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Computational-Thinking Based Learning Activities for Physics in Indonesian New Curriculum Through a Student Worksheet Development

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ABSTRACT
This research aims to investigate the practicality of the CT-based learning integrated in the physics high school subject through a development of student worksheet. The CT-based learning adapted from Palts and Pedaste's problem-solving cycle for CT and involved Weintrop's taxonomy of CT activities in math and science as the reference activities. The study used Plomp's model, started from the preliminary research, followed by the development phase and evaluation that contained the validity content and practicality evaluation. The content showed high validity scores thus it was continued with the practicality evaluation by carrying out a micro-evaluation to the target users that involved observation, interview, and questionnaire addressing. The evaluation showed that the learning activities through the student worksheet had high practicality scores thus it is possible to be used and adapted to other subject matters.

INTRODUCTION

During recent years, educational stakeholders across the world have been promoting a fundamental skill that is mentioned as important as literacy and numeracy, namely Computational Thinking (CT) [1]. The concept of Computational Thinking (CT) was introduced prior by Seymour Papert [2] in 1980, and it came out became popular after Wing's paper labelled it with term "Computational Thinking" and emphasized it as a thought process and a problem solving type [3] so that it is more than an ability to program [4], but a competency that is transferable to other disciplines [5] [6]. Due to its importance and applicability as a problem-solving strategy for a wide range of domains, CT is considered as one of the fundamental 21st century skills. [6] [7] [8] [9] [10] [11].

As a thinking still, CT can be taught in two ways. The first way is by providing a certain course to teach the expected skills such as adding computer science subject to the curriculum, while the second way is by integrating the skills to the subjects that are being studied [12]. In many countries, CT had been introduced to their curriculum such as in Estonia, Israel, Finland, Great Britain, and all Australian states [1] [12] [13]. Meanwhile in Indonesia, since CT is not yet introduced to the curriculum thus there is no particular subject added to learn CT, the most possible way to implement CT learning in class is by the integration of the skills to existing subjects that are existing in the curriculum.

However the CT research were still at the embryonic stage [11]. Applying CT to the learning challenges the teachers. Most teachers have no clear idea of how to develop CT in the classroom since the strong understanding of CT is not yet known [11], and even when teachers had no significant problem in understanding the underlying process in CT, designing appropriate learning associated with CT was still a challenge [14]. Nonetheless, the integration of CT in a number of subjects were made by Maharani et al [15] through math for early-age school students, Widiningrum [16] using Scratch media for high school physics subject, and Muliyati [17] through a worksheet development for the undergraduate students.

As the effect of COVID-19, school closures have impacted almost 90% of the student population in more than 100 countries [18]. Due to school closures, many countries across the range of subjects, grade levels, and geographical region in the USA, Australia, and Europe, had experienced learning loss [19]. Likewise, the learning loss is also potential in Indonesia. The worst scenario estimated by the World Bank was that Indonesia would suffer 0,7 years of learning loss for 8 months school closures, while in fact, the school closures had been implemented for nineteen months [3]. As means of recovery and prevention to further effects of the learning loss, the Ministry of Education and Culture of Indonesia implemented a new curriculum namely *Kurikulum Merdeka* (The Independent Curriculum) which focuses on literacy and numeracy, and typically more flexible, allowing educators to have more time in applicating a deeper learning on the essential subjects, as well as character and competency building [20]. It can be an opportunity and a threat to associate CT learning with the existing subjects at school, especially to the students that potentially experienced the learning loss in which they would experience the loss of learning enthusiasm, concentration, literacy, discipline, and hospitality [21].

Acquiring a skill or an ability takes time and practice rather than facts, knowledge, or information [22]. Therefore, bringing CT to the class requires activities that can be carried out by students so that they can experience and learn the skills themselves. Consequently, a worksheet is required to guide students' activities to follow the learning stages in order. The aim of this research is to associate CT-based learning through physics subjects by developing a CT-based student worksheet.

The prior research on CT worksheet development was conducted by Mulyati et al [17]. But, it was for physics students at the undergraduate level. Meanwhile, Widiningrum [16] conducted the CT worksheet development for physics in the high school level, but it was created for the old curriculum, therefore it has not met some requirements of the learning of the new curriculum. The novelty of this research is that the worksheet's development of CT-learning for physics is made and adjusted for the new curriculum, *Kurikulum Merdeka* (The Independent Curriculum) and it follows the problem-solving cycles model for CT provided by Palts and Pedaste which consists of three stages, namely defining the problem, solving the problem, and evaluating the solution. Therefore, this can be one of the newest of the CT learning worksheet integrated with physics for High School students in *Kurikulum Merdeka* that follows the CT model of Palts and Pedaste.

METHOD

The research is a development research conducted using Plomp's model which consists of three phases namely preliminary research, development or prototyping phase, and assessment phase [23]. There were two criterion that were evaluated. The first was relevance (content validity), means that the worksheet and its design was developed based on scientific knowledge. While the other was practicality, means that the worksheet is expected to be usable in the targeted settings.

During the preliminary research, the requirement analysis was conducted as the basis for the development process by doing a literature review as well as interviews and questionnaire addressing to depict the activities which are considered important and therefore potential to be carried out at the class. The interviews were held to four physics teachers of four prior school in implementing the Independent Curriculum. The teachers were chosen purposively due to their experience as the prior in implementing the new curriculum which allow them to have better insight about the learning process in The Independent curriculum.

After the requirement analysis and literature review, the development phase begun by addressing all the preliminary research result to tentative details of all module components. The list was used as the basis of Prototype I. Then, the prototype I was developed and evaluated through the expert appraisals. If the prototype was considered valid, the next evaluation is ready to carry out.

The worksheet unit was then evaluated by generating a micro-evaluation, where a small group of target users uses parts of the worksheet outside its normal user setting [23]. It involved questionnaire addressing, observation, and interview. The target user included in the microevaluation was the teachers and ten students of XI grade in Al-Azhar Syifa Budi Senior High School Solo, while the part of the worksheet that is being practiced was the first sub-material. The micro-evaluation focused on evaluating the practicality for the purpose of refinement.

The validity and practicality of the module was assessed by addressing a Likert scale questionnaire to the teacher after the learning activities of the students. the questionnaire were calculated with Kappa Cohen formula that is shown in Equation 1 [24].

$$\kappa = \frac{\rho - \rho^e}{1 - \rho^e} \qquad (1)$$

κ = Kappa moment that represents the level of practicality of the product
ρ = number of values given by the assessors divided by the maximum value
ρ^e = the subtraction of maximum value by the total of value given by the assessors divided by the maximum value

Kappa moment (κ) ranges from 0 to 1 which represents each decision category as shown in Table 1.

Table 1. Categories of Decisions According to Boslaugh [24]

Total Score (κ)	Classification
$0.81 < \kappa < 1.00$	Very High
$0.61 < \kappa < 0.80$	High
$0.41 < \kappa < 0.60$	Medium
$0.21 < \kappa < 0.40$	Low
$0.01 < \kappa < 0.20$	Very Low
$\kappa < 0.00$	Invalid

The practicality became the focus because the product has to be ensured that it can be practiced, considering Plomp's logical hierarchy that if the intervention is not considered practical, then it does not make sense to investigate its effectiveness [23].

RESULTS AND DISCUSSIONS

Knowing Computational Thinking

Many definitions were proposed by researchers to describe Computational Thinking. The prior in introducing CT, Wing defined CT as a thought process evident to problem formulation and problem solution, thus it can be represented in forms enabling their execution by an information-processing agent [3]. Unfortunately, the definition still lacks information about the skills and aspects dimensions to develop CT. Therefore, Palts & Pedaste [2] had conducted a review that resulted in a model for developing CT Skills, which consisted of three-staged problem-solving cycle that relies on CT as a problem solving method that is carried out algorithmically. The stages consist of defining the problem, solving the problem, and analysing the solution. This model was used in this research as a problem-solving cycle and was carried out to students' learning in the worksheets. The stages of the model are shown in Table 2.

Table 2. Stages for CT Skills Development by Palts & Pedaste [2]

Stage	Name of Stage	Skills Involved
1	Defining the problem	Formulating the problem; abstraction; problem reformulation; and decomposition.
2	Solving the problem	Collecting and analyzing data; algorithmic design; parallelization and iteration; and automation.
3	Analyzing the solution	Generalization; evaluation and testing

The activities that can be used in order to bring CT to the class has been classified by Weintrop et al on their taxonomy of computational thinking in mathematics and science (CT-MS) which consists of four major categories. The CT-MS taxonomy categories are shown in Table 3.

Table 3. Taxonomy of Computational Thinking in Science and Mathematics [25]

No	Practice Categories	Activities
1	Data Practices	Collecting, creating, manipulating, analyzing, and visualizing data
2	Modelling and Simulation Practices	Using computational models to understand concepts as well as to find and test solutions; assessing, designing, and constructing computational models
3	Computational Problem-Solving Practices	Preparing problems for computational, solutions; programming; choosing effective computational tools; assessing different approaches/solution to a problem; developing modular computational solutions; creating computational abstractions; troubleshooting and debugging
4	System Thinking	Investigating a complex system as a whole; understanding the relationships within a system; thinking in levels; communicating information about a system; defining systems and managing complexity

Since CT is a mental skill, computing-related and programming activities were not necessarily required in order to bring CT to the class [26]. The activity of CT learning without the use of computer is called unplugged [27] [28]. This is the type of CT-activity that were going to be delivered to the class.

Preliminary Research Result

The preliminary research showed that the teachers had a very good perception of the curriculum implementation. Based on the interview held with four physics teachers, the most provided learning method was independent learning (3 of four teachers), discussion (all teachers), and the lecture methods mixed with demonstration or video presentation (all teachers) all in turns. None of the four teachers had practised CT-based learning, although one of them assumed that the CT-based learning might have been carried out without knowing the term.

On the other hand, CT-based learning is regarded as important. The highest rate belongs to data practices and computational problem solving (note that the programming and computational tool involvement were eliminated since this research focused only on unplugged activities), followed by modelling and simulation as well as system thinking.

Worksheet Specification

The Computational Thinking-Based worksheet was particular for temperature and heat subjects. The learning objective was taken from the standard learning stages flow (ATP) provided by the Curriculum. In this research, it focused on analysing the state of matter and its characteristics as well as its behaviour when absorbing and releasing heat. This worksheet contains five sub-materials, respectively (1) the temperature, (2) heat and its flow mechanisms, (3) heat and its effect to the temperature change, (4) heat and its effect on the state of matter, and finally (5) the thermal expansions. Each sub-material contained one of Weintrop's CT-MS Taxonomy categories which is arranged using the CT problem-solving model by Palts & Pedaste that begins with defining the problem, followed by solving the problem, and finally evaluating the solution. The scaffolding was provided in questions and clues to allow students to do the learning based on the expected learning flow.

In the first chapter, there are two activities. The first activity discusses the relationship between the temperature and a matter's particle kinetic movement by providing a case of how to get rid of stains on cloth material without using detergent by applying the temperature principle. Students are expected to understand that the higher the temperature the looser the particle bond and the faster the motion of the matter's particle, hence, the use of hot water can be a solution to remove the stain faster. The second activity displayed the news about the lowest temperatures that happened on two given dates, where a student was making a thermometer with the given boiling water and freezing water points. Students are expected to solve the thermometer readings on both days.

Chapter II consists of two activities. Activity A discusses the concept of thermal conductivity which demands students to choose the appropriate material to maintain the temperature of a piece of ice in the hot open air. An experiment is performed using three different containers of different materials where a block of ice with the same dimension is put on each container. They will observe the time required to melt the ice for each material and discover the relationship between a material's thermal conductivity coefficient and its heat flow. Activity B provides a case about the application of radiation where students should suggest the colour of the outfits to be worn in hot weather. To solve the problem, they observe the temperature change of three glasses of different coloured water within the same volume and same initial temperature which are put under the sun, every amount of time.

The third chapter discusses heat and its effects on the temperature, particularly the Black's principles. The students solve the maximum volume of boiling water that has to be used to make a warm beverage with the water not higher than a certain given temperature, with a given volume and initial temperature.

Chapter IV discusses the influence of heat in changing the state of matter. The problem is how to maintain the low temperature without freezing the matter. Students will experiment the supercooling and snap-freezing by putting less than a half glass of water in a glass put in the middle of the ice which was given salt. The temperature should reach minus without freezing. Then it is replaced outside the container slowly and followed by giving a little block of ice. The water is expected to freeze rapidly.

The last chapter discusses thermal expansion that is related to global warming. The students are introduced to some news about the increase in the water level in Indonesia and in the world. Then, in groups, they are instructed to find the answer about the possible water level height in 30 years with given possible temperature increase, the area of Indonesian sea, the epipelagic depth of the sea, and seawater salinity. In order to know the volume expansion coefficient, they will make the model of seawater expansion due to the sun's heat using saltwater with the equivalent water salinity with the sea. Then, they create and analyse the graph to obtain the expansion coefficient value.

Validation Result

The worksheet was validated by two experts and shown the very high score to each attributes group. The validation results were shown in Table 4

Table 4. The Validation Results of The Worksheets

Attributes	κ	Classification
Language	0.94	Very High
Presentation	0.94	Very High
Subject Matter	0.93	Very High
Instructional Design	0.92	Very High
Curriculum	0.91	Very High
Computational Thinking	0.91	Very High

The high content validity performed by the worksheet allowed the worksheet to continue the next evaluation stage.

Practicality Result

After the worksheet was validated and revised, four physics teachers of four schools evaluated the expected practicality of the worksheet. The revision was made at the cover page to change the term "XI IPA" (Grade 2 Science) because there is no more science class in the new curriculum. Thus, to identify the target users, it was changed into "XI F" whereby F represented the student's phase. Then other was that the time allocation should be reconsidered. The practicality questionnaire score is shown in Table 5. It shows that the worksheet is expected to be very practical to be brought to the class.

Table 5. The Validation Results of The Worksheets

Attributes	κ	Classification
Scientific Truth	0.95	Very High
Efficiency	0.82	Very High
Ease of Use	0.89	Very High
Attractiveness	0.93	Very High
Benefits	0.89	Very High

Observation and Interview Results

A whole of activities in the first sub-material was practised and the students' responses were observed. The first sub-material had two activities. The first activity was to find out the relationship between the temperature and a matter's particles' kinetic motions through experiment, while the second activity was about the work of temperature scale conversion involving discussion as the main problem-solving activity. At first, students looked more excited because they had never used the laboratory for physics beforehand. Then, the first problem found after the worksheet were shared. They looked confused about what to do and tend to ask the teacher. The problem was that students were not used to read the instruction and likely to ask the teacher rather than reading the instructions. After the teacher guided students to read the information, they could continue the activity.

The next problem was that most students made mistakes in rearranging the experiment steps. Thus, the part was changed into the true arrangement, and to allow them to pay attention to the working orders, the checklist space was added in each step. The third problem was related to time allocation whereby the first activity (the experiment) exceeded the provided time. However, it can be managed in the second activity by stating the time limit of the group activity.

Three students were interviewed to know their responses. In common, the three students mentioned that they were interested in the learning activities because the learning activities were different because of the experiment. Based on the three students, doing experiments made it easier to understand and remember what they learned. One of the three stated that by practicing, they can make their own arguments on things they were observing. Doing practicum became the easiest part of the learning process, while for the most difficult parts were analysing data and drawing the conclusion.

Discussion

1. Requirement Analysis

Rejeki [21] mentioned in his analysis of the learning loss that COVID-19 has affected students in some ways, namely the decrease in study enthusiasm, concentration, literation, discipline, and hospitality. According to the interview, the students had a deterioration in their attitudes in class after COVID-19. They took longer to understand the material and had lower enthusiasm than the previous year. Yet, they were still able to follow the learning. Nevertheless, teachers mentioned that involving some media such as PowerPoint presentations, virtual labs, and other interesting activities, made students more attentive to the learning process. Further, it affected their learning result.

Teachers rated CT learning activities included in Weintrop's taxonomy as important to bring into physics learning, except programming and data manipulation. It is because teachers considered ti as heavy for students' learning load. Moreover, it is not compulsory in the curriculum.

2. CT Practices of The Worksheet

This worksheet was designed with CT unplugged activities which does not require programming skills. Since it follow Palts and Pedaste's CT-learning model, every activity consists of three stages, namely defining the problem (stage I), solving the problem (stage II), and evaluating the solution (stage III).

The CT taxonomy categories involved in the Chapter I and Chapter II are data practices and computational problem-solving. While Chapter III involved computational problem-solving and Chapter IV involved data practies, Chapter V involved computational problem-solving, data practices, and modelling.

The first stage in every chapter begins with problem formulation, which is delivered by questions that guide the students to formulate the problem and which quantities are important to solve the problem. Particularly in Chapter III, the problem formulation is followed by abstraction through the instruction to answer questions, choose necessary information, and put it in the right position on the table. Then in Chapter V, the decomposition was performed in stage I by identifying the physics concept that happens to the problem, recognising the main equation, and putting it into fractions. The fractions are in the form of each quantity involved in the equation that later will be solved one by one.

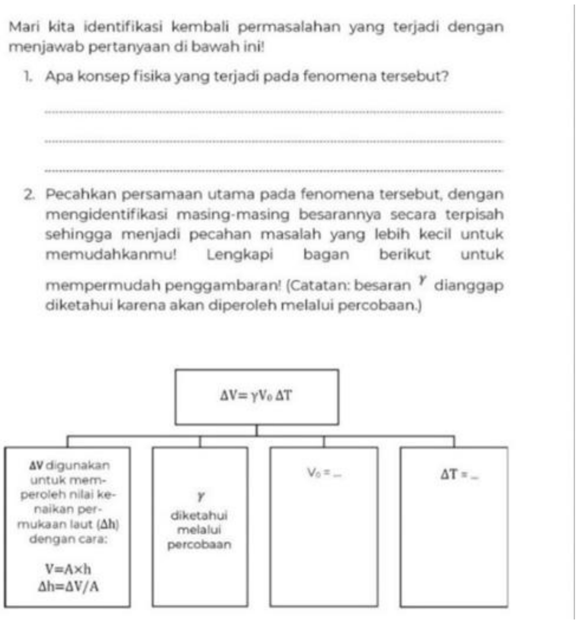

***Fig 1.** The Example of Decomposition Skill Activity of The Worksheet*

In stage II, the data collection and analysis skills evolved throughout the experiment, except in Activity II of Chapter I which only involved algorithmic thinking and iteration. For example, in Activity I of Chapter I, students collect data on the liquid condition each unit of time, whether the colouring has spread a little, a whole, or not spread at all. Then, they analyse the results and answer the questions that lead them to a conclusion. Algorithmic thinking in Activity II of Chapter I is performed by providing steps to follow in order to find the solution, such as filling the tables, representing the data to the illustration, and using the equation to solve the problem. Then, after the solution is found, students are expected to repeat the steps to find the thermometer reading on the other date. Here the iteration skills are engaged.

In stage III of all chapters, students do evaluation and generalisation. For example, in Chapter I, they evaluate the possible effects of their solution on the environment and generalise the phenomenon so that the evaluation and generalisation skills are engaged. Meanwhile, in chapter III, students are asked if a similar problem happens under different circumstances. Then, the generalisation takes place by rewriting the common steps of the problem-solving process to be used to solve similar problems. Finally, in chapter IV, evaluation and generalization skills are involved by finding the similarities and differences in how the phenomena work among all types of liquid and generalising through guiding instructions to rewrite the conclusion of the physics concept they learned from the activity.

3. Criteria of Kurikulum Merdeka Learning inside the Worksheet

The worksheet also has criteria of *Kurikulum Merdeka* learning, namely: essential; interesting, meaningful, and challenging; relevant and contextual; and continuous. The essentiality means that the subject is conceptual through the learning experience and cross-discipline. This criterion was assessed by the expert validators through the validity evaluation in the development phase of the research and confirmed by the students in the micro-evaluation phase.

The second criterion is interesting, meaningful, and challenging, which means that the teacher should be able to build up the interest of the students and engage them to participate actively in the learning [29]. Students mentioned the practicum made them less sleepy so that they could participate better in learning as well as understand and remember the physics concepts more easily. This indicates that the learning is interesting and meaningful for them. They also mentioned that they could reflect the daily phenomena which are related to the concepts they have learned and have meaningful evolvement in their knowledge. Additionally, they rated the work as capable of challenging them to think more profoundly regarding the phenomena, particularly, through the analysis section.

The relevancy and contextuality of the learning were associated with the linkage of the student’s initial cognitive and learning experience, as well as suitable to the student’s time and location background [29]. The use of problem-based learning in this worksheet was an attempt to implement contextual learning [30]. Some recent news was provided on the problem to allow them to connect to real-world events. Students rated the activity as relevant and contextual to their background. Other than that, this worksheet is also capable of encouraging them to sustainable living. For instance, in Chapter I, students are asked about the side effects of using hot water for daily laundry despite its capability to remove stains faster, while in Chapter 5 students discuss global warming and their attitudes towards the phenomenon. This becomes the attempt to introduce to students that the environment and its future are theirs and their responsibility as demanded by the curriculum.

The last is continuous, which represents the relation of learning activities to the student’s study phase [29]. To ensure that the subject material contents are essential and continuous, the subject material was made based on the general learning stage flow (ATP) provided by the ministry and the requirement questionnaire result on the preliminary research. The material was validated by the experts and teachers. Besides, students confirmed that the learning is appropriate to their phase so that neither the learning is too easy nor too difficult for them. Instead, they can connect them with the daily events.

4. Advantages and Disadvantages

Some major aspects become the advantages and disadvantages of the worksheet. First, its design is simple and practical. The worksheet was designed as a printout because it would be used by students who experience learning loss, which is associated with being easy to distract and less controllable when using digital devices [21]. The worksheet obtained a high score in the practicality assessment. Students mentioned it as easy to use because it was not too thick and students could write their answers directly. On the other hand, the blank spaces for writing the answers were provided sufficiently. In addition, the detailed and clear instructions made the worksheet easier to understand. The visual design of the module was also described as simple and suitable for their age for it was neither too empty nor crowded; so were the colours. Finally, the design and its colours were not boring. Instead, it was pleasing and interesting.

Despite the worksheet's clarity, attractiveness, and ease of use, there were unfamiliar terms that hindered students from doing their activities. For this reason, additional definitions or spaces were given to let students write the definitions of the terms to prevent confusion about the terminology. The introduction of those terms is also recommended at the beginning of the class.

Additionally, although the non-digital tools have advantages to students' motivation, focus, and engagement in learning, it does not serve what the technology can serve, such as wide accessibility, cost reduction, and carbon emission and environmental impact reduction [32] because teachers need to print the worksheets, therefore, the printing cost is required. Moreover, it should be printed in colour to maintain its visual attractiveness. Other than that, the use of printed copies will impact the environment.

The worksheet has the potential to evolve students' motivation and engagement; as well as to create a positive learning atmosphere. Students repeatedly mentioned about their interest in the practicum activities that affected their motivation and participation in learning. Motivation drives students to be able to face challenges, understand the process, and apply the concepts in real circumstances [31]. According to the interview, the activities helped them to understand more easily and to link the concepts to real-world phenomena. In addition, although they felt pushed to think harder, they found it enjoyable.

The unplugged CT activities through experiment, discussion, and the use of non-digital worksheets were the attempts to minimise the digital distractors. PérezJuárez et al [32] reported that in a class of students using a laptop as their tool in learning, almost two-thirds of student's time was spent on the off-task computer activities, which affected the engagement of students in the learning, and further brought them into negative effects. In this worksheet, students are directed to focus on more challenging practical works. Students mentioned that the activities allowed them to be more focused and engaged in the learning. Finally, students gave positive responses towards the varying activities, showing their interest, enthusiasm, and engagement in learning, thus, the creation of a positive learning atmosphere was fulfilled.

This worksheet also has the potential to develop CT skills without programming, since it was designed with CT unplugged activities which do not require programming skills. Allowing them to practice the learning flow (the three-phase problem-solving cycle) repeatedly would support skill improvement, which would not only increase the ability but also decrease cognitive load [33].

Nonetheless, time management becomes a challenge in using this worksheet because the practicum and discussion activities take time. However, verbal assertion of the time limitation is needed. The class should be conditioned as much as possible to allow the students to focus and use their time properly. If the time is spent effectively, the provided CT skills practices will be experienced by students entirely.

Students' low literacy habits and willingness to read become challenges too. They tend to ask the teacher rather than reading the instructions on the first-hand. The problem was solved by giving verbal explanations, introducing the worksheet's part at the beginning, and observing each group's problems regularly. Although the instructions in the worksheet were already detailed, the verbal instructions are suggested to be delivered, especially at the beginning of the learning when they had no prior experience with the CT-based learning fashion. Verbal communication also has to be maintained to build strong engagement between students and the teacher [34] which allows good interactivity and fast feedback during learning. On the other hand, it was also reported to affect students' achievement [34].

As mentioned by the teachers in the preliminary research, students' perception towards learning was still influenced by their prior education level which was usually teacher-centred, and it became a challenge to transform the learning fashion from the K-13 curriculum to *Kurikulum Merdeka*. Students' common opinion about good learning still depicted their tendency to perceive learning as an activity of receiving the teacher's information about a piece of knowledge passively, taking notes, and encountering exams. Despite their interest in the experimental activities, they perceived that the learning was not happening or not good, if it did not go through that flow. This was a representation of the teacher-centred learning style through the lecture method that they might have experienced in their prior education level. It is reasonable since the lecture method was known as historical and most used, not only in Indonesia but also all around the world [35]. As a result of the lecture method, students tend to perceive learning as activities happen only when the teacher explains [36].

Two of three students perceived the guiding questions and clues given on the worksheet as "exercise questions" (*soal latihan*), not as the scaffolding that led them to find the final solution. Their mindsets and perceptions toward learning became one of the major challenges when introducing CT-based learning that required more independent activities. Teacher engagement is required through regular assistance in the learning process. Verbal instructions and communications in the learning process should be maintained to manage the learning to happen appropriately. It is important to ensure that the learning takes place the way it was designed to allow it to have satisfying effects on students.

Suggestions

The practicality and the validity of the worksheet became the main focus of the evaluation in this research to ensure that it can be used, assuming a logical hierarchy whereby if the worksheet is not considered practical, then it does not make sense to investigate its effectiveness [23]. The more practical the worksheet and its learning flow, the more possibility it can be practised many times. Although the practicality of the worksheet has been evaluated, the effectiveness of the teaching module would be an important thing to discover through semi-summative assessment phase the formative evaluation of the practicality and effectiveness are all carried out. More schools from all level can also be involved to describe the appropriateness of the worksheet to various level of schools. Finally, it is suggested to develop the English version of the CT-based teaching module to enhance wider users and readers.

CONCLUSION AND SUGGESTION

The worksheet contained learning activities adapting from Palts and Pedaste's problem-solving cycle for CT is practical thus it can be used in the classroom to introduce students with CT-based learning experience, furthermore, to make it habitual so that it would lead them to the CT skill improvement. Nevertheless, further research is required to find out how effective the implementation of CT learning adapted from Palts and Pedaste's model of problem-solving cycle involving Weintrop's taxonomy of CT-MS through a student worksheet.

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