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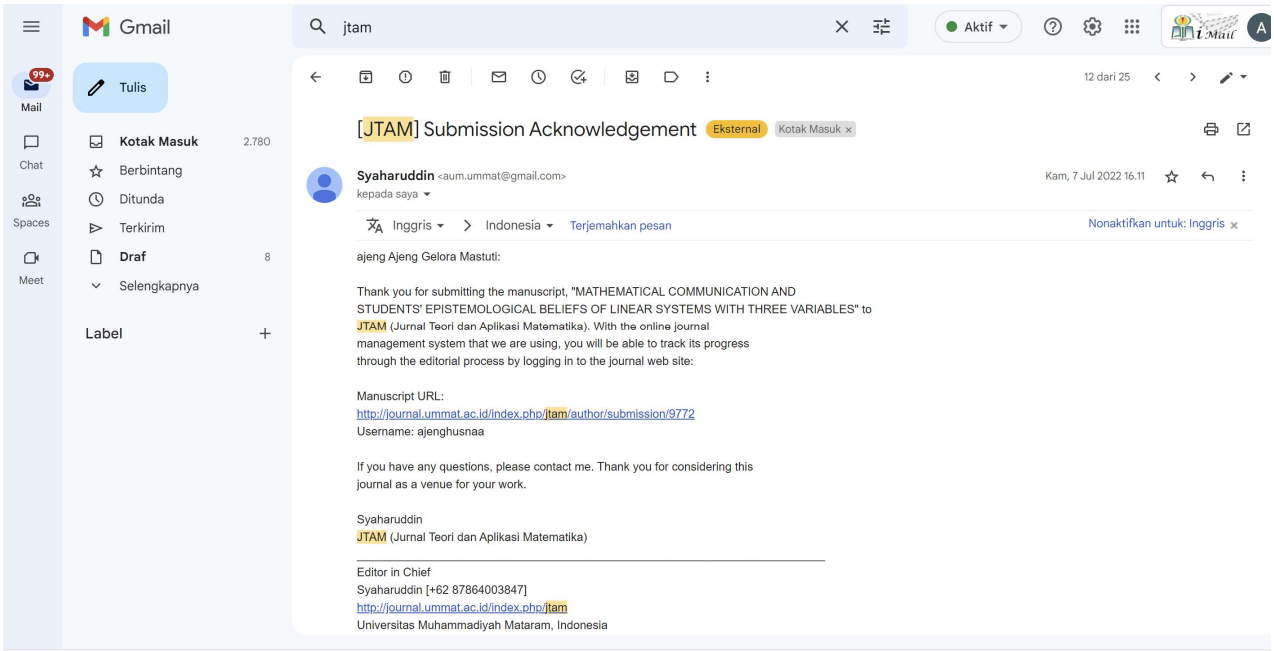

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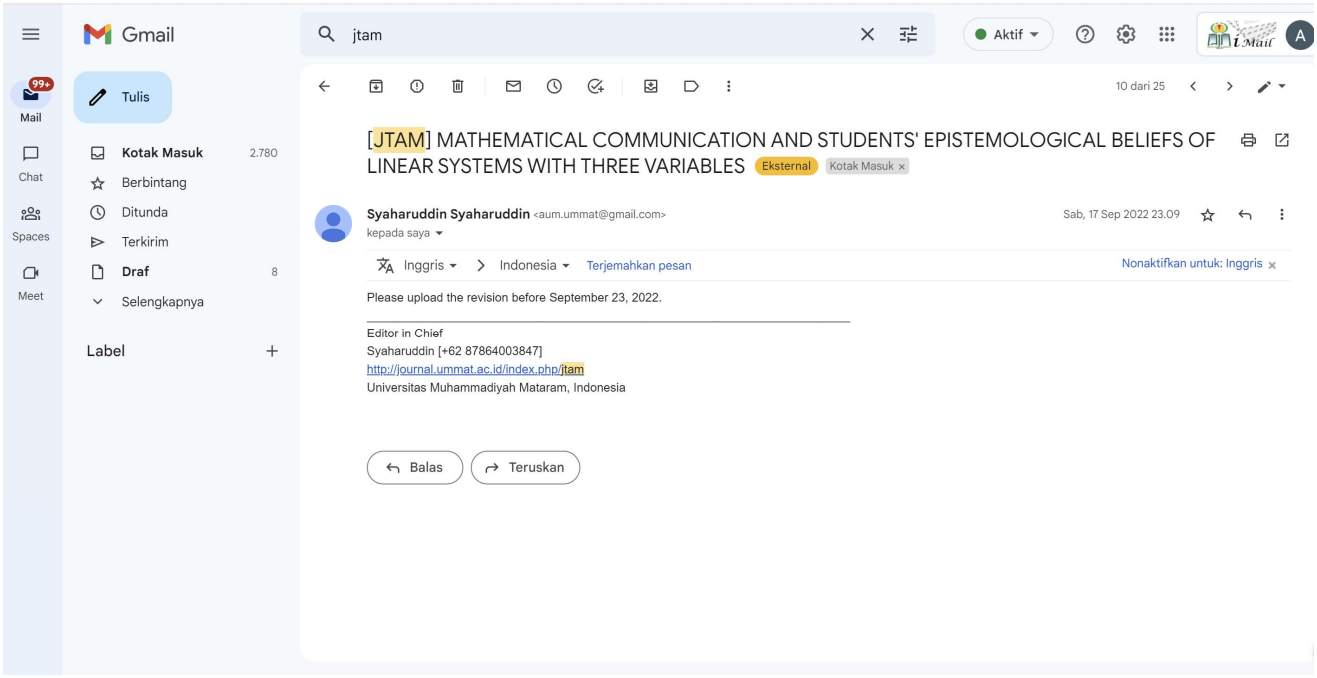

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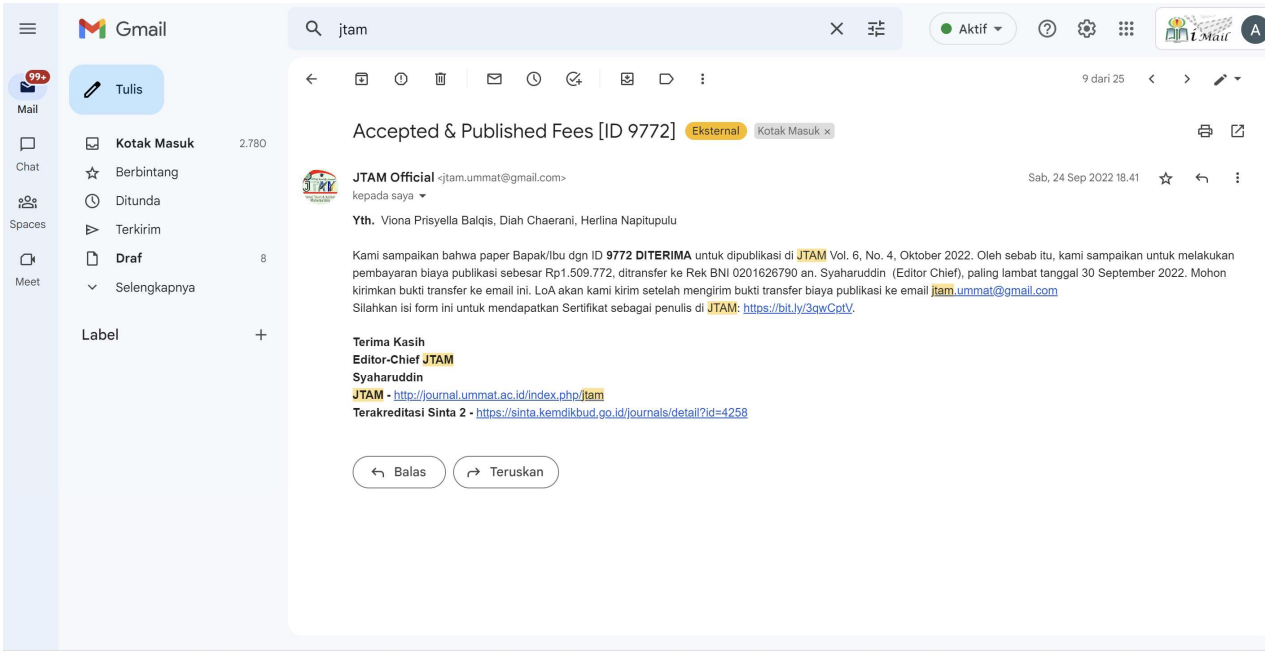

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Yth. **Dr. Ajeng Gelora Mastuti, M.Pd**
dari **Institut Agama Islam Negeri Ambon**

Dengan hormat,
Berdasarkan hasil penelaahan sementara dari tim reviewer seminar tentang judul dan abstrak, maka diputuskan bahwa paper Bapak/Ibu yang berjudul "***STUDENTS' EPISTEMOLOGICAL BELIEFS OF LINEAR SYSTEMS WITH THREE VARIABLES***" diterima akan dipublikasikan di **JTAM (Pend. Matematika & Matematika), Sinta 2**. Selanjutnya, Bapak/Ibu diharapkan segera submit fullpaper untuk dilakukan review lebih lanjut oleh tim reviewer jurnal tersebut.

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Mathematical Communication and Students' Epistemological Beliefs of Linear Systems with Three Variables

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ABSTRACT

Epistemological beliefs simultaneously affect mathematical communication skills. The higher the epistemological beliefs of a person's ability to formulate concepts, convey ideas, and hone ideas to convince others, the more mathematical communication skills will increase. This qualitative study uses three variables to describe mathematical communication and students' epistemological beliefs on linear system material. The subjects in this study were students who had epistemological beliefs from the test results, and students who were taken were students who were able to meet the indicators of epistemological confidence. Data collection techniques are tests, interviews and documentation. The results of this study indicate that students have beliefs that do not change or remain in solving test questions. The method used is more consistent with the way of solving, which according to students, is easy to do, able to solve problems by multiplying exercises and repeating what has been learned, solving problems by following the steps and methods of completion taught by the teacher, students can estimate answers or problem solving because of problems The subject obtained is obtained from experience and observations in everyday life.

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A. INTRODUCTION

Communication mathematics epistemological beliefs play an important role in academic behaviour, such as influencing the use of techniques in learning (Löfström & Pursiainen, 2015; Soleimani, 2020). For example, students who view knowledge as the same, unchanging and stable tend to use the technique of memorizing scientific facts (Taber, 2013). In contrast to students who view knowledge as dynamic, they will prioritize aspects of understanding information. Moreover, students who believe that understanding technology is the best strategy for learning will have better results during the final exam than those who believe that memorization is the best technique (Ghufron & Suminta, 2017; Sönmez, 2018).

Mathematical communication skills are students' abilities which include activities to communicate thoughts or ideas with symbols, tables, diagrams, and mathematical expressions to clarify a problem. According to Rohid et al. (2019) mathematical communication skills need to be the focus of attention in mathematics learning because through communication, and students can organize and consolidate mathematical thinking and explore mathematical ideas. In addition, according to Zulhelmi & Anwar (2021) mathematical communication skills have an important role in learning mathematics as a tool for exploiting mathematical ideas and

connecting between mathematical material. So mathematical communication skills are very important to be developed in students (Tong et al., 2021; Utari et al., 2020; Zulhelmi & Anwar, 2021).

Based on the research of Schommer et al. (1992) epistemological beliefs affect mathematical communication skills. The higher a person believes in his ability to both formulate concepts, convey ideas, and hone ideas to convince others, the more mathematical communication skills will increase (Albay, 2019). Mathematical communication and epistemological beliefs refer to students' ideas about the nature of knowledge (i.e., what individuals believe to be knowledge) and the nature of knowing (i.e., how individuals acquire knowledge) (Nacaroğlu & Kızkapan, 2021). In the initial study that the researcher conducted on three Madrasah Aliyah in Maluku, preliminary tests and interviews were conducted at this observation stage. From the results of the initial tests carried out, students were able to complete the test questions. However, when the interview was conducted, students seemed doubtful about what they were doing, even though they thought the job they got was wrong. This shows that students are unaware of the nature of knowledge and the nature of knowing. It relates to mathematical communication as well. One is students' hesitation in converting story questions into mathematical modelling.

Mathematical communication consists of two aspects: written and oral communication (Maulyda et al., 2020). Oral communication can take the form of students' arguments in solving a problem. Written communication can take the form of student work in solving a problem (Pantaleon et al., 2018; Sumaji et al., 2019). To be able to communicate solutions to problems, students sometimes feel unsure about communicating their work. They are afraid if they make a mistake and doubt whether their answer is correct or not. Some students know the problem's final result but do not write down the steps of the solution. It is described as an epistemological belief that causes students' mathematical communication to be low. Based on the research of Schommer et al. (1992) epistemological beliefs simultaneously affect mathematical communication skills. The firmer the epistemological beliefs of a person's ability to formulate concepts, convey ideas, and hone ideas to convince others will increase mathematical communication skills (Hofer & Pintrich, 1997; Schoenfeld, 2016).

Many studies address the importance of developing high-level epistemological beliefs on learning processes (e.g., choice of learning approach and cognitive strategies) and outcomes (e.g., academic achievement, learning motivation)(Choung et al., 2020). Lin et al. (2020) found that students with more complex epistemological beliefs (i.e., knowledge is uncertain, evolving, mind-brain constructed, and recognizing the value of experimentation) tend to use deep learning strategies, communicate, and have diverse motivations. Students who believe in the certainty of knowledge tend to use learning strategies that focus on motivation. Regarding the relationship between epistemological beliefs and communication, it has been emphasized that epistemological beliefs influence communication (Duong et al., 2022; Lin et al., 2020).

Based on the initial study and research background above, the research objective of this article is to describe the mathematical communication and epistemological beliefs of Madrasah Aliyah students in problem-solving related to a linear system with three variables. This article is expected to be a reference for teachers and other researchers to learn about the relationship

between mathematical communication and students' epistemological beliefs. In addition, it becomes a reference for planning more effective learning and providing rich task mathematics.

B. METHODS

This research is a qualitative descriptive study. This qualitative study aims to describe how mathematical communication and epistemological beliefs of Madrasah Aliyah students in problem-solving are related to a linear system with three variables. Qualitative description is a data processing method that aims to analyze factors related to the object of research by presenting data in more depth to the object of research (Creswell, 2013).

The subjects of this study consisted of 2 students (S1 and S2) who were consistent in mathematical communication and epistemological beliefs. Therefore, the subject of this study is saturated data from 11 students who were successfully selected through screening of prospective subjects from three different *Madrasah Aliyah*. The data acquisition of students' scores based on the mathematical communication rubric can be seen in Table 1.

Table 1. Student's Value Based on Mathematical Communication Ability

Total Students	Category
2	High
9	Moderate
0	Low

The researcher used two students with high ability in the mathematical communication test because they met three indicators of mathematical ability based on the NCTM. The three indicators include (a) expressing mathematical ideas through oral, written, and visual drawing; (b) understanding, interpreting, and evaluating mathematical ideas verbally and written; (c) using mathematical notation and describing the relationship with the situation model.

To determine the best way to determine the epistemological beliefs of *Madrasah Aliyah* students in solving problems related to a linear system with three variables. First, the researcher prepared test questions related to a linear system with three variables and interview guidelines according to indicators of mathematical communication and epistemological beliefs. Then the process will be observed using a video camera.

This study investigates how mathematical communication and students' epistemological beliefs develop over time. The indicators of mathematical communication skills used according to the NCTM (National Council of Teachers of Mathematics, 2000). At the same time, the epistemological belief indicators used are Innate/fixed ability, effort/process, authority/expert knowledge, and certainty knowledge (Chan & Elliott, 2004). Table 2 describes the indicators of epistemological belief based on the theory of Chan and Elliott, as shown in Table 2.

Table 2. Indicators of epistemological belief based on the theory of Chan and Elliott

Aspects of Critical Thinking Facione	Indicator
Innate/Fixed Ability	Good students do not have to study hard at school because some humans are born with a good way of learning for themselves, namely solving problems based on the ideas or practices of each student.
Effort/Process	The learning process is urgent and aims to make students who learn get positive behavioural changes as expected. That is, students, understand the subject matter being taught.
Authority/Expert Knowledge	According to the step-by-step procedure, solving mathematical problems is precise as explained/given by the expert (teacher).
Certainty Knowledge	Knowledge is obtained through scientific methods that guarantee more certainty of truth.

Data analysis focused on the actions of each student during tests and interviews. In addition, the researcher analyzed every data recorded in the video, which was included in the category of student actions and interview data was submitted to the researcher directly.

C. RESULT AND DISCUSSION

Before knowing the mathematical communication and epistemological beliefs of students of class XI IPA, the researcher first measured the initial knowledge of 111 students of class XI IPA. In this study, the researcher used an initial test instrument on subject selection and a second test on epistemological beliefs, interviews, and documentation. The results of the initial test encompassed 11 students as prospective subjects; 7 students fulfilled the indicators of mathematical communication and epistemological beliefs selected by the researcher, then the researcher's choice was strengthened based on the direction and consideration of the mathematics teacher to serve as prospective research subjects to measure students' epistemological beliefs. Furthermore, the researchers conducted a second test of mathematical communication and epistemological beliefs and continued with the interview process. It turned out that seven students met the indicators of mathematical communication and epistemological beliefs from 7 students divided into two groups with different problem-solving patterns. Each group selected one student to be interviewed. So the researcher has two subjects, namely S1 and S2, as shown in Table 3.

Table 3. Summary of Communication Mathematics in Epistemological Beliefs Test Results S1 and S2

Indicators Epistemological Beliefs	Indicators Communication Mathematics	S1	S2
innate/fixed ability authority/expert knowledge Authority/Expert Knowledge certainty knowledge	1. express mathematical ideas verbally and in writing 2. understand, interpret, and evaluate mathematical ideas orally, in writing 3. use mathematical notation and describe relationships with situation models	The subject solves the problem by symbolizing markers, notebooks and pencils as x, y and z, then simplifies the problem in the form of a linear system with three variables and steps for completion using the substitution method.	The subject solves the problem by symbolizing markers, notebooks and pencils as x, y, and z, then simplifies the problem into a linear system with three variables and solves the problem using the elimination method.

1. Mathematical Communication and Innate/Fixed Ability

Based on the results of the epistemological confidence test, S1, according to Table 3, shows that in solving a linear system with three variables according to the innate/fixed ability indicator, S1 can solve the test questions and the solutions carried out are the following the completion steps listed in Table 3 supported by the results of interviews conducted by researchers according to indicators of communication mathematics and innate/fixed ability, as shown in Figure 1.

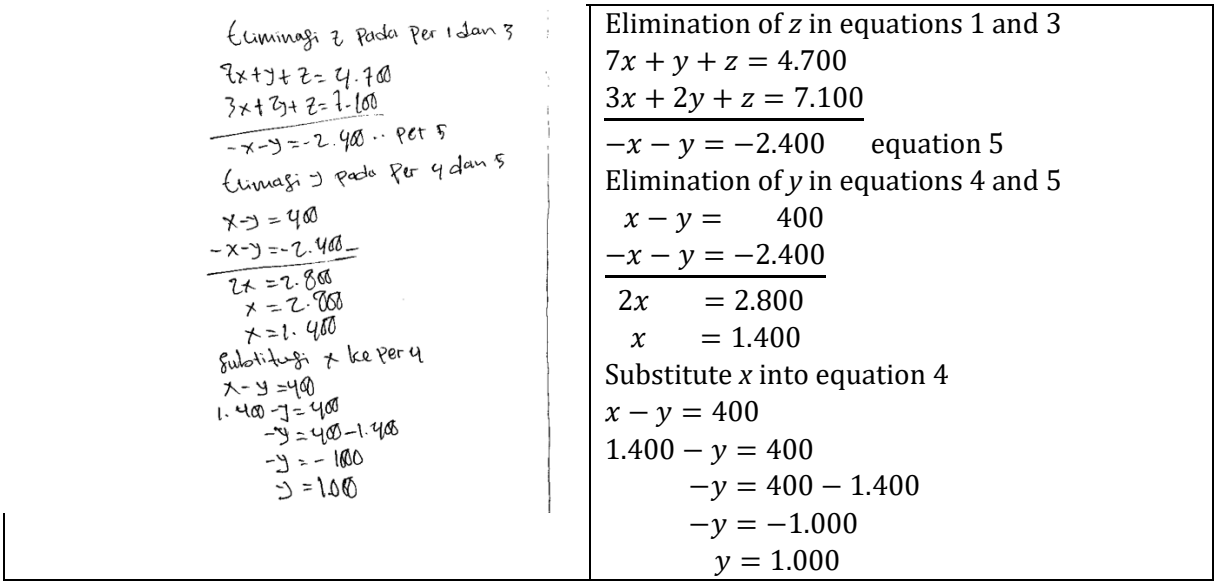

Figure 1. Answer S1 using the elimination method

Based on the results of the S1 work, the researcher clarified the subject's innate abilities. The following is an excerpt from an interview with S1.

T : How do you solve a linear system problem with three variables to the best your ability?
S1 : The method is to use the solution method, which in my opinion, is easier
T : What solution method did you use to solve the problem?
S1 : I use the substitution method
T : why the substitution method?
S1 : because I find it easier to add quickly and do substitutions, that's why I like counting in mathematics
T : how do you solve the story problems in this problem?
S1 : To make things easier, I made an example and then changed the form of the problem to a linear system with three variables.
T : Are there any difficulties working with a linear system with three variable questions?
S1 : No, it's not easy to do it when I was asked to solve it using a solution method other than substitution
T : Why is that?
S1 : I have a weakness if combining several methods because the result is slower than using the substitution method

The results of the tests and interviews above show that S1 has an innate ability to calculate fast. S1 think that solving a linear system with three variables is easier by using the substitution method than other methods such as elimination, mixed and graph methods which he considers

slower when solving problems. Based on the S2 epistemological trust test results, Table 3 shows that in completing a linear system with three variables according to the innate/fixed ability indicator, S2 can complete the test questions, and the completion is carried out following the complete steps listed in Table 1. This is supported by the results of interviews carried out by researchers according to indicators of innate/fixed ability, as shown in Figure 2.

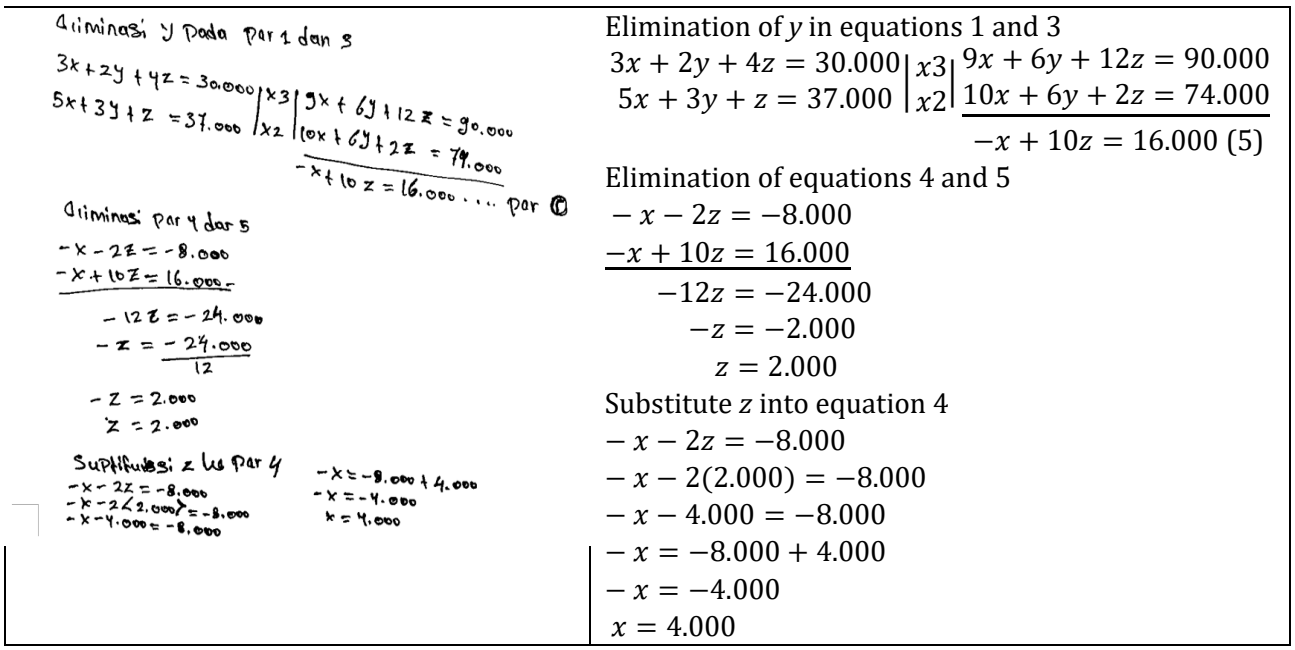

Figure 2. Answer S2 using the mixed method

> "...I tend to work on problems based on my intuition. I don't stick to any one step. So if conclusions are drawn I tend to often use mixed methods. My ability to add quickly is also the basis for solving this problem".

The results of the tests and interviews above show that S2 can solve problems by solving using the elimination method. Furthermore, it is easier and faster to solve a linear system with three variable questions using mixed methods than in other forms. The method used is more adhered to by using mixed methods.

The tests and interviews above show that S1 and S2 have different innate abilities. If S1 does it easily using quick calculations, S2 does it using intuitive thinking, instead of using one method but claiming which method is the easiest. In addition, S1 and S2 can express mathematical ideas verbally and in writing. S1 and S2 understand, interpret, and evaluate mathematical concepts orally and can explain to researchers how to solve problems. S1 also expresses mathematical communication through mathematical notation using the substitution method, while S2 expresses mathematical communication utilising a method that he considers easy, namely the mixed method.

Research on epistemological beliefs shows that students' abilities do not change or remain in solving problems using methods that students think are easy and fast to solve. These answers show that the subject has met the indicators of epistemological belief, namely innate/fixed ability. Schommer-Aikins (2011) suggest that in this dimension, students have the perspective that good students do not have to study hard on campus because some humans are born with

good ways of learning for themselves. In contrast, Mastuti et al., (2022) found that only gifted students were creative and successful in solving mathematical problems. Innate ability is the belief that the ability to learn is more innate than acquired or acquired (Heyder et al., 2019). Innate/fixed abilities affect students' mathematical communication. The higher the student's confidence because the innate/fixed ability will make it easier for students to communicate in writing and orally (Ashim et al., 2020).

2. Mathematical Communication and Learning Effort/ Process

Based on the S1 epistemological belief test results, Table 1 shows that solving the problem of a linear system with three variables problems is in accordance with the learning effort/process indicator. Therefore, S1 can complete the test questions, and the completion follows the steps listed in Table 1. This is supported by the results of interviews conducted by researchers according to the learning effort/process indicators.

T : Why did you solve the problem?
S1 : Because I practice more questions and repeat what I have learned before
T : Have you ever studied similar questions?
S1 : Yes, once, when the teacher taught a linear system with three variables material, and I also studied at home regarding the matter
T : What methods have you studied to solve this problem?
S1 : elimination, substitution, mixed and graph method
T : What are the steps of completion that you are working on based on the method of completion that you have learned
S1 : Yes, I solved the problem based on the method of solving that I learned, either studying in class with a math teacher or studying on my own through books
T Have you ever worked on a question like this?
S1 : Yes, I have. When the math teacher asked us to complete the practice questions, then we were given tasks to do at home

Based on the results of the tests and interviews above, it shows that S1 can solve problems by increasing practice questions and repeating what has been learned and the completion steps, as well as the settlement methods used based on the knowledge, gained when studying mathematics in class and at home. S1 is more appreciative of the process by repeating or practising questions regularly. In addition, S1 experienced positive changes by studying the material individually and paying attention to the teacher in teaching a linear system with three-variable in the classroom.

Based on the results of the epistemological confidence test, S2, according to Table 1, shows that in solving a linear system with three variables according to the authority/expert knowledge indicator (knowledge comes from an authority who knows more or is more expert), S2 can solve the test questions and the solutions made is following the completion steps listed in Table 1. This is supported by the results of interviews conducted by researchers according to indicators of authority/expert knowledge (knowledge comes from authorities who know more or are more experts).

> "...I learned this theory from one of the online tutors, such as "Ruang Guru". The rest often practice at home and often do assignments from the teacher. So I am more familiar with using mixed methods."

The results of the tests and interviews above show that with the knowledge gained from the learning process and the effort to acquire knowledge, S2 can solve problems by increasing practice questions and repeating what has been learned. The completion steps and the settlement method are based on the knowledge obtained when learning mathematics in class and at home. In addition, the S2 utilizes online teachers to practice problem-solving skills related to a linear system with three variables.

S1 and S2 make Learning Effort/ Process by doing exercises repeatedly. Both subjects have confidence because of the Learning Effort/Process that they do gradually in class and at home, both independently and online. This has an impact on his mathematical communication skills. S1 and S2 express mathematical ideas fluently; besides, they easily convey ideas and arguments when interviewed.

Research on epistemological beliefs shows that according to what has been learned, students can solve problems by increasing practice questions and repeating what they have learned. The steps of completion and solving methods are based on the knowledge gained when learning mathematics in class and at home. These answers show that students have met the indicators of epistemological beliefs, namely Learning Effort/Process. This is in line with the research of Deslauriers et al., (2019), which states that knowledge is obtained through learning efforts, and the learning process is the knowledge most students believe. In line with what was conveyed, Vermunt & Donche (2017) stated that student behaviour in learning tends to be determined by their beliefs in acquiring knowledge. Students who believe that the ability to understand lessons is determined by the amount and length of learning effort they make tend to change and improve the way they learn to increase their intelligence and abilities (Limeri et al., 2020).

3. Mathematical Communication and Authority/Expert Knowledge

Based on the results of the epistemological confidence test, S1, according to Table 1, shows that in solving a linear system with three variables according to the authority/expert knowledge indicator (knowledge comes from an authority who knows more or is more expert), S1 can solve the test questions. The solutions carried out are following the completion steps listed in Table 1. This is supported by the results of interviews conducted by researchers according to authority/expert knowledge indicators (knowledge comes from authorities who know more or are more experts).

T : Has the teacher ever taught you how to solve the problem?
S1 : Yes, I have
T : How did you solve the problem according to what the teacher taught you?
S1 : I solve the problem by following the completion steps taught by the teacher
T : Did you solve the question exactly in the steps taught by the teacher?
S1 : Yes, exactly
T : Has the teacher ever taught you another way to solve a linear system with three variables other than your method?
S1 : Yes, I have. Such as using the Elimination method mixed and graphs
T : Why do you solve the problem in this way?
S1 : Because the teacher also teaches like this

The results of the tests and interviews above show that to solve the linear system with three variables questions, the teacher taught him how to solve a linear system with three variables. In addition to using the substitution method, the teacher has also introduced other ways to solve a linear system with three variables, such as using the elimination method, mixed and graph and steps. The completion steps used by S1 are exactly the same as those taught by the teacher.

Based on the S1 epistemological belief test results, Table 1 shows that in solving a linear system with three variables according to the authority/expert knowledge indicator (knowledge comes from the authority who knows more or is more expert), S1 can solve the test questions. The solutions made are by the completion steps listed in Table 1. This is supported by the results of interviews conducted by researchers according to indicators of authority/expert knowledge (knowledge comes from authorities who know more or are more expert).

> "...in addition, there is a learning community that is guided by math students. Apart from practicing mixed methods solving, what I often do is occasionally try other methods. Many exercises in the "Ruang Guru" application, complete some teacher assignments, and sometimes discuss with a learning community with math students doing internships at our school."

Based on interviews with S2, the researcher claims that S2 performs more than one authority or expert. S2 also has a learning community with math students interning at their school. In addition, S2 claims that occasionally using other methods is considered easy. Trust in the epistemology of S2 increases when S2 feel they have several learning communities both at school, at home, and in online tutoring.

S1 and S2 claim that the teacher is authority/expert knowledge. Although S2 also has a learning community with math students interning at their school. S1 and S2 both take advantage of learning exercises at home and online. S1 and S2 know that their fluency in expressing mathematical communication in writing cannot be separated from authority/expert knowledge. Including when S1 and S2 convey arguments about their ideas orally during interviews.

Knowledge comes from people who know more or are more expert (authority/expert knowledge), such as teachers, learning communities, or reference books, compared to logic and thought alone. In this dimension, students do not have a knowledge perspective, thus believing that information from reference books is correct and that teachers should convey the material in the learning process (Schommer-Aikins, 2011). On the other hand, it is different for students with more sophisticated epistemological beliefs, which emphasise the notion that knowledge comes from the construction of thought alone.

4. Mathematical Communication and Certainty Knowledge

Based on the results of the epistemological belief test, S1, according to Table 1, shows that S1 can predict the answer or solution to the question because the questions relate to real life and the questions are definite in real life. S1 can complete the test questions, and the completion is following the completion steps listed in Table 1. This is supported by the results of interviews conducted by researchers according to the certainty knowledge.

T : Is a linear system with three variables confident in daily life?
S1 : Yes
T : Is it a linear system with three variable valuables in everyday life?
S1 : Yes, useful. Like calculating the price of an item we buy
T : How to operate a linear system with three variables in real life or daily life?
S1 : when my mother ordered me to buy cooking spices at the store
T : Is it possible to operate a linear system with three variable materials in daily life?
S1 : Yes, like knowing the price of good
T : What obstacles are faced in everyday life when using materials in a linear system with three variables?
S1 : None

Based on the tests and interviews, it shows that in completing the test questions, S1 can predict the answers or solutions to the problems given because the problems obtained by S1 are obtained from experiences and observations experienced during S1 every day. Contextual problems help students relate concepts to their experiences. Based on the results of the epistemological belief test, the S2 shows can operate a linear system with three variables in real life. They can predict answers or solutions to questions because the questions relate to real life and the questions are definite in real life. This is indicated by the statement S2 as follows.

"....my confidence increases when I know that the problems given are the same as the ones I face in my daily life."

S1 and S2 beliefs are related to their daily experiences. Therefore, certainty Knowledge S1 and S2 occur because the problems they face are related to everyday problems. This, of course, relates to their mathematical communication, making conveying ideas more realistic and logical. In addition, it makes it easier for students to model in mathematical form.

Based on the results of tests and interviews, it was shown that in solving the S2 test questions, they could predict the answers or solutions to the problems given because the problems obtained by S2 were obtained from S2 experience and daily observations. Research on epistemological beliefs shows that with definite knowledge in everyday life, the subject can predict the answer or solution to the given problem. Because the problems obtained by students are obtained from experiences and observations experienced when students are asked by their mother to buy something in a store, these answers show that students have met the indicators of epistemological beliefs, namely certainty knowledge. Students who believe that knowledge is tentative and unpredictable and that knowledge is a fact-formulating process in which individuals independently construct their ideas will have better regulation of learning (Wade & Kidd, 2019).

D. CONCLUSION AND SUGGESTIONS

Based on the discussion of the research results, it can be concluded that students' epistemological beliefs in solving linear systems with three problem variables are four indicators of epistemological beliefs. First, innate/fixed abilities, where students have innate abilities in the form of calculations and intuitive thinking abilities. Second, the effort/learning process in which students complete a linear system with three variables using methods and

completion steps according to the knowledge gained while studying in class or at home, and students believe in the knowledge gained from their business or learning process and repeat it many times in task practice. Third, knowledge of authority/expert where students complete a linear system with three variables using methods and completion steps following the knowledge obtained from teachers, learning communities, and tutoring. Students are confident in the knowledge obtained from experts. Fourth is certainty knowledge, where students solve linear systems with three variables based on experiences and observations experienced in everyday life, and students believe that knowledge is certain in everyday life. Finally, all indicators of epistemological beliefs affect students' mathematical communication. High student confidence will affect expressing mathematical ideas orally and in writing, understanding, interpreting, and evaluating mathematical ideas orally and in writing, as well as using mathematical notation and describing relationships with situation models. The next interesting research is to discuss teachers' epistemological beliefs related to their pedagogical abilities and their effects on students' epistemological beliefs.

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