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Mathematics Student Decision Making Based on Self-Efficacy in Probabilistic Thinking

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Abstract. One thing that needs to be considered in the thinking process is the ability to make decisions. Decision-making includes probabilistic thinking. Decision-making is usually done after going through a series of processes. This study discusses how mathematics student decision-making is based on self-efficacy in probabilistic thinking. This research is descriptive qualitative research. The validity of research data with triangulation techniques. The results show that decision-making in probabilistic thinking requires a series of processes, namely understanding the problem, having initial intuition, choosing the right strategy, doing numeracy, then evaluating, and then making a decision. For subjects who have high self-efficacy, the subject makes decisions that fulfill all the elements in decision making. Subjects with self-efficacy are in the decision-making process, the use of numerical concepts is still not right, but the other elements have been met. For subjects with low self-efficacy abilities, they are still less precise in initial intuition, numeration, and final evaluation so the decision making is still not right.

Key words: decision making; self-efficacy; probabilistic thinking

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INTRODUCTION

Making the right decisions in dealing with problems is needed in this life. Problems that arise in this case, can be in various fields, can be economics, education, health, agriculture, military or security, and so on. So to decide in dealing with these problems need the ability to think. These problems sometimes contain elements of uncertainty, so probabilistic thinking skills are needed. One thing that needs to be considered in the thinking process is the ability to make decisions. Decision-making is required to minimize risk or maximize profit. Decision-making is a process that involves choices. The process generally consists of several steps: identifying problems, generating alternatives, evaluating alternatives, selecting alternatives, implementing decisions, and evaluating the effectiveness of decisions (Lunenburg, 2010). Making decisions in dealing with all problems requires courage (Rahmawati & Triyono, 2017).

The process of solving problems and making rational decisions will follow the following procedure, define the problem and the factors that influence it, construct decision criteria and goals, formulate the relationship between goals and existing variables, identify and evaluate existing alternatives, best alternative choices, and implement decisions (Adair, 2010; Sproull, 2018). According to Sproull (2018), the roadmap in decision-making is making a statement of objectives, determining decision criteria, developing a list of potential options, assessing the risk of each option, calculating decision factors, and making and implementing decisions.

Furthermore, there are four conditions in decision making, namely decision making under conditions of certainty, decision making under uncertainty, decision making under risk, and decision making with hierarchy. The probabilistic problem is a problem of uncertainty that contains elements of many choices. Decision-making in terms of probability is decision-making under uncertainty (Prastyawan & Lestari, 2020). The thing that needs to be considered in making decisions is the presence of intuition. Intuition is a hunch that is formed by the subconscious mind. The subconscious mind will quickly filter knowledge and past experiences into an idea or ideas (Ikhwani et al., 2022). The idea or idea becomes a brief consideration in deciding without doing an analysis or a long thought process first.

In the brain, there are two types of thinking systems, namely the conscious system and the unconscious system (subconscious). The part of the brain that regulates the human conscious system is the left brain which works more slowly. This brain system is the center for being able to analyze, help think rationally, and work based on facts and experiences that have happened. We consciously know everything this system does. Associated with decision-making in probabilistic

thinking. Probabilistic thinking usually solves non-routine problems of mathematical problems that contain uncertainty. Three categories show Higher Order Thinking (HOTS) abilities, namely: (1) bringing up the transfer of one concept to another, (2) examining ideas and information critically, (3) using the information to solve problems (Brookhart, 2010) (Shodiqin et al., 2021). Based on the HOTS category, probabilistic problem solving contains these three categories, this shows that probabilistic problem solving requires higher order thinking skills (HOTS).

There are several opinions about the categories in probabilistic thinking that have been built, including (Nacarato & Grando, 2014) in building probabilistic thinking there are four stages or phases, namely the classical concept phase, the frequency or empirical concept phase, the subjectivist concept phase, the axiomatic or formal concept phase. Meanwhile (Jan & Amit, 2009) constructing probabilistic reasoning offers four categories, namely the type of strategy, representation, use of probabilistic language, and the nature of cognitive barriers. Humans are often faced with various situations or problems in everyday life. Problems are part of human life. A situation is said to be a problem if there is a gap between reality and expectations. Problems with this element of uncertainty are also often referred to as probabilistic problems.

Based on the results of research on probabilistic thinking showed that the majority of students did not have a clear idea about probability construction (Sharma, 2012, 2016). Students' probabilistic thinking processes cannot be seen from the age factor alone (Mahyudi, 2017). Some students indicated that their probabilistic thinking level was below their age. The results of the study (Taram, 2017) show that students who have a field-dependent learning style are at level 2 while field independent are at level 4 or numeric. So it is necessary to study the analysis of probabilistic thinking and its benefits for prospective teachers so that students can think probabilistically in solving problems better. Based on the study, researchers are interested in analyzing the analysis of decision-making in probabilistic thinking in solving probabilistic problems.

The probabilistic thinking process is a cognitive process and a psychological process. According to (Kerlin, 1992) learning is a cognitive process that is influenced by several factors such as individual circumstances, prior knowledge, attitudes, individual views, content, and way of presentation. In the learning process, students are influenced by the ability of mathematical connections and students self-efficacy (Ningrum, 2020). The psychological process of self-ability contains four types of psychological processes, namely: a) cognitive processes, namely the thought patterns that encourage or inhibit cognitive behavior; b) the motivational process, namely behavior that aims to evaluate his appearance; c) affective processes, namely behaviors that control the thought process in overcoming threats; d) the selection process, namely the cognitive, motivational and affective processes that help build self-efficacy and achieve goals (Bandura, 1997). The higher a person's self-efficacy for his ability to formulate concepts, convey ideas and sharpen ideas to convince others, the higher his mathematical communication skills (Hamidah, 2012). Self-efficacy has a positive effect on students' communication skills (Hendriana & Kadarisma, 2019). The purpose of this research is to describe how mathematics students' decision-making in probabilistic thinking is based on self-efficacy with high, low, and medium levels.

METHODS

This type of research is descriptive qualitative research, in this qualitative analysis analyzes the decision-making of mathematics students in probabilistic thinking based on self-efficacy. Qualitatively, the subjects in this study were students who had taken courses in probability theory, and mathematical statistics conducted at PGRI University Semarang. Subject selection is based on the ability of self-efficacy with high, medium, and low categories.

The selection of subjects in the study was done intentionally, namely by purposive sampling technique. This is based on the tendency of researchers to choose information based on information on certain problems in depth and can be trusted to be a source of data (Miles & Huberman, 1994; Sukestiyarno, 2020). In other words, the contacted subject unit is adjusted to certain criteria determined based on the research objectives (Sugiyono, 2014). Based on the study, the following things need to be considered in decision-making in dealing with probabilistic problems, understanding the problem of uncertainty, guessing answers or intuitions, choosing strategies to solve problems, doing numbers to see risks, and decision-making.

The written test is as follows:

In the game, two boxes are provided, each containing a ball numbered 1 to 6. In the ball game, participants take a ball from each of the boxes, and when picking it up the eyes must be closed. Next, answer the following questions:

a. Is it possible, impossible, or certain to happen in picking up the ball, the participant can take the ball with a total number of 4? Explain in detail the calculation.
b. Which one has the most odds or odds, the sum numbered less than 8 or more than 8? Give your reason using the count!

Data that has been successfully excavated in the field, is collected and recorded in research activities. The data validity technique used in this research is the triangulation method. The results of the written test and the results of interviews with a student were compared and concluded that the data had stronger validity. The procedure for analyzing the data obtained from the results of written tests and interview results to conclude is carried out by following the processes: (1) data reduction; (2) data presentation; and (3) drawing conclusions and verification (Miles & Huberman, 1994; Sukestiyarno, 2020).

RESULTS AND DISCUSSION

The description of decision-making for mathematics students in probabilistic thinking begins with a student self-efficacy questionnaire. Research instruments in the form of self-efficacy questionnaires, written tests, and interview guidelines have previously been validated. The validation results show that the research instrument is feasible and can be used for research. The results of the self-efficacy questionnaire from students who have taken the probability theory course can be seen in Table 1.

Furthermore, self-efficacy criteria were determined based on self-efficacy abilities, from the questionnaire given to as many as 73 students, the average value of self-efficacy abilities or X = 91.219, and with a standard deviation of self-efficacy abilities Sd = 11.956. The criteria for categorizing self-efficacy subjects are found in Table 1.

Table 1. Criteria for categorizing self-efficacy subjects

No	Criteria Formula	Results	Criteria
1	$X \geq \bar{X} + Sd$	$X \leq \bar{X} + Sd$ =104.18	High
2	$\bar{X} - Sd < X < \bar{X} + Sd$	$80{,}263 < X < 104.18$	Medium
3	$X \leq \bar{X} - SD$	$X \geq 80.263$	Low

With the self-efficacy criteria in Table 1, the results of the criteria for selecting subjects based on the level of self-efficacy are as follows:

Table 2 Criteria for selecting self-efficacy subjects

No	Criteria Self-Efficacy	Amount	Subject Code
1	High	10	AL, ID, AN, DL, DM, AM, HD, ANK, **HM,** AH
2	Medium	52	FF, HA, NL, WK, LA, AR, DA, ES, MH, **SN**, EA, SM, NA, KN, AB, FE, NC, AS, SD, KM, SM, MW, HK, AF, FK, DY, ID, MR, IZ, AD, LH, DP, RM, KN, HK, DA, LS, SDA, IUA, IS, AB, ER, AW, GE, AN, NH, KS, SN, FF, NS, DK, FK
3	Low	11	LI, **SW**, PL, NS, TK, SF, RN, WS, YM, MA, AD,
	Amount	73	

Of the self-efficacy subjects, one self-efficacy subject was selected, for high HM subjects, medium SN subjects, and low SW subjects. Based on the criteria for selecting high, medium, and low self-efficacy subjects in Table 2, one self-efficacy subject was selected for each, for the high self-efficacy category the subject HM was selected, for the medium self-efficacy category the subject SN was selected, and for the self-efficacy category, the subject was selected. -low efficacy selected SW subject. After selecting a subject, then each subject is given a written test above. Furthermore, the written test of probabilistic problems from the subject of mathematics students based on self-efficacy was sought to find out how the mathematics student's

decision-making was.

Results from high self-efficacy HM subjects

From the written test for the subject of high self-efficacy with the subject of HM, the results are based on the sample space material, events, and probabilities as follows:

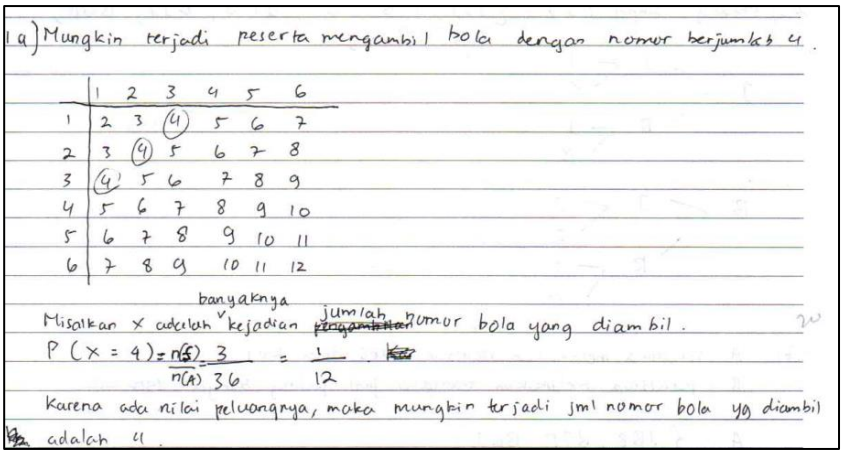

Figure 1. The results of the work of the subject of HM

Based on the results of work number 1a. by the subject HM in Figure 1. The subject is able to understand the problem of uncertainty. The subject has guessed the initial answer or intuition correctly. The subject can understand the strategy to solve the problem by finding the sample space by taking the ball. The sample space was obtained by the source of HM as many as 36. Furthermore, the subject of HM in doing the numeration to see the risk can get the correct chance of $P(X = 4) = \frac{3}{36}$. After conducting the evaluation, it was concluded and made a decision that it was possible that four balls would be drawn.

P-1: Question for number 1a, are there any initial conjectures maybe, impossible
S.HM: or certain before revealing the answer, prior to elaborating the answer?
P-2: My initial guess is already there, my answer is probably. This includes a sample space of 4. It is possible to take it possibly. I read once straight this is possible.
Can you convey a strategy or way of constructing to answer that maybe with an explanation?
S.HM: Once I guessed maybe. I explained it was possible, then what are the chances and must be calculated. According to what I learned first, if there are two boxes, the contents of the ball are listed in the right table from 1, 2, 3, 4, 5, and 6, for the bottom 1, 2, 3, 4, 5, and 6. corresponding column and row. Column one and row one are written 2, column one row two is written 3, and so on. Then I saw the probability that there were four out of 36. So the odds are $\frac{3}{36} = \frac{1}{12}$.

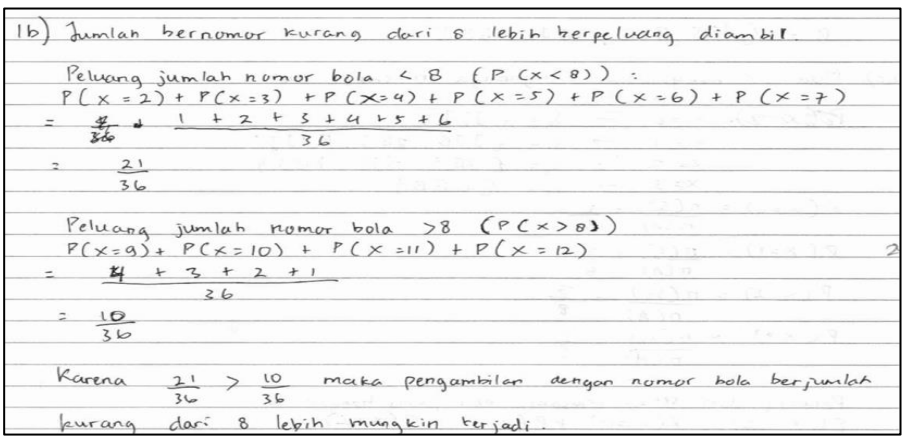

Figure 2. The results of the work of HM Subjects

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After doing the numeration on number 1b, it is found that the probability of less than 8 is 21/36, and the probability that the ball is drawn with a total of more than 8 is 10/36. Then the subject concludes and makes a decision that the probability of less than 8 is greater than the probability of the number of balls being more than 8.

Results of SN Subjects with medium self-efficacy

The written test of the SN subject with medium self-efficacy obtained a description of the decision-making as follows:

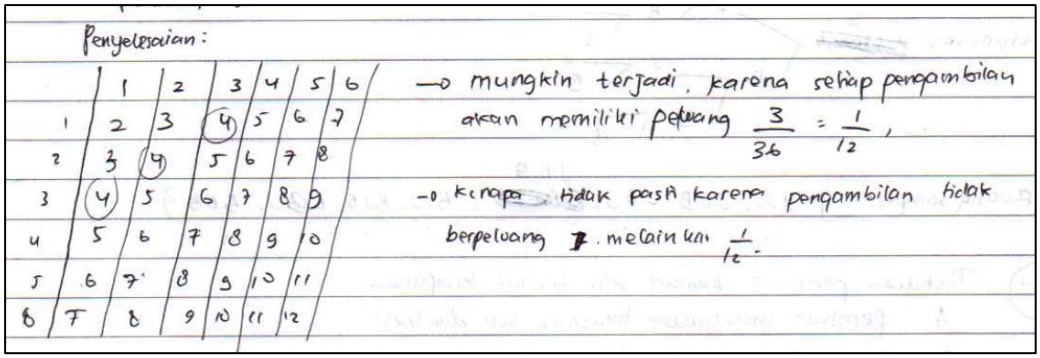

Figure 3. The results of the work of SN subjects

Based on Figure 3, the results of work no. 2a of the subject of HM in Figure 1. SN subjects can understand the problem, understand the problem of uncertainty, the subject can guess the answer or have intuition, and the subject can choose a strategy to solve the problem by looking for the sample space from taking the ball. The sample space is obtained as much as 36, and the subject in doing the numeration to see the risk can get the correct chance of P(X=4)= 3/36. After conducting the evaluation, a decision was made. The decision maker chooses the possibility to be able to pick up four balls.

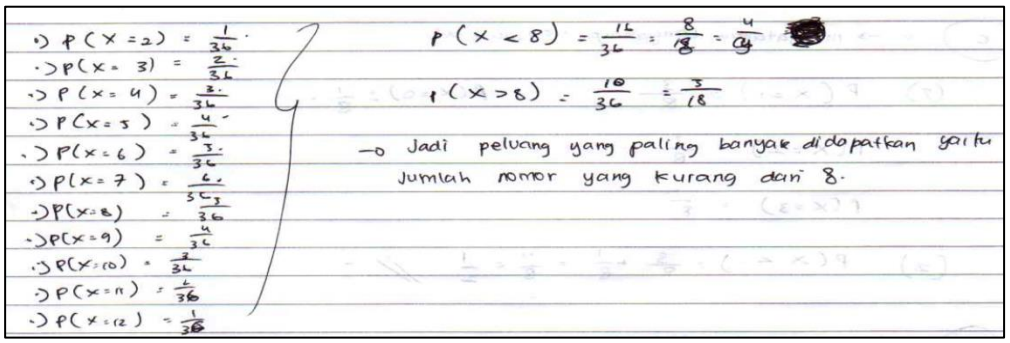

Figure 4. The results of the work of SN subjects

After doing the numeration in the case of comparison of opportunities by the subject of SN in number 1b found that the probability of less than 8 is 16/36 which should be 21/36. While the probability that the ball is drawn with a total of more than 8 is 10/36. Seen an error in calculating the probability that is less than 8. But then the subject of SN in concluding or making decisions correctly. This information is supported by the following interview results.

P-14 : Based on the calculations, what was the guess?
S.SN : It turned out that my guess was right, even though there was an inaccuracy in the calculations.
P-15 : What's the conclusion, sis?
S.SN : So the most likely chance is the number of numbers less than 8.

Furthermore, the subject of SN stated that the probability of getting a ball less than 8 was greater than the probability of the number of balls being more than 8.

Results of SW Subjects with Low self-efficacy

From the written test for low self-efficacy subjects with SW subjects, the results are based on the sample space material, events and

probabilities as follows:

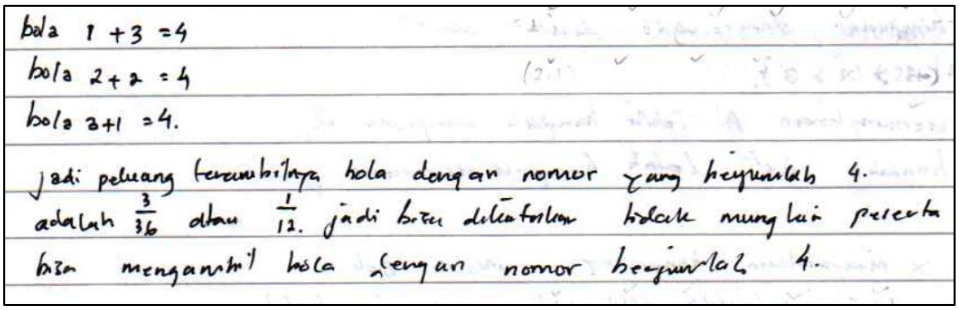

Figure 5. The work of SW Subjects

Based on work no. 2a. from the subject SW in Figure 5, the subject was able to understand the problem of uncertainty but was still hesitant. The SW subject has not been able to guess the answer (intuition), and the SW subject is not yet complete in choosing a strategy to solve the problem by finding the sample space from taking the ball. The sample space is obtained in as many as 36 but is not detailed. SW subjects in doing numeration to see the risk can get the correct chance of $P(X = 4) = \frac{3}{36}$. At the end of the decision-making, the SW subject has not been able to evaluate properly. This can be seen by the subject in drawing the conclusion that it is impossible to pick up four balls. This is supported by the results of the interview with the SW subject as follows.

P-24 : Is this the right answer? (see Answer no. 1a)
S. SW : No, sir.
P-25 : It can be said, why is there a 3/36 chance, but it is said to be impossible?
S. SW : Because I focus, on this value, but not others, but the conclusion in my mind is not possible.
P-26 : Initial guess is impossible, huh?
S. SW : Yes, because many guesses.
P-28 : The guess is impossible, but after calculating what is the result?
S. SW : It should have been possible, but it was written impossible.

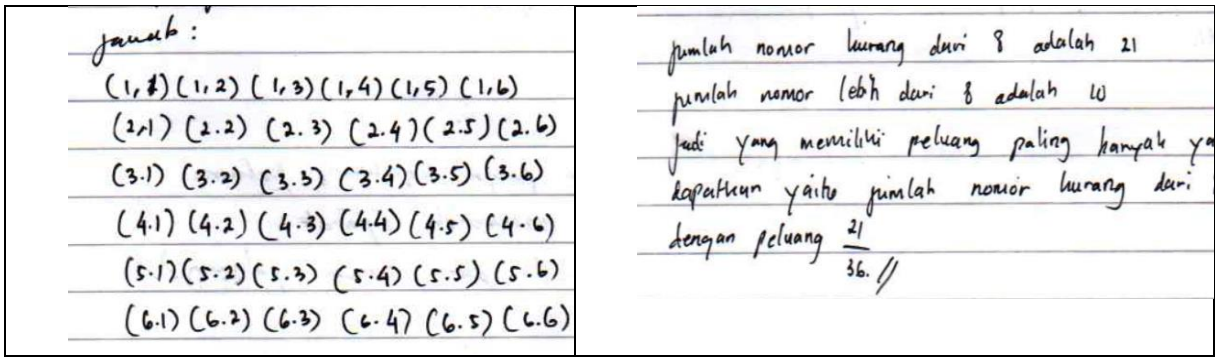

Figure 6. The work of the subject of SW no.1b

After doing the numeration by subject SW at number 1b, the subject can mention the sample space, namely {(1,1),(1,2),(1,3),(1,4),(1,5),(1,6),..,(6,5),(6,6)}, obtained a sample space of 36, it is found that the probability of less than 8 is 16/36 which should be 21/36, and the probability that the ball drawn is more than 8 gets 10/36.

P-53 : From a numeration or calculation, initially you can find 21/36, is it from the formula you had before, or is it supposed to be something like this?
S. SW : About this.
P-54 : How can you get 21/36, is it your concept or does it have a previous basis?
S. SW : The concept itself ee..for the basic theory, I forgot sir
P-55 : The basic theory is forgotten, right? How about?
S. SW : About this (while pointing to the answer), understand a little theory.

Uncertainty decision-making data is based on self-efficacy with consideration of problem understanding, initial intuition, choosing the right strategy, numeracy, and decision-making. Table 3 is obtained as follows.

Table 3. Probabilistic thinking decision-making based on self-efficacy

No	Self-efficacy	Probabilistic Problem	Understanding the problem	Early Intuition	Strategy Choice	Numeraci	Decision-making
1	High	Opportunity	Can	have	Able to choose	Can	Can Be Right
		Opportunity comparison	Can	Have	Can	Can	Can Be Right
2	Medium	Opportunity	Can	Have	Can	Less precise	Exactly still in doubt
		Opportunity comparison		have	Can	Less precise	Exactly still in doubt
3	Low	Opportunity	Can	None yet	Already	Less precise	Not Right
		Opportunity comparison	Can	None yet	Still in doubt	Less precise	Can be right and doubt

Based on Table 3 above, subjects with high self-efficacy abilities can be good at making decisions in probabilistic thinking. This is shown by the subject of HM to be good at understanding problems related to opportunities and comparing opportunities, having the right initial intuition, having problem-solving strategies, and being able to do the right numeration to minimize the risks that exist. Furthermore, making decisions can be right and without hesitation.

Furthermore, the ability of moderate self-efficacy can be right but still unsure. This is because, in understanding problems related to opportunities and comparing opportunities, they can be good, have the right initial intuition, and have problem-solving strategies, but the ability in numeracy is still not right. So that the SN subject makes decisions in probabilistic thinking that can be right but there are still doubts.

Furthermore, subjects with low self-efficacy abilities are not appropriate for making probabilistic thinking decisions for ordinary opportunity problems. This is because understanding the problem can be good, but intuition is not there, having a solution strategy can be good, but numeracy skills are not clear and not precise so probabilistic thinking is not right in making decisions. Probabilistic thinking decision making for comparison of opportunities, low self-efficacy subjects can understand the problem, but do not have intuition, have a strategy but are still unsure, and the numerical results are not clear and not precise, but the decision making can be right but there are still doubts. Limited information by decision-makers makes decisions made to find solutions less than optimal (Lunenburg, 2010). In today's era, data-based support for decision-making in terms of education and teaching is very much needed (Lv, 2021).

Estimating the likelihood of certain events occurring, and the impact of something, is not an easy task, especially if it involves other factors, so it requires strong analysis in decision making (Sproull, 2018). Decision-making in the field is influenced by interdependence (additive and destructive social interference), which sometimes involves individuals and teams (Lawless, 2019).

Individuals who have high self-efficacy tend to be able to deal with problems well, have strong beliefs (Granziera & Perera, 2019), dare to face challenges and risks, are aware of their own strengths, are easy to interact with others, and are tough and do not give up (Hendriana et al., 2017; Sumarmo et al., 2019). it becomes support in the process of making a good decision. Subjects with high self-efficacy will have a level of probabilistic thinking at the numerical level (Shodiqin et al., 2022). So that someone has a good ability in making probabilistic thinking decisions, in order to have a good understanding, have the right intuition, have problem-solving strategies, and can do the right numeration to minimize the risks.

CONCLUSION

Based on the results and discussion, it can be concluded that decision-making in probabilistic thinking requires a series of processes, namely understanding the problem, having initial intuition, choosing the right strategy, doing numeracy and evaluation, then making a decision. For subjects who have high self-efficacy, the subject makes decisions that fulfill all the elements in decision making. Subjects with medium self-efficacy are in the decision-making process, the use of numerical concepts is still not right, but the other elements have been met. For subjects with low self-efficacy abilities, they are

still less precise in initial intuition, and numeracy, so their decision-making is still not right. Decision-making skills are very important for every individual to face everyday problems in today's era, both uncertainty and definite problems.

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