Cognitive style and gender differences in a conceptual understanding of mathematics students

W Kusumaningsih*, H A Saputra and A N Aini
Pendidikan Matematika, Universitas PGRI Semarang, Semarang, Indonesia

*Corresponding author’s email: widya.kusuma81.wk@gmail.com

Abstract. This study aimed to analyze the understanding of mathematics concepts of cognitive style students based on gender in the matrix material. This research is descriptive research with a qualitative approach. The data collected from high school students of class XI in a cognitive style of male and female. The technique of data collecting used in this research are tests, interviews and also equipped with documentation. The data analysis techniques in this research are data reduction, data display and conclusion/verification. The data validity used triangulation technique. The results showed that cognitive style between male and female students have a similarity understanding of mathematics concepts in indicators that give examples or examples of the counter of the learned concepts and have differences in understanding of mathematics concepts; redefine the concepts in mathematics; connect the various concepts in mathematics as well as outside mathematics; identify the characteristic of procedure or theory and present the idea in various forms of mathematical representation. Based on data analysis, it can be concluded that the understanding of mathematics concepts of cognitive style on the male is better than on the female.

1. Introduction
The improvement of mathematics education quality is very substantial in improving the quality of human resources in order to have knowledge, skills and attitudes that are oriented towards increasing mastery of science and technology. One of the goals of mathematics learning is that students are expected to have good abilities in understanding mathematical concepts. In understanding mathematical concepts, students must be able to distinguish between factual knowledge and procedures [1]. Students have the ability to understand concepts if students are able to (1) Explain the concept or be able to re-express what has been communicated to him. (2) Using concepts in a variety of different situations and (3) Developing some of the consequences of a concept [2].

Mousad said that understanding concepts is reflected through individual abilities to produce what can be considered as examples and what cannot be considered as examples of concepts; using forms and graphics to express concepts; using mathematical, manual, technological and intellectual processing; besides modelling and translating ideas using codes, phrases and relationships for conceptual communication [3]. Concept understanding not only knows the definitions and rules in mathematics, but the knowledge of concepts that must be done with abstraction and generalization of certain examples [4]. Concept understanding allows students to solve mathematical problems in various new forms and settings [5]. A student to be able to master the subject matter of mathematics well, students must understand well the previous concepts which are the prerequisites of the concept being studied [6].

In fact, every student has different characteristics from other students in the ability to understand mathematical concepts. Differences in characteristics can include different ways of receiving,
organizing, and processing information received. This is what is called the cognitive style. Cognitive style is a process of control or style which is self-management, as a situational intermediary to determine conscious activity so that a learner is used to organize and organize, receive and disseminate information and ultimately determine behaviour [7]. Cognitive style is a unique way of learning in acquiring and building knowledge that is used to describe the way individuals think, feel, and remember information [8]. According to Kagan, there are two categories of cognitive styles, namely reflective cognitive style and impulsive cognitive style [9]. Impulsive and reflective cognitive styles are considered different from each individual in shaping concepts [10]. Reflective has a long response time in finding solutions, making fewer errors. On the contrary, impulsivity has a fast response time in finding solutions, tends to make high errors [11].

In relation to cognitive style, women are more reflective than men who are more impulsive, so the only variable that seems to affect impulsivity / reflective is gender [12]. Gender is one dimension that also influences the conceptualization process in mathematics education [13]. Gender is a socio-cultural construction which in principle is a cultural interpretation of gender differences [14]. The influence of gender factors (the influence of differences between men and women) in mathematics is due to the biological differences in the brains of boys and girls that are known through observation, that girls are generally superior in the field of language and writing, while boys are superior in the field of mathematics, because of its better spatial abilities [15]. Gender differences that women and men have different preferences in the use of problem-solving strategies and conclude that men do better in solving mathematical problems than women [16].

Research by the American Psychological Association based on the latest analysis of international research the ability of women throughout the world in mathematics is no worse than the ability of men. This means that there is no significant difference between women's and men's mathematical abilities [17]. So there is no significant difference between every mathematical aspect between men and women [18]. Based on some opinions and research results described above shows that there is a link between the ability to understand concepts, cognitive styles and gender, so that there is a comparison in the ability to understand concepts based on cognitive and gender styles.

The problem in this study is how the ability to understand the mathematical concepts of class XI high school students in the cognitive reflective style of men and student reflective cognitive style of women. The purpose of this study is to determine the ability to understand the mathematical concepts of class XI high school students in the cognitive reflective style of men and student reflective cognitive style of women.

2. Methods
This research is a descriptive study with a qualitative approach. Subjects taken were one student with a reflective cognitive style of male and one female student taken from a group of reflective students with the longest and most accurate time (most correct) in answering all items. This research instrument is a test sheet and interview guidelines. The test sheet consists of a cognitive style test of Matching Familiar Figure Test (MFFT) and a test of the ability to understand mathematical concepts. Data collection in this study was carried out using several methods, namely the test method, and the interview method and equipped with documentation methods to capture all the important things done during the study so that all activities can be recorded properly. After each subject is given tests and interviews then analysed according to activities in data analysis, namely data reduction, data display and conclusion drawing/verification. Furthermore, to check the validity of the data, technical triangulation is used by checking the data to the same source with different techniques. Data from technical triangulation are valid data which are the results of research.

In this study, the data analysis techniques used were qualitative data analysis techniques from Miles and Huberman. Miles and Huberman suggest that activities in qualitative data analysis are carried out interactively and take place continuously until complete so that the data is saturated. Activities in data analysis, namely data reduction, data display and conclusion drawing and verification, along with the explanation:
1) Reduction data is means summarising, choosing the main things, focusing on things that are important, looking for themes and patterns and discarding unnecessary ones
2) Display data, in qualitative research, the performance of data can be done in the form of brief descriptions, charts, relationships between categories, flowcharts and the like. The researcher presents the data in this study using a short story described in the form of a narrative, and then the data is shown in the way of tables to facilitate researchers in analysing the data obtained

3. Results and Discussion

3.1 Cognitive Style Test
To determine that the students were cognitive reflective style, MFFT (Matching Familiar Figure Test) was used. On the test there are 13 questions in the form of images. In each question there is one standard image and eight variation images. Among the eight variation images there is one image that is the same as the standard image. The student's task is to choose one of the same or similar variation images. Selected subjects were as many as two students consisting of one male student and one female student with reflective cognitive style. The choice of subject is for consideration with the mathematics teacher as well. In the cognitive style test students in one study class obtained median time of the amount 37 and the median frequency answered as much 1,961,5385. After finding the median time and frequency of answering, students' cognitive style graphs can be seen on Figure 1.

Figure 1. Grouping Cognitive Style of Students.

From graph 1, the criteria are obtained as a reference in categorizing students' cognitive styles. The criteria can be seen in table 1.

| Cognitive style       | Time (seconds) | Frequency       |
|-----------------------|----------------|-----------------|
| Fast-Accurate         | $t < 37$       | $f < 1,961,5385$|
| Impulsive             | $t < 37$       | $f \geq 1,961,5385$|
| Slow-Not Accurate     | $t \geq 37$    | $f \geq 1,961,5385$|
| Reflective            | $t \geq 37$    | $f < 1,961,5385$|

3.2 Test of Understanding of Mathematical Concepts
The results of the written test and the results of the interviews show that there is a comparison of the ability of conceptual understanding between students' cognitive and reflective styles of men and women. Cognitive style is considered different from each individual in shaping concepts [10]. Gender is one
dimension that influences the conceptualization process in mathematics education [13]. Women are more reflective than men who are more impulsive, so the only variable that seems to be influenced by gender is cognitive style [12]. From some of these opinions support that there is a link between the ability to understand concepts, cognitive styles and gender, so that there is a comparison in the ability to understand concepts based on cognitive and gender styles.

Between men and women look better at male students. Women and men have different preferences in the use of problem-solving strategies and conclude that men do better in solving mathematical problems than women [16]. High-ability male students have better mathematical abilities than female students who are also highly capable [19].

Descriptively the ability to understand mathematical concepts between subjects of cognitive reflective male and female subjects is as follows:

1) Restating the concepts that have been learned
On this indicator there is a difference between the cognitive and reflective styles of men and women. Subjects in the reflective cognitive style of women are not able to define concepts completely and correctly but are able to show statements that are definitions of concepts. Unlike the reflective cognitive-style subject of men who are able to define concepts and strengthen their answers by showing statements that are definitions of the concept.

2) Identifying the nature of the operation or concept
On this indicator there is a difference between the cognitive and reflective styles of men and women. This is shown in the answer to the subject's reflective cognitive style, the man is unable to prove the two characteristics of the same operation, thus giving rise to the wrong answer. In contrast to the subject of female reflective cognitive style that is able to identify the nature of the operation or concept by proving two characteristics of the same operation completely and correctly.

3) Providing examples or examples of counter (opposite examples) of the concepts learned
On this indicator there are similarities between the subjects of cognitive reflective style of men and women. Both subjects are able to provide arguments which are examples or examples of counter (opposite examples) of the concepts learned. And between subjects the reflective cognitive style of men and women is also able to apply the concept to the example that the subject takes in his argument.

4) Presenting concepts in various forms of mathematical representations (tables, graphs, diagrams, sketches, mathematical models or other methods)
On this indicator there is a difference between the cognitive and reflective styles of men and women. Subjects of male reflective cognitive style were not able to present concepts in various forms of mathematical representation, namely mathematical models but were able to determine the results of the mathematical model that the subject presented. In contrast to the subject of female reflective cognitive style that is able to present concepts in various forms of mathematical representation, the mathematical model and subject are able to determine the results of the mathematical model that the subject presents.

5) Linking various concepts in mathematics and outside mathematics
On this indicator there is a difference between the cognitive and reflective styles of men and women. Subjects in the reflective cognitive style of women were unable to link the previous concepts into various other concepts in mathematics completely and correctly but were able to make conclusions by linking the concept. In contrast to the subject of male reflective cognitive style that is able to associate previous concepts into various other concepts in mathematics and be able to make conclusions by linking the concept.

While the comparison of the results of the description and analysis of the results of the written test and the interview of the ability to understand the concepts of the reflective subjects of men and women can be seen in Table 2.
Table 2. Comparison of the Understanding Ability Concepts of Male and Female Reflective Subjects.

| No. | Indicator of understanding of mathematics concepts | Valid Subject Data Male Reflective | Valid Subject Data Female Reflective |
|-----|---------------------------------------------------|-----------------------------------|--------------------------------------|
| 1   | Redefine the concepts in mathematics               | a. Can state the definition of the concept with its own language completely and correctly | a. Can state the definition of the concept with its own language but still not appropriate |
|     |                                                   | b. Can show statements that are definitions of concepts | b. Can show statements that are definitions of concepts |
| 2   | Identify the characteristic of procedure or theory | a. Can identify the concept in accordance with the results of the resolution of the problem but still not appropriate | a. Can identify the concept in accordance with the results of solving the problem completely and correctly |
|     |                                                   | a. Can provide other examples of concepts that are determined completely and correctly | a. Can provide other examples of concepts that are determined completely and correctly |
|     | That give examples or examples of the counter of the learned concepts | b. Can apply the concepts specified in other examples that the subject gives | b. Can apply the concepts specified in other examples that the subject gives |
| 3   | Present the idea in various forms of mathematical representation | a. Can present concepts in the form of mathematical representations but still not appropriate | a. Can present concepts in the form of a complete and correct mathematical representation |
|     |                                                   | b. Can present the results of problem solving according to the instructions in the problem | b. Can present the results of problem solving according to the instructions in the problem |
| 4   | Connect the various concepts in mathematics as well as outside mathematics | a. Can link the previous mathematical concepts to the complete and correct problem solving | a. Can link the previous mathematical concepts into problem solving but still not appropriate |
|     |                                                   | b. Can make conclusions by linking mathematical concepts | b. Can make conclusions by linking mathematical concepts |

4. Conclusions
Based on the results of the research and discussion that has been described, it can be concluded that the results of the analysis of the ability of conceptual understanding between students' cognitive and reflective styles of men and women have similarities in the indicators giving examples or examples of contra of the concepts learned and have differences in the indicators restating the concepts has been studied; linking various concepts in mathematics and outside mathematics; identify the nature of operations or concepts and present concepts in various forms of mathematical representations. Overall between students' cognitive style of reflective men and students' cognitive reflective style of women in the ability to understand concepts better students' cognitive style of male reflective.

There are still weaknesses in this study, therefore there are suggestions for future researchers, including: (1) this study does not provide treatment, but only gives tests to the subject to know the ability to understand the concept, therefore in understanding concept understanding is needed in the process of learning mathematics, (2) this study only takes a few indicators of the ability to understand the concept, therefore looking at the more detailed conceptual understanding abilities needed to take all indicators (3) the results of this study obtained that there are differences in cognitive and gender styles of students, because It is necessary to note the differences in cognitive and gender styles in teaching that have been done by the teacher.
5. References

[1] Chris N and Mbah 2017 Impact of Modern Technologies in Understanding Mathematical Concepts in Nigerian Secondary Schools: A Study of Imo State Secondary Schools International Journal of Education and Evaluation 3 (5)

[2] Duffin J M and Simpson A P 2000 A Search for understanding Journal of Mathematical Behavior. 18 (4) 415-427

[3] Khashan and Khaled Helmi 2014 Conceptual and Procedural Knowledge of Rational Numbers for Riyadh Elementary School Teachers Journal of Education and Human Development 3 (4)

[4] Zuya, et.all 2017 Conceptual and Procedural Knowledge of Pre-service Teachers in Geometry. International Journal of Innovative Education Research 5 (1) 30-38

[5] Ghazali, N H Che., and E Zakaria 2011 Students' Procedural and Conceptual Understanding of Mathematics Australian Journal of Basic and Applied Sciences 5 (7) 684-691.

[6] Zevika, Mona., et al. 2012 Improve the Concept Understanding Ability of Class VII Students of Padang Panjang 2 State Junior High School Through Cooperative Learning Type Think Pair Share Accompanied by Mind Maps Journal of Mathematics Education 1 (1) 45-50

[7] Bassey, W Sam and U Grace. 2009 Cognitive Styles, Secondary School Students’ Attitude and Academic Performance In Chemistry In Akwa Ibom State– Nigeria

[8] Sellah, Lusweti., et.all. 2017 Analysis of Student-Teacher Cognitive Styles Interaction: An Approach to Understanding Learner Performance Journal of Education and Practice 8 (4)

[9] Warli 2010 Mathematical Ability of Relative and Impulsive Children. Proceedings. 30 January 2010. Muhammadiyah University Malang.

[10] Bazzargani and D Taghipour 2013 Impulsivity–Reflectivity, Gender And Performance On Multiple Choice Items. International Journal of Language Learning and Applied Linguistics World (IJLLALW) 4 (2) 194-208

[11] Michalska, Paulina, and L Zajac 2015 The Measurement of Cognitive Style Reflection-Impulsivity in The Adulthood-Result of Own Study. Polskie Forum Psychligiczne 20 (4)

[12] Rastegar, Mina., and Honarmand N M 2016 Field Dependence/Independence, Impulsivity/Reflectivity, Gender, and Cloze Test Performance of Iranian EFL Learners. European Scientific Journal 12 (8)

[13] Keitel C 1998 Social justice and mathematics: Gender, class, ethnicity and the politics of schooling. Berlin: Freie Universitat Berlin.

[14] Udousoro U J 2011 The Effects of Gender and Mathematics Ability on Academic Performance of Students in Chemistry An International Multidisciplinary Journal Ethiopia 5 (4)

[15] Geary D C, et.all. 2000 Sex Differences in Spatial Cognition, Computational Fluency, and Arithmetical Reasoning. Journal of Experimental Child Psychology 77 337-353.

[16] Zhu Z 2007 Gender differences in mathematical problem solving patterns: A review of literature. International Education Journal 8 (2) 187-203.

[17] Nafi’an MI 2011 Students' Ability to Complete Gender-Based Story Questions in Primary Schools. Prosiding. December 3, 2011. FPMIPA UNY

[18] Nepal B 2016 Impact of Gender and Location on Mathematical Thinking and Mathematics Achievement. Journal of Advanced Academic Research (JAAR)(Online).

[19] Kusumaningsih W et.all. 2018 Gender differences in algebraic thinking ability to solve mathematics problems. Journal of Physics.