The Analysis of Mathematics Students' Computational Thinking Ability at Universitas Siliwangi

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Abstract. The rapid development of science and technology requires students to master various abilities and skills in order to compete globally. No exception students in mathematics education study programs. One of the abilities students must have is the ability to think computationally. Computational thinking ability is part of the problem-solving ability that is the ability of students to solve problems through decomposition skills, pattern recognition, algorithm thinking, abstraction and generalization of patterns to get a solution. The purpose of this research is to describe the computational thinking ability students' of Mathematics Education study program through the mathematics modelling courses.

1. Introduction

The education system in Indonesia experiences developments every year in line with the times. Also in the 21st century is an era where technology, especially information technology and computers are everywhere. There are at least four skills that must be mastered in the 21st century known as 4C, namely Collaboration, Communication, Critical Thinking and Creativity. In addition to these four capabilities, mastery of informatics science is also needed, so that the Indonesian nation is not only a user of technology, but can also advance the nation and state with digital works that support the resolution of increasingly complex life problems. However, according to various credible survey institutions the world education system in Indonesia, occupies a position below. One reason is because it has not yet implemented Computational Thinking (CT) which requires students to think problem solving in a structured, critical and logical way [1]. Therefore it is necessary to train the capabilities that support this. This ability is known as computational thinking ability or known as Computational Thinking Ability (CTA).

Computational Thinking was first introduced by Seymour Papert, then popularized by Janette M. Wing [2]. Wing states that Computational Thinking will be a basic skill used by everyone in the world in the mid-21st century [3]. According to Quinn Computation Thinking (CT) offers a logical, explorative, expandable and collaborative way to solve complex problems in a state of change [4]. Starting in 2014, the British government included programming material in the primary and secondary school curriculum that aims to introduce Computational Thinking early on to students. The British government believes that CT can make students more intelligent in understanding the technology that is

around them [5]. This can be imitated by Indonesia as a step in facing the changing times by starting to apply it at the tertiary level, especially the mathematics education study program where graduates will become teachers who will transform knowledge in students.

Mathematics education students are individuals who will have a role in 21st century development must be equipped with supporting abilities. Times that continue to change with the support of various technological advances become a major challenge for mathematics education students who later will be math teacher candidates to prepare various abilities to support mathematics learning. Based on this matter, mathematics education students as mathematics teacher candidates are expected to have various abilities, one of which is the Computational Thinking ability. Through CT is expected to help students in making decisions and solving problems.

The mathematics modeling courses given at the Siliwangi University mathematics education program besides aiming at developing students 'mathematical thinking skills also aim to develop students ability in mathematization the problems in daily life into mathematical models to be solved. Therefore, the problem solving ability is the focus of this subject to be mastered by the student through The mathematics modeling courses. CT which is a problem solving process is very likely to appear when the students compiling to make mathematical modeling.

Based on this, it is necessary to investigate how the ability of Computational Thinking students of mathematics education in Siliwangi University as a starting material in the development of various approaches, methods and media that can develop the Computational Thinking ability of students as their provisions in facing the challenges of the times through the mathematics modelling courses.

2. Method

This research used the qualitative method [6]. The research subjects were students of mathematics education in the fifth semester of the mathematics modeling course consisting of 9 people. Data collection techniques using observation, interviews and documentation. Data analysis was carried out qualitatively by triangulating data, reducing data and displaying data.

3. Result and Discussion

3.1. Computational Thinking (CT)

Computational thinking is an important skill for students including prospective teacher students. CT skills help students develop skills for the needs of future job opportunities, especially in the era of the industrial revolution 4.0. Developments in technology and computer science have resulted in demands for skills that students must have in soft skills such as reasoning and problem solving, so that they are able to compete in this era and have long-term success.

Computational thinking is one approach to problem solving. Computational thinking (CT) is a problem solving process that includes a number of characteristics, such as logically ordering and analyzing data and creating solutions using a series of ordered steps (or algorithms), and dispositions, such as the ability to confidently deal with complexity and open-ended problems [3]. CT is essential to the development of computer applications, but it can also be used to support problem solving across all disciplines, including math, science, and the humanities. Students who learn CT across the curriculum can begin to see a relationship between subjects as well as between school and life outside of the classroom. Computational thinking skills are defined as a set of problem-solving skills based on computer techniques required for almost all careers, not just scientists but also in other fields, such as doctors, teachers, or farmers [7]. In line with this opinion, Aho stated that states that computational thinking as a thought process involves problem formulation so that students can solve problems through calculation and generalization steps [8].

Wing [3] emphasizes that CT is a process that involves activities formulating problems and expressing solutions such as how computers or machines work effectively. In line with this, CT is expressed as a mental activity to automatically abstract problems and solutions [9]. This means that, CT skills help a person in formulating problems through effective and planned channels so that effective solutions are obtained. Based on this definition, students who have a well-developed CT will be able to

articulate the problem appropriately, design a logical solution according to the right stages, so as to be able to predict what might happen from each stage designed to obtain an effective solution.Hemmedinger [10] argues that teaching Computational thinking means teaching how to think as an economist, physicist, artist and to understand how to use computing to solve problems, create and find new questions that can be explored in a useful way. Furthermore Furber [11] states that CT involves the process of recognizing computational aspects in the surrounding environment, applying tools and techniques from computer science to understand and reason about natural and artificial systems and processes. Furthermore, the CT thought process in solving problems in the form of mental orientation through the conversion of a number of inputs into outputs through certain algorithms [12]. However, teaching CT is not the same as teaching computer science [13]. Like the opinion expressed by wing, CT skills are the ability to think like a computer and are soft skills that are included in the problem solving approach.

According to Gagne the object of learning mathematics is divided into direct and indirect objects. Among the indirect objects students must have through learning mathematics is to form students' mathematical thinking skills including the ability to reason, investigate, communicate, compile algorithms and problem solving. Therefore, it is very possible to observe the emergence of CT abilities of students in learning mathematics including developing CT skills through learning mathematics.In this study, the ability of CT is based on the opinion of experts, which is one of the skills of problem solving approaches in learning mathematics which includes decomposition skills, recognizing patterns, abstractions and algorithms. Decomposition is the skill of breaking a complex problem into small pieces, making it possible to assess the problem and find all the steps needed to solve the problem. As an illustration, this skill for example by giving projects to students to make something by giving examples of projects that have been completed. Recognizing Patterns is the ability to see or recognize or look for patterns in a given problem. Then find out if there are more effective ways that can be used to solve the problem. Abstraction, i.e. generalizing patterns by identifying relevant and irrelevant information from the given problem situation. Algorithm Design, i.e. arranging steps and rules needed in order to get the desired results every time.

3.2. Mathematics modeling

Learning mathematics in its development is often a memorization of formula activities and is identical with meaningless calculations. Often the learning outcomes become memorized learning and rarely use the real context around students, including students. This situation indirectly shapes the students' perception of mathematics. In fact, prospective mathematics teachers should be able to see mathematics as a model or problem abstraction in everyday life to be solved through meaningful learning.

Mathematical modeling is an important aspect that needs to be developed in the process of learning mathematics. Mathematical modeling is a process of gaining mathematical understanding through real world contexts [14]. Whereas Giodano and Wier [14] stated that mathematical modeling is the compilation of a description of some real-world behavior into mathematical parts called the mathematical world. Illustration of mathematical modeling [15] is presented in the following figure 1.

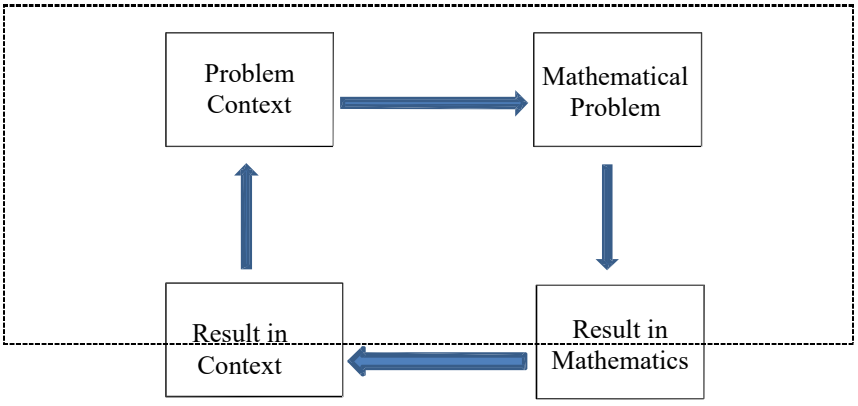

Figure 1. Problem Solving Proccess

Based on this opinion, mathematical modeling is the process of translating a problem in a real context into a mathematical form to be resolved, then the results of the settlement are translated back into the original context.

Besides mathematical modeling is a field of mathematics that seeks to present and explain physical systems or problems in the real world in mathematical statements in order to obtain an understanding of these real world problems become more precise. Mathematical modeling is a process that uses mathematics to represent, analyze, make predictions or provide insights about real world phenomena. Simply put, a mathematical model is an attempt to describe a phenomenon in the form of a mathematical formula so that it is easy to learn and do calculations.

According to Bliss, Fowler & Galuzzo [16] mathematical modeling is a representation of a system or scenario used to get a qualitative and / or quantitative understanding of some real-world problems and to predict future behavior. Based on this opinion there are six stages in mathematical modeling. The Six Stages are shown in Figure 2 below.

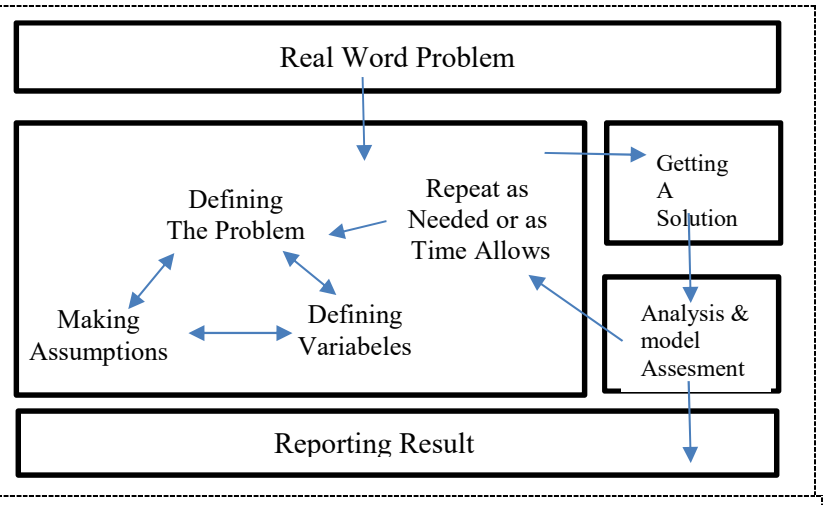

Figure 2. Mathematics Modeling Proccess

3.2.1. Define the problem statement

Real-world problems can be broad and complex. It's important to distill conceptual ideas into concise problem statements that will show exactly what the output of your model looks like.

3.2.2. Make assumptions

At the beginning of your work, it might seem that the problem is too complex to make any progress. That is why it is necessary to make assumptions to help simplify the problem and sharpen focus. During this process, you reduce the number of factors that affect your model, thus deciding which factors are most important.

3.2.3. Defining variables

What are the main factors that influence the phenomenon that you are trying to understand? Can you list these factors as measurable variables with the units specified? You might need to differentiate between independent variables, dependent variables, and model parameters. In understanding these ideas better, you will be able to determine the input of the model and make mathematical relationships, which eventually form the model itself.

3.2.4. Get a solution

What can you learn from your model? Does it answer the question you originally asked? Determining a solution might involve calculating papers, evaluating functions, running simulations, or solving equations, depending on the type of model you developed. It might be useful to use software or other computing technology.

3.2.5. Model analysis and assessment

In the end, one must step back and analyze the results to assess the quality of the model. What are the strengths and weaknesses of the model? Are there certain situations when the model doesn't work? How sensitive is the model if you change the assumptions or change the value of the model parameters? Is it possible to make (or at least show) the possibility of improvement.

3.2.6. Report model results

You might be amazing, but no one will know unless you can explain how to use or implement it.

3.3. Computational thinking in mathematics modeling

Mathematical modeling courses aim to develop students' skills in making mathematical models from real life contexts through observation, analysis and model design and completion. In addition, in more detailed mathematical modeling includes six stages in accordance with those proposed by Bliss, Fowler & Galuzzo [16] namely defining the problem, making assumptions, defining variables, getting solutions, analyzing and modeling the assessment and reporting of the results. This mathematics modeling course is held in semester 5. Beginning of the lecture, students are given knowledge related to mathematical modeling, then students are given the task to observe various problems that exist around students who need solutions and can be made mathematical models.

Various problems in the daily lives of students (real world problems) are expressed and then discussed to be solved and make mathematical models. At the stage of making mathematical models, students go through several stages, namely starting to define problems, create variables, and make assumptions or possible solutions and models of those problems. At this stage students discuss with each other both with other students and with lecturers. At this stage students are also indirectly being trained in computational thinking skills by breaking down a problem into smaller parts and sorting out the important parts that can be used to make models. Then students observe patterns that might be used and applied in the model to be made. Recognizing Patterns is the ability to see or recognize or look for patterns in a given problem. Then find out if there are more effective ways that can be used to solve the problem.

Furthermore, after students get a model or solution of real-world problems. The model is analyzed whether the model is appropriate and then the student performs an abstraction, which is to generalize the pattern by identifying relevant and non-relevant information from the mathematical model that has been made. After that, the algorithm is created as the most appropriate model of real world problem solutions that are being solved. At this stage students' computational skills are trained, namely abstracting and making algorithms. After getting the right mathematical model, the final step is to report the results obtained as a solution to the problem solving done.

One example of a problem that is solved by a student is that there is one student who has problems in managing internet quota so that the initiative is to solve the problem so that he can predict the

expenditure of internet quota in one month and make a mathematical model as a solution to predict quota expenditure in one month. First, students gather information and observe patterns of use of applications that are often used and require how much internet quota is used. At this stage students begin to use computational thinking skills, namely decomposition and recognizing patterns. At the mathematical modeling stage this stage is defining the problem by trying to make various assumptions in problem solving and making variables that affect the use of internet quotas this is done in order to create an appropriate mathematical model.

After students get the right model, students test the model if it is applied in other situations. At this stage students analyze and conduct an assessment of mathematical models through the abstraction and testing of appropriate algorithms. This trains the ability of computational thinking at the stage of abstraction and algorithm development. Various tests are conducted so that students are sure to get a mathematical model that can be applied in solving students' problems, namely creating a mathematical model to manage the effective use of internet quotas.

4. Conclusion

Mathematical modeling courses conducted at the fifth semester students of the Siliwangi University mathematics education study program train students' computing abilities. This can be seen in problem solving activities in making mathematical models that are right from real problems experienced by students in daily life. In making mathematical models, students are guided to do decomposition, recognize patterns, perform abstractions and make appropriate algorithms, so that mathematical models can be found that can be a solution of the problem being solved. The expectation of students as prospective teachers is trained in computational thinking so that later they can solve various problems in real life.

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