C30_Sudi Prayitno

by Sudi Prayitno Sudi Prayitno

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Contributors:
R Setiawan, Eko Minarto, Pujiadi, Dwi Ratna S, Budi Setyono,Liyana Wulandhari , Buddin Al Hakim, Atmini Dhoruri, Dwi Lestari, Eminugroho Ratnasari, Firdaus, Liem Chin, Erwinna Chendra, Agus Sukmana, MV Any Herawati, Dafik, I.H. Agustin, K. Rizqy Aprilia, Boby Gunarso, G Pramesti, Febriani Astuti, Kartiko, Sri Sulistijowati Handajani, Iqbal Kharisudin, Dedi Rosadi, Abdurakhman, Suhartono, Fitriati, Pratikno, Jajang,Zulfa A,Regina Wahyudyah S.A, Andy Rudhito, Happy Christanti, Susi Susanti, Dita Apriliyanti, Dewi Handayani, Kriswandani, Mefa Indriati, Erdawati Nurdin, Nizaruddin, Budi Waluyo ,Khafidurrohman Agustianto, Adhistya Erna Permanasari, Sri Suning Kusumawardani, Sudi Prayitno, Masrukan, Bambang Eko Susilo, Deddy Irawan,Suhito, M.A. Nuha, Rooselyna Ekawati, Stephanus Ivan Goenawan, and Ferry Rippun

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e-mail: publisher@usd.ac.id

SUPPORT INSTITUTION:

Department of Mathematics,
and Department of Mathematics Education. Sanata Dharma University, Yogyakarta.
Correspondence:
Sanata Dharma University, Kampus III,
Paingan Maguwoharjo, Depok Sleman.
Yogyakarta

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Mathematical Communication Profile of Field Independent Student in Solving Mathematics Problem Based on Gender Differences

Sudi Prayitno
Mathematics Education Program, University of Mataram, Jl. Majapahit 62 Mataram

E-mail: sudiunram@gmail.com

Abstract. This study aimed to describe the mathematical communication profile of junior high school students' in solving mathematics problem based on differences in cognitive style and gender. This article is specialized to profile subjects with Field Independent (FI) cognitive style. Mathematical communication is the ability of students to understand, express and interpret mathematical ideas using language approaches and mathematical representations, either orally or in writing. Mathematical communication aspect examined in this study include the subject's ability to disclose (1) the understanding of the problem, (2) the use of mathematical objects, (3) the use of mathematical language, (4) the use of a mathematical representation, and (5) an explanation about the settlement mathematics. The data of this qualitative research obtained through the written answer of the subject and in-depth interviews. Credibility of data is done through the triangulation of time. The results show that female and male subjects can solve math problem is given. To understand the problem, both subjects have similar perspectives, as comparing the text and picture information. Female subject perform a combination in making symbols, while the male subject using abbreviations. Female subject explain verbally smoothly, while the male subject substandard.

1. Background

Mathematical communication is one capability that should developed to students in education in Indonesia as mentioned in Government Regulation No. 19 year 2005 about National Standards of Education [4]. It is also stated in the document of Standards Process for School Mathematics in the United States, which includes (1) problem solving, (2) reasoning and proof, (3) communication, (4) connections, and (5) representation [18]. Ontario Ministry of Education [19] (in The Literacy and Numeracy Secretariat) also state the importance of mathematical communication, mathematical communication is an essential process for learning mathematics because through communication, students reflect upon, clarify and expand their ideas and understanding of mathematical relationships and mathematical arguments. Mathematical communication need to be the focus of attention in the study of mathematics, because through communication students can organize and consolidate think math and students can explore mathematical ideas. Habituation provides argument against the answer, and to respond to other people's answers will make the learning of mathematics more meaningful. Mathematical problem solving will be less meaningful if it couldn't be understood by others. Therefore, the role of mathematics communication becomes very important in the study of

mathematics. Mathematical communication is needed to communicate about ideas or mathematical problem solving, whether oral, written, or visual, both within and outside mathematics learning mathematics.

Mathematical communication is one of interesting issue to be researched. Researchers in mathematics education are in agreement that communication is essential to the learning of mathematics [22]. In mathematical communication, language plays a key role in the mathematics classroom. Language regularly used to describe mathematics processes, to read and interpret mathematics notation, and to define and to understand mathematics terms [1]. Research on increasing of mathematical communication is often associated with the implementation of a learning model. Darkasyi [3] relate to implementation of quantum learning model. Saragih [24] linked with cooperative learning model type STAD. Wicaksono [27] relate to cooperative model type TGT. Fahradina [8] relate to implementation of group investigation model. Tandililing [26] linked with PQ4R strategy with refutation text. These studies are the latest illustration of the desire to promote the learning of mathematics through enhanced communication skills of students through the implementation of various mathematical learning models.

Mathematical communication is the ability of students to use mathematics as a tool of communication (language of mathematics) and the student's ability to communicate mathematics learned as the content of the message should be delivered [17]. According to Kennedy and Tipps [14], mathematical communication include skill in (1) the use of mathematical language that is presented in the form of oral, written, or visual, (2) the use of mathematical representations presented in the form of written or visual, and (3) the interpretation of mathematical ideas, using the term or mathematical notation to represent mathematical ideas, as well as describe the relationships or mathematical models.

Results of previous studies show that mathematical communication competence of Indonesia students is still low. Shadiq [25] found the fact that in some parts of Indonesia, most students have difficulty in resolving questions about problem solving and translate word problem into mathematical models. This shows that communication skills and problem-solving mathematics student is still not good. Similarly Izzati [12] to get an overview of students due to lack of communication during the learning of mathematics is still low to give attention to the development of this ability. The same was found by Kadir [13] that the ability of junior high school students' mathematical communication in coastal areas is still low, both in terms of ranking schools, and learning models. It is a dilemma, the competence of mathematical communication is important for students, but the fact is not sufficient competence. Therefore, in-depth research about the profile of students' mathematical communication skills in solving mathematics problems need to be done. To better describe the kinds of explanations given students and the language they use, Brenner [2] was developed a communications framework for Mathematics which summarized in table 1 bellow.

Table 1. Communication framework for Mathematics

Communication About Mathematics	Communication in Mathematics	Communication With Mathematics
1. Reflection on cognitive process. Description of procedures, reasoning. Metacognition—giving reasons for procedural	1. Mathematical register. Special vocabulary. Particular definitions of everyday vocabulary. Modified uses of everyday	1. Problem-solving tool. Investigations. Basis for meaningful action.

	decisions		vocabulary. Syntax, phrasing. Discourse.		
2.	Communication with others about cognition. Giving point of view. Reconciling differences.	2.	Representations. Symbolic. Verbal. Physical manipulatives. Diagrams, graphs. Geometric.	2.	Alternative solutions. Interpretation of arguments using mathematics. Utilization of mathematical problem-solving in conjunction with other forms of analysis.

Mathematical communication would be discussing here is part of communication in mathematics. In this study, students is given a problem, they solve it. To get mathematical communication, need exploration which expressing mathematical vocabulary, special vocabulary or definition, representation, symbolization, numeric, graph, diagrams, verbal communication, and so on.

Discussion mathematical communication profile junior high school students in this article in terms of gender and cognitive style differences. Cognitive style and gender are two inherent characteristics of each individual. Cognitive style and gender are often used as a reference in a range of research, especially research that examines a difference. Ratumanan [21] examined the effect of different cognitive style on learning achievement in mathematics. Dewi [7] examined the influence of gender on mathematical communication skills student teachers. This article is part of a dissertation study raised based on gender and cognitive styles. But the subject that is discussed in this article is limited in subjects with cognitive style Field Independent (FI). It refers to the opinion of Witkin [28] associated with more rigor on the FI subject.

Cognitive style is a characteristic of the process of cognition is consistent and reflected on the individual. Cognitive style can be seen as the establishment of a stable or a person in the habit of giving responses to, remember, think, and solve problems [28]. Cognitive style divides individuals into three types, namely Field Dependent (FD), Field Neutral (FN), and Field Independent (FI). A person's cognitive style characteristic of FN is between FD and FI. Differences characteristic of individuals with FD and FI cognitive styles in general are: (1) FD Individuals growing niche to view the problem globally, easily influenced by the background of the context, (2) Individuals FI growing niche to interpret the problem analytically, not influenced by the background of context, so that it is capable of abstracting the elements of the context or background of its context [28].

Gender is a social concept that distinguishes between men and women [11]. Santrock [23] stated that gender is sex that refers to the socio-cultural dimension of a person as male or female. The concept of gender is the inherent nature of men or women who are shaped by social factors and cultural. Zhu [29] states that students' mathematical abilities of male and female students are different. It is based on standard math tests such as the Scholastic Assessment Test-Mathematics (SAT-M) carried by Gallagher et al in the last decade. Goos [9] mentions that many of the results of recent studies that present the difference in learning achievement, attitude and participation are influenced by gender differences. Researchers now realize that the difference in students' mathematics learning outcomes are influenced by gender differences are not absolute, often confused, it is also influenced by socio-economic background. Further Goos [9] concluded that overall gender differences in mathematics learning interpretation depends on the content of the task, the nature of knowledge and skills that are assigned, as well as the current state of the task. Results of the study (Dewi [6]) concluded that the completeness of mathematical communication female students is better than male

students, but the accuracy of mathematical communication male students better than female students. In addition, oral communication female student is better than male students, except for students who are capable of higher mathematics. Based on the research results can be concluded that gender differences have contributed to describe a person's profile in solving problems and communicating the results, but this difference has not been consistent. Thus inconsistent results in studies involving a study of gender differences in different age groups and different cultural groups could not be explained only by gender. Therefore, gender differences still need to be investigated further, including in this study, which is associated with a student's mathematical communication ability in solving mathematical problems.

Students' mathematical communication profiles that are discussed in this study will be analyzed based on indicators mathematical communication. Mathematical communication competences are assessed NCTM [18] are includes (1) the ability of states mathematical ideas orally, in writing, and visually, (2) the ability to interpret and evaluate mathematical ideas both orally and in writing, and (3) the ability to use the terms, symbols, and structures to model mathematical situations. While Greenes and Schulman [10] formulate mathematical communication skills in three areas, namely (1) states the mathematical ideas through oral, writing, demonstrations, and describes it visually in a different type, (2) to understand, interpret, and assess the ideas presented in writing, orally, or in visual form, and (3) construct, interpret and connect diverse representations of ideas and relationships. Based on those opinions, mathematical communication in question in this research is the ability to understand and express mathematical ideas in writing and orally. This capability includes the ability to express (1) understanding the problem and the object of mathematics, (2) the use of mathematical language, (3) the use of mathematical representations, (4) the use of mathematics skill, and (5) the explanation of resolution process.

2. Methods

This study is a qualitative researches, the research seeks to find meaning or essence behind the symptoms that occur. This study aimed to describe the profile of students' mathematical communication ability in solving mathematical problems in terms of gender differences and cognitive style. Selection of subjects is done by providing a test of cognitive style known as Group Embedded Figure Test (GEFT) and data collection math scores of students. Subjects were selected in this study is the student who has the same mathematical ability, in this study were students capable of high mathematics. Based on the distribution of results GEFT from high math ability students, chosen students which have different cognitive style and gender, with a healthy condition (not disabled) and is willing to cooperate in this research. Subjects who complete the study consisted of four students of junior school class VIII which has equal mathematics ability. In this article only discussed for the two subjects with FI cognitive style. The research instruments are a math problem and guide the interview. Questions used in this study first conducted validation on aspects of material, construction, and language. Instrument questions used in this study was validated by five experts in mathematics education, and has made improvements associated with suggestions from the experts.

Data retrieval is done by giving the problem, followed the students do in writing, explaining the answer verbally, and followed by in-depth interviews and verbally explain again terminated. So that interviews can be conducted in accordance purposes of research, any interview process following the guidelines of the interview. Every encounter with the subject of mathematical communication profiles reveal only for a matter of course. It is intended to allow the retrieval of data can focus, the students did not experience fatigue or boredom when interviewed. The results of written tests, oral, and interviews documented. Verbal explanations and documents stored in the form of video interviews,

and compiled the transcript. Data were analyzed following the model of Miles and Huberman [16], namely data reduction, data display, and drawing conclusion or verification.

3. Results and Discussion

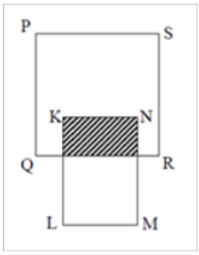
The discussion in this article is limited to two subjects which different in gender, but the same in cognitive style, ie both of Field Independent (FI). For the next discussion, the female subject was coded SPFI, while the male subject was coded SLFI.

Both subjects have each given two equivalent mathematical problems and in-depth interviews conducted with regard to both of these issues. SPFI written answers (also SLFI) to the first and the second problem is consistent, as well as the content and level of truth answers. By using mathematical communication indicators that have been developed in the study of theory, conducted in-depth interviews SPFI (also SLFI) on the two issues raised. Results also showed consistency interview answer when completing the first and second issues. Thus it can be said that the research data obtained from SPFI (also SLFI) is credible and to do an analysis of the data.

The first mathematics problem given to SPFI (also SLFI) is:

Mathematics problem:

Consider the figure beside!
PQRS is square and KLMN is rectangle. PQ = 12 cm, LM = 5 cm, and KL equal to two times LM. The area of unshaded region is 156 cm^2. What is the area of shaded region?
Explain your answer!



3.1. Results of SPFI (Female Subject)

Data retrieval begins by giving to the subject a mathematics problem. Then the subject matter of the work to be completed, followed by in-depth interviews. Here are the results of the written answer of SPFI.

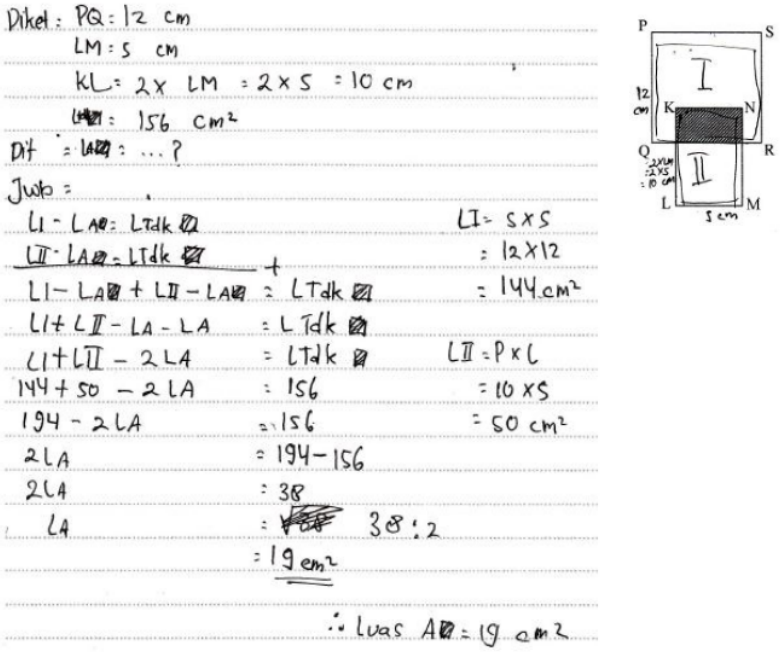


Figure 1. Written answer of SPFI subject

Answer of female subject SPFI in Figure 1 is a correct answer. If you look up, this answer using many symbols, whether in the form of letters or small picture. In each sub-results, the subject SPFI include units of the object in question, in this case using the unit square of centimeter to the area of shape that counted.

Based on solving problem processes, written answers paper, and in-depth interviews were recorded video, research data of SPFI that has been credible can presented as data item as follow:

(1) SPFI read the problem, then solving the problem to finish.
(2) SPFI checking the answer by repeating the calculations that have been done.
(3) SPFI explained his understanding of the problems is given. Subject to understand the existing problems by reading, observing the figure in question, then her understanding was written in what is known and what is asked in the question.
(4) SPFI explain verbally after the work that has been completed. The way of SPFI to explain it is to read and designate an existing drawing or writing on the answer sheet.
(5) SPFI explain mathematical objects contained in the problem. In this case, the subject explains the notion square, draw a square with a ruler and measure the length of each side. Subject also explain the notion rectangle, draw a rectangle, explaining the parts of a rectangle.
(6) SPFI explain the symbols in a square or rectangle figure, namely the symbols that express the sides of equal length, and the symbol of a right angle.
(7) SPFI explain the symbols used in writing the results of the math problem. The symbols used include symbols with the letter 'L', which means area, 'tdk' means not, the box with lines ('▒') means shaded, 'LI' mean square area , 'LII' means rectangle area, 'Ltdk▒' means the not shaded area, 'LA▒' and 'LA' means the shaded area.

(8) SPFI explain the formulas used to help resolving problem, namely the formula of the area of square, the equation about square area minus the shaded area equal to the not shaded in top position, the equation about the area of rectangle minus the shaded area equal to the not shaded area at bottom position, then create combined that equations by summing of two previous equations.
(9) SPFI explain unit area is square centimeter
(10) SPFI explains that the symbol can be changed with another symbol.
(11) SPFI makes a brief representation to calculate the area of the shaded region like in the math problem by algebraic skills.

Drawing conclusion of research data SPFI get description of mathematical communication profile of SPFI in solving mathematical problems, as follows:

(1) SPFI understand the questions well, but the disclosure of the understanding of the given problem is only focused on the questions presented in the form of text, while the understanding of the parts of questions presented in the form of figure is not described explicitly. SPFI can explain mathematical objects that exist in a problem of complete and accurate use of figure, but become less complete if explain it using words or verbal. For example, SPFI can draw a square with any symbols which accompanying.

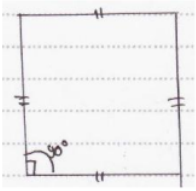


Figure 2. SPFI draw a square

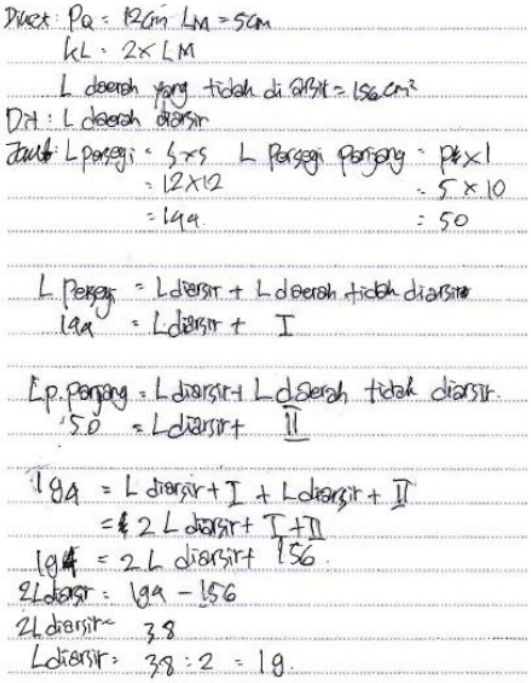
But SPFI define a square is shape which has all sides in the same length and its angle is right angle. She was not mentions number of its side.

(2) SPFI using symbols in presenting problem-solving, but the symbols used have not been consistent and not described before using it. SPFI symbolization performed by using combination, which makes the single symbols, then set together to make other, more complex symbols. Thus it can be said that SPFI use mathematical language well, but for certain cases are still not consistent. For example: SPFI use two symbols for one meaning, symbols 'LA▒' and 'LA' have the same meaning, that are shaded area. Besides that, SPFI use a symbol for three meaning, symbol "Ltdk▒" has means not shaded area in top position, not shaded area in bottom position, and not shaded area for whole area.
(3) SPFI using representations that to solve a problem. She utilizing formulas commonly used, and create a new formula based on things that are understood from a given math problems. Thus it can be said that SPFI can apply representations that have been owned previously and can create new representations based on the new situation it finds.
(4) SPFI have the mathematical skills to support progress toward solving problem given to her. She using all arithmetic operations on real numbers system, and also using algebraic operations.
(5) SPFI can explain a math problem resolution process smoothly and thorough, but there are some parts that are wrong pronunciation. SPFI explain verbally from the understanding of the given problem, what is known, and what is being asked in the problem. Then SPFI explain things that

can be done directly on the matter to solve problems and how to conduct an examination of the answer. SPFI explained in a voice clear and smooth.

3.2. Results of SLFI (Male Subject)

Data SLFI retrieval also begins by giving one mathematics problem. Then, the subject matter of the work to be completed, followed by in-depth interviews. Here are the results of the written answer of SLFI.



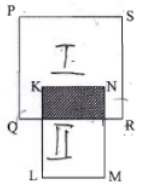


Figure 3. Written answer of SLFI subject

Answer of male subject SLFI shown in Figure 2 is a correct answer as well. If consider that, this answer using a little symbols, that is only using some letters. In each sub-results, the subject SLFI never put the units of the object in question.

Based on solving problem processes, written answers paper, and in-depth interviews were recorded video, research data of SLFI that has been credible can presented as data item as follow:

(1) SLFI read the problem, then continued solve the problems to finish
(2) SLFI verbally explain the answer that has been completed. He explain how the subject was pointing at figure and reading the results of his written work
(3) SLFI explained his understanding of the problems. Subject understand the existing problems by reading the question was repeated twice, look at the picture in question, then compare text information and figure, then proceeds written understanding of what is known and what is asked in questions.
(4) SLFI explain mathematical objects contained in the problem. In this case, the subject explains the notion square, draw a square with a ruler. Subject also explain some characteristics of a rectangle, and draw a rectangle.

(5) SLFI explain the symbols in a square or rectangle picture, namely the symbols that express the sides of equal length, and the symbol of a right angle.
(6) SLFI explain the symbols used in writing the results of the math problem. The symbols used include symbols with the letter 'L', which means the area, 'I' means the square area which is not shaded, and 'II' means area of rectangle which is not shaded.
(7) SLFI using formulas to help resolving problems, namely the formula area of the square, equation about a square area equal to the shaded area plus the not shaded area, rectangles area, the equation about rectangle area equal to the shaded area plus the not shaded area, create relationships combined with the summation of two previous equations.
(8) SLFI explain unit area is square centimeter
(9) SLFI explained that the symbol can be changed with another symbol.
(10) SLFI make a brief representation to calculate the area of the shaded region with the analogies to things that have been doing and check the truth of the formula

While drawing conclusion of research data SLFI get description of mathematical communication of SLFI in solving mathematical problems, as follows:

(1) SLFI understand the questions well, but the disclosure of the understanding of the given problem is only focused on the questions presented in the form of text, while the understanding of the parts of questions presented in the form of figure is not described explicitly. SLFI can explain mathematical objects that exist in a matter of complete and accurate use of images, but become less complete if explain it using words or verbal. In this case, SLFI define square is shape with all sides has equal length. He was not mention number of sides and right angle as a necessary and sufficient condition.
(2) SLFI use a little symbol in the present problem-solving, the symbols used are also not consistent and not described before using it. For example, symbols “I” and “II” has the same meaning, that is not shaded area. In fact, both different position, top and bottom position.
(3) SLFI uses representations that to solve a problem. SLFI utilizing formulas commonly used, and create a new formula based on things that are understood from a given math problems. Thus it can be said that the SLFI may apply representations that have been owned previously and can create new representations based on the new situation it finds.
(4) SLFI have the mathematical skills to support progress toward math answer given to him. SLFI use all arithmetic operations on the real number system, and also using algebraic operations. SLFI little use graffiti to perform calculations.
(5) SLFI can explain a math problem resolution process as a whole, but less smoothly, there are still some parts that wrong pronunciation. SLFI explain verbally from the understanding of the given problem, what is known, and what is being asked in the matter. Then SPFI explain things that can be done directly on the matter to solve problems and how to conduct an examination of the answer. SLFI explained in a voice that is not too obvious and less smoothly.

3.3. Discussion

The difference between SPFI and SLFI profile seen in several indicators, as follows:

(1) The use of the language of mathematics, SPFI more productive in creating new symbols by creating a single symbols and then use combinatorial ability to make other symbols related. While SLFI use a little symbol, i.e. symbols that have been known in math before.

(2) The use of mathematical skills, particularly numeracy skills. SPFI always use graffiti to perform calculations, while SLFI not use graffiti to calculations involving two-digit numbers.
(3) The explanation of problem solving processes, SPFI explained smoothly and completely, while SLFI explain it completely, but less smoothly, so the need to question inducement that a complete explanation.

The results are consistent with the results of research Dewi [6] which states that the completeness of mathematical communication female subjects better than male subjects. In this study, female subjects are more productive in the use of mathematical language and explained more fully in the process of resolving the problem orally. Verbal communication problems, also in accordance with the opinion of Dewi [6] that the subject of women's verbal communication is better than male subjects. In a preliminary study, Prayitno [20] also get the same results with this research, that verbal communication female subjects tend to be better than male subjects. These results also fit the opinion of Dagun [5] stated that in general, female has higher scores for verbal ability. Verbal communication advantages possessed female subjects also in accordance with the opinion of Maccoby and Jaclin [15]. Thus, the results of this study reinforces the notion that female subjects more fully and smoothly in mathematical verbally communicate.

Cognitive style of both the subject is Field Independent (FI). Both subjects can explain representations are used and made to solve the problem in detail. This is consistent with the characteristics of a person's cognitive style FI proposed by Witkin et al [28] found FI individuals tend to think analytically that detail.

4. Conclusion

Mathematical communication profile junior high school students in solving mathematical problem that are discussed in this article can be described as follows:

(1) Female subject with cognitive style of Field Independent can understand the problem well, but the understanding of the figure was not disclosed. This subject uses mathematical language to complete, can use and create mathematical representations properly, have adequate math skills, and be able to explain the process of mathematical problem solving completely and smoothly.
(2) Male subject with cognitive style Field Independent can understand the problem well, but the understanding of the figure was not disclosed. This subject using the language of mathematics with a little symbol, can use and create mathematical representations properly, have adequate skills, and be able to explain the process of mathematical problem solving to complete, but less smoothly.

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