Gender differences of mathematical critical thinking skills of secondary school students

Mawaddah¹, A Ahmad¹ and M Duskri²
¹Syiah Kuala University, Jl. Teuku Nyak Arief Darussalam, Banda Aceh 23111, Indonesia
²Ar-Raniry State Islamic University, Jl. Syeikh Abdul Rauf Kopelma Darussalam, Banda Aceh, Indonesia

E-mail: anizarahmad.aud@fkip.unsyiah.ac.id

Abstract. One of the competencies in the curriculum of 2013 is to develop creativity, curiosity, the ability to formulate questions to form critical thinking that is necessary for modern life and lifelong learning. It is therefore essential to create an instrument to measure students’ mathematical critical thinking skills. This study aimed to describe mathematical critical thinking skills of secondary school students in solving mathematical problems concerning gender based on developed instruments validated by four experts. Four students selected from 30 students of Year 9 in one of junior high school in Banda Aceh. The instruments used in this study are critical thinking skills and interview guidance. The results showed that the critical thinking skills of female students were slightly better than that of male students. The findings of this study imply that there is a gender difference in mathematical critical thinking skills and therefore it is required to develop instruments that enhance the critical thinking of both male and female students.

1. Introduction
Critical thinking is needed by students to solve everyday and mathematics problems. Critical thinking as the ability to analyze and evaluate information (the ability to analyze and evaluate data or information) [1]. Critical thinking skills include reasoning skills and reflective thinking focusing on deciding what to believed and do [2]. One of the objectives of mathematics learning in the 2013 curriculum is to develop students' skills in understanding mathematical concepts, explaining interconnectedness between concepts, and using concepts or algorithms flexibly, accurately, efficiently and appropriately in problem-solving. Based on the demands of the curriculum, the current learning process developed in Indonesia demands students to be actively involved in the process of teaching and learning activities to develop problem-solving ability. Associated with the aspects of problem-solving skills in mathematics, a student is required to have higher order thinking skills. Ministry of Education and Culture Republic of Indonesia Press Workshop stipulated that "Implementation Curriculum 2013" in 2014 said that learning mathematics is designed so that the students have to think critically to solve the problem. Critical thinking skills should be incorporated into the mathematics curriculum so that students can learn critical thinking skills and apply them to improve understanding of logical connections between ideas, create and evaluate arguments, and solve problems systematically [3]. Therefore, mathematics learning should emphasize the thinking process of students.
Many factors must be considered in studying mathematics, such as willingness, ability, particular intelligence, readiness of teachers, readiness of students, curriculum, and presentation methods. One factor that is not less important is the gender factor of students. Gender differences certainly cause physiological differences as well as affect the psychological differences in learning, so that male and female students have differences in learning mathematics.

Psychologically males and females are different. Females are more interested in real life issues, whereas males are more interested in abstract aspects [4]. The difference between males and females in learning mathematics, that the males are superior in reasoning, whereas females are superior in accuracy, precision, carefulness, and thoughtfulness [5].

Since childhood, male students are known to be more natural at recognizing problems. However, their concern in solving the problem is lower than of female students who tend to give more effort to problem-solving, commonly found male students lazy around in the classroom during the learning process [6].

Based on the above description, it is necessary to develop critical thinking instruments to analyze the critical thinking skills of mathematically male and female students using these instruments. This paper only examines the mathematical critical thinking skills of male and female students using the developed instrument, then the problem formulation in this research is how the mathematical critical thinking skills of secondary school students in solving mathematical problems reviewed of sex?

2. Method
This study aims to explore information about students' mathematical critical thinking skills. This research was conducted on Year 9 students of one secondary school in Banda Aceh. The subjects were selected based on test result about critical thinking skills. According to the test data of critical thinking skills, the researcher chose four students who were communicative and had high and medium mathematical skills because the researcher wants the students who could give or convey the ideas, ideas, and reason so that the researcher could explore deeper to the research subject. To choose a communicative student then the researcher discussed with the teacher of mathematics teacher in the class, this is because the teacher knows better the characteristics of the students. Based on the results of the discussion, then selected four subjects consisting of two male students and two female students.

Instruments used in this research consist of critical thinking skills and interview guidelines. The question instrument of critical thinking skills in this research is a question of mathematical story for the material system of two linear equations, the number pattern and set. This instrument was developed based on validation process by four experts, namely two lecturers of mathematics as an expert of learning evaluation and mathematics subject matter, one mathematics teacher as a practitioner of mathematics learning, and one colleague who has attended mathematics learning evaluation workshops and have done publication of paper scientifically like this research. Based on the assessment of the four validators it was concluded that the problem used met the criteria "worthy using with a little revision." The problem is given to the subject of research to be done for approximately 1 hour and continued with the interview. The interview guide is intended to guide researchers in uncovering the process of critical thinking of students in solving mathematical problems. The questions in the interview guide are structured according to the stages of the critical thinking indicator. Interview guidelines are used to keep the interview focused on the issues to be expressed.

The data collected in this study there are two types, namely the data of the work (answer) the subject of solving mathematical problems and subject interview data. The process of taking data is also carried out in two stages, the first stage is given the test of critical thinking skills-I followed the interview of each subject after the subjects did the test, and the second stage was given the test of critical thinking skills-2 followed the interview of each subject after the subject did the test. The critical thinking indicator used in this study is the critical thinking indicator according to Facione [7] which consists of interpretation, analysis, evaluation, inference, and explanation.
3. Result and discussion
Based on data analysis and test results, the following describes students' critical thinking skills for each indicator: interpretation, analysis, evaluation, inference, and explanatory.

3.1. Interpretation
According to the results of students' critical thinking skills test for interpretation indicator, male and female students could interpret the problem, that is to understand and explain the problem, and could interpret the meaning of data from a problem, meaning that the interpretation is easy for the students. This is in line with Anderson [8] stating that the interpretation is part of the level of understanding and belongs to the low-level thinking, so most students are able to meet this indicator. Here is one example of student answers in interpreting the problem.

![Figure 1. Student's answer in interpreting problems.](image1)

3.2. Analysis
According to the results of students' critical thinking skills test for analysis indicators, male and female students could determine the questions correctly and examine the outcome of the problem, but both male subjects are unable to use the correct strategy to solve the problem. This indicates that female students could solve the problem well. According to research Robbins [9], in females, the smaller the hippocampus, the better it works. Experts investigate how the hippocampus works and say that the female brain works more effective and efficient because the neurons that arrange the female brain communicate better with each other than the neurons in the male brain. Therefore, females have the ability to complete the tasks assigned without having to involve large numbers of neurons in the process, and their small size may represent more intense neuronal packing of cells or more active signals in females so they can work more effectively and efficiently in many ways. Here is one example of student answers in analyzing the problem.

![Figure 2. Student's answer in analyzing problems.](image2)
3.3. Evaluation

According to the results of students' critical thinking skills test for evaluation indicators, male and female students access connection between statement correctly and reject a statement based on predetermined criteria, but both male subjects could not use the right strategy to solve the problem. Lack of exercise in evaluating resulted in low students' critical thinking skills [10,11]. This indicates that the female students are more rigorous in problems solving than male students. This is also supported by the results of research Krutetskii [5] which states that there are differences in character between males and females. Generally, males are better at reasoning while females are better regarding accuracy, thoroughness, and thoughtfulness of thinking. Here is one example of student answers in evaluating the problem.

![Figure 3. Student’s answer in evaluation problems.](image)

3.4. Inference

According to the results of students' critical thinking skills test for inference indicators, male and female students could identify the elements needed to conclude. This is following the results of the research Arif [12] which said that male and female students could solve problems in the inference indicators. Here is one example of student answers in the problem.

![Figure 4. Student’s answer in inference problems.](image)
3.5. Explanatory
According to the results of students’ critical thinking skills test for explanatory indicators, male and female students could explain or state the thought based on evidence, methodology, and provide logical reasons based on the results obtained. This is in accordance with the results of the research Arif [12] which said that male and female students could meet the explanatory indicators. Here is one example of student answers in explaining the problem.

![Image of a math problem and answer]

**Figure 5.** Student’s Answer in explanatory problems.

4. Conclusions
From the analysis and discussion that has been described, in interpreting the problem, female and male students could write down the information from a given problem, write down the information from the problem with their language, and could give the data meaning of the problem. At the analyzing the problem, male and female students could determine the question of the problem, re-examine the outcome of the problem, but the male students could not use the correct calculation. At the evaluating the problem, male and female students could access connection between statement correctly, could to rejected a statement based on predetermined criteria, but the male students could not use the correct strategy to solve the problem. At the inference, the problem, male and female students could use relevant information in the matter, could to explain the connection of each information available, and could to make conclusions based on the information provided in the matter. Concerning explaining the problem, male and female students could explain the completion that has been done and gave reasons based on the conclusions taken. Based on the above description, female students meet all aspects of critical thinking indicators, while male students meet only 12 aspects of critical thinking indicators, so it can be concluded that the critical thinking skills of female students are slightly better than male students solve math problems.

References
[1] Duron R, Limbach B and Waugh W 2006 Critical Thinking Framework for Any Discipline *International Journal of Teaching and Learning in Higher Education* 2006 17 160
[2] Ennis R H 1985 *A Logical Basis for Measuring Critical Thinking Skills* (Educational Leadership)
[3] Chukwuyenum and Nelson A 2013 Impact of Critical thinking on Performance in Mathematics among Senior Secondary School Students in Lagos State. *IOSR Journal of Research & Method in Education (IOSR-JRME)* 3 18
[4] Ekawati A and Wulandari S 2011 Perbedaan Jenis Kelamin Terhadap Kemampuan Siswa dalam Mata Pelajaran Matematika (Studi Kasus Sekolah Dasar) *Jurnal Ilmu-Ilmu Sosial* 3 19

[5] Krutetskii V A 1976 *The Psychology of Mathematics Abilities in School Children* (Chicago: The University of Chicago Press)

[6] D’Zurilla J Maydeu-Olivares A and Kant G L 1998 Age and Gender Differences In Social Problem-Solving Ability *Journal Personality and Individual Differences* 25 241

[7] Facione 1990 *Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction “The Delphi Report” Executive Summary* (California: The California Academic Press)

[8] Anderson L W and Krathwohl D R 1999 *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives* (New York: Longman)

[9] Robbins S P 1998 *Perilaku Organisasi* (Jakarta: PT. Prenhallindo)

[10] Snyder L G and Snyder M J 2008 Teaching Critical Thinking and Problem Solving Skills *Spring/Summer* L(2)

[11] Peter E E 2012 Critical Thinking: Essence for Teaching Mathematics and Mathematics Problem Solving Skill. *African Journal of Mathematics and Computer Science Research* 5 39

[12] Arif M and Hayudiyani M 2017 Identifikasi Kemampuan Berpikir Kritis Siswa Kelas X TKJ Ditinjau dari Kemampuan Awal dan Jenis Kelamin Siswa di SMKN 1 Kamal *Eduitic-Scientific Journal of Informatics Education* 4 1