Functional Thinking Profile of Junior High School Student in Solving Mathematical Problem Observed by Differences of Sex

A P Siregar\(^1\), D Juniati\(^2\), and R Sulaiman\(^3\)

\(^1\)Postgraduate in Mathematics Education, Universitas Negeri Surabaya, Ketintang, Surabaya, 60231, Indonesia
\(^2,3\)Department of Mathematics, Universitas Negeri Surabaya, Indonesia

Corresponding author: \(^1\)ardiantosiregar@mhs.unesa.ac.id

Abstract. This study involving 2 grade VIII students was taken place in SMPK Anak Bangsa Surabaya. Subjects were selected using equal mathematics ability criteria. Data was collected using provision of problem-solving tasks and followed by a task-based interview. Obtained data was analysed through the following steps, which are data reduction, data presentation, and conclusions. Meanwhile, to obtain a valid data, in this study, researchers used data triangulation. The results indicated that in the problem number 1 about identifying patterns, the subjects of male and female show a tendency of similarities in stating what is known and asked the question. However, the male students provided a more specific answer in explaining the magnitude of the difference between the first quantity and the increased differences in the other quantities. Related the activities in determining the relationship between two quantities, male subjects and women subject tended to have similarities in the sense of using trial and error on existing mathematical operations. It can be concluded that the functional way of thinking both subjects is relatively identic. Nevertheless, the male subject showed the more specific answer in finding the difference between the two quantities and finding the correspondence relationship between the quantities.

1. Introduction
Mathematics education has an important role in the development of science and technology. In daily life, there are many problems that can be solved by using mathematics. In fact, not all problems faced in daily life are mathematical problems, but to solve those problems a mathematical thinking is required. Krulik & Rudnick [1] said a problem is a situation, quantitative or otherwise, that confronts an individual or group of individuals, that requires resolution, and for which the individual sees no apparent path to the solution. Therefore, the problem in this study is defined as a situation where the student does not know the answer and he/she needs steps to solve it.

Reston [2] suggests that mathematics curricula should emphasis on the development of mathematical concepts rather than procedural knowledge only. In the learning process, children are less encouraged to develop their thinking skills. In fact, the learning process in the classroom tends to make the children memorizing information. One of the important potency that students have is thinking. A potency that needs to be developed precisely and gradually should be more implemented in order to a deal with the
students’ future life. In learning mathematics, students are expected to reason and think logically, analytically, critically, creatively, and can work together.

There is a point of view that the orientation of math in school highlight more on the "mathematics as the product of thinking" neglecting attention to the thinking process itself. Solso [3] said that thinking is defined as the process of generating new mental representations through information transformation involving complex interactions among mental attributes such as judgment, abstraction, reasoning, imagination, and problem solving. Therefore, it can be concluded that the process of thinking of students in learning mathematics is very important. It is expected that the students are able to understand the mathematics material in depth and can overcome the difficulties that happen gradually.

According to Schawnk [4] in the development of algorithms, student thinking types are divided into two types of thinking processes namely predicative and functional. Functional thinking is indispensable in mathematics because it is one of the main keys in algebraic thinking that contains generalization of functions. In this case, Smith [5] defined functional thinking as "A thinking representation that focuses on the relationship of two or more variations of the number of general-centred relationships that ultimately result in a function". Smith [5] said that there are three methods in developing the functional thinking. They are: (1) recursive patterning involves finding variation within a sequence of values; (2) covariational thinking is based on analyzing how two quantities vary simultaneously and keeping that change as an explicit, dynamic part of a function's description (eg, "as x increases by one, y increases by three"); and (3) a correspondence relationship is based on identifying a correlation between variables (eg, "y is 3 times x plus 2") ). (Blanton & Kaput [6,7]).

One way that can be used to sharpen the functional thinking ability is by solving math problems. Solving mathematical problems requires an understanding of mathematical concepts. The lack of understanding of the relationships among concepts is seen when the students solve math problems. Solving a problem is not only concerned with the final answer, but also the settlement process should also be considered. In solving the problem of mathematics, students are expected through the process step by step in a way that their thinking process can be observed.

Results of a study conducted by Krutetskii [8] stated that in thinking, female students are superior in accuracy, precision, and inequality. On the other hand, male students tend to be less thorough, hasty and tend to finish things in a short way. Furthermore, Schawbnk [9] stated that it is very difficult to find a functional thinking subject. However, this finding is not supported in the case of Indonesia and China that the women perform functional thinking well. The study related to the functional thinking profile of students that has been done by McEldeen & Jhanson [10,11] and Tanish [12] encourages researchers to describe the functional profile of students in solving mathematical problems in terms of sex differences. Therefore, this paper would discuss functional thinking profile of junior high school student in solving mathematical problem observed by differences of sex.

2. Methods
This study is descriptive qualitative study that aims to describe the functional thinking activity of junior high school students in solving mathematical problems based on gender differences. This study was conducted at SMP Kristen Anak Bangsa Surabaya. The subject of this study is 1 male student and 1 female student who have equal mathematics ability (score difference no more than 5) selected from 24 grade VIII students consist of 12 male and 12 female students. The main instrument is the researcher himself while the supporting instruments consist of mathematical ability tests, problem solving tasks and interview guidelines.

Data collection techniques in this study were designed in several stages. They are (1) providing problem solving tasks on the subject, (2) asking the subject of think-aloud before, during, and after filing the problem as well as an interview, and (3) recording in audio and visual at the time of the interview. Data analysis is done by reducing data, presenting data, and drawing the conclusion. The functional thinking activities in solving the problems are presented in Table 1.
| No | Mental activity                                      | Aspects observed                                              |
|----|-----------------------------------------------------|---------------------------------------------------------------|
| 1  | Identifying patterns                                | • Identifying the information contained in the problem        |
|    |                                                    | • Recognizing the difference between two quantities.          |
|    |                                                    | • Specifying another value for the next data                  |
| 2  | Determining the relationship between two quantities | • Recognizing the one-to-one relationships between the two quantities. |
|    |                                                    | • Specifying the value for the data in question.              |
| 3  | Stating common rules                                | Determining the general rules between two quantities using algebraic notation. |

3. Results and Discussion

Subjects in this study were selected based on the results of equivalent mathematical ability resulted from mathematics ability tests (with difference no more than 5) and different gender. The mathematics ability test is adapted from UN problem. Subsequently the subject was given the task of problem solving and followed by interviews. Furthermore, the functional thinking activity of the subject is expressed by referring to each student's functional thinking activity in solving the problem.

3.1 Functional thinking profile of male subject

The following are the findings of functional profile of male subject in solving mathematical problems.

3.1.1. Problem number 1

In identifying patterns, student began by looking at what was known in the matter, as seen from the student's statement of what was known. After student declared what was given in the student's problem, student stated that the problem would be related to the pattern. Furthermore, student stated that every first quantity increased then the other quantity also increased.

In the activity of determining the relationship between the two quantities, the student began by trial and error. That was to try what relationship can be found between quantities one with the other. In the activity of stating the general rule, student wrote the rules that were originally and verbally become algebraic. Furthermore, to test the truth of the rules written algebraically, the students tried the truth by replacing the value of n with some examples and finding the correct results with what was known in the matter.

![Figure 1. Male performance on problem 1](image-url)
3.1.2. Problem number 2
In identifying patterns, student began by looking at what was known in the matter, as seen from the student's statement of what was known. After student declared what was known in the student's problem, he declared that the problem would be related to the pattern and the same as the problem of number 1. Next, the student stated that each set made was added then the required material also increased.

In the activity of determining the relationship between the two quantities, the student declared that question 2 was easier to understand than question 1 so the student also stated that in this case everything was very clear. Furthermore, in recognizing the relationship between two quantities, students directly used the multiplication rule by multiplying each quantity with the desired number of sequences.

In the activity of stating the general rules, student wrote the rules that were originally and verbally became algebraic. This could be seen from the results of student work in the problem 2 of problem solving tasks 1 that student wrote to make n series, many flower required was n multiplied 2 plus n multiplied 3 plus n multiplied 1 and on the problem 2 of problem solving tasks 2 student wrote to make n gifts, many fruit required was n multiplied 3 oranges plus n times 5 apples plus n times 4 pears.

![Image of student work](image)

**Figure 2.** Male performance on problem 2

3.2 Profile of female functional thinking
The following are the findings of functional profile of female subject in solving mathematical problems.

3.2.1. Problem number 1
In identifying patterns, student began by looking at what was known to the problem. After student realized that if the first quantity increased then the other quantity also increased. This was in accordance with the statement of students on problem 1 of problem solving tasks 1 which stated if the pool box of catfish increased then total of the required feed was also increased and on problem 1 of problem solving tasks 2 declared the longer production of bark produced more and more.

In activity of determining the relationship between two quantities, the problem began with a trial and error. That was to try what relationship can be found between quantities one with the other. As in problem 1 of problem solving tasks 2, student initially tried to use multiplication and then proceeded with addition, at first it looked right, but in the next experiment it was not true. Furthermore, the student tried in another way by multiplying and then followed by subtraction and in the end the student found the one-to-one relationship between the two quantities by declaring in verbal language.

In activity of stating the general rule, student wrote the rules that were originally and verbally became algebraic. Furthermore, to test the truth of the rules written algebraically, student tried the truth by replacing the value of n with some examples and finding the correct results with what was known in the problem.
3.2.2. Problem number 2
In identifying patterns, student began by looking at what was known to the problem. Furthermore, student stated that each set made was added then the required material also increased. In activity of determining the relationship between two quantities, student directly used the rules of multiplication by multiplying each quantity by the desired number of sequences.

In activity of stating the general rule, student wrote the rules that were originally and verbally became algebraic. This was seen from the results of student work as in the problem 2 of problem solving tasks 1, student wrote to make n series, many of the required interest was n multiplied by 6 and on problem 2 of problem solving tasks 2 student wrote to make n the gift, many of the required fruit was n multiplied 12.

4. Conclusions
Based on results of data analysis above, it can be concluded that the functional thinking activity of male and female subject has been doing in every activity. However, the manner of male and female subjects in the first activity tends to be different. In the activity of identifying pattern, the male subject explained the increasing quantity more specifically. Furthermore, in the activity of determining the one-to-one relationship, the male subject on problem 2 does not directly add the required material, but through multiplication processes of many ranges that will be made with each material for one circuit. Based on results of this study, it can be suggested to educators to provide training and guidance to female students in order to develop their functional thinking.

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