incomplete, and/or inappropriate	3
	Most of the pictures and data presented are useless, incomplete, and/or inappropriate	2
	All pictures and data presented are useless and inappropriate or there are no images and data	1

Problem solving steps	Description	Score
Physics approach	The physics approach chosen is in accordance with the problem and complete	5
	The chosen physics approach contains few errors	4
	Some of the concepts and principles of the chosen physics approach are incomplete and/or inappropriate	3
	Most of the physics approaches chosen are incomplete and/or inappropriate	2
	All selected concepts and principles are not appropriate or there is no physics approach	1
Specific application of physics	The specific application of the concepts and principles of physics according to the problem and complete	5
	The specific application of the concepts and principles of physics contains few errors	4
	Some specific applications of physics concepts and principles are incomplete and/or contain error	3
	Most specific applications of physics concepts and principles are incomplete and/or contain errors	2
	All specific applications of physics concepts and principles are inappropriate and/or contain errors or there is no specific application of physics concepts and principles	1
Mathematical procedures	The mathematical procedures presented are appropriate, structured, and complete	5
	The suitability of the mathematical procedures used contains few omissions or errors	4
	Part of the mathematical procedure is missing and/or contains errors	3
	Most of the mathematical procedures are missing and/or contain errors	2
	All the mathematical procedures are not appropriate and/or contain errors or there are no mathematical procedures	1
Logical progression	All problem solutions are clear, focused, and logically connected	5
	The solution is clear and focused with a bit of inconsistency	4
	Some of the solutions are unclear, unfocused, and/or inconsistent	3
	Most parts of the solution are unclear, out of focus, and/or inconsistent	2
	All solutions are unclear, unfocused, and/or inconsistent or there is no logical evidence	1

Table 2. Well-Structure Physics Problem-solving Steps

Problem solving [14]	**Definition**
Useful description	Summarize important information in the form of representations of physics descriptions in various forms and specific problems
Physics approach	Choose the right concepts and principles that are useful for solving problems
Specific application of physics	Applying the concepts and principles of physics to certain conditions in the problem
Mathematical procedures	Choose appropriate mathematical procedures and follow mathematical rules to obtain problem-solving results
Logical progression	Communicate goal-focused reasoning and evaluate solutions in terms of clarity, focus, and logical organization

The data analysis technique in this research is descriptive analysis. The analysis was carried out by verbally describing students' problem-solving abilities and students' computational thinking abilities based on the scores obtained. The problem solving ability of students in this study is basedon indicators adopted by Doctor as shown in Table 2 above.

The indicators of computational thinking used in this study include abstraction, generalization, decompotition, algorithms, and debugging as shown in Table 3.

Table 3. Computational Thinking Ability Indicators

Indicators [15]	**Definition**
Abstraction	Ability to determine required components and ignore unneeded components
Generalization	The ability to find general patterns of similarities/ differences found in a given problem so that it can be applied to different problems
Decomposition	Ability to break down complex problems into simple problems that are easier to understand and solve
Algorithm	Ability to design a step by step of actions of how to go about solvinga problem
Debugging	Ability to identify, delete, and correct errors

RESULTS AND DISCUSSIONS

One of the questions that the students solved was the 2014 High School Physics National Examination Package 3 number 15 which was modified so that students had to make a representation of the problem in the form of a sketch or picture. Figure 2 presents the answers of students who get the lowest score and Figure 3 presents the highest score.

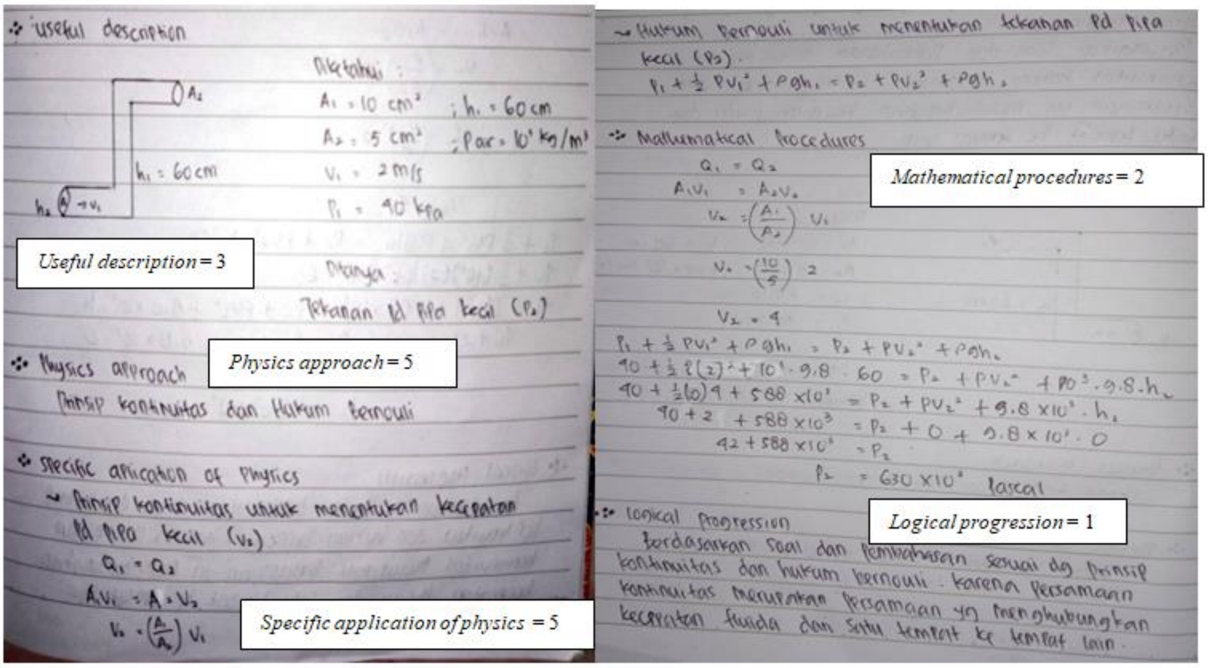

Fig 2. *The student's answer with the lowest score*

Based on Figure 2, students did not describe all the information contained in the questions correctly which appeared on the sketch but was still inaccurate so a score of 3 was obtained for the useful description step. The physics concept that will be used is appropriate so that a score of 5 is obtained for the physics approach step and the written mathematical equations are in accordance with the physics approach so that a score of 5 is obtained for the specific application of the physics step. Most of the mathematical procedures used contain errors. The velocity of the pipe with a larger cross-section (v_2) is not equipped with the right physics unit and the answers obtained through mathematical procedures are still wrong, so a score of 2 is obtained for the mathematical procedures step. There is no statement that explains the suitability of the answer with the theory used so that a score of 1 is obtained for the logical progression step.

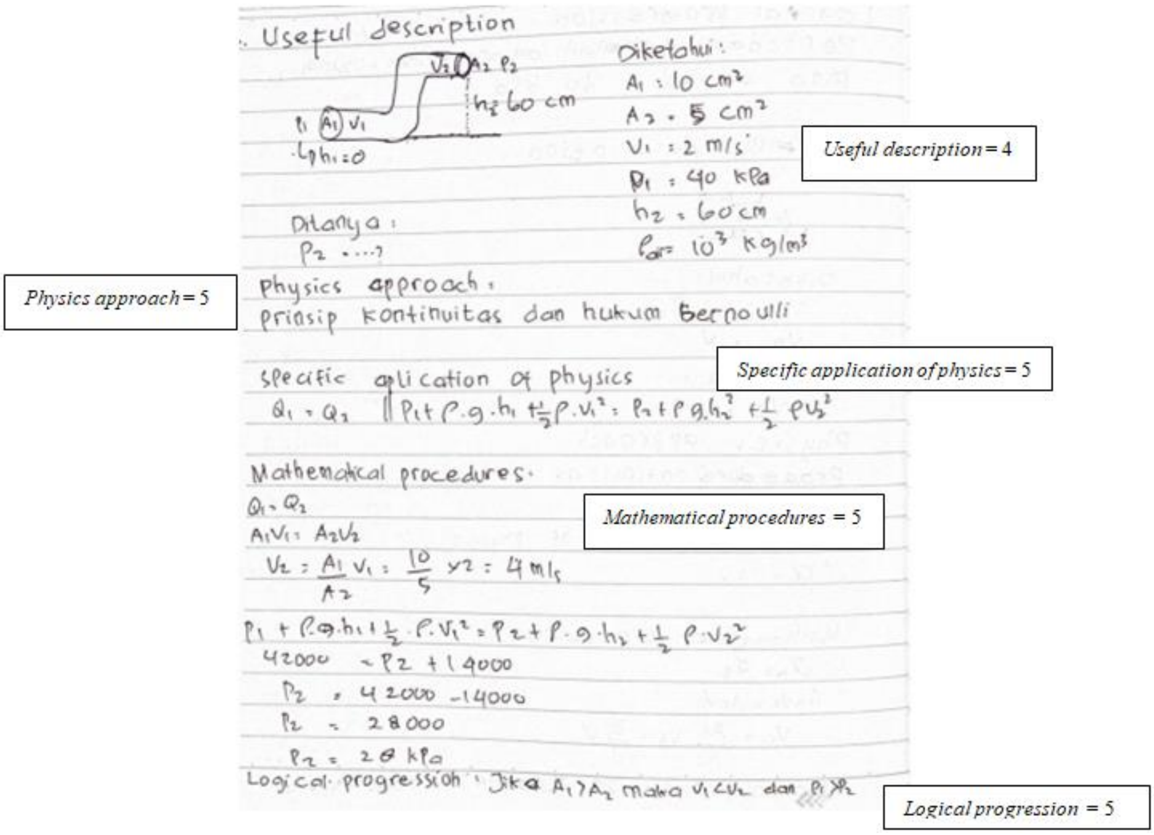

Fig 3. *The student's answer with the highest score*

Based on Figure 3, students have described the information contained in the questions correctly but contain a few errors, where there is no difference in the cross-sectional area at the end of the pipe so that a score of 4 is obtained for the useful description step. The physics concept that will be used is appropriate so that a score of 5 is obtained for the physics approach step and the written mathematical equations are in accordance with the physics approach so that a score of 5 is obtained for the specific application of the physics step. The mathematical procedure used is correct so that a score of 5 is obtained for the mathematical procedures step and there is a statement that explains the suitability of the answer with the theory used so that a score of 5 is obtained for the logical progression step.

The useful description step directs students to summarize important information from well-structured physics questions in the form of sketches and physics symbols and determine specific problems so that they will help students understand the problem. In the application of the ExPRession model, multirepresentation abilities are needed that allow students to integrate and organize all the information contained in the problem so that problems are more easily solved [16] [17]. In this step, students are trained to identify relevant and less relevant information. The relevant information will then be converted into a sketch accompanied by a description in the form of physical symbols with the value of each known physical quantity in the problem. Through these steps, students are trained in abstraction abilities in computational thinking. In accordance with a theory states that the activity of changing representations can improve abstraction abilities in computational thinking [18]. Students who have adequate abstraction thinking abilities have an impact on better understanding problems and are able to determine specific problems or in computational thinking called the ability to decompose complex problems into simple problems. In other words, students are trained to use abstraction thinking techniques in organizing information and then determining specific problems (decomposition) through the results of abstraction thinking. This is in line with the results which state that respondents perform decomposition and abstraction when understanding the problem by reading the questions carefully and determining the relevant data [19]. This shows that the respondent has understood what was asked about the problem and identified the parts that make sense [20].

The physics approach and specific application of physics step direct students to determine the concepts and principles of physics that will be used in solving problems. In this step, students are trained to recognize problem patterns based on the information described in the useful description step so that it will help students determine the right physics equation for problem-solving. In accordance with a theory explains that multiple representations are needed in solving physics problems because a faster understanding is needed to describe and explain the relationship between variables related to the physical structure itself includes mathematical modeling [21]. Through these steps, students are trained in generalization abilities in computational thinking. This is in line with an axplanation that the respondent tries to make a formula to solve the problem, which is the respondent's generalization stage to obtain a general form [19]. Students are considered to have generalization abilities in solving well structure problems if students are able to recognize problem patterns so that students can determine the physics approach and mathematical equations that will be used in solving problems.

The mathematical procedures step directs students to solve problems using mathematical equations that have been planned in the specific application of the physics step in a sequential and structured manner. Through this step, students are trained to design a series of actions sequentially step by step in solving problems or called algorithmic abilities in the context of computational thinking. This is in accordance with the opinion which states that when the scene is carrying out the plan, the respondent performs algorithmic steps in the context of computational thinking [19].

The logical progression step directs students to communicate their reasoning and evaluate the solutions obtained related to clarity, focus, and logical organization. In Figure 3, it appears that there is an explanation regarding the solution obtained in accordance with the theory used so that the solution is considered logical. Through this step, students are trained to identify the answers obtained. The aspect of debugging ability in computational thinking is to identify answers, remove, and fix errors [22]. Based on the expert opinion, it can be said that the process of evaluating the solution for the tested well structure problem has trained students debugging abilities in the context of computational thinking but is still in the aspect of identifying answers and providing arguments for the solutions obtained. In other words, there are debugging aspects that cannot be observed through the application of the ExPRession learning model in solving the well structure problem, namely removing and fixing errors. Students who have debugging abilities in solving well structure problems in the application of the ExPRession learning model should be able to identify answers and provide arguments as a result of answer analysis associated with the principle of continuity and Bernoulli's law. If there are errors in answers, students are asked to review and make improvements to get the correct answer. Students' debugging abilities in solving well structure problems can be observed through the use of Matlab software to detect and identify errors, and then correct errors through an iterative process until an appropriate solution is obtained [23].

The debugging ability of students in this study cannot be measured validly due to the limitations of the assessment instrument which is still in the form of print media, so it is recommended for further research to use software that is able to display traces of student work in the debugging stage and quantitative research is needed to measure the linear correlation between students' problem-solving abilities and computational thinking abilities.

CONCLUSION AND SUGGESTION

Based on the result and discussion, it can be concluded that there is a relationship between students' problem-solving abilities and students' computational thinking abilities. In making a useful description, abstraction and decomposition abilities are needed to organize information in the problem and determine a specific problem, while to determine the physics approach and specific application of physics, generalization abilities are needed in identifying problem patterns. In solving mathematical procedures, algorithm abilities are needed so that mathematical procedures are sequential and structured, while to find out logical progressions, debugging abilities are needed to identify errors and correct them. The suggestion in this study is the need for quantitative research to specifically determine the correlation between problem-solving abilities and students' computational thinking skills and it is recommended to involve technology that makes it easier for researchers to record student work tracks in solving problems so that students' debugging abilities can be identified validly.

ACKNOWLEDGMENTS

We would like to thank the headmaster, teachers, students, and educational staff of SMAN 1 Bangunrejo, so these research activities can run smoothly. We also would like to thank FKIP University of Lampung for the permission given in conducting this research.

REFERENCES

[1] Trilling, B., & Fadel, C. (2009). *21st Century Skills_ Learning for Life in Our Times, 1st ed*. San Francisco: Jossey-Bass A Wiley Imprint.

[2] Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: What is involved and what is the role of the computer science education community?. *Acm Inroads*, *2*(1): 48-54.

[3] Doleck, T., Bazelais, P., Lemay, D. J., Saxena, A., & Basnet, R. B. (2017). Algorithmic thinking, cooperativity, creativity, critical thinking, and problem solving: exploring the relationship between computational thinking skills and academic performance. *Journal of Computers in Education*, *4*(4): 355-369.

[4] Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3): 33-35.

[5] Wing, J. M. (2014). Computational thinking benefits society. *40th anniversary blog of social issues in computing*, *2014*, 26.

[6] Yadav, A., Mayfield, C., Zhou, N., Hambrusch, S., & Korb, J. T. (2014). Computational thinking in elementary and secondary teacher education. *ACM Transactions on Computing Education (TOCE)*, *14*(1): 1-16.

[7] Labusch, A., Eickelmann, B., & Vennemann, M. (2019). Computational thinking processes and their congruence with problem-solving and information processing. In *Computational thinking education* (pp. 65-78). Springer, Singapore.

[8] Ansori, M. (2020). Pemikiran Komputasi (Computational Thinking) dalam Pemecahan Masalah. *Dirasah: Jurnal Studi Ilmu Dan Manajemen Pendidikan Islam*, *3*(1): 111-126.

[9] Csizmadia, A., Curzon, P., Dorling, M., Humphreys, S., Ng, T., Selby, C., & Woollard, J. (2015). Computational thinking-A guide for teachers.

[10] Prince, M., & Felder, R. (2007). The many faces of inductive teaching and learning. *Journal of college science teaching*, *36*(5): 14-20.

[11] Herlina, K. (2020). *Model Pembelajaran ExPRession untuk Membangun Model Mental dan Kemampuan Problem Solving*. Yogyakarta: Graha Ilmu.

[12] Ainsworth, S. (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and instruction*, *16*(3): 183-198.

[13] Polya, G. (1957). *How to Solve It: A new Aspect of Mathematical Method, Second edi*. Princeton: Princeton University Press.

[14] Docktor, J. L., Dornfeld, J., Frodermann, E., Heller, K., Hsu, L., Jackson, K. A., ... & Yang, J.

(2016). Assessing student written problem solutions: A problem-solving rubric with application to introductory physics. *Physical review physics education research*, *12*(1): 010130.
[15] Angeli, C., Voogt, J., Fluck, A., Webb, M., Cox, M., Malyn-Smith, J., & Zagami, J. (2016). A K-6 computational thinking curriculum framework: Implications for teacher knowledge. *Journal of Educational Technology & Society*, *19*(3): 47-57.
[16] Herlina, K., Nur, M., & Widodo, W. (2017, January). Development of Optics Learning Model to Build Mental Models and Problem Solving Ability. In *International Conference on Mathematics and Science Education* (pp. 53-59). Atlantis Press.
[17] Herlina, K., Widodo, W., Nur, M., & Agustini, R. (2016). Penerapan Model Pembelajaran “ExPRession” untuk Meningkatkan Kemampuan Problem Solving: Secara Numerik dan Secara Eksperimen.
[18] Gautam, A., Bortz, W., & Tatar, D. (2020, February). Abstraction through multiple representations in an integrated computational thinking environment. In *Proceedings of the 51st ACM Technical Symposium on Computer Science Education* (pp. 393-399).
[19] Maharani, S., Kholid, M. N., Pradana, L. N., & Nusantara, T. (2019). Problem solving in the context of computational thinking. *Infinity Journal*, *8*(2): 109-116.
[20] Reiss, K., & Törner, G. (2007). Problem solving in the mathematics classroom: The German perspective. *ZDM*, *39*(5): 431-441.
[21] Opfermann, M., Schmeck, A., & Fischer, H. E. (2017). Multiple representations in physics and science education–why should we use them?. In *Multiple representations in physics education* (pp. 1-22). Springer, Cham.
[22] Selby, C., & Woollard, J. (2013). Computational thinking: the developing definition.
[23] Maulina, H., Abdurrahman, A., & Sukamto, I. (2021). How to Bring Computational Thinking Approach to The Non-Computer Science Student’s Class???. *Jurnal Pembelajaran Fisika*, *9*(1): 101-112.