COMPUTATIONAL THINKING INSTRUMENTS AS A PROBLEM-SOLVING METHOD IN OBJECT-ORIENTED PROGRAMMING MATERIALS IN VOCATIONAL SCHOOLS

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ABSTRACT

This study aims to develop a Computational Thinking (CT) instrument on Object-Oriented Programming material as a tool for measuring the level of CT in the problem-solving abilities of Vocational High School students. The Plomp model of R&D analysis is used as a research flow. There are four stages of CT instrument development, namely 1) preliminary investigation stage, 2) design stage, 3) realization stage, and 4) evaluation stage. The research method uses a quantitative approach with statistical analysis. The research subjects were 35 Grade 10 students at SMK Negeri 11 Bandung. The findings show that PBO material is suitable for use as a medium for developing CT instruments. Based on the results of the material expert validation and the instrument showed very good results. The instruments developed have been tested for validity, reliability, level of difficulty, and discriminatory power. There were 80 out of 100 questions which were declared valid and reliable for use. The difficulty level of the instrument is in the easy category (46 questions) and medium (54 questions). Meanwhile, the differentiating power of the instrument was in the range of sufficient (17 questions), good (57 questions), and very good (10 questions). The CT instrument developed in this study has categories of 24 abstraction questions, 20 pattern recognition questions, 18 decomposition questions, and 18 algorithm design questions. With the completion of this instrument, it is hoped that it can assist teachers or researchers in measuring problem-solving abilities, especially students' CT abilities.

***Keywords**: Computational Thinking, Learning Instruments, Object-Oriented Programming, Problem-Solving.*

I. INTRODUCTION

The intelligence level of the Indonesian population is still relatively low. Based on data from the 2022 World Population Review, the average IQ score for the population in Indonesia is 78.49. Factors causing the low level of intelligence of the Indonesian population, one of which is due to the low level of problem-solving ability. As Smak [1] states that the learning process by prioritizing problem-solving abilities can increase intelligence [2]. One method that can be used to improve students' problem-solving skills is Computational Thinking.

Computational Thinking (CT) is a framework for thinking using a computational point of view to determine a solution to a problem. CT is a cognitive skill that makes it possible to solve complex problems, identify patterns, and divide a problem into small steps, organize and create a series of systematic steps and build data representations through simulation [2]. CT discusses the components of ways to generate solutions to a problem, designing systems and understanding behavior as well as abstraction and decomposition when solving a problem [4].

There are several studies that have discussed Computational Thinking. Nuraeni et al. [5] conducted research on how to identify students' Extranous Cognitive Load in developing CT skills through learning food webs. In addition, there are several studies that link the Problem Based Learning learning model to the CT skills of elementary school students [6,7]. Other research is linking CT with mathematics learning [8,9], CT on students' High Order Thinking Skill problem solving abilities [10], and the development of CT-based multimedia [11]. However, there has been no research that has developed a training instrument for solving student problems through the CT method in object-oriented programming subjects at the Vocational High School (SMK) level.

Therefore, this research was conducted with the aim of developing CT instruments in Object Oriented Programming (PBO) subjects as a measuring tool for CT levels in problem solving abilities of SMK students, especially in the Computer Technology and Informatics major. The novelty of this research is the development of CT instruments in PBO subjects and the development of instruments aimed at problem solving training for SMK students.

II. METHODS

Plomp's Research and Development (R&D) analysis model was used in this study. The Plomp model consists of 4 stages, namely the preliminary investigation stage, the design stage, the realization stage, and the evaluation stage [12]. Figure 1 shows the CT instrument development flowchart. Quantitative method with statistical calculations used in this study. Statistical analysis is used to test the validity, reliability, level of difficulty, and differentiability of the instruments we have made.

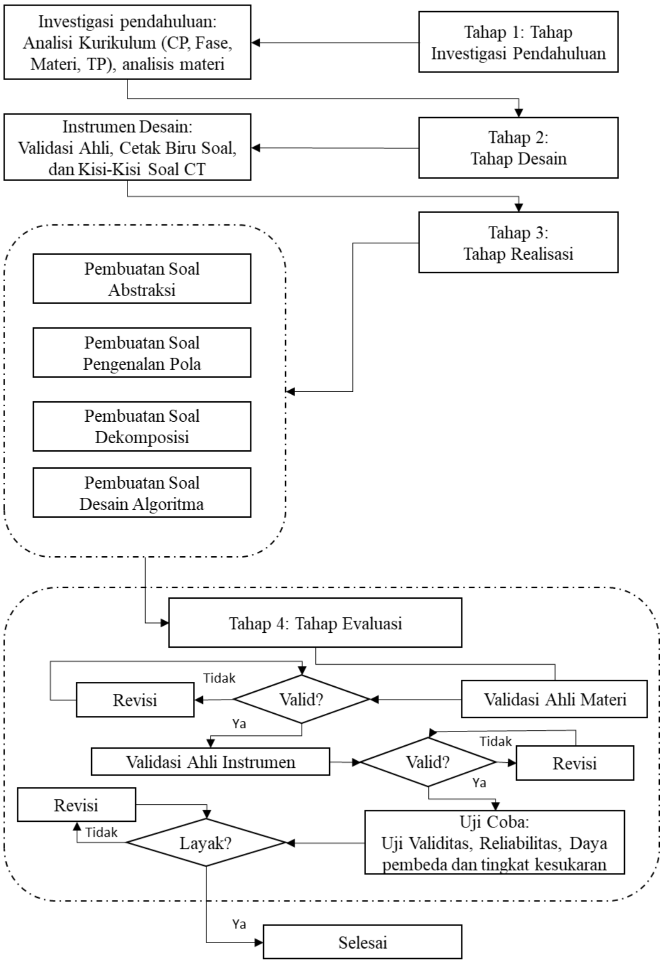


Figure 1. CT instrument development flowchart

A. Preliminary Investigation Stage

At the preliminary investigation stage, an evaluation of the need for CT instrument development was carried out. The preliminary investigation stage carried out was material analysis. Material analysis was carried out to analyze the CT components contained in the PBO material. Material classes, attributes, methods, packages, objects, constructors, destructors, encapsulation, and inheritance in PBO are used as the basis for making CT instruments. The teaching materials are prepared by taking into account the Learning Outcomes (CP) in the PBO elements of the Basics of Software Development and Game Development Phase E subjects at the Vocational High School level which are available on the https://guru.kemdikbud.go.id/ page. The analysis of the CT component in PBO material was carried out by converting the material to possible practice questions. The CT method was analyzed for each item component. We analyze the CT components that are suitable for solving problems in the questions that have been prepared. In this study, in order to strengthen the preliminary investigation stage, we made a Student Worksheet (LKPD) for PBO material and analyzed the CT component in the LKPD that had been made.

B. Design Stage

The design phase was carried out to produce an initial design of the CT instrument. The tools developed at this stage are expert validation instrument sheets and test blueprints. The expert validation instrument used is the Learning Object Review Instrument (LORI). This stage resulted in the design of the CT instrument for PBO material which consisted of test questions in multiple choice format, answer sheets, and a grid of indicators for each question. Test questions are designed based on material analysis in the form of material names, indicators of material achievement, learning objectives and cognitive levels. CT indicators, namely abstraction, pattern recognition, decomposition, and algorithm design are used as the basis for making CT instruments.

C. Realization Stage

The realization stage is carried out based on the results of the design that has been done. The realization stage consists of 4 steps, namely making the CT instrument abstraction component, making the CT instrument the pattern recognition component, making the CT instrument the decomposition component, and making the CT instrument the algorithm design component. Each CT component question is made based on the framework and principles of each CT component.

1) Abstraction Questions

The initial stage of making abstraction questions is done by determining the appropriate PBO material. After that, learning objectives with cognitive levels of knowledge (C1), understanding (C2), and application (C3) were selected in making abstraction questions. Multiple choice questions are then made based on the learning objectives of the predetermined PBO material. The multiple-choice questions are about skills. The form of story questions on the application of everyday life related to PBO is arranged to be the main part of determining abstraction questions. The questions are made by taking into account that the answers to these questions require students to look for the subject matter and ignore some other parts that are not used to answer abstraction questions.

2) Pattern Recognition Questions

Pattern recognition questions are made with the initial step of choosing PBO material and learning objectives as in making abstraction questions. Pattern recognition questions were made at the level of cognitive analysis (C4) and synthesis (C5). The cognitive level is determined based on the learning objectives that have been prepared during the material design process. Multiple choice questions in the pattern recognition component are included in the type of skill questions. Pattern recognition CT component questions are made by determining 2 or more problems. After that, these problems are grouped by solution criteria or similar types of problems. Problems with similar solving criteria or solutions are then made into one multiple choice item with pattern recognition CT indicators.

3) Decomposition Questions

Decomposition questions are made at the level of cognitive analysis (C4) and synthesis (C5). Not much different from abstraction questions, decomposition questions are made using story type questions. The questions made are of the types of skills and application or analogy of the PBO concept in everyday life. The answer choices made are a formulation of the solution to the problem presented in the question. Students are required to choose the fastest and most efficient steps or problem-solving formulations.

4) Algorithm Design Questions

Algorithm design questions are made with the application cognitive level (C3). In the material algorithm design section, the selected material is the stage of making the PBO program using the Java language. The question of algorithm design requires students to choose the steps for programming the concepts of class, attribute, method, object, constructor, encapsulation and inheritance in the right and student-matic PBO. Another form of algorithm design problem is a sequence of steps from a PBO program code. In making algorithm design questions, we pay attention that these questions are required to be able to train students in compiling a systematic problem-solving step. In addition, students' ability to convert PBO material concepts into programming languages is also our consideration in compiling questions.

D. Evaluation Stage

The evaluation stage is divided into three parts, namely material validation, question validation, and testing of revised questions that have been validated by experts. The first part of the material validation was carried out by 3 PBO material experts, namely two lecturers in Computer Science Education, Indonesian University of Education and one teacher at SMK Negeri 1 Cimahi. The second part of instrument validation was carried out by two Computer Science Education Lecturers, Indonesian University of Education. The third part of the instrument implementation trial was carried out after the questions were declared valid by the expert. The instrument was tested on students to determine the level of validity, reliability, level of difficulty, and item discrimination. Respondents who participated in the instrument trial stage were 35 grade 10 students at SMK Negeri 11 Bandung, Indonesia.

III. RESULT AND DISCUSSION

A. Results of CT Component Analysis on PBO Material

Table 1 shows the results of the CT component analysis in PBO. The results of the analysis show that the CT components, namely abstraction, pattern recognition, decomposition, and algorithm design are used to solve problems in PBO. The abstraction and pattern recognition components are the most dominant CT components used in solving PBO problems. Meanwhile, decomposition components and algorithm design are used but not dominant.

TABEL I
RESULTS OF CT COMPONENT ANALYSIS ON PBO MATERIAL

CT Components	Total
Abstraksi	13
Pengenalan Pola	10
Desain Algoritma	7
Dekomposisi	5

Table 2 shows the results of the CT component analysis on the Student Worksheet (LKPD). In this study, 4 LKPD were made. The results of the analysis show that in LKPD 1 the abstraction and pattern recognition components are used to solve each problem. Meanwhile, LKPD 2, LKPD 3, and LKPD 4 all CT components namely abstraction, decomposition, pattern recognition and algorithm design are used to solve problems presented in LKPD.

These results indicate that the PBO subject can be used as a means of Computational Thinking training to improve students' problem-solving abilities. PBO is a subject that requires students to have CT skills and learn about how to understand and recognize problems, students are required to think systematically in solving a given problem and make it happen in the form of a programming language [13].

TABEL II
RESULTS OF THE CT COMPONENT ANALYSIS ON THE PBO LKPD

LKPD Code	CT Components
LKPD 1 (Class and Object 1)	Abstraction and Pattern Recognition
LKPD 2 (Class and Object 2)	Abstraction, Decomposition, Pattern Recognition and Algorithmic Design
LKPD 3 (Constructor and Destructor)	Abstraction, Decomposition, Pattern Recognition and Algorithmic Design
LKPD 4 (Enkapsulasi and Pewarisan)	Abstraction, Decomposition, Pattern Recognition and Algorithmic Design

B. Material Expert Validation Results

Table 3 shows the results of the material validation test by experts. The material expert validation value obtained an average content/material quality aspect of 86.7%, alignment with learning objectives of 86.7%, feedback and adaptation aspect of 86.7%, motivational aspect of 86.7%, and presentation aspect of 86.7%. The average value obtained from the material feasibility test by material experts is 86.7%. Based on these results it is known that the material used is included in the "Very Good" category, as shown in Figure 2.

TABEL III
RESULTS OF VALIDATION BY MATERIAL EXPERTS

No	Aspect	Total Judgement	Number of Question	Ideal Score	Score	Percentage
1	Kualitas Isi/Materi	3	4	60	52	86,7%
2	Keselarasan Tujuan Pembelajaran	3	11	165	143	86,7%
3	Umpan Balik dan Adaptasi	3	1	15	13	86,7%
4	Motivasi	3	1	15	13	86,7%
5	Presentasi Desain	3	3	45	39	86,7%

No	Aspect	Total Judgement	Number of Question	Ideal Score	Score	Percentage
		Rata-Rata			52	86,7%

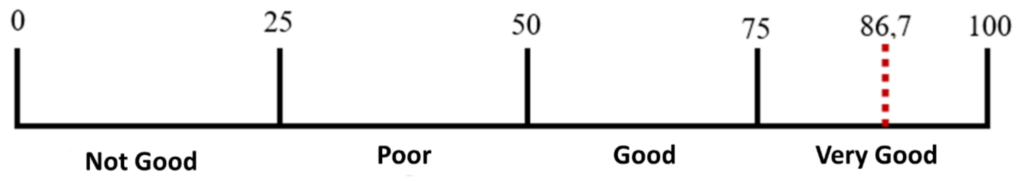


Figure 2. Results of material category based on expert validation test

C. PBO Instrument Validation Results

In this study, the total number of initial instruments made was 100 questions. The instrument is divided into two types, namely pretest and posttest with the number of each question is 50 items. The PBO instrument is adjusted to the material, question indicators, cognitive level, and CT components. The PBO instrument was then validated by experts. The expert validation results show several revisions to some of the item items, such as item number 4, 11, 16, 17, 24, 25, and so on. The researcher corrected each item, so that 100 items were declared valid and feasible to be tested.

1) Validity test

Table 4 shows the classification of the results of the pretest and posttest instrument validity. Based on the results of the pretest item validity test, it was found that there were 4 questions in the very low category, 1 item in the low category, 14 questions in the sufficient category, 23 questions in the high category, and 8 questions in the very high category. Meanwhile, the classification of the results of the posttest instrument validity test, shows that out of 50 items there are 8 questions in the very low category, 2 questions in the low category, 9 questions in the sufficient category, 20 questions in the high category, and 11 questions in the very high category.

TABEL IV
CLASSIFICATION OF INSTRUMENT VALIDITY

Category	*Pretest*		*Posttest*	
	Number of Question	Percentage	Number of Question	Percentage
Very Low	4	8%	8	16%
Low	1	2%	2	4%
Fair	14	28%	9	18%
High	23	46%	20	40%
Very High	8	16%	11	22%
Total	**50**	**100%**	**50**	**100%**

2) Reliability Test

Table 5 shows the classification of the reliability test results on the pretest and posttest instruments. Based on the results of the pretest reliability test, a correlation coefficient of 0.974 was obtained, meaning that the pretest instrument was included in the very high category and was reliable. Meanwhile, the classification of the reliability test results on the posttest instrument, obtained a correlation coefficient of 0.967, meaning that the posttest instrument is included in the very high category and is already reliable.

TABEL V
CLASSIFICATION OF INSTRUMENT RELIABILITY

Pretest			
Number of Question	**Correlation coefficient**	**Category**	**Conclusion**
50	0,974	Very High	Reliable
Posttest			
Number of Question	**Correlation coefficient**	**Category**	**Conclusion**
50	0,967	Very High	Reliable

3) Difficulty Level Test

Table 6 shows the classification of the difficulty level of the pretest and posttest items. Based on the results of the difficulty level test on the pretest questions, it was found that 29 questions were included in the easy category, 21 questions were included in the medium category, and none of the questions were in the difficult category. Meanwhile, based on the results of the difficulty level test on the posttest questions, it was found that 17 questions were included in the easy category, 33 questions were included in the medium category, and none of the items were in the difficult category.

TABEL VI
CLASSIFICATION OF INSTRUMENT DIFFICULTY LEVELS

Category	***Pretest***		***Posttest***	
	Number of Question	**Percentage**	**Number of Question**	**Percentage**
Easy	29	58%	17	34%
Medium	21	42%	33	66%
Difficult	0	0%	0	0%
Total	**50**	**100%**	**50**	**100%**

4) Discriminating Power Test

Table 7 shows the classification of the results of the differentiating power test on the pretest and posttest instruments. Based on the results of the classification of the discriminating power of the pretest items, it was found that there were 4 items in the very good category, 27 items in the good category, 11 items in the sufficient category, 8 questions in the poor category, and no items in the very bad category. Meanwhile, the results of the classification of the discriminating power of the posttest items showed that there were 6 items in the very good category, 30 items in the good category, 6 items in the sufficient category, 8 items in the poor category, and no items in the category of very poor discriminating data.

TABEL VII
CLASSIFICATION OF INSTRUMENT DISCRIMINATING POWER

Category	***Pretest***		***Posttest***	
	Number of Question	**Percentage**	**Number of Question**	**Percentage**
Very Bad	0	0%	0	0%
Bad	8	16%	8	16%
Fair	11	22%	6	12%
Good	27	54%	30	60%
Very Good	4	8%	6	12%
Total	**50**	**100%**	**50**	**100%**

B. Results of Development of CT Instruments on PBO Material

This study produced 80 CT questions which have been validated as feasible to use. The CT instruments in this study were divided into two, namely 40 pretests and 40 posttests. Table 8 shows the categorization of the CT components for each item. Based on Table 3, it is known that of the 80 PBO questions, there are 24 abstraction questions, 20 pattern recognition questions, 18 decomposition questions, and 18 algorithm design questions. Meanwhile, Table 9 shows an example of the form of problem development questions for each CT component.

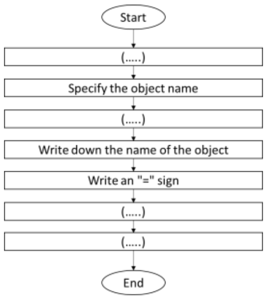
This study produced 80 CT instruments as an evaluation tool or assessment for measuring students' problem-solving abilities, especially for CT skills in PBO material. Each instrument developed has been validated by experts, both material experts, education experts, and CT experts. Assessment or assessment is an important component in learning as an effort to improve and measure the quality of education [14]. Assessment is used to determine the achievement of a lesson that has been carried out [15]. We have great hopes that the completion of this research can help teachers and readers measure students' CT problem solving abilities, especially vocational students through PBO material.

TABEL VIII
CT COMPONENT CATEGORIES FOR EACH QUESTION NUMBER

CT Component	*Pretest*		*Posttest*	
	Number of Question	Nomor of Question	Number of Question	Nomor of Question
Abstraksi	11	1, 3, 5, 9, 12, 13, 14, 15, 16, 17, 18	13	1, 3, 5, 6, 9, 12, 13, 14, 15, 16, 17, 18, 19
Pengenalan Pola	11	2, 7, 8, 10, 19, 20, 21, 22, 23, 24, 25	9	2, 8, 10, 20, 21, 22, 23, 24, 25
Dekomposisi	9	6, 33, 34, 35, 36, 37, 38, 39, 40	9	7, 33, 34, 35, 36, 37, 38, 39, 40
Desain Algoritma	9	4, 11, 26, 27, 28, 29, 30, 31, 32	9	4, 11, 26, 27, 28, 29, 30, 31, 32
Total	**40**		**40**	

TABEL IX
EXAMPLES OF QUESTIONS FOR EACH CT COMPONENT

CT Indicator	Cognitive Level	Question Form	Answer
Abstraction	C3	Farah is one of the many students in grade 10 of a Vocational High School majoring in Game Software Development (PPLG). When he first entered school, he was asked for some data by the school, such as full name, place of birth, date of birth, parents' names, and parents' occupation. Farah's task while at school is to study and follow the rules at school. These data are needed by the school for data collection on students who enter the school. Based on the story above, if we relate it to the concept of PBO, which of the following statements is TRUE! a. Farah is an attribute b. Full name, place of birth, date of birth, parents' names, and parents' occupations are an attribute c. Students are an attribute d. Learning and following the rules is an attribute e. Development of software and games, high school and school is an attribute	B
Pattern recognition	C4	• Anita created 2 classes in the "Initial Registration" program, namely the Registration class and the Login class, in the Registration class there were attributes of name, date of birth and gender. Whereas in the Login class there are username and password attributes. Attributes in the Registration class can be accessed by the Login class, whereas attributes in the Login class can be accessed by the Registration class. • Bayu created 3 classes in the PPDB program, namely the Student class, the Parents class and the School class. In class Bayu students create several attributes, namely name, gender, age and address. Bayu determines that the attribute in the Student class can be accessed by the Parent class and the School class even though the two classes are not inherited classes from the Student class. Based on the two conditions above, it can be seen that Anita and Bayu have the same pattern in determining access rights to the class attribute that they will create, namely …. a. Attributes in the Registration class, Login class, Student class all have public access rights, because these access rights allow attributes and methods to be accessed by each class. b. Attributes in the Initial Register class, Login class, Student class all have public access rights, because these access rights allow attributes and methods to be accessed by only their derived classes. c. Attributes in the Registration class, Login class, Student class all have protected access rights, because this access right allows attributes and methods to be accessed by only their derived classes. d. Attributes in the Registration class, Login class, PPDB class all have private access rights, because these access rights allow attributes and methods to be accessed by each class. e. Attributes in the Registration class, Login class, Student class all have global access rights, because these access rights allow attributes and methods to be accessed by each class.	A
Decompositi on	C3	Reptiles are one type of animal that exists on earth. Reptiles come in all shapes, sizes and habitats. Reptiles have their own characteristics, namely breathing through the lungs and reproduce by laying eggs. There are many names of	A

CT Indicator	Cognitive Level	Question Form	Answer
		animals that belong to the type of reptile animals, such as crocodiles, snakes and lizards. What is the simplification strategy for carrying out the tasks that must be carried out to create a PBO program based on the explanation about reptiles above? a. Create a reptile class; create attribute shape, size, habitat, and name; create a breathing and breeding method; create crocodile, snake and lizard objects b. Create an animal class; create attribute shape, size, habitat, and name; create a breathing and breeding method; create a reptile object c. Create a reptile class; make attribute breathe and reproduce; create shape, size, habitat, and name methods; create crocodile, snake and lizard objects d. Create an animal class; make attribute breathe and reproduce; create shape, size, habitat, and name methods; create a reptile object e. Create crocodile, snake and lizard classes; create attribute shape, size, habitat, and name; create a breathing and breeding method	
Algorithm Design	C3	Complete the flowchart below with the appropriate and sequential process steps to instantiate or create an object from the Vehicle class!  Process Step Selection: A: Create a class named Vehicle B: Write the Vehicle class constructor method C: Write down the object's data type, namely Vehicle D: Write the object keyword, namely "new" E: Write down the object's data type i.e. String a. A → [specify the object name] → E → [write the object name] → [write the "=" sign] → B → D b. A → [specify the object name] → E → [write the object name] → [write the "=" sign] → D → B c. A → [specify the object name] → C → [write the object name] → [write the "=" sign] → D → B d. A → [specify the object name] → C → [write the object name] → [write the "=" sign] → B → D e. A → [specify the object name] → B → [write the object name] → [write the "=" sign] → D → C	C

IV. CONCLUSION

Development of Computational Thinking (CT) instruments on Object Oriented Programming material as a tool to measure the level of CT ability in solving problems for Vocational High School students. The Plomp model of R&D analysis is used as a research flow. There are four stages of CT instrument development, namely 1) preliminary investigation stage, 2) design stage, 3) realization stage, and 4) evaluation stage. The results of the study show the conclusion that relevant PBO material is used as material for developing CT instruments. The expert validation test value was 86.7%, meaning that the material for the CT instrument was included in the very good category. The questions developed amounted to 100 questions, but 80 questions had a high level of validity and were reliable for use with a pretest correlation coefficient of 0.974 and a posttest of 0.967. The difficulty level of the instrument is in the easy category (46 questions) and medium (54 questions). Meanwhile, the differentiating power of the instrument was in the range of sufficient (17 questions), good (57 questions), and very good (10 questions). The CT instrument developed in this study has 24 abstraction categories, namely 11 pretest questions (1, 3, 5, 9, 12, 13, 14, 15, 16, 17, 18) and 13 posttest questions (1, 3). , 5, 6, 9, 12, 13, 14, 15, 16, 17, 18, 19). 20 pattern recognition questions, namely 11 pretest questions (2, 7, 8, 10, 19, 20, 21, 22, 23, 24, 25) and 9 posttest questions (2, 8, 10, 20, 21, 22) , 23, 24, 25). 18 decomposition questions, namely 9 pretest questions number (6, 33, 34, 35, 36, 37, 38, 39, 40) and 9 posttest questions number (7, 33, 34, 35, 36, 37, 38, 39, 40). 18 algorithm design questions, namely 9 pretest questions (4, 11, 26, 27, 28, 29, 30, 31, 32) and 9 posttest questions (4, 11, 26, 27, 28, 29, 30, 31) , 32). The research results tend to help teachers in the teaching and learning process, carry out evaluations and determine tools to measure students' CT abilities. This research produces a framework for developing CT instruments on PBO material.

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