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How The Students Computational Thinking Ability on Algebraic?

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Abstract— Computational thinking is very needed in the 21 century where we live in digitalization era. There is a global movement to include computational thinking in the school curriculum. This research aims to describe how computational thinking students in solving the algebraic problem. We use the qualitative descriptive method. The subject was three students enrolled in an Algebra course in their first year at a large university in the Javanese, Indonesia. The result shows that the first step when solving the problems is an abstraction. The second step is decomposition. After the students decide what the information in-keep and what in ignore, they did the decomposition process. Then generalization to make a generic term, the last step is algorithmic. The algorithmic process is the applications of the generalization before. The method finds out the solution, especially algebra, can be done without the debugging process. The recommendation for future research views the computational thinking in another subject, need to be reviewed if computational thinking will be included in the school curriculum in Indonesia. It is also necessary to develop computational assessment in mathematics education.

Index Terms— Computational thinking, education, mathematics, curriculum, learning, algebraic, problem solving.

1 Introduction

In response to the increasing demand to compete in the global economy, countries need to prepare students with appropriate technical knowledge and communication skills to compete in the twenty-first century [1]. One step in dealing with this is to include computational thinking into the curriculum [2]–[5]. Computational thinking is one of the skills critical for successfully solving problems posed in a technology-driven and complex society [6].

Computational thinking is the students' fundamental skill in education, and it was equal with reading and arithmetics skill [7], [8]. According to [9], learning by computational thinking as a fundamental skill in all of the school curriculum will improve the students' abstract thinking, algorithmic, and logic. They were also more all ready to solve complex and open problems. They were powered by [10], who argued that the training of computational thinking in class would use in their education and future. Activities based learning strategy is a strategy to help for increasing youth cognitive and can point their learning effectively by manipulation activity and real utterance [11]. Computational thinking considered the primary role of competency because students recently not only working in the subject who computational influenced, although in contextual also and in global economic [2], [12].

Mathematics is one of the subjects in the school curriculum. So that, application of computational thinking in mathematics can improve students conceptual in mathematics. The mathematics needed learning activity that gives a direct experience to support their skills on problem-solving [13]. Computational thinking and mathematics have a reciprocal relationship, computational used to enrich mathematics and science learning, and applied mathematics and science context to enhance computationally [5].

The primary motivation to show the computational thinking is needed in math class as a response to the knowledge that more computerization will be applied in work [14]. Mathematics ability considered as the core factor which can predict the learning student ability [12]. The researchers argued that mathematics thinking has an essential role in computational thinking [15]–[17] because mathematics problem solving is construction process [18]–[20]. The construction process of the solution needs an analytical perspective to solve the unique and fundamental problem for students. Computational thinking can increase the number sense and arithmetic ability [21], [22] who influenced by thinking style, perceive academics and attitude towards mathematics [23]. Additionally, computational thinking can also be influenced by the level of class and duration of mobile usage [24]. The cognitive habits which can support to improve computational thinking are spatial reasoning and intelligence [25], [26]. Algebra is a benchmark to decide the student's opportunity to forward their study in college.

2 Research Methods

Our study was a descriptive qualitative research, whereas the students were enrolled in an Algebra course in their first year at a large university in the Javanese, Indonesia. Algebra provides the conceptual basis for treating multivariable calculus in any number of dimensions. Three students (of 31 enrolled) responded to our request for volunteers to participate in a clinical interview all of these were accepted, and they were one male and two females. Students were interviewed individually; the interviews lasted about one hour and took place at the end of the course when necessarily all course material had been covered. The discussion revolved around the following task,

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If the p,q,r ∈ Z, determine the value of q in the equation below!

$$p + \frac{1}{q + \frac{1}{r}} = \frac{25}{19}$$

We determined that the task has the potential to measure the student's computational thinking. It was a non-routine problem. We asked several follow-up questions to probe students' intuition and solution procedures, whether students could formulate their solution procedure in computational thinking, and whether they could justify their procedure. The interviews were videotaped and transcribed, and students' written work produced during the interviews was retained. These recordings, transcripts, and written documents formed the corpus of data analyzed in this study. Computational thinking's components consisted of abstraction, decomposition, generalization, algorithmic, and debugging [27]. Abstraction is the skill to decide what information about an entity/object to keep and what to ignore. Decomposition is the skill to break a complex problem into smaller parts that are easier to understand and solve. Generalization is the skill formulate a solution in generic term so that it can be applied to different problems. Algorithmic is the skill to devise a step-by-step set of operations/actions of how to go about solving a problem. Debugging is the skill to identify, remove, and fix errors — we analyze how the three volunteers solving the problem based the computational thinking's components. We coded students' utterances and their written solution as abstraction, decomposition, generalization, algorithmic and debugging, for example, we usually coded written solution of students including "they write what is known from problems" as an abstraction. Here they can decide what the information to keep or ignore. "They write what is known from problems and what is asked" as a decomposition. "They write and utterances the step-by-step of the solution process" as an algorithmic. "They write and utterances the errors and fix it" as a debugging.

3 RESULTS

The students in our interviews were largely successful in solving this task and all with the different procedure of each. The first student with initial “L” read the problem and understand what is asked i.e., looking for the value of q although L didn't write that on his solution. L understand that p, q, r are integers and symbolized by Z. L decide that he was thinking about the integer properties. So that, L did abstraction. L write the problem in the first line of his solution, then L breaking down the problem by multiplying all of the terms with (q+1/r) in order to simplify the fraction (the fraction has no denominator). L did a decomposition completely. Then L using distributive of multiplication to solve the problem step-by-step because there are the same variables, i.e. (q+1/r). This process is algorithmic because L solve the problem step-by-step according to the concept he has. L find out the value of q, but the solution is a fraction, not an integer. L forget that q is an integer, so he feels already solving the problem. L didn't fix his error. The value of q still a fraction. L considered that this problem is an open-ended problem. The answer of L can be view in **Figure.1** below.

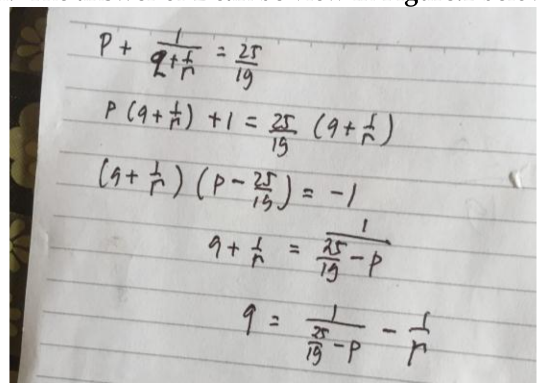

Figure. 1. The answer of L

The second student with initial "A" understood the question provided but did not write down what was asked, and she knew that p, q, r are integers. So that she decided to use the integers' properties. Here she did the abstraction by deciding what information from the problem that keeps getting the solution. "A" viewed the left segment as a mixed fraction, and the right segment was a normal fraction. "A" breaks down the complex problem to smaller problem by breaks down the right-hand column into two-part summaries of the same denominator because the right segment is a common fraction that can be converted into a mixture, where the numerator value is greater than the denominator. She did the decomposition process. In the second row, "A" chose 19/19 because of 19/19 = 1 (based on known p, q, r integer). Thus the solution for p is found to be 1. Then "A" sees 1/(q + 1/r) = 6/19, remembering 1/(1/a) = a then "A" changes the shape of the right column to 1/(19/6) with a reason to make it easier to find the solution is because the two columns have the same shape which is equal to the number 1. So that the denominator in the left column is the same as the denominator in the right. From that point, A concludes with the idea as before which is to turn 19/6 into a two-part sum which is taken 18/6 because in the left column there is 1/r so that in the right column the number is 1/6. After checking it turned out that 18/6 = 3 is a whole number. So get the solution q = 3. But the subject writes down all the solutions and doesn't realize that what is being asked is the only solution of q. From that, the subject does not re-evaluate what is being asked. But "A" re-checks by instilling the values of p, q, r into the equation. The answer to "A" can be viewed in **Figure 2**. below.

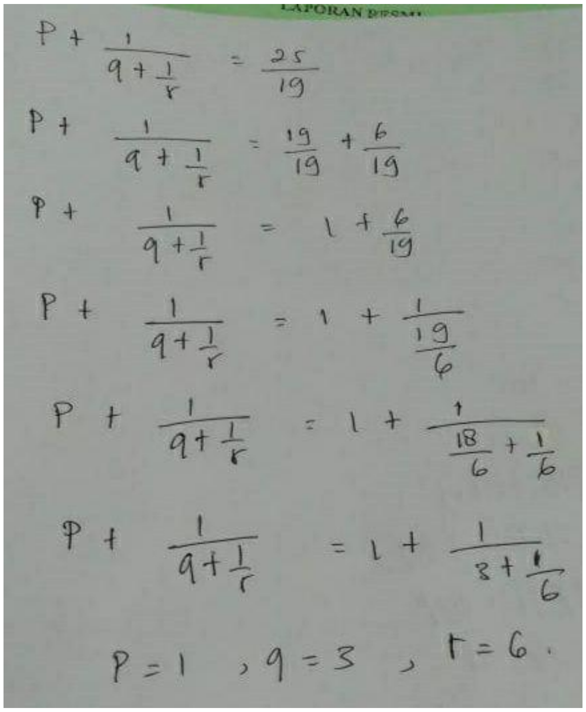

Figure 2. the answer of "A"

The third student with initial "S" wrote down what was known and what was asked. "S" understands that p, q, r are integers. When writing what is known the "S" made a writing error on r but was immediately justified (incorrect writing of R is r). "S" sees the right segment is an ordinary fraction that can be converted into mixed fractions. Because p is an integer, it is clear that the left side is also a mixed fraction. So that p = 1 is obtained because of 25/19 if it is converted to a mixed fraction into 1 + 6/19. After that, "S" writes 1/(q + 1/r) = 6/19. For a moment he thought, he found number 1 as the numerator on the left side. Based on 1/(1/a) = a, he can find the q + (1/r) value, 19/6. With the same steps as before, 19/6 are ordinary fractions that can be converted to mixed fractions. then 19/6 = 3 +(1/6). It is clear that q = 3 and r = 6. Because the right and left segments have the same form. The subject writes the answer to be q = 3. "S" also checks by substituting the values p, q, and r to the equation. The answer of "S" can be viewed in **Figure 3**. below

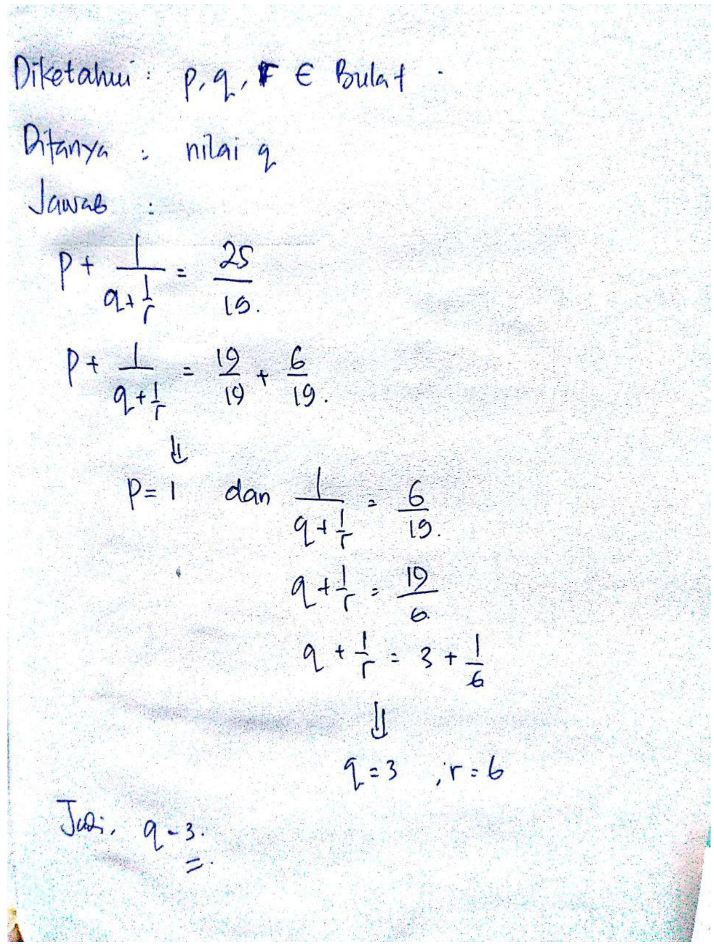

Figure 3. the answer of "S"

4 Discussions

Some authors view computational thinking as innovative learning. [28] review about the exploration of computational thinking in preschool math learning environments. The result shows that it is needed to provide a model for thinking about how to extend CT into other disciplines in early childhood. [29] reveal that computational thinking in mathematics teacher education can be improved the teacher in learning. Then [30] discuss the impact of computational thinking workshops on high school teachers. The results show that high school teachers must be understanding the perception of computational thinking and computer science, as well as to the identification of the best tools and resources which high school teachers are most likely to use and which can be used to implement computational thinking in core curriculum standards, including mathematics.

All of the subjects did the abstraction by deciding the integers' properties to solve the problem. They also break down the complex problem to smaller problem in a different way. "A" and "S" break down the complex problem to smaller problem by changing the form of the improper fraction to a mixed fraction. In other, "L" break down the complex problem to smaller problem by multiplying all of the terms with (q+1/r) in order to simplify the fraction (the fraction has no denominator). There is no generalization process in the "L" solution. "A" and "S" using the same procedure when the generalization, that is they think the generic form is equation concept i.e., the form of right expression is equal to the form of left expression. All of the students did the algorithmic process are different from each. "L" using the routine process of solving an algebra problem. "A" and "S" using the procedure according to the generalization that they write before. "L" didn't debug his solution. He considered that the problem was incomplete and he thinks that the solution was still equation form. So that he also thought that the problem was open-ended. "A" did the debug by checking the values of p, q, and r then substitution them to the equation. "S" did the debug process by she revised her mistake of writing.

5 Conclusion

CT has entered the educational landscape, and it is crucial that faculties of education programs understand how it will impact teaching and learning and how they might address the added knowledge that teachers need to develop. CT integration also affords new approaches to mathematics problem-solving. The first step when solving the problems is an abstraction. The second step is decomposition. After the students decide what the information in-keep and what in ignore, they did the decomposition process. Then generalization to make a generic term, the last step is algorithmic. The algorithmic process is the applications of the generalization before. The process finds out the solution, especially algebra, can be done without the debugging process. The recommendation for future research views the computational thinking in another subject, need to be reviewed if computational thinking will be included in the school curriculum in Indonesia. It is also needed to develop the computational assessment in mathematics education.

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