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Development of Student Worksheets Based Computational Thinking for Derivatives of Algebra Function

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ABSTRACT

Computational Thinking (CT) is one of the important thinking skills in the 21st century. However, mathematics has not been widely developed in the classroom learning process. The results of the initial study show that there is no student worksheet based on compuational thinking for high school students. This study aims to develop a Student Worksheet (LKPD) based on Computational Thinking the derivatives of algebra function of for high school students. This type of research is development research with ADDIE model development research design. The steps are analysis, design, development, implementation, and evaluation. The research subjects were high school students of grade 11 who received material on the derivatives of algebraic functions. The research instruments were student worksheet as a development product, expert validation questionnaires, teacher practicality questionnaires, and student response questionnaires. The product developed in this study is a CT-based math worksheet for the derivatives of algebraic functions for high school students. This product is validated by material experts and mathematics learning experts. Furthermore, the practitioner test by high school mathematics teachers and questionnaire responses by high school students, the number of students are 20 people. The results of this study are the Mathematics Student Worksheets based on Computational Thinking material for the derivatives of algebra fuction for high school students that are valid and practical. The resulting LKPD contains CT steps, namely abstraction, generalization, decomposition, algorithmic, debugging. This worksheet is one way to integrate computational thinking in mathematics learning.

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A. INTRODUCTION

Several studies have stated that the ability of Computational Thinking (CT) is important for the 21st century. The OECD even released that one of the most important abilities in future abilities and future education is CT(OECD, 2018). This capability was even included in the PISA framework for 2021. In the draft released by the OECD in 2018 that included CT in the 2021 PISA assessment (OECD, 2018). The National Education Technology Standard for Students even states one of six important skills that students must have and are taught in schools, namely the concept of technology and its operation(Syahputra, 2018).

The ability of students about technology, not only about how to operate a computer or surf the internet. This is a challenge for students and an inseparable part of human development. Students' knowledge of technology is not only about internet ow to operate a computer, more than that it must involve the ability to design, solve problems, contribute to technology creation, even to the stage of understanding the social and ethical consequences of the technology (Maharani, Nusantara, As'ari, & Qohar, 2020).

Computational Thinking is an ability that must be possessed and learned by students in learning. So it is important in learning this ability to be included and even paid attention to. Even mentioned CT is a cognitive skill and is expected to be owned by everyone. Furthermore, in education, CT abilities are very closely related to problem solving abilities(Maharani, Nusantara, As'ari, & Qohar, 2020).

The history of computational thinking is closely related to computer learning and informatics. In fact, since 2012 the United Kingdom has incorporated CT into its curriculum through learning informatics. Meanwhile, European Union countries have begun to discuss the integration of CT into their educational curriculum from 2016-2017 (Bocconi, Chioccariello, Dettori, Ferrari, & Engelhardt, 2016). However, along with the importance of computational thinking skills not only as computer programmers but rather as thinking processes, so some experts state that this ability can be integrated and stimulated through mathematics subjects at school so that some experts state that this ability can be integrated and stimulated through mathematics at school.

CT stimulate students by mathematics and science. This is closely related to the characteristics of mathematics. This is because mathematics can train students to think logically, systematically, and analytically whose goal is to solve problems (Cahdriyana & Richardo, 2020). In addition, according to Zapata-Ros mathematics is closely related to divergent thinking, creativity, problem solving, abstract thinking, recursion, literacy, collaboration, patterns, synthesis and metacognition which are all important parts of Computational Thinking (Zapata-Ros, 2019).

CT defined by Ansori, computational thinking as a way of understanding and solving complex problems using computer science concepts and techniques such as decomposition, pattern recognition, abstraction and algorithms(Ansori, 2020). Some of the CT indicators are problem decomposition, algorithmic thinking, pattern recognition, abstraction and generalization (Cahdriyana & Richardo, 2020). Computational thinking is an innovative mindset in identifying phenomenalife to provide various practical solutions to the problem studied. Workflow carried out chronologically and comprehensively as the dimensions of computational thinking (Fajri&Utomo, 2019).Abstraction is defined as selecting the important elements of an object and selecting the basic ones so that they can be processed. While generalization goes hand in hand with abstraction, namely making general problems. Decomposition is defined as breaking or partitioning a complex problem into smaller problems to make them easier to work with. While the algorithm is the skill of compiling solutions and carrying out step by step solutions that have been compiled. Algorithms are technical skills needed to perform the calculation process. While debugging is the ability to recognize incorrect actions or calculations, including the ability to re-examine answers and correct these errors (Cahdriyana & Richardo, 2020).

The importance of this ability according to experts needs to be stimulated through learning mathematics. This CT ability can be stimulated through the provision of questions in mathematics learning (Cahdriyana & Richardo, 2020). However, the questions given are not included in routine questions but are more complex questions.

Several previous studies have discussed about computing capabilities. Maharani examines the importance of computational abilities in learning mathematics to face the era of society 5.0 (Maharani A. , 2020). His research revealed that the development of computational thinking must involve complex thinking and given off difficult problems. Furthermore, Zahid examines the latest PISA framework which incorporates mathematical computational capabilities into the latest PISA 2021 assessment (Zahid, 2020). This study examines

Indonesia's chances of achieving better PISA scores by strengthening students' computational thinking processes because students who have this computing ability will emphasize students on how to do take real life situation and translate it in context think itself. Thought process this computation will devide the dimension think in their respective categories have a practical role and fungtion operational. However, from various studies on computational thinking, Cahdriyana & Richardo's research stated that computational abilities can be stimulated through mathematical problems (Cahdriyana & Richardo, 2020).

Basically the ability in mathematics apart from giving questions, can also be stimulated in the learning process through student worksheet. According to its function, LKPD can affect students' abilities. Research states that students' STEM abilities can be stimulated through the use of STEM-based worksheets (Lathiifah & Kurniasi, 2020). In addition to this study, several previous researchers revealed the results that student worksheet could improve students' critical abilities, learning outcomes, and mathematical reasoning (Malahayati, 2017)(Sari, Febrian, & Tambunan, 2021)(Prasetyono & Hariyono, 2020). However, until now there has been no LKPD based on Computational Thinking that has been developed for high school mathematics learning, especially the the derivatives of algebraic functions. The researcher conducted an interview with a mathematics teacher at one of the schools in Bangka Regency, that there was no CT student worksheet given for high school students, especially mathematics. So far, what students have done is student worksheet based on contextual problems and that is only for certain materials. Based on the above, the importance of computational ability and its integration in learning mathematics. Because computational thinking is a problem-solving technique with a very wide application, not only to solve problems related to computer science, but also to solve various problems in everyday life as well as problems in mathematics. As we know, problem solving in mathematics requires a gradual thought process. By having this computational thinking ability, students will learn how to think in a structured way.

So it is necessary to have student activities in learning that can support computing abilities. This study aims to develop student worksheet based on Computational Thinking mathematics on algebraic function derivative material for high school students. The material derived from algebraic functions is chosen because the characteristics of this material are closely related to CT indicators, namely abstraction, pattern, algorithm, and decomposition.

B. METHODS

This research method is development research. The development model used is ADDIE analysis, design, development, implementation, and evaluation). This development method was chosen because this study intends to develop CT-based mathematical worksheets derived from algebraic functions. The model is arranged systematically in an effort to solve problems in learning or related to learning resources and materials. The research phase follows the stages of the ADDIE research model. The research flow can be described in the following chart.

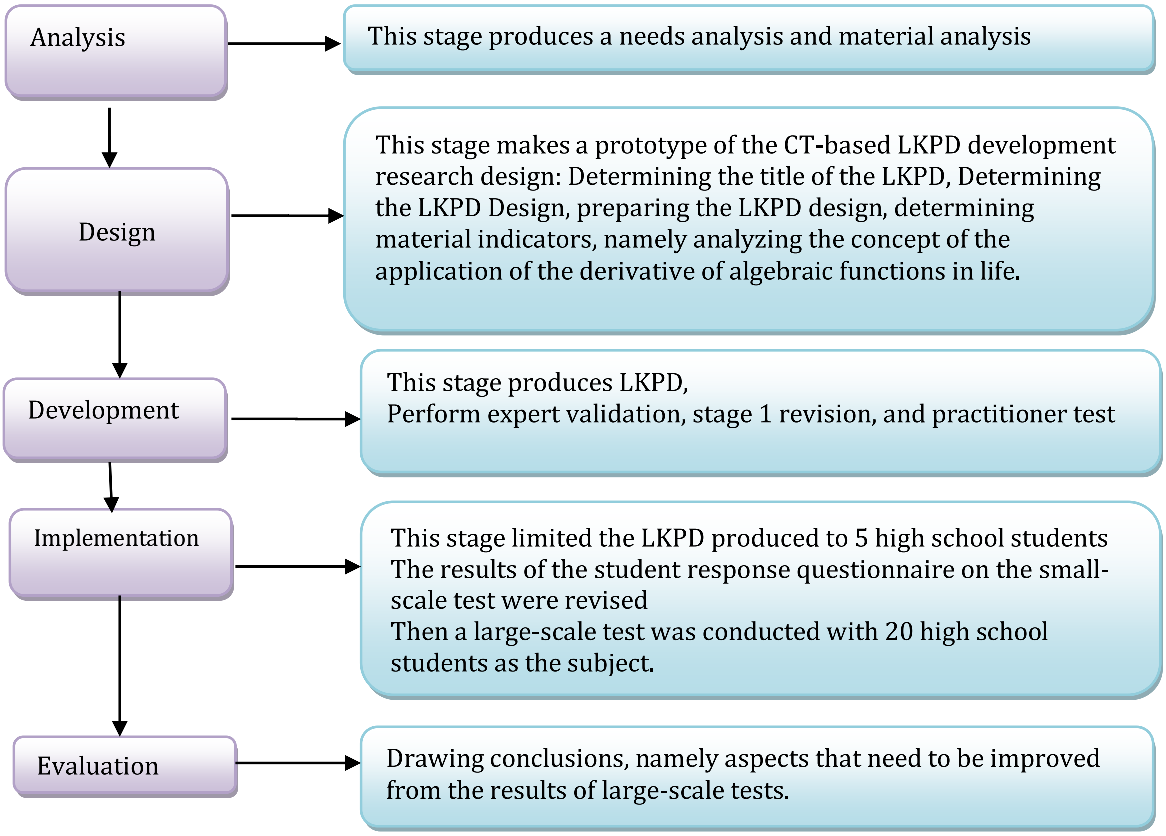

Figure 1. ADDIE Model Research Flow

The research subjects for the small-scale test were 5 high school students. Meanwhile, in the large-scale test, there were 20 high school students. Expertvalidation, namely two experts. Mathematical material experts, especially algebra and mathematics learning experts who come from lecturers in the mathematics study program. Practitioner testing by high school teachers who teach grade 11.

The data collection technique used an expert response questionnaire instrument, practitioner response questionnaire, student response questionnaire, observation sheet, and LKPD which were answered directly by students. Data analysis techniques are qualitative analysis based on expert and practitioner advice, as well as quantitative percentages involving questionnaire scores from experts, practitioners, and students.

Data analysis carried out on the data collection instrument was LKPD analysis, analysis of data validation results from material expert questionnaires, practitioner test analysis, analysis of small-scale test results. LKPD validation was measured using a 5-scale Likert scale, with a valid level of 1-5 with a description of 1 being invalid, 2 being less valid, 3 being quite valid, 4 being valid, and 5 being very valid. The scores that have been obtained based on expert judgment are then converted into percentages. This percentage is calculated using the formula (1):

$$V=\frac{\sum x}{\sum x_i}\times 100\% \qquad (1)$$

With the description of the formula is V the percentage of validity, x is the total number of expert ratings, and x_i is the total number ideal value. After the percentage results are known, the level of validity of the developed LKPD is then grouped into product validity criteria as shown in Table 1.

Table 1. LKPD Validity Level Criteria

Validity Criteria	**Validation Level**
85% <V≤ 100%	Very valid
70% <V≤ 85%	Valid
50% <V≤ 70%	Less valid
V≤ 50%	Not Valid

The level of practicality uses a scale of 1-5 with a statement of scale 1 stating impractical, scale 2 stating less practical, scale 3 stating quite practical and scale 4 stating practical, scale 5 stating very practical. Then this score is converted into a percentage calculated using the formula (2):

$$V=\frac{\sum x}{\sum x_i}\times 100\% \quad (2)$$

With the description of the formula is V the percentage of practicality level, x is the total number of student scores, and x_i is the total number ideal value. This percentage is used to see the level of practicality of a material or learning resource. Including LKPD. More complete in Table 2.

Tabel 2. Practical Level Criteria

Practical Criteria	Validation Level
75.01% -100 %	very practical
50.01% -75,00%	practical
25.01% - 50.00%	less practical
00.00% - 25.00%	not practical

C. RESULT AND DISCUSSION

1. Research result

a. Analysis

The initial analysis resulted in the need for CT worksheets in mathematics learning. LKPD was chosen as a tool that needs to be developed in stimulating computational thinking because of the characteristics of LKPD as learning materials that students are familiar with and in accordance with student characteristics. Teachers are not difficult to develop LKPD. The next step is to analyze the appropriate material to support CT. That is the derivative of an algebraic function. Due to the characteristics of the derivatives of algebraic functions which are difficult for students, this material is full of mathematical reasoning, this material is also the basis of many other materials and other subjects. The material presented in the student worksheets is to solve daily problems that go through the process of derivative functions. The analysis carried out includes core competence, learning indicators, and learning objectives of high school mathematics for mathematics material derived from algebraic functions.

b. Design

In the design phase, the researcher wrote student worksheets based on the results of the analysis. The design prototype includes material indicators, learning objectives, working instructions, formulas for derivative functions. Then basically it contains illustrations of problems in everyday life that can be solved by derivatives. The solution is directed at the CT step. Namely abstraction, generalization, decomposition, algorithm, and debugging. To complete it, motivation is added in the form of interesting sentences from national heroes.

c. Development

Student worksheets developed for three lessons. During the development stage, LKPD was made in accordance with KD, SK, and learning objectives. Based on the ADDIE model, the initial LKPD design was validated by experts. This worksheet is validated by two expert judgement. The results show that the LKPD is valid with some suggestions for improvement. Based on the presentation of the validity of the formula number (1). The results of expert validation are depicted in the following diagram.

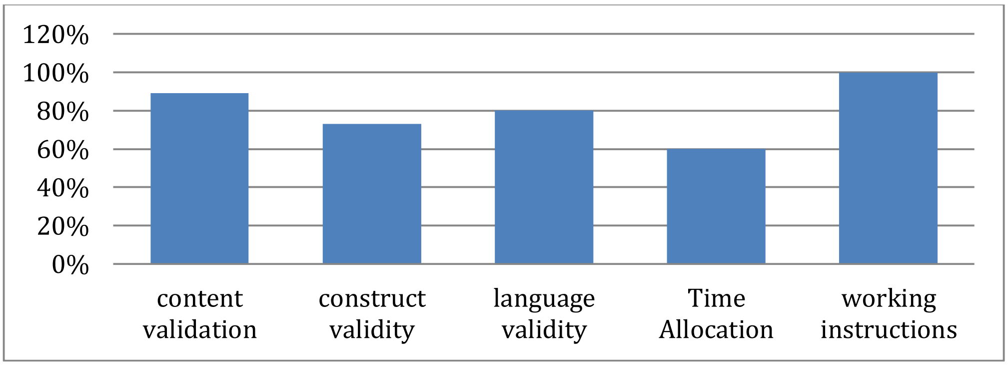

Figure 2. Expert Validation Questionnaire Results Diagram

The results of the expert validation questionnaire stated that it was very valid with the questionnaire score for content validation was 89%, the score for construct validity was 73%, for language in the LKPD was 80%, time allocation was 60% and the score for indicators regarding working instructions was 100%. Based on the results of the analysis of the construct aspect and the time allocation aspect, several improvements were made according to the suggestions.

In addition to these proportions, the validators suggest that the CT steps on student worksheets should not be reversed. Must be arranged in order.Then for the step part the algorithm must be made in a flowchart. Illustrations on some problems must be replaced because they do not support students' computational thinking. After making improvements according to the advice of experts, the next stage is carried out, namely the practitioner or user test. At this stage, student worksheet and user response questionnaires are given to teachers who teach mathematics in grade XI. The results of the practitioner response questionnaire are shown in the following diagram.

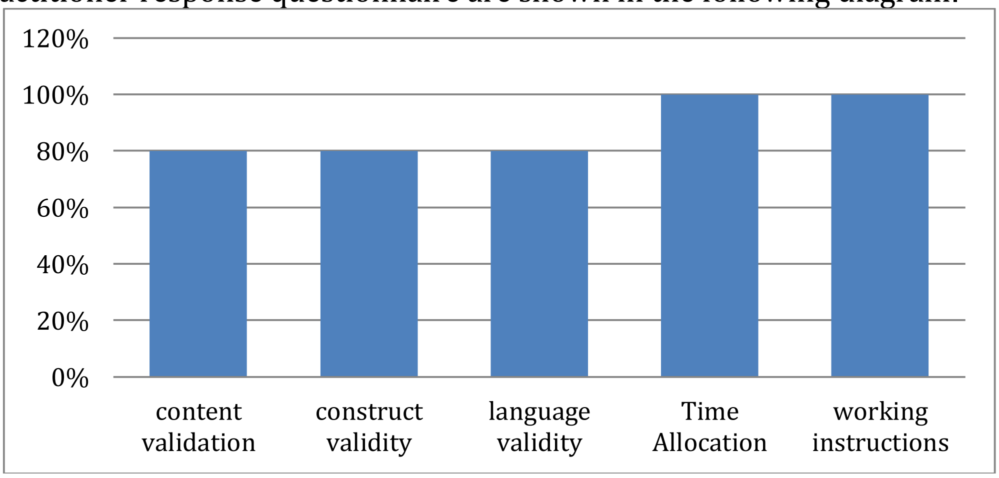

Figure 3. Practitioner Test Questionnaire Results

The results of the questionnaire obtained on content validation, namely 80%, construct validation score 80%, language validation 80%, time allocation validation 100%, and validation of work instructions, namely 100%. Suggestions for improvement include: (1). some uses of the x variable symbol should be italicized; (2). indicators and learning objectives should be arranged systematically in order to make it easier for students to read and understand them; (3). motivational use of the hero's words, excellent; (4). the use of flowcharts in the algorithmic step is very helpful for students in compiling solutions.

d. Implementation

The next stage is to conduct a small-scale test. This is included in the delevopment stages of the ADDIE development model. The small-scale test came from 5 high school students. The student response questionnaire score is 4.5, which means it is practical. In the small-scale trial stage, students worked on this LKPD for 3 meetings. In accordance with the number of meetings on LKPD. The time it takes students to do it is almost two hours of lessons. In the debugging step or re-checking the compiled algorithm, students find it difficult.

Because this procedure they arenot used to before. Then in the step of compiling the algorithm, students find it difficult to answer using a flowchart. But they mention that this is new and as a challenge to think more. After the LKPD small-scale test has been carried out, it can be continued with the implementation stage, namely large-scale testing. For the form of illustrations in the form of stories, students can understand well. It's just that following the computational thinking step by step, which is rather difficult, is in the part of compiling algorithms with flowcharts and then doing the debugging steps.Based on expert advice, students should be able to see the flow of procedures according to the flowchart so that the operations are similar to input, output, and outcome in a computer system. The following presents the results of students working on the LKPD.

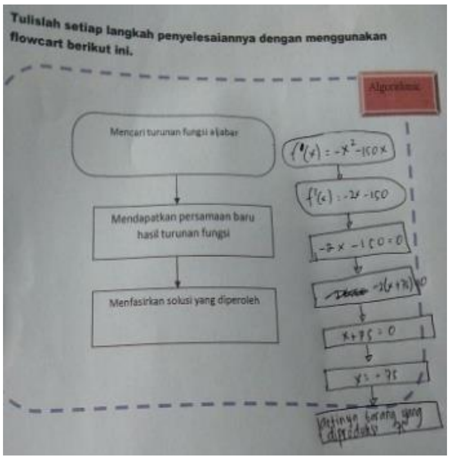

Figure 4. Student Answer Results on Small-Scale Test

In Figure 4, students make their usual answers in LKPD meeting 1. Students state that this new thing is difficult. However, for LKPD 2 and 3, they have started to get used to making flowcharts. practical test based on student responses. The results of the LKPD based on Computational Thinking are practical and can be used for algebraic function derivatives for high school students with a questionnaire score of 83%. Based on the criteria of practicality that 83% is included in the level of practicality is very practical.

In the large-scale test phase, 20 high school students were involved. At this stage students work on the LKPD and are given a student response questionnaire. This stage is carried out after revising the results of the small-scale test. The selected subjects are different from the subjects on the small-scale test. The results obtained at this stage are the LKPD practical test based on student responses. The results of the LKPD based on Computational Thinking are practical and can be used for algebraic function derivatives for high school students with a questionnaire score of 83%. Based on the criteria of practicality that 83% is included in the level of practicality is very practical.

e. Final Product: Student Worksheet Based on Computational Thinking

The following is a cover display, problem illustration, and learning steps for LKPD Computational Thinking material derived from algebraic functions developed in this study.

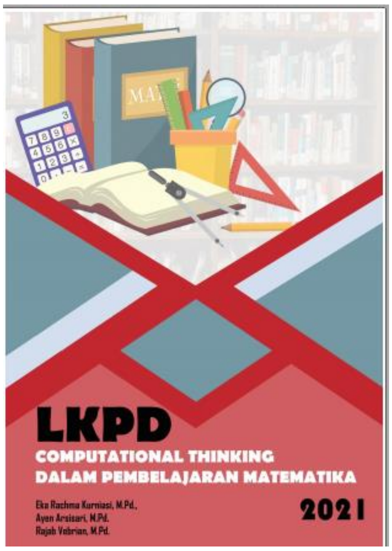

Figure 5. LKPD face view

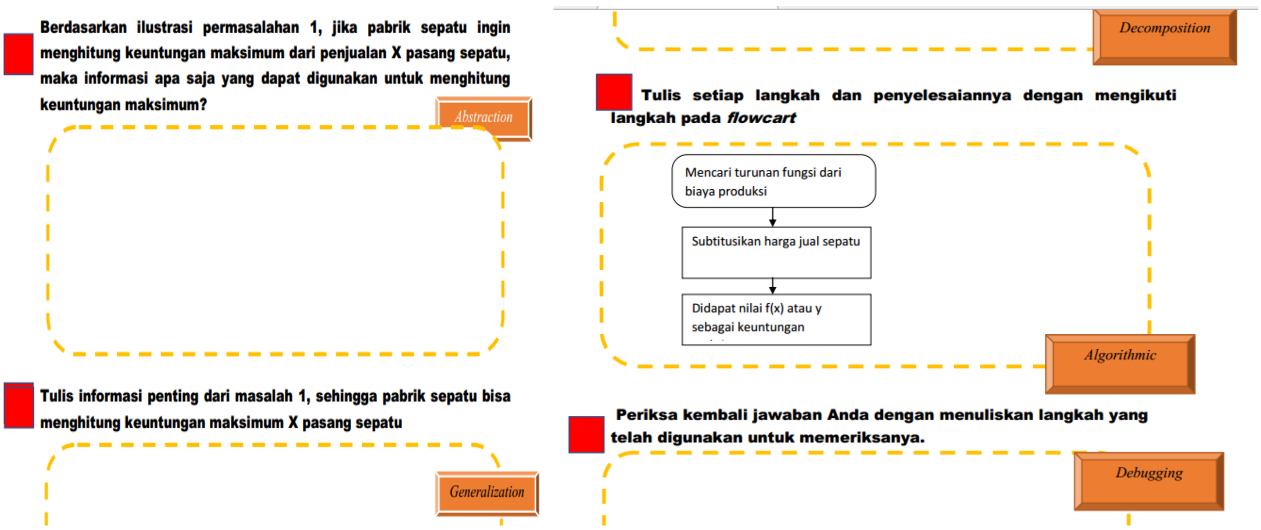

Figure 6. CT step

In Figure 6, the cover is made to contain only the title. The KD, learning objectives, and learning indicators are presented on the next page.On the first page of the LKPD contains the student's identity, then material indicators and work instructions. Then students are given problem illustrations to lead to computational thinking. This illustration serves to lead students into problems which will be solved with the concept of derivative functions. Furthermore, the learning steps are made in the stages of computational thinking, namely abstraction, generalization, decomposition, algorithmic, debugging.

2. Discussion

Computational thinking is indeed something that must be stimulated in students. In some research, stimulation can be from test instruments, electronic modules, e-learning, and student worksheets. In this study, the results of the mathematical worksheets for the derivatives of algebraic functions are produced. This worksheet is one way to integrate computational thinking in learning mathematics. Later it can be used to stimulate students to think computationally. This stimulation relates to the importance of Computational Thinking as a cognitive ability in the 21st century. In this study, the stimulation of computational thinking through LKPD is expected to make students accustomed to carrying out these thinking processes in learning. Accustomed to doing CT steps in analyzing a given problem in the problem.

The results of literature studies and field studies from (Ariesandi, Syamsuri, Yuhana& Fatah, 2021) show that it is necessary to developed teaching materials in the form of inquiry-based electronic modules to improve computational thinking skills in high school sequences and series material. Research from (Rahmadhani&Mariani, 2021) shows that Digital Base learning projects are effective on students' computational abilities in solving middle school math problems. The importance of this was also conveyed in previous research which stated that learning by including computational thinking skills and mathematical thinking with reference to their cognitive style will provide valuable experience to students as a provision for themselves in dealing with polemics and life phenomena in society later (Fajri, Yurniawati, & Utomo, 2019). The meaning of this is that learning mathematics is not only procedural ability, it is more important to interpret and build students' cognitive.

Furthermore, other research states that apart from learning, computational thinking can also be stimulated by giving questions or instruments with CT indicators. Research (Kawuri, Budiharti, & Fauzi, 2019) states that abilities that can be developed by applying tests with a computational thinking approach include problem-solving skills and critical thinking skills. Therefore, the next research (Sa'diyyah, Mania, & Suhartini, 2021) develop test instruments to measure students' computational abilities that are valid and usable for junior high school students.

Research on computing capabilities is growing. Many things are done to support this ability, both through LKPD and through habituation of students to do tests with computational thinking indicators. The next research (Lestari&Annizar, 2020) also examines how students answer PISA questions in terms of students' computational abilities. The results show that subjects who have high computational thinking skills meet clear, precise, and relevant indicators. In addition, the subject meets appropriate and relevant indicators based on aspects of concepts and ideas, while on the aspect of point of view it meets clear and broad indicators. However, the subject inference aspect is only meet logical indicators.

D. CONCLUSION AND SUGGESTIONS

Based on the results of the study, it can be concluded that this research produces worksheets based on computational thinking on mathematics subjects derived from algebra that are valid and practical for high school students. The steps in the CT student's worksheet are generated using the definition of the CT thought process, namely abstraction, generalization, decomposition, algorithmic, debugging. It was found that students need to be provided with information to clarify the implementation of each CT step. The results of the validation state that from the aspect of content, appearance, material, time suitability and students' thinking skills that this worksheet is valid. Meanwhile, based on the responses of students and practitioners, they stated that this LKPD can be used with a very practical level of practicality. This study produced a CT worksheet to stimulate the CT thinking process in learning mathematics. Further research could also stimulate computational thinking through CT-based questions. The implication of this research is that developing mathematical computational skills can be done through CT-based student worksheets.

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