

Probabilistic Thinking Ability of the Students of Mathematics Education Bachelor's Degree in Terms of Their Cognitive Style

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Abstract——Probabilistic thinking is one of the internal factors which are very influential towards the students' ability. However, research regarding the probabilistic thinking has not been massively done. The students' cognitive style, which is defined as the individual trend to retrieve, to process, to construct, and to represent information based on their experiences, needs attention from the lecturers in higher education. The purpose of this research is to find out the percentage and the description of probabilistic thinking ability of the students of mathematics education bachelor degree. This research is a descriptive qualitative research. We measured 58 students regarding their probabilistic thinking. The data were grouped into some levels. Then, we identified their cognitive style by using the instrument of Group Embedded Figure Test (GEFT). This research resulted in the descending order of percentage of probabilistic thinking ability as follows: 51.724% of Level 1 (subjective), 17.241% of Level 3 (informal-quantitative), 17.241% of Level 2 (transitional), and 8.621% of Level 4 (numerical). While the descending order of the percentage of students' cognitive style is as follows: 50.000% of mobile FD and mobile FI, 29.310% of fixed FD, and 20.690% of fixed FI.

Keywords: *probabilistic thinking, cognitive style, leveling*

I. INTRODUCTION

The students' mathematical ability is influenced by some factors, both external and internal factors. Some researchers show that the influence of internal factors is dominant. One of the internal factors is students' thinking ability, including the spatial thinking ability, the rigor mathematics thinking ability (Fitriyani, 2013), the literacy thinking ability, the probabilistic thinking ability, and the statistical thinking ability (Martadiputra, 2014; Helgason & Jobe, 2010).

Research related to probabilistic thinking has not been done massively. There is a few of them such as Jones (1997, 1999) and Polaki (2002) who invented the leveling of probabilistic thinking and recommended a future research to investigate if the

framework designed to describe the students' probabilistic thinking is suitable with the students having diverse language and cultural background. Furthermore, Sharma (2012) shows that there are many students use strategies based on cultural experience (faith, daily activities, and school experience) and intuitive strategies. Sujadi (2008) developed leveling suggested by Jones, et al (1997, 1999) and added a level of probabilistic thinking for the junior high school students who have not been taught by probability material. Maftuh (2014) suggested that the probabilistic reasoning of the junior high school students in a problem-solving related to the probability of an event tends to be biased in responding various situations in the context of uncertainty. Meanwhile, their reasoning in each step of solving probability problem shows that the subjects took decisions quickly about the strategy used to solve the problems. The results of these research are very interesting and are needed to be followed up in higher education level since understanding the students' potential will help the lecturer to deliver the material in terms of the learning approach, the weight of the material, and the guidance and attention towards them.

The Indonesian Framework of National Qualification (KKNI) mentions that bachelor degree is categorized at level 6 which means that the graduates have to master the theories of a certain field in general and some specific concepts in depth and then apply them to a problem solving procedural way (Ministry of Law and Human Rights, 2012). The last statement in the regulation has a strong relationship with the bachelor degree graduate competence, namely having higher order thinking abilities including probabilistic thinking ability. Thus, lecturer needs to guide the students to reach the desired level.

In the other hand, the students' individual trend to retrieve, to process, to construct, and to represent information based on their experiences, which is known as the cognitive style, needs attention from the lecturer since it will influence how they learn in the higher education. Witkin, et al (1977) classified

the cognitive styles into some types, namely the field-independent (FI) and field-dependent (FD). The cognitive style classification is based on the individual ability to distinguish the relevant aspect in a certain situation.

This paper tries to find out and to describe the relationship between the students' probabilistic thinking ability and their cognitive styles. This research takes the scope of the students of mathematics education department of Ahmad Dahlan University in the first semester of academic year 2016/2017.

II. THEORETICAL BACKGROUND

A. *Probabilistic Thinking and Its Leveling*

The process of probabilistic thinking of the students is a higher order thinking process as it is described by Soeparno (2001:25) who explains about the characteristics of cognitive development by Jean Piaget in which logic and probability belong to formal operation stage. The important aspect developed in mathematics learning is developing the students thinking competence, especially in higher education level. Thus, the lecturer has to pay attention towards this aspect in the classroom. Furthermore, Piaget explains that in order to understand the probability process, the student has to know two basic operations, namely the combination system and proportion calculation. The student has to be able to use combination system which enables him to see all possibilities from the existing elements. He also has to be able to calculate proportion such that he can catch and calculate a probability that $\frac{2}{3} = \frac{4}{6}$.

A probabilistic situation is a problem which involves uncertainty. It is a problem which refers to a random activities or experiment which can result in various possibilities, but the exact result can be determined before. The term of probabilistic will be used to describe the students' thinking in responding various probabilistic situations (Sujadi, 2008). The fundamental material in probabilistic theory which is used to measure the probabilistic thinking of the students includes the sample space, the probability of an event, the conditional probability, and the case of independence (Jones & Thornton, 2005).

Probabilistic thinking ability is one of the various processes of thinking and it is categorized as a higher order thinking process. The level of probabilistic thinking as explained by Jones, et al (1997, 1999) includes 4 levels, namely: (a) Level 1 (Subjective): The students' thinking continuously depends on the subjective reason. (b) Level 2 (Transitional): It is a transition from subjective thinking to quantitative thinking. The students' thinking is naive and often changes in quantifying probability. (c) Level 3 (Informal Quantitative): This level shows the use of generative strategy in

listing the result of the two-stage experiment, and the students have the ability to harmonize and to quantify their thinking about sample space and probability. (d) Level 4 (Numerical): Students can make the appropriate relation of sample space and its probability, and they can use numerical measurement appropriately to describe the probability of an event.

Meanwhile, after researching on the students of VII grade of junior high school, Sujadi (2008) developed these Jones levels by adding one more level before Level 1, namely the Pre-Subjective level. Thus, there are 5 levels of probabilistic thinking stages, namely: (1) Pre-subjective, (2) Subjective, (3) Transitional, (4) Quantitative, and (5) Numerical.

According to Hirsch & O'Donnell (2001), fallacies in probalistic reasoning can happen because of misconception of probability. Several studies about probabilistic thinking have been done by experts. Amir & Williams (1999) explains that culture including language, faith, and experience (e.g. games) influence the knowledge of informal probabilistic of the students. The informal probabilistic knowledge (e.g. informal concepts, intuition, heuristic, result approach, etc) influence the students' probabilistic thinking. The level of probabilistic thinking will influence how the students learn formal probabilistic knowledge (e.g. formal concepts, skill, combinatoric, etc).

Sharma (2012) said that many students use strategies based on their cultural experience (faith, daily life, and school experience) and intuitive strategy, while the results confirm several findings of the other studies and it upper hands what is discussed in the literature study. The use of faith, daily activities, and school experience is more general than what is discussed in the literature. This paper tries to recommend some implications for teachers and researchers. Overall, the findings suggested by Bishop (1994) gives assumption that the formal mathematics education might generate conflict between the culture of students' daily life culture and the mathematics culture. Indeed, probability has some cultural aspects which may differ from the daily experience and faith. The ideas discussed in this section have implication in teaching and research.

B. *Cognitive Style*

Cognitive style, according to Goldstein (1978), refers to individual characteristics in the effort of organizing conceptual environment. In more detail, Aiken (as cited in Kheirzadeh, 2011) defines the cognitive style as the approach to receive, recall, and think which individual tends to use them to understand their environment. From the two opinions above, we can summarize that cognitive style is a way which individual prefer to

use to process information as a response towards the environmental stimuli. There are individuals who get information as it is, and there are other who re-organize the information by their own way.

Cognitive style has two poles which do not show the excellence of one to another. Each pole tends to have positive value in certain circumstance and negative value in the other one. Brown (as cited in Kheirzadeh, 2011) states that among the possible number of cognitive styles, only a few have received the attention of second language researchers. These are ambiguity tolerance, left/right brain functioning, reflectivity/impulsivity, and field-dependence/independence.

Cognitive Style of Field Independent

According to Witkin (1977), individual who has field-independent cognitive style has characteristics as follows: (1) having the ability to analyze and to separate the object from its environment, (2) having the ability to organize objects, (3) having an impersonal orientation, (4) choosing an individual profession, (5) giving priority to internal motivation and internal reinforcement. Characteristics of the individual who has cognitive style type field independent in activities during the learning process, namely: (1) more interested in internal reinforcement and internal motivation, and (2) tend to construct information by themselves. Based on the theories above, individuals who have cognitive style type field independent are individuals who tend to look at an object composed of discrete parts and separated from its environment, able to analyze to separate stimuli from the context, able to restructure, impersonal oriented, and work with motivation and internal reinforcement.

Cognitive Style of Field Dependent

Some of the characteristics of individuals who have cognitive style field dependent has been identified by Witkin (1977) and his colleagues, namely: (1) tend to think globally; (2) tend to accept existing structures, (3) has a social orientation, (4) are likely to choose a profession that emphasizes social skills, (5) tend to follow the objectives given, and (6) tend to work with external motivation and more interested in the external reinforcement.

The characteristics of the individual with field dependent as explained by Ramirez and Castaneda (as cited in Khoury, 2013) are as follows: (1) tend to think globally, saw the object as a unity with the environment, so that perception is influenced by environmental changes, (2) tend to accept existing structures not because it lacks the ability to restructure, (3) has a social orientation, making it seems more thoughtful, sensitive, attentive, friendly, and impressive individual to another, (4)

tend to follow the objectives given, (5) tend to choose a profession or occupation which emphasizes the social skills.

Based on the theories above, it can be concluded that individuals who have cognitive style field dependent are people who tend to think globally, looking at the object and its environment as a single entity, socially oriented, prefer a structured environment, adhering to the existing purpose, and prioritize motivation and external reinforcement. Individuals with fields dependent want learning has to fulfill the following conditions: (1) learning materials are structured, (2) learning objectives are structured properly, (3) external motivation, (4) external reinforcement, and (5) guidance or instructions the teacher.

The difference of individual characteristics between field dependent and field independent can be seen in Table 1. The characteristics difference has advantages and weakness for the students and both of them are important to be considered in learning.

Table 1. Difference of Individual Characteristics of *Field-Dependent* and *Field-Independent*

Field Dependent	Field Independent
- Social Oriented	- Impersonal oriented
- Featuring external motivation	- Featuring internal motivation
- More influenced by external reinforcement	- More influenced by internal reinforcement
- Seeing object globally	- Seeing object consists of discrete parts and separated from its environment.
- Thinking globally	- Thinking analytically
- Tend to choose occupation which prioritizing social skill and humanities	- Tend to choose an occupation which prioritizing analytical competence.

Research by Niaz (as cited in Kozhenikov, 2007) results on the Embedded Figure and Figural Intersection Tests: mobile FI, mobile FD, fixed FI, and fixed FD. Although Niaz did not provide strong evidence that the Figural Intersection Test does, in fact, measure the mobility–fixity dimension, her results revealed an interesting pattern.

This is because in the results of measurements

using instruments Group Embedded Figures Test (GEFT) there are three extreme points of interest to be addressed: the first point is they who got the lowest score, hereinafter referred to fixed FD, the second point is they who scored intermediate which was then called by mobile FI and mobile FD, and the third point is they who obtained the highest score is then called with the fixed FI.

III. METHOD

This research is a descriptive qualitative research, where researchers measure the students related to their probabilistic thinking ability. The material used are sample space, events and probability of an event, random variable and its probability. From the data analysis, it will result in the probabilistic thinking ability of the students, grouped by level, as mentioned in Table 2. Furthermore, we identified the subject's cognitive style. In this study, the identification was carried out based on the test results of cognitive style with GEFT instrument which consists of 25 items divided into three parts, of which 7 item in Part I of the exercise and 18 items in sections II and III as the core of GEFT. Each correct answer which means the subject is able to precisely shape thicken simple images which are hidden in the complex image, given a score of 1. In this research, subjects who score > 9 classified as FI and subjects who score ≤ 9 classified as FD. This classification is broken down by the existing three extreme points: (1) Lower extreme or pure FD group (fixed FD): subjects who received a score of 0-6, (2) the middle extreme or group between FD and FI (mobile FD, and mobile FI): subjects who received scores between 7-12, and (3) the upper extreme or pure FI group (fixed FI): subjects who received a score of 13-18, so that in its analysis of the follow three extreme points.

The research subject was the students of mathematics education study program of Ahmad Dahlan University in the academic year of 2016/2017. There were 2 classrooms, 19 students of class A and 39 students of class B. Thus the number of the subject was 58 students.

The results of measurements of probabilistic thinking ability, and the categorization of cognitive style, both are combined to determine subject that meets the predefined categories. The data analysis was done based on subjects who meet the category. Besides, we further conducted interview towards students selected as a representative of each level in the process of probabilistic thinking. This is done to delve into some of the constraints associated with the probabilistic thinking ability and their cognitive style categories respectively.

Before all classes were given treatment, first we measured their probabilistic thinking process. From the student test results, we know the student

group level of probabilistic thinking ability, namely: (a) Level 1 (Subjective): The students' thinking continuously depends on the subjective reason. (b) Level 2 (Transitional): It is a transition from subjective thinking to quantitative thinking. The students' thinking is naïve and oftenly changes in quantifying probability. (c) Level 3 (Informal Quantitative): This level shows the use of generative strategy in listing the result of the two-stage experiment, and the students have the ability to harmonize and to quantify their thinking about sample space and probability. (d) Level 4 (Numerical): Students can make the appropriate relation of sample space and its probability, and they can use numerical measurement appropriately to describe the probability of an event. The guidance of the instrument can be seen in Table 2.

Table 2. Instrument Guide and Indicator of Probabilistic Thinking Level of The Students of Mathematics Education of Ahmad Dahlan University In Probability Subject

Sub topi c	Level 1 (Subject ive)	Level 2 (Transiti onal)	LEVEL 3 (Informal - Quantitative	LEVEL 4 (Numeri cal)
Sa mpl e Spa ce	• Const ructi ng the elem ents of samp le spac e inco mple tely and with out a patte rn.	• Const ructin g the elem ents of sampl e space almos t compl etely and with a patter n.	• Const ructi ng the elem ents of samp le spac e com plete ly but havi ng no patte rn.	• Const ructin g the elem ents of sampl e space comple tely and follo wing a patter n.
Event and Its Proba bility	• Not defini ng nor deter minin g the event and its proba bility	• Defini ng and deter minin g the event but some fallaci es still are found.	• Const ructin g elemen ts of an event by follo wing certai n patter n • Writi ng all elemen ts of	• Constr ucting elemen ts of an event by follow ing certai n patter n • Deter minin g the proba bility

Furthermore, from the results of measurements of probabilistic thinking ability, and the categorization of cognitive style, both are combined to determine a subject that meets the predefined categories. The data processing based on data from a subject that meets these categories is shown in Table 3.

In order to answer the research problem, we analyzed the data by using mix-methods, which combines quantitative analysis and qualitative analysis based on the result of the test, leveling categorization, and interviews.

Table 3. Combination Level of Probabilistic Thinking Ability and Cognitive Style Category

	<i>Fixed FD</i>	<i>Mobile FD, and Mobile FI</i>	<i>Fixed FI</i>
Level 1 (Subjective)	Level 1, and <i>Fixed FD</i>	Level 1, and (<i>mobile FD, and mobile FI</i>)	Level 1, and <i>fixed FI</i>
Level 2 (Transitional)	Level 2, and <i>Fixed FD</i>	Level 2, and (<i>mobile FD, and mobile FI</i>)	Level 2, and <i>fixed FI</i>
Level 3 (Informal - Quantitative)	Level 3, and <i>Fixed FD</i>	Level 3, and (<i>mobile FD, and mobile FI</i>)	Level 3, and <i>fixed FI</i>
Level 4 (Numerical)	Level 4, and <i>Fixed FD</i>	Level 4, and (<i>mobile FD, and mobile FI</i>)	Level 4, and <i>fixed FI</i>

IV. RESULTS AND DISCUSSION

The result of data collection both probabilistic thinking ability and cognitive style are shown in Table 4. It shows that 58 research subjects can be categorized as follows: 30 students or 51.724% belong to Level 1 (Subjective), 13 students or 22.414% belong to Level 3 (Informal-Quantitative), 10 students or 17.241% belong to Level 2 (Transitional), and 5 students or 8.621% belong to Level 4 (Numerical).

Table 4 shows that among 58 subjects, the descending order of the cognitive style is: 29 students or 50.000% belong to *mobile FD and mobile FI*, 17 students or 29.310% belong to *Fixed FD*, and 12 students or 20.690% belong to *Fixed FI*.

The highest percentage of the cognitive style is the category of Level 1 is *mobile FD and mobile FI* (25.862%), followed by *Fixed FD* (13.793%), and *Fixed FI* (12.069%). These results show that the students' cognitive style is dominated by *mobile FD and mobile FI*. However, the

probabilistic thinking ability at the Level 1 viewed from the cognitive style between *fixed FD* and *fixed FI* is relatively balanced. The results of interviews with the subjects in this level are: (1) they were still confused on the number of elements of the sample space because the number of students in the class is unknown, (2) they got difficulty in understanding the problem, (3) they thought that the problems were too difficult and it was lack of time to solve them, see Figure 1.

Table 4. Measurement Result of Probabilistic Thinking Ability Combined with Cognitive Style

	<i>Fixed FD</i>	<i>Mobile FD, and Mobile FI</i>	<i>Fixed FI</i>	Sum
Level 1 (Subjective)	8 (13.793%)	15 (25.862%)	7 (12.069%)	30 (51.724%)
Level 2 (Transitional)	6 (10.345%)	3 (5.172%)	1 (1.724%)	10 (17.241%)
Level 3 (Informal - Quantitative)	2 (3.448%)	9 (15.517%)	2 (3.448%)	13 (22.414%)
Level 4 (Numerical)	1 (1.724%)	2 (3.448%)	2 (3.448%)	5 (8.621%)
Sum	17 (29.310%)	29 (50.000%)	12 (20.690%)	58 (100%)

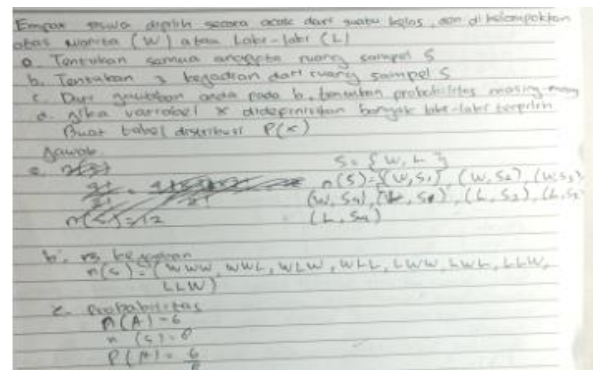


Figure 1 .Sample of Student's Answer Sheet on Probabilistic Thinking Ability Level 1 and Cognitive Style

These results show that they still have not been able to develop probabilistic thinking well. They are still influenced by subjective things. Their level of understanding of the problem/literacy is still low, and this level has the greatest percentage compared to another level.

The highest percentage of the cognitive style is the category of Level 2 is *fixed FD* (10.345%), followed by *mobile FD and mobile FI* (5.172%), and *Fixed FI* (1.724%). These results indicate that students' cognitive style is dominated by *fixed FD*. While the probabilistic thinking ability on Level 2 viewed from the smallest percentage of cognitive style is *fixed FI*. The results of interviews with the subjects that are in this position are: (1) They are still confused with the problems given since when

they compare with the previous problem, it is vastly different, (2) They were confused in writing a number of elements of the sample space because the number of students in the class is unknown, (3) They forgot the formula, (4) They thought that the problems were too difficult and it was lack of time allocation, see Figure 2.

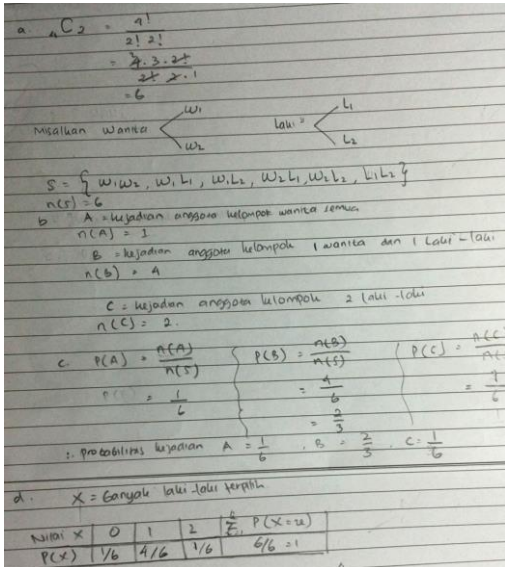


Figure 2. Sample Answer Sheet Student on Probabilistic Thinking Ability Level 2 and Cognitive Style

These results show that they still have not been able to develop probabilistic thinking well, they are still affected by problems that have been tested, the level of understanding of the problem/literacy is still low, and although this level has a lower percentage than the other level, it should be concerned.

The highest percentage of the cognitive style in the Level 3 is the category of *mobile FD* and *mobile FI* (15.517%), followed by *fixed FD* and *Fixed FI* which have the same percentage (3.414%). These results indicate that students' cognitive style is dominated by *mobile FD* and *mobile FI*. While the probabilistic thinking ability on Level 3 viewed from the cognitive style is a balance between *fixed FD* and *fixed FI*.

The results of interviews with the subjects in this position are: (1) they are still a little difficulty in understanding the problem, (2) they are assessing the problem much more than the previous year, (3) their difficulty in determining the amount of the sample space S, but they keep trying, see Figure 3.

These results show that they still have not been able to develop probabilistic thinking well, though they are still affected by problems that have been tested, the level of understanding of the problem/literacy is good enough, and although this level is not as significant as the other level, it should be concerned.

The percentage of the cognitive style in the Level 4 is the category of *fixed FD* (1.724%), followed by *mobile FD* and *mobile FI* and *Fixed FI* which have the same percentage (3.448%). The results show that there is no cognitive style which dominates the categories. The interesting thing is that there is still a percentage of *fixed FD* in this level.

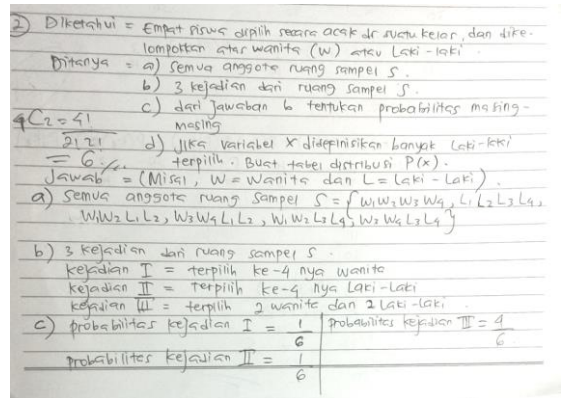


Figure 3. Sample Answer Sheet Student on Probabilistic Thinking Ability Level 3 and Cognitive Style

The result of interview towards subjects in this position is: (1) They think that the problems are challenging, (2) They tried to understand the problem such that they can determine all elements of the sample space, (3) They used strategy to keep trying, (3) it was lack of time, (4) the problem is more difficult than the previous year. These results show that they are able to develop probabilistic thinking well, they have the will to solve the problems properly, so that they can determine all the members of the sample space S. The level of understanding of the problem/literacy is good, this level has the smallest percentage compared to another level, but it should be concerned on how to increase the number or percentage for this level, see Figure 4.

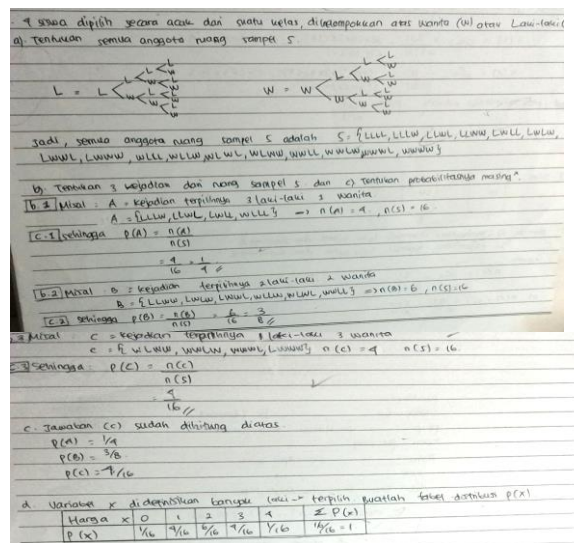


Figure 4. Sample Answer Sheet Student on Probabilistic Thinking

Ability Level 4 and Cognitive Style

V. CONCLUSION

A brief conclusion can be drawn as follows.

- The highest percentage of the cognitive style in the probabilistic thinking Level 1 (51.724%) is dominated by *mobile FD* and *mobile FI*. However, the probabilistic thinking ability at the Level 1 viewed from the cognitive style between *fixed FD* and *fixed FI* is relatively balanced. The results of interviews with the subjects in this level are: they still have not been able to develop probabilistic thinking well. They are still influenced by subjective things. Their level of understanding of the problem/literacy is still low, and this level has the greatest percentage compared to another level.
- The highest percentage of the cognitive style in the probabilistic thinking Level 2 (17.241%) is dominated by *fixed FD*. While the probabilistic thinking ability on Level 2 viewed from the smallest percentage of cognitive style is *fixed FI*. The results of interviews with the subjects that are in this position are: they still have not been able to develop probabilistic thinking well, they are still affected by problems that have been tested, the level of understanding of the problem/literacy is still low, and although this level has a lower percentage than the other level, it should be concerned.
- The highest percentage of the cognitive style in the probabilistic thinking Level 3 (22.414%) is dominated by *mobile FD* and *mobile FI*. While the probabilistic thinking ability on Level 3 viewed from the cognitive style is a balance between *fixed FD* and *fixed FI*. The results of interviews with the subjects in this position are: they still have not been able to develop probabilistic thinking well, though they are still affected by problems that have been tested, the level of understanding of the problem/literacy is good enough, and although this level is not as significant as the other level, it should be concerned.
- The smallest percentage of cognitive style in the probabilistic thinking Level 4 (8.621%) is the category of *fixed FD* (1.724%). There is no cognitive style which dominates the categories. The interesting thing is that there is still a percentage of *fixed FD* in this level. The result of interview are: they are able to develop probabilistic thinking well, they have the will to solve the problems properly, so that they can determine all the members of the sample space *S*. The level of understanding of the problem/literacy is good, this level has the smallest percentage compared to another level, but it should be concerned on how to increase the number or percentage for this level.

The descending order of the percentage for probabilistic thinking ability is 51.724% of Level

1 (subjective), 17.241% of Level 3 (informal-quantitative), 17.241% of Level 2 (transitional), and 8.621% of Level 4 (numerical). While the descending order of the percentage of students' cognitive style is as follows: 50.000% of *mobile FD* and *mobile FI*, 29.310% of *fixed FD*, and 20.690% of *fixed FI*.

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