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AN ANALYSIS OF SENIOR HIGH SCHOOL STUDENTS' MATHEMATICAL COMMUNICATION ABILITY BASED ON SELF-EFFICACY AND GENDER

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ABSTRACT

Mathematical communication skills are one of the skills that students need in the 21st century. This study aimed to describe the mathematical communication skills of high school students based on self-efficacy and gender. The research method used is descriptive qualitative. Six subjects from 103 students of class XI-MIPA were determined based on the categories of self-efficacy and gender. The results of this study are (1) students who have high self-efficacy can achieve all indicators of mathematical communication skills, male students are better than female students; (2) students who have moderate self-efficacy can achieve two indicators of mathematical communication skills, female students are better than male students; and (3) students who have low self-efficacy only achieve one indicator of mathematical communication skills, female students are better than male students. It can be concluded that there are differences in the mathematical communication skills of high school students based on the level of self-efficacy. In addition, there are differences in mathematical communication skills between male and female students. Educators can use this research as a reference in choosing the appropriate learning model.

ANALISIS KEMAMPUAN KOMUNIKASI MATEMATIS PESERTA DIDIK SMA BERDASARKAN *SELF-EFFICACY* DAN GENDER

Kata Kunci:

Gender
Komunikasi matematis
Self-efficacy

ABSTRAK

Kemampuan komunikasi matematis merupakan salah satu kemampuan yang perlu dimiliki peserta didik di abad ke-21. Tujuan penelitian ini adalah mendeskripsikan kemampuan komunikasi matematis peserta didik SMA berdasarkan *self-efficacy* dan gender. Metode penelitian yang digunakan adalah kualitatif deskriptif. Enam subjek dari 103 peserta didik kelas XI-MIPA ditentukan berdasarkan kategori *self-efficacy* dan gender. Hasil penelitian ini adalah (1) peserta didik yang memiliki *self-efficacy* tinggi dapat mencapai seluruh indikator kemampuan komunikasi matematis, peserta didik laki-laki lebih baik daripada peserta didik perempuan; (2) peserta didik yang memiliki *self-efficacy* sedang dapat mencapai dua indikator kemampuan komunikasi matematis, peserta didik perempuan lebih baik daripada peserta didik laki-laki; dan (3) peserta didik yang memiliki *self-efficacy* rendah hanya mencapai satu indikator kemampuan komunikasi matematis, peserta didik perempuan

lebih baik daripada peserta didik laki-laki. Dapat disimpulkan bahwa terdapat perbedaan kemampuan komunikasi matematis peserta didik SMA berdasarkan *tingkat self-efficacy*. Selain itu, terdapat perbedaan kemampuan komunikasi matematis antara peserta didik laki-laki dan perempuan. Pendidik dapat menggunakan penelitian ini sebagai referensi dalam memilih model pembelajaran yang sesuai.

1. INTRODUCTION

Mathematics is one of the fundamental sciences that plays a crucial role in advancing science and technology [1]. Along with developing science and technology, students must have various abilities to learn mathematics. In line with [2], students must be able to communicate, collaborate, think creatively, and think critically in the 21st century to compete globally. Students must be able to communicate since it facilitates their ability to express and explore their ideas. During the learning process, it is simple for students to freely express their thoughts and ideas to teachers and peers if they can communicate effectively [3]. Moreover, students can enhance mathematical abilities by communicating mathematical ideas [4].

Communication ability in mathematics is known as mathematical communication ability. Students' ability to clearly and coherently communicate their ideas, describe, and explain mathematical ideas defines their mathematical communication ability [5]. Students with strong mathematical communication skills find it easier to solve mathematical problems. Mathematical communication ability assists students in explaining their ideas when confronted with mathematical problems [6]. Mathematical communication ability also helps students comprehend their surroundings' problems, plan solutions, complete settlement steps, and draw conclusions [7]. This statement emphasizes the significance of students' mathematical communication abilities. However, in the context of Indonesian education, students' mathematical abilities continue to be a challenge.

Students' capacity for mathematical communication can be impacted by some variables, including self-efficacy [8]. A person's self-efficacy is a belief that they can complete tasks and achieve specific goals [9], [10]. In learning mathematics, students' self-efficacy is shown in how they complete the math tasks at school. Students with high self-efficacy never give up when completing complex tasks because they consider them a challenge that must be solved [11], [12]. In contrast, students with low self-efficacy prefer to avoid complex tasks and do not put in their best effort, resulting in poor performance [13]. As a result, students with a high category of self-efficacy will have better mathematical communication abilities. That statement is consistent with the findings that someone with high self-efficacy affects their abilities, such as explaining concepts, conveying ideas, and developing their thoughts. Their mathematical communication ability is also high [14].

In addition to self-efficacy, gender can influence mathematical communication ability [15], [16]. Male and female students solve problems differently. Gender differences also show differences in ability when communicating mathematical ideas between male and female students in several aspects: writing, drawing, and mathematical expressions [17]. This statement shows that gender can influence mathematical communication ability.

Research on mathematical communication skills, self-efficacy, and gender has been carried out, including the relationship between self-efficacy and mathematical communication skills [13], [14], [18], [19], gender relations with students' mathematical abilities [12], [20], [21]. However, in previous studies, no one has discussed the relationship between mathematical communication skills with self-efficacy and gender by categorizing students' self-efficacy using the Rasch model analysis. This study aims to describe the mathematical communication skills of high school students based on self-efficacy and gender. The researcher wishes to describe students' mathematical communication abilities in terms of self-efficacy and gender by categorizing the subjects' self-efficacy using the Rasch model analysis assisted by the Winstep application.

2. METHOD

Descriptive research with a qualitative approach is the research method in this study. According to Sanjaya, the qualitative descriptive method is research conducted to describe a situation in depth [22]. The goal of this study is to present data in the descriptive form to describe students' mathematical communication ability based on self-efficacy and gender. The test was given to 103 students in grade XI-MIPA. Purposive sampling was used to select research subjects based on the Rasch model analysis. Six subjects were chosen based on their self-efficacy level and gender. Interviews will be conducted with the selected subjects depending on the outcomes of the mathematical communication ability test. Figure 1 depicts the research procedure.

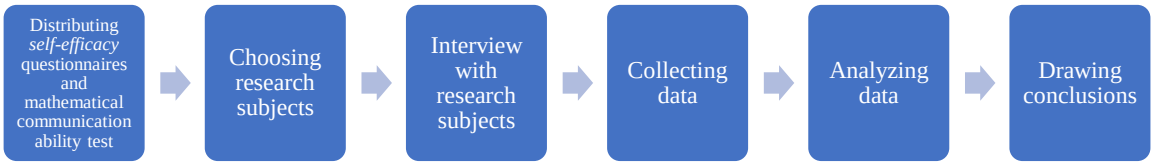

Figure 1. Research Procedure

The self-efficacy questionnaire instrument used in this study is adapted from Sumarmo, which contains 28 items [23]. The self-efficacy questionnaire employs a Likert scale with four response options. The test instrument of mathematical communication ability consists of five items according to the indicators of mathematical communication ability: written text (explaining mathematical ideas in writing), mathematical expressions (defining ideas or problem situations into the mathematics symbols or mathematical models), and drawing (explaining mathematical ideas in the visual form) [24].

To strengthen the results of previous tests, interviews are required for this study. The interview technique used is semi-structured interviews, where interviews are conducted according to interview guidelines but can be adapted to circumstances. This study's data analysis comprised data reduction, presentation, and conclusions. This study's data validity relies on triangulation techniques, which examine data from the same source using different techniques.

3. RESULTS AND DISCUSSION

This study categorizes students' self-efficacy using the Rasch model analysis. The self-efficacy questionnaire was tested on 103 students consisting of 38 male and 65 female students. Students who have filled out the self-efficacy questionnaire are divided into three categories of self-efficacy: high, moderate, and low. The output can be seen in Figure 2.

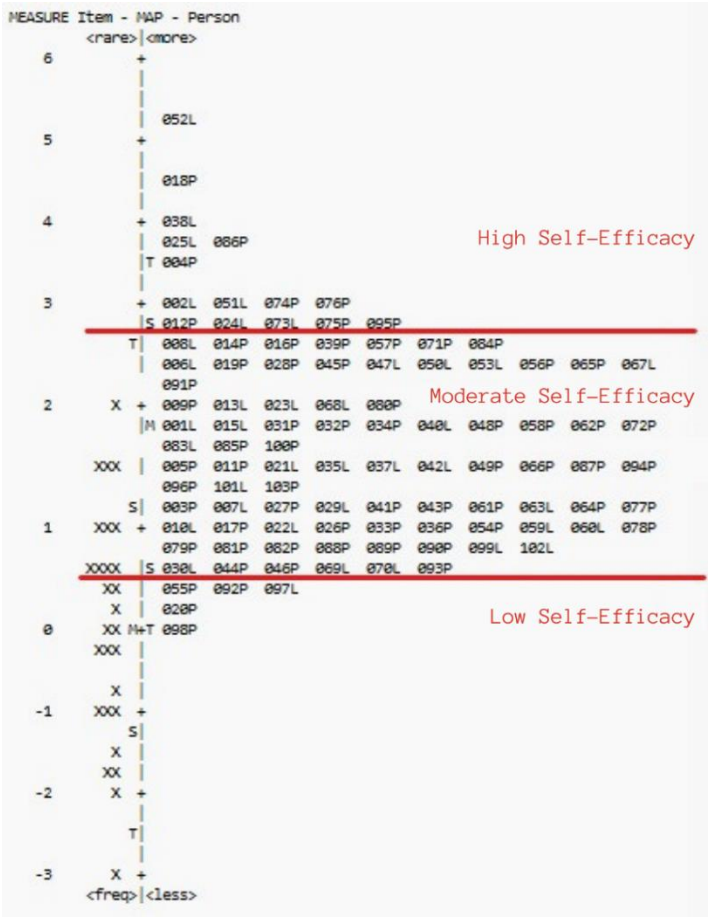

Figure 2. Person-Item Map of Students' Self-Efficacy

Based on Figure 2, it is shown that there are seven male students and eight female students with high self-efficacy. Then, the moderate self-efficacy category consists of 30 male and 53 female students. Last, the low self-efficacy category includes a male student and four female students. Six subjects were selected in this study, shown in Table 1.

Table 1. Research Subject Code

Subject	Subject Code	Description
073L	HSM	Male subjects with high self-efficacy
074P	HSF	Female subjects with high self-efficacy
007L	MSM	Male subject with moderate self-efficacy
062P	MSF	Female subject with moderate self-efficacy
097L	LSM	Male subjects with low self-efficacy
020P	LSF	Female subjects with low self-efficacy

Of six subjects, the mathematical communication ability test results showed different answers to each other. The following is an analysis of the subjects' mathematical communication ability test results based on three categories of self-efficacy.

3.1 High Self-Efficacy

Figure 3 shows HSM test results for mathematical communication ability. From Figure 3, it can be shown that HSM can write down what is known and asked. HSM used a table for identifying what is known and asked completely and correctly. In addition, HSM also seemed to state the idea of a complete settlement plan. Furthermore, HSM can make mathematical models by supposing x as the number of apples, y as the number of

pears, and determining inequalities $x + y \leq 140$ and $4x + 3y \leq 480$. Then, its special conditions $are\ x \geq 0$ and $20 \leq y \leq 80$. To solve the problem, HSM converts the first and second inequalities into equations and determines the coordinates of the graph. Next, HSM figures out the solution area by drawing a graph completely and correctly. Based on the graph, HSM can conclude the problem.

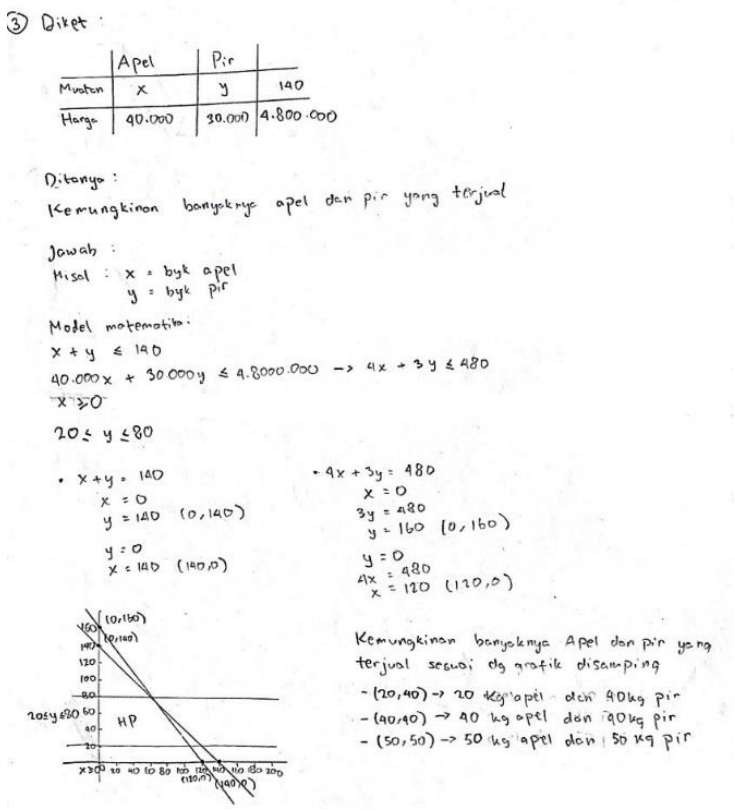

Figure 3. HSM Mathematical Communication Ability Test Results

Next, Figure 4 shows HSF test results for mathematical communication ability. During the interviews, HSM could explain the steps for solving the problems confidently and smoothly. HSM can explain the meaning of the question, the methods used in solving problems, the meaning of the mathematical symbols used in mathematical models, perform calculations correctly, and draw conclusions appropriately. In addition, HSM can also explain how to draw a graph and determine the solution area. From the interviews and test results, HSM can solve the questions well and achieve all mathematical communication ability indicators. In line with Saidah et al., the higher the self-efficacy of students, the greater their effort and persistence in completing tasks [25]. From Figure 4, HSF can write down what is known from the questions, but HSF does not write down what is asked. HSF used a table to identify the information completely and correctly. HSF also seemed to state the idea of a complete settlement plan. Next, HSF makes mathematical models by supposing x as apples, and y as pears, although it is not written clearly, determining inequalities $x + y \leq 140$ and $4x + 3y \leq 480$ with its special conditions $20 \leq y \leq 80$ and $x \geq 0$. HSF converts the inequalities into equations and determines the coordinates of the graph. Also, HSF determines the solution area by drawing the graphical form completely and correctly, even though HSF does not put several numbers at the coordinate points and does not write down the conclusions.

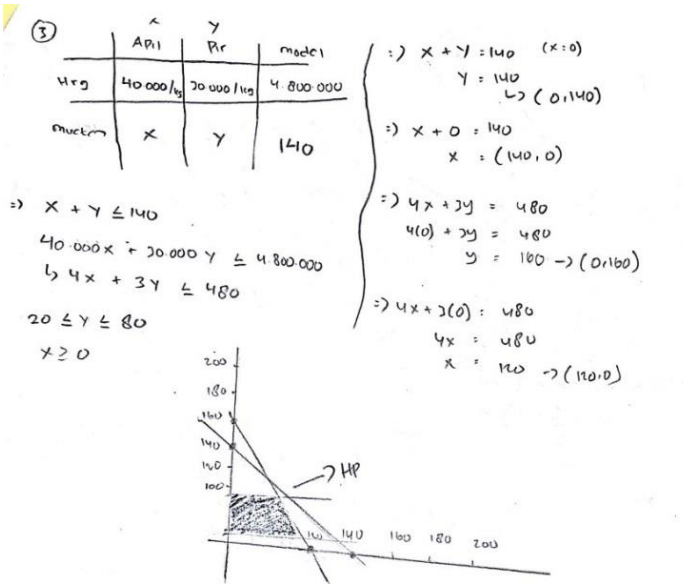

Figure 4. HSF Mathematical Communication Ability Test Results

The answers that HSF has written are supported by interviews that have been carried out. HSF can explain the information from the questions even though HSF does not write them on the answer sheet. HSF can also explain the completion steps according to what is written, but HSF has not been able to explain the conclusions obtained. Based on Figure 3 and the interview results, HSF achieves all indicators of mathematical communication ability. However, there is still a little confusion in explaining conclusions. That statement is supported by the research results that show students with self-efficacy have good achievement indicators of mathematical communication ability [26]. Based on the analysis results, subjects with high self-efficacy can do well on all indicators of mathematical communication ability, whereas male subjects are better than female subjects. This is also supported by the results of research by Pertiwi & Siswono that male students are better than female students in presenting information and using mathematical symbols systematically in solving mathematical problems [21]. The two subjects also showed confidence in their abilities and never gave up on solving the problems they faced.

3.2 Moderate Self-Efficacy

Figure 5 shows MSM test results for mathematical communication ability.

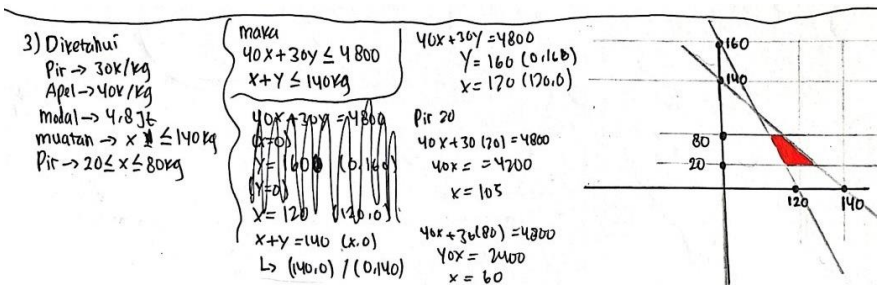

Figure 5. MSM Mathematical Communication Ability Test Results

From Figure 5, it can be shown that MSM can write down what is known even though he does not write what is being asked. Next, make mathematical models by determining inequalities $40x + 30y \leq 4800$ and $x + y \leq 140$, then converting the inequalities into

equations to determine the coordinates of the graph. MSM substitutes $y = 20$ and $y = 80$ into the equation to get the number of apples and determines the solution area by drawing in graphical form, but it is not correct, so the answer of MSM is not quite right.

During the interviews, MSM was quite sure of the answers that had been written, but there were inaccuracies in writing the answers. MSM makes a few mistakes: pears are supposed to be x. When confirmed through interviews, it turns out that MSM was not careful in writing them. MSM can also explain the meaning of the mathematical symbols used and perform calculations correctly, but the conclusion is incorrect. Furthermore, MSM admits that it is still confused in drawing a graph to determine the solution area. From interviews and test results, MSM can achieve two indicators of mathematical communication ability: written text and mathematical expressions, although he draws the wrong conclusions. That statement is consistent with the findings of another research that students with moderate self-efficacy still make some mistakes on several indicators [18]. Next, Figure 6 shows MSF test results for mathematical communication ability.

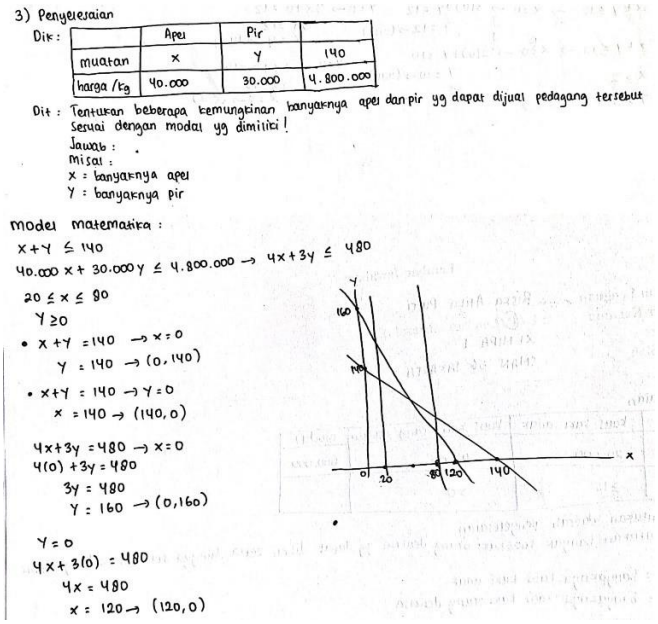

Figure 6. MSF Mathematical Communication Ability Test Results

Figure 6 shows that MSF can write down the information in a table. MSF can also make mathematical models by supposing x as the number of apples, y as the number of pears, and determining inequalities $x + y \leq 140$ and $4x + 3y \leq 480$. MSF wrote the special conditions $20 \leq x \leq 80$ and $y \geq 0$. Next, MSF converts the inequalities into equations and determines the coordinates from the first and second equations. MSF also makes a graph based on the coordinates it finds, but she does not show the solution area or write any conclusions.

From the results of the interviews, MSF can confidently and smoothly explain the steps of completion confidently and smoothly. MSF can explain the information from the questions, the method used to solve the problem, the meaning of the mathematical model, and how to determine the coordinates of the graph. Still, in the special conditions section, MSF is not careful in writing it, so the graph is wrong. In addition, MSF has not been able to explain how to determine the solution area. This shows that MSF can only fulfill the indicators of writing text and mathematical expression even though there are inaccuracies in writing the special conditions of the problems on the questions. In line

with the statement that students with self-efficacy only achieve two of the three indicators of mathematical communication ability [27]. Although subjects with a moderate category of self-efficacy can achieve several mathematical communication ability indicators, female subjects are better than male subjects on written text indicators. This is further confirmed by the findings of Baby's study, which indicate that female students' writing skills (written text) are better than male students [20]. The two subjects were also confident about their abilities and tried to solve the questions well, even though, at some point, they had little doubt about their ability to answer the questions.

3.3 Low Self-Efficacy

Figure 7 shows LSM test results for mathematical communication ability.

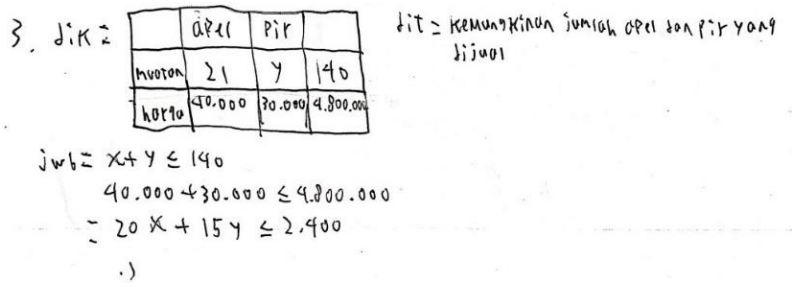

Figure 7. LSM Mathematical Communication Ability Test Results

From Figure 7, it can be shown that LSM writes down what is known and asked. LSM writes information that is known in the table, but there is information written that does not match the information in the question. Next, LSM makes mathematical models by determining inequalities $x + y \leq 140$ and $40000 + 30000 \leq 4800000$, then simplifying them. So, it becomes $20x + 15y \leq 2400$. LSM did not continue the completion steps and did not write down the conclusions obtained from the problems.

During the interviews, LSM answered questions only in essence. In the known information section, the LSM admits that there was an error in writing it, but LSM can use the information to make mathematical models. Furthermore, LSM could only explain a little of the mathematical model and could not proceed with the completion steps because he did not understand the material on the system of linear inequalities of two variables. This shows that LSM is not confident in his abilities. Therefore, LSM can only achieve one indicator in written text. In line with the study's results, students with low self-efficacy are not good at achieving indicators of mathematical communication ability [28]. Next, Figure 8 shows LSF test results for mathematical communication ability.

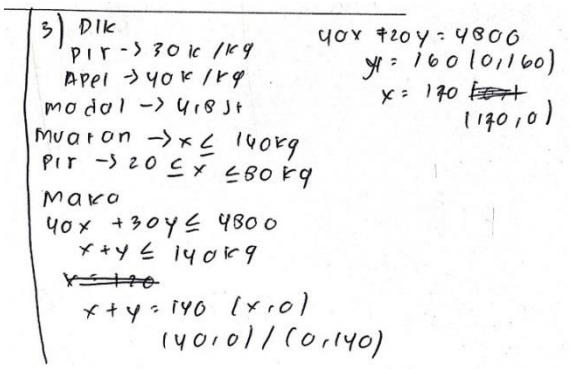

Figure 8. LSF Mathematical Communication Ability Test Results

From Figure 8, it can be shown that LSF writes down what is known but does not write down what is asked. Next, LSF makes mathematical models according to what is known. The mathematical models made by LSF $40x + 30y \leq 4800$ and $x + y \leq 140$. LSF continues the completion steps by making x and y equal 0, so LSF obtains the coordinate points. LSF does not draw a graph to determine the solution area and does not write the conclusions from the problem.

Based on the test results and interviews, LSF answered questions hesitantly but could explain what was known and asked even though there were a few errors. In addition, LSF can explain the written mathematical model but cannot explain how to determine the coordinates that have been written. In line with other research, one of the characteristics of students with low communication ability is not being able to give reasons for the answers that have been written [29]. LSF can't also draw a graph to determine the solution area and draw conclusions. So, LSF has not met the mathematical communication ability indicators, which are mathematical expressions and drawing.

From the analysis results, subjects with low self-efficacy cannot solve the problem properly because they do not understand the material of the linear inequality system of two variables. This means subjects with low self-efficacy did not want to try to solve the problem because of their negative mastery experience. According to Van Dither et al., one of the causes of low self-efficacy in students is the mastery experience, where previous negative mastery experiences will be a significant factor in decreasing students' self-efficacy [30]. Besides that, subjects with low self-efficacy are also unsure about their abilities and easily give up, so they do not try to properly solve the problems they face. This fits with other research that students with low self-efficacy tend to doubt their ability to finish a task [13]. Subjects with low self-efficacy can only achieve one indicator of mathematical communication ability, so subjects with a low category of self-efficacy have poor mathematical communication ability. Female subjects are better than male subjects. This is in line with research by Saidah et al., students with a low category of self-efficacy have poorer mathematical communication ability than students with high and moderate categories of self-efficacy [25].

Based on the results, this study is still limited to a linear inequality system of two variables material, and the subjects were only from grades XI-MIPA. This study can be developed by using a learning approach or model. The findings of this study are expected to provide information and knowledge about how self-efficacy and gender affect students' mathematical communication skills. Furthermore, this study can be a foundation for future research on mathematical communication skills in terms of high, medium, and low self-efficacy, as this influences students' mathematical communication skills, particularly when solving mathematical problems. Aside from that, it will be important in the future to consider how gender affects students' mathematical communication skills to further analyze gender.

4. CONCLUSION

According to the findings and discussion, students with high self-efficacy can achieve all indicators of mathematical communication ability, namely written text, mathematical expressions, and drawing, with male students outperforming female students on the written text and mathematical expressions indicators. Students with moderate self-efficacy can achieve two indicators of mathematical communication ability, namely written text and mathematical expressions, with female students outperforming male students in both areas. Students with moderate self-efficacy are fairly certain of their answers, do not give up easily, and strive to complete their

assignments well. Students with low self-efficacy achieve only one indicator of mathematical communication ability, written text, in which female students outperform male students. Students with low self-efficacy tend to feel uncertain about the answers and give up easily when faced with complicated mathematics problems. It can be concluded that there are differences in the mathematical communication skills of high school students based on the level of self-efficacy. In addition, there are differences in mathematical communication skills between male and female students. Educators can use this research as a reference in choosing the appropriate learning model.

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