Gender and mathematical abstraction on geometry

N Fitriani\(^1\)*, P Nurfauziah\(^1\)

\(^1\)Pendidikan Matematika, Institut Keguruan dan Ilmu Pendidikan Siliwangi, Jl. Terusan Jenderal Sudirman, Cimahi 40526, Indonesia

*Email: nhe.fitriani@gmail.com

Abstract. This research is conducted due to low mathematical abstraction ability of junior high school students, since that mathematical abstraction is an important skill for both male and female students so that it is considered important to study gender factors for mathematical abstraction abilities. The objective of this research is to find out whether there is a significant difference between male and female mathematical abstraction abilities after using scientific approach supported by Excel VBA. This research was conducted to 16 female students and 15 male students of 9th grade at one of the junior high schools in West Bandung, Indonesia. The method in this study is quasi experimental by comparing the abstraction abilities of male and female students after being through by scientific approach assisted by Excel VBA. The instrument of this research is 3 questions about mathematical abstraction questions. The results of this study indicate that there are significant differences in mathematical abstraction between male and female students for some indicators after using the Scientific approach assisted by VBA Excel, this means the Scientific approach which assisted by Excel VBA can show the differences of mathematical abstraction between male and female students.

1. Introduction
Mathematical abstraction ability is one component that is included in advanced mathematical thinking, so it is not an easy thing to master. Mathematical abstraction ability are very important for students, because through this construction, concepts can be formed. The concept should be constructed and not given directly to students [1], if so, the learning process that occurs will be more meaningful and lasting. But in reality, this abstraction ability is still not mastered by students in Indonesia [2]. Based on this, the ability of abstraction is deemed necessary to be mastered by students.

Abstraction has an important role in mastering Geometry [3], through which students are directed to identify forms by observing similarities, classifying them based on the characteristics of objects, discovering the nature of a concept, and constructing concepts from each forms. There are several experts who examine this, and one of them is [4–8], but their study is not related to topic of geometry, based on this statement, it is very interesting to study the abstraction in geometry.

In some literatures, topic of geometries is relatively assessed by gender. According to several studies; there are differences in geometric abilities between male and female students [9,10]. In this study, geometry studies between male and female will be seen based on their abstraction abilities. In abstraction capabilities there are several indicators, namely Perceptual Abstraction (Indicator 1), Internalization (Indicator 2), Interiorization (Indicator 3) [11]. These indicators have different characteristics, especially in learning geometrics. In Perceptual Abstraction, students seems to be familiar with the properties of mathematical objects based on utilization of physical objects and re-conceptualized previous experience relating to topic. In Internalization, students can represent their thoughts in the form of mathematical symbols, words, or diagrams and also able to solve/ manipulate
problems. Interiorization, students can reorganize (collect, compile, develop, and coordinate) concepts into new understandings or new knowledge. Based on the description, it will be reviewed in each indicator of abstraction ability between male and female students.

Gender problems are the latest research in mathematics learning, both male and female have their own characteristics in their mathematical abilities, including the abstraction in understanding geometry. Research on discovering the differences between male and female brains has developed rapidly in recent years. Some studies discuss the causes of various emotional differences, behavior, mindset and intelligence shown by male and female [12]. It was found that there were many physiological differences between the male and female brains that resulted in differences of cognitive behavior and processing (including those concerning mathematical abstraction in studying geometry).

According to Muhammad [12], women have a corpus kalosum that is bigger and more developed than men, this results in women being able to use both brains in a balanced manner compared to men. The next difference is in the size of the brain that regulates the production and process of language. In this section, women are more developed so that they have better abilities in terms of verbal abilities. Another difference is the difference in the size of the inferior pariental lobe, which is the part that functions in mathematical abilities. This part of men is bigger than women, especially in the left part of the brain. Based on the expert's opinion, women tend to have better communication and mathematical representation than male students, while men tend to be better at processing and analyzing data or problems.

Male advantage is the most evident in high-ability models and for solving problems and require complex spatial competencies [13]. Based on this, it appears that the spatial abilities of men tend to be more developed and complex, including the ability to design, to measure, abstraction and to manipulate physical objects. Based on the experts' opinions above, it is interesting to study abstraction in geometry in terms of gender.

2. Method
The method in this study is quasi-experimental since there was manipulation of treatment in one class. The study was conducted to 31 students, including 16 female students and 15 male students in grade of 9 in one of the junior high schools in West Bandung of academic year 2018/2019. The instruments used is 3 questions related to mathematical abstraction. First, students were given a preliminary test to see the initial ability of mathematical abstraction between male and female students, then students were through by using the Scientific approach assisted by VBA Excel for 8 sessions of three dimensional figure with curved surface and finally students were given a post-test to compare the abstraction abilities between male and female students.

3. Result and Discussion
The following are three mathematical abstraction questions in a special geometry concept under the topic of Build Curved Side Space, shown in the picture below
After 8 meetings using the Scientific approach assisted by Excel VBA, then the data of the pretest and posttest were processed using SPSS software, following the summary results in the descriptive statistics Table 1.

Table 1. Descriptive statistic between male and female student

|          | Male | Female |
|----------|------|--------|
|          | Indicator 1 | Indicator 2 | Indicator 3 | Indicator 1 | Indicator 2 | Indicator 3 |
| Pretest  | 4.47 | 4.93   | 4.80 | 4.56 | 4.81 | 4.44 |
| N        | 15   | 15     | 15   | 16   | 16   | 16   |
| s        | 0.52 | 0.46   | 0.86 | 0.51 | 0.54 | 0.72 |
| Posttest | 16.67 | 11.20  | 17.20 | 11.13 | 16.38 | 12.13 |
| N        | 15   | 15     | 15   | 16   | 16   | 16   |
| s        | 1.67 | 1.21   | 1.61 | 1.75 | 2.16 | 1.67 |

Table 1 above shows shows the results of descriptive statistics for pre-test and post-test on abstraction abilities of male and female students. The results of these tests are reviewed based on indicators of abstraction ability. Based on the data above, it can be seen that the average pretest of all indicators shows an average that is no significant different between male and female. After 8 meetings, the students were given post-tests. The average score obtained for indicator 1 in men is 16.67 while for women 11.13, there is a significant different and is assumed that males’ abstraction ability better than females’ in the first indicator. The average score obtained for the second indicator; for men is 11.20 while for women 16.38, it projects a significant different and it is assumed that women’s abstraction ability is better than male students for the second indicator. Finally, for the third indicator male students obtained an average score of 17.20 and female students of 12.13, it was suspected that male students had better abstraction skills in third indicator compared to female students.

3.1. Normality Test for Abstraction Ability based on the Indicator on Male and Female Students

To test a different average rate, you must first do a normality test. In the normality test, the criteria used are if sig. 0.05 then the data is normally distributed. Table 2 below is the result of a summary of the normality test for pretest and posttest data on the ability of abstraction between male and female students based on their indicators.
**Table 2. Kolmogorov-smirnov normality test (KS)**

pretest and postest abstraction result of male and female

| Indicator | Male | | Female | | | | |
|-----------|------|---|----|---|---|---|---|
|           | KS   | Sig | KS | Sig | KS | Sig | KS | Sig |
|           | 0.350| 0.000| 0.320| 0.000| 0.396| 0.000| 0.386| 0.000|
| Pretest   | 0.425| 0.000| 0.346| 0.000| 0.357| 0.000| 0.327| 0.000|
|           | 0.290| 0.001| 0.357| 0.001| 0.240| 0.000| 0.274| 0.000|
|           | 0.366| 0.000| 0.240| 0.000| 0.414| 0.000| 0.388| 0.000|
| Postest   | 0.510| 0.000| 0.000| 0.000| 0.140| 0.000| 0.000| 0.000|

Based on table 2 above, it can be seen that the value of sig. of the pretest on first indicator for male and female students is the same namely 0.000, it means that it’s <0.05 it can be concluded that data is not normally distributed. On the second indicator, the value of sig. on the pretest for male and female is 0.000 which means <0.05 it can be concluded that data is also not normally distributed. For the third indicator, sig pretest for male is 0.001 and for female 0.000, both are <0.05, it can be concluded that data is not normally distributed. For posttest, sig in first indicator for male is 0.000 and for female is 0.140, it means that this indicator is <0.05, it can be concluded that data is not normally distributed. For second indicator, sig. of posttest for male is 0.000 and for female is 0.002, both of them are <0.05, it can be concluded that data is not normally distributed. Lastly, the result of third indicator for male and female was 0.000, both of them <0.05 can be concluded that the data were not normally distributed. All data for pretest and posttest on each indicators showed that the were not normally distributed, so that the next process is the Mann n- Whitney test.

### 3.2 Average Difference Tests for Abstraction Ability based on the Indicators on Male and Female Students

In this research, there are some analysis to be taken, including analyzing the initial ability of students on the abstraction and the ability of the students on the abstraction after 8 meetings treatments. The normality test has been done before, the whole data is concluded that all data both pretest and post-test on abstraction ability based on indicators for male and female are concluded to be not normally distributed. Based on this, the next test that conducted is the average different test using Mann-Whitney U, with the criteria if Sig ≥0.05 then it can be concluded that there is no difference of mathematical abstraction between male and female students. Table 3 shows the result of the Mann-Whitney U test for pretest and posttest on abstraction ability based on indicators of male and female.

**Table 3. The mann-whitney test of abstraction ability based on the indicators for male and female students**

| Indicator | Male | | Female | | | | |
|-----------|------|---|----|---|---|---|---|
|           | Mann-Whitney U | | | | | | |
| Pretest   | 108.500 | 113.000 | 91.500 | | | | |
|           | Z       | -0.525| -0.432| -1.270| | | |
| Asymp. Sig (2-tailed) | 0.600 | 0.665 | 0.204 | | | |
| Posttest  | 3.500 | 9.000 | 6.000 | | | | |
|           | Z       | -4.678| -4.532| -4.672| | | |
| Asymp. Sig (2-tailed) | 0.000 | 0.000 | 0.000 | | | |

Based on the results of Mann-Whitney test seen on Table 3 above, we can see that in the pretest for first indicator the gain value Sig is 0.600, the second indicator obtain the Sig of 0665, and the third indicator gain value Sig is 0204, according to the result, the entire Sig is ≥ 0.05 then based on the decision-making criteria there is no difference in the initial ability of mathematical abstraction between male and female students.
For post-test, first indicator obtained a Sig value of 0.00, second indicator obtained a Sig value of 0.000, and third indicator obtained a Sig value of 0.000, based on the data, the Sig value is < 0.05 then based on decision-making criteria that there were differences in the ability of mathematical abstraction between male and female students.

When viewed from the processing of descriptive statistical data, it can be seen that the average abstraction ability for first indicator, namely Perceptual Abstraction of male students get a greater average than female students. On this indicator, male students show that they are familiar with the mathematical properties of the object based on the utilization of the physical objects and re-conceptualize with previous experience relating to the subject (Hong and Kim). Below is a picture of the results of the work of male and female students for the first indicator.

**Figure 2.** Example of student work on first indicator, female (under) and male (upper)

In Figure 2 above, it shows that male students are better acquainted with the traits in mathematical objects and more proficient in manipulating physical objects [13]. Regarding experience, male students have much better experiences than female students. Thus, it is very suitable if male students have better abilities in terms of abstraction abilities specifically in first indicator.

From descriptive statistics process, it appears that the average ability of abstraction to second indicator (Internalization); female students obtain a greater average score compared to male. In this indicator, female students can present their ideas in good image rather than male students. Male students tend to be lazy in sketching or drawings and compiling arguments in sentences. Below is a picture of the results of the work of male and female students for second indicator.
Translate in English
2) a) prism
To determine the area of the base and height can be through the volume rectangular prism

\[
V = \text{base area} \times \text{height}
\]

For example, \( t = 4 \)

base area

Translate in English
The volume of water is the same = 308 l = 308,000 cm

a) The n-faceted prism is a tube. The tube is the base prism and the n-shaped roof (circle)

b) Rectangular prism n-faceted prism

\[
V = \text{base area} \times \text{height} \quad V = \text{base area} \times \text{height}
\]

\[
308,000 = (p \times l) \times t \quad 308,000 = \pi r^2 \times t
\]

Figure 3. Example of student work on second indicator, female (under) and male (upper)

In figure 3 above, it shows that female students have better communication skills than male students. Male students tend to be more adept at working on complex questions, but not to represent a mathematical problem.
For the average ability of abstraction at three indicators, namely Interiorization, male students were able to organize (collect, organize, develop, and coordinate) concepts into a new understanding better than female students. Below is a picture of the results of the work of male and female students for third indicator.

![Example of student work on third indicator](image)

Translate in English
The concept used is the volume of the tube, because the base and roof are circular, although the size of the fingers is not the same

**Figure 4.** Example of student work on third indicator, female (under) and male (upper)

In figure 4 above, it shows that male students have spatial abilities that tend to be more developed and complex than female students, including such as the ability to design, measure and coordinate a new understanding.

**4. Conclusion**

Based on the results of the analysis, students' abstraction abilities were not the same between male and female students. But the difference occurs in different indicators. In indicators that require deep, critical and complex thinking, male students tend to be better. But for indicators relating to problem representation, female students tend to be more carefully and better than male students.

**Acknowledgments**

We would like to express our gratitude to IKIP Siliwangi, because for the funds provided through competitive grants given, this research can be finished and the results can be disseminated and published.

**References**

[1] Hendriana H and Fitriani N 2019 Mathematical Abstraction of Year 9 Students Using Realistic Mathematics Education Based on the van Hiele Levels of Geometry *J. Didakt. Mat.* 6 1–11

[2] Fitriani N, Suryadi D and Darhim 2018 Analysis of mathematical abstraction on concept of a three dimensional figure with curved surfaces of junior high school students Analysis of mathematical abstraction on concept of a three dimensional figure with curved surfaces of junior high school stud *J. Phys. Conf. Ser.* 1132 1–7

[3] Mitchelmore M C and White P 2007 Abstraction in mathematics learning *Math. Educ. Res. J.* 19
1–9

[4] Komala E 2018 Analysis Of Students ’ Mathematical Abstraction Ability By Using Discursive Approach Integrated Peer Instruction Of Structure Algebra II Infinity 7 25–34

[5] Dewi I, Siregar N and Andriani A 2018 The analysis of junior high school students ’ mathematical abstraction ability based on local cultural wisdom The analysis of junior high school students ’ mathematical abstraction ability based on local cultural wisdom J. Phys. Conf. Ser. 1088

[6] Subroto T and Suryadi D 2018 Epistemological obstacles in mathematical abstraction on abstract algebra Epistemological obstacles in mathematical abstraction on abstract algebra J. Phys. Conf. Ser. 1132

[7] Drager K W and Hansen D 2014 The Relationship between Abstract Reasoning and Performance in High School Algebra (University of Kansas)

[8] Ozmantar M F and Roper T 2004 Mathematical abstraction through scaffolding Proceedings of the 28th Conference of the International vol 3 pp 481–8

[9] Haviger J and Vojkuvkova I 2014 The van Hiele geometry thinking levels : gender and school type differences Social and Behavioral Sciences vol 112 pp 977–81

[10] Weldeana H N 2015 Gender positions and high school students ’ attainment in local geometry Int. J. Sci. Math. Educ. 13 1331–54

[11] Hong J Y and Kim M K 2016 Mathematical abstraction in the solving of ill-structured problems by elementary school students in Korea Eurasia J. Math. Sci. Technol. Educ. 12 267–81

[12] Triyadi R 2013 Kemampuan Matematis Ditinjau dari Perbedaan Gender (Universitas Pendidikan Indonesia)

[13] Geary D C 1999 Sex Differences in Mathematical Abilities : Commentary on the Math-Fact Retrieval Hypothesis Contemp. Educ. Psychol. 274 267–74