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Literacy Description of Probability for the Senior Secondary School Students in Makassar City

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Abstract. This development research has obtained an assessment model of probability literacy in senior secondary school students. Such literacy is crucial because the statistical assessment as part of mathematics today in senior secondary schools tend to emphasize technical procedures with many mathematical formulae. Literacy of probability consists of five basic competencies, namely: (1) understanding the concept of probability, (2) insight into the application of the probability concepts, (3) skills in calculating the value of probability, (4) careful interpretation of the probability value, and (5) skills in visualization and communication of probabilities and conclusion that may be drawn from them. This study maps ability levels in these five competencies across Makassar City, identifying weaknesses in several questions about probability literacy that need to be revised. The emphasis on the concept of literacy is a major strategy to improve learning in secondary schools. These five competencies are mapped according to the type of questions that refer to the guidelines for implementing the skills of the 21st-century Curriculum 2013 in senior secondary school. The level of probability literacy achieved by high school students in Makassar is categorized as medium (47%-72%), highlighting an overall need for improved learning strategies that emphasize the five basic competencies. Additionally, morning classes are seen to correspond to a higher level of achievement than afternoon classes, for all five competencies.

1. Introduction

Today, statistical material is still in the senior secondary school mathematics curriculum, even though statistics and mathematics have different paradigms of thinking. Statistical proposals as a problem-solving process consist of four components: (1) formulating questions, (2) collecting data, (3) analyzing data, and (4) interpreting data [1]. In line with the development of science and technology, learning mathematics in accordance with the 2013 Curriculum needs to be designed to accommodate the 21st Century students' skill needs. The three main perspectives on the quantification of uncertainty which are classical, frequent, and subjective interpretations of probability are also promoted [2]. While the first two are emphasized in most school curriculum materials, the subjective notion of probability either is neglected or has minimal mention. Yet, it is closely related to what people commonly used for everyday reasoning.

In general, learning of probability as a part of mathematics aims to make students have the skills or literacies of probability [3]. Probability skills are part of life skills that must be possessed by students, especially in the development of reasoning, communication, and solving problems



encountered in the daily lives of students. Probability is always used in all aspects of life in the 21st Century.

Learning of probability in senior secondary schools is directed to encourage students to find out from various sources, able to formulate problems, not just solve simple problems in everyday life. Besides, learning is directed to train students to think logically and creatively rather than just to think mechanically and be able to work together and collaborate in solving problems. Thus, probability literacy is a strong basis for statistical literacy. The objectives of this study are to identify the level of probability literacy achieved by the senior secondary school students in Makassar as well as to compare the level of achievement between morning classes and afternoon classes.

1.1. Theoretical framework

1.1.1. Formulation of the Problems. Based on the writer's observation, statistical learning in general as part of mathematics in senior secondary school today still emphasizes technical procedures with so many formulas. This kind of learning is boring and scary for students. Therefore, it is necessary to formulate learning strategies that are challenging and fun. The study of true statistics emphasizes the literacy of statistics that sees statistics not only as a presentation in the form of numbers but also as the numbers with the context. Probability is a basic concept that is crucial in statistics. Thus, the questions that need to be answered in this study [4] are as follows:

1. How do senior secondary school students understand the concept of probability?
2. How do the senior secondary school students' insights apply the concept of probability in a real-life context?
3. What is the ability of senior secondary school students in calculating the value of probability?
4. What is the accuracy of senior secondary school students in interpreting the calculated probability value?
5. How are senior secondary school students' skills in visualizing and communicating information from the value of probability?

To answer these five questions, a probability literacy assessment instrument has been developed. The assessment instrument was developed through five steps [5] as follows:

1. formulating the operational definition of probability literacy;
2. making instrument baselines;
3. prepare an appraisal draft containing the items of the instrument;
4. conduct expert tests on the validity of the items of the instrument;
5. conduct empirical tests to obtain valid and reliable instruments, and answer the question: Is the theoretical construction that builds the operational definition of probability literacy supported by empirical facts?

1.1.2 Position of Probability in the Senior Secondary School Curriculum. Material of probability becomes part of the mathematics material in senior secondary school. The mathematics competency of basic education and secondary education is described by one topic, namely statistics and probability [3]. Using descriptive statistics from grouped data, enumeration rules, and probability in solving problems of daily life is a competency that must be obtained by senior secondary school students. The use of statistics includes (measures of concentration and data distribution) presented in the form of frequency distribution tables and histograms, as well as the rules of enumeration (addition, multiplication, permutation, combination) probability values. Using inferential statistics which include the distribution of binomial probabilities related to the binomial probability function, and the characteristics of normally distributed data, is part of the senior secondary school curriculum.

The syllabus of statistics must be flexible, contextual, and provide opportunities for teachers to develop and implement learning, as well as accommodate local advantages. Based on these principles, the syllabus component covers basic competencies, learning materials, and learning activities. The learning description contained in the syllabus is an alternative activity that is designed based on activities. The learning is alternative and inspiring so the teacher can develop various models that are suitable to the characteristics of each subject. In implementing this syllabus, teachers are expected to be creative in developing materials, managing the learning process, using learning methods and models, which are adapted to the situation and conditions of the community and the level of development of students' abilities.

Mathematics education [3] including statistics in schools is expected to contribute to supporting the achievement of primary and secondary education graduate competencies through learning experiences, to be able to:

1. understand the concepts and apply mathematical procedures in everyday life;
2. make a generalization based on patterns, facts, phenomena, or existing data;
3. carry out mathematical operations for simplification, and analysis of existing components;
4. carry out mathematical reasoning which includes making guesses and verifying them;
5. solve problems and communicate ideas through symbols, tables, diagrams, or other media to clarify the situation or problem;
6. foster positive attitudes such as logical, critical, careful, thorough, and do not give up easily in solving problems.

1.2. Statistical Literacy

Statistical learning needs to emphasize statistical literacy in building statistical thinking. From the previous discussions, it can be taken the operational formulation of statistical literacy includes five basic competencies: (1) understanding statistical concepts, (2) insight into the application of statistical concepts in the real world, (3) calculating skills and making graphics, (4) the accuracy of statistical interpretation; and (5) the visualization and communication skills of the results of statistical analysis. This definition is derived from the ideas and results of some researches [6-12].

Part of statistical literacy is the ability to discuss individual data understanding, reactions to data, and concerns about conclusions, and communication about statistical information [13]. The statistical community stresses that educated citizens must understand the basic concepts of statistics, interpret and critically evaluate statistical messages so that they can detect statistical abuse by policymakers, such as doctors, governments, and others. At the same time, related to the problem of statistical literacy is the ability to communicate, the relevance and the importance of statistics for non-statisticians. The ability to communicate statistically, evidence is identified as an important theme in the relationship between statistics and the outside world and is a big problem for the statistician profession. Addressing the question of communicating statistically, that cultural change is needed so that information techniques are communicated to practitioners and the public in such a way that they can use and understand them. The best way for further statistical literacy is to educate statistical consumers and people who present statistical facts to the public.

2. Methods

This research was conducted in the odd semester and even semester of the 2019 school year. The research subjects were high school students in the city of Makassar. The Plomp development model used is in line with the development of an assessment instrument that uses the development model from Thiagarajan, Semmel, and Semmel [14], the 4-D model (Define, Design, Develop, and Disseminate). Researchers adapted this model to the 4-P model (Definition, Design, Development, and Dissemination). An explanation of development research can be seen in Plomp [15]. The

instrument developed was in the form of a basic test of probability literacy in the form of multiple-choice questions of 30 questions, the lattices test probability literacy can be seen in Table 1.

Table 1. The lattices test probability literacy

No.	Competencies/Indicators	Question Numbers
1.	understanding concept of probability	1, 2, 3, 4, 5, 6
2.	insight into the application of the probability concept	7, 8, 9, 10, 11, 12
3.	skills in calculating the value of probability	13, 14, 15, 16, 17, 18
4.	careful interpretation of the probability value	19, 20, 21, 22, 23, 24
5.	visualization and communication skills for information from the probability values	25, 26, 27, 28, 29, 30

The instrument that has been developed is applied to the samples. Samples were taken at SMA Negeri 11 Makassar on September 26 - 27, 2019. SMA Negeri 11 was chosen as its accreditation was "A", which could represent all senior secondary schools in Makassar City. All senior secondary schools in Makassar City are accredited A except for SMA Negeri 20 which is accredited B. Trials and data collection were followed by 83 grade XII students consisting of three classes Matematika dan Ilmu Pengetahuan Alam (MIA), namely MIA-2 (28 students), MIA-3 (24 students), and MIA-4 (31 students).

3. Result

3.1. Data analysis

Data analysis is carried out in two stages:

1. analysis of validity, reliability, difficulty level, discrimination levels, and the functioning of the distractors instrument of probability literacy assessment [16];
2. data analysis results from the use of probability literacy assessment instruments on a sample of selected students (descriptive and inferential analysis).

A description of the difficulty level of the questions is shown in Table 2. Then, the discrimination levels of the questions are shown in Table 3.

Table 2. Distribution of the difficulty level of probability literacy according to indicators

No	Competencies/Indicators	easy	moderate	difficult	Total
1.	understanding concept of probability	1	5	0	6
2.	insight into the application of the probability concept	1	4	1	6
3.	skills in calculating the value of probability	3	2	1	6
4.	careful interpretation of the probability value	3	3	0	6
5.	visualization and communication skills for information from the probability values (KVK)	4	1	1	6
Total		12	15	3	30
Percentage		40	50	10	100

Table 3. Distribution of the discrimination levels of probability literacy according to indicators

Discrimination levels	Category	Frequency
<i>Negative Sign</i>	<i>No discrimination</i>	2
<i>0.00 – 0.19</i>	<i>Weak discrimination</i>	12
<i>0.20 – 0.39</i>	<i>Moderate discrimination</i>	14
<i>0.40 – 0.69</i>	<i>Good discrimination</i>	2
<i>0.70 – 1.00</i>	<i>Very good discrimination</i>	0

3.2. Construct validity

To guarantee the validity of the instrument, the validity of the construct needs to be tested. Confirmatory factor analysis was performed to see the validity of the construct based on the operational definition of the variable. Confirmatory factor analysis was performed with a latent variable model. This analysis confirms the operational definition of probability literacy in five competencies (indicators) as shown in Figure 1.

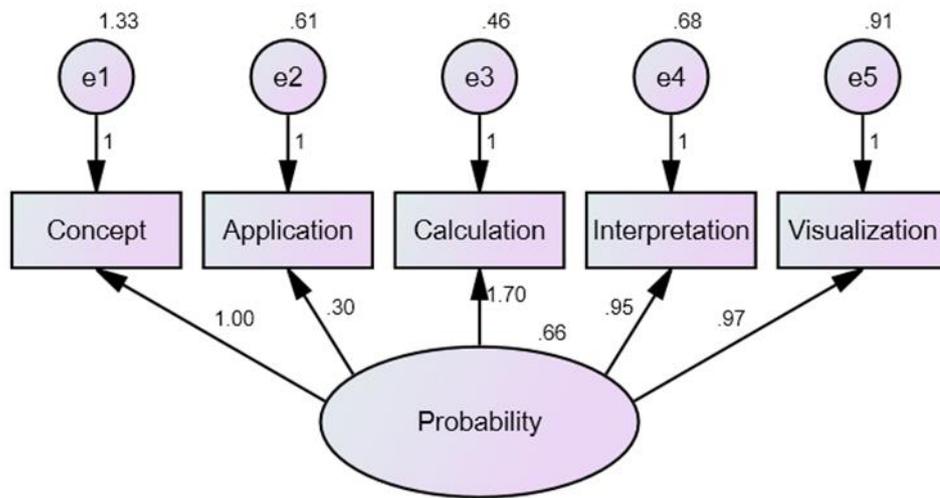


Figure 1. Confirmatory factor analysis for probability literacy

The goodness of test of the model gives the value of Chi-square = 7.563, degrees of freedom = 5, and probability level = 0.182. As the value of $p = 0.182 > 0.05$, this model can be accepted with a confidence level of 95% (level of significance $\alpha = 5\%$). The acceptance of this model is also in accordance with the support of the Goodness of Fit Index (GFI) = 0.963 and the Adjusted Goodness of Fit Index (AGFI) = 0.888 and the Root Mean square Residual (RMR) = 0.072 with sample size = 83. The contribution of each indicator partially is also been seen in Table 4. From this table, it was seen that all indicators were significant with 99% confidence level ($p < 0.001$) and 98% ($p = 0.016$). These results indicate that the operational definition of variables is supported by empirical facts.

Table 4. Results for the validity of the construct test

No	Competencies		Est.	S.E.	C.R	P
1.	understanding concept of probability	← PL	1.000			
2.	insight into the application of the probability concept	← PL	1.702	0.339	5.022	<0.001
3.	skills in calculating the value of probability	← PL	0.304	0.126	2.419	0.016
4.	careful interpretation of the probability value	← PL	0.950	0.204	4.659	<0.001
5.	visualization and communication skills for information from the probability values	← PL	0.971	0.218	4.449	<0.001

Note: PL: probability literacy

3.3. Descriptive Data Analysis

Overall achievements of 83 students can be seen in Table 5. From the average value, the competencies that achieve the highest and the lowest level of achievement are "visualization and communication skills for information from the probability values" (72%) and "insight into the application of the probability concept" (47%), respectively. The proportion achievement for other competencies, that are, "careful interpretation of the probability value", "skills in calculating the value of probability", and "understanding concept of probability" are 67%, 55%, and 51%, respectively. These results can provide an overview for secondary school students accredited "A" in Makassar City.

Table 5. Means and standard deviations of probability literacy for 83 high school students

No	Competencies	Means	% Achievement	Standard deviations
1.	understanding concept of probability	3.0723	51	1.42095
2.	insight into the application of the probability concept	2.8313	47	0.82372
3.	skills in calculating the value of probability	3.2892	55	1.55022
4.	careful interpretation of the probability value	4.1326	67	1.13450
5.	visualization and communication skills for information from the probability values	4.3494	72	1.24385

The maximum score for every competency is 6.0

Percentage of achievement < 25 , $25 - 75$, and > 75 are categorized low, medium, and high, respectively [16]. Based on this categorization, it can be concluded that overall student achievement is categorized as medium (47% and 72%).

3.4. Inferential Data Analysis

The three classes of grade XII that were sampled experienced different learning processes time. MIA-2 classes studied in the morning starting at 7.30, while MIA-3 and MIA-4 classes studied in the afternoon starting at 13.00. Table 6 shows the distribution of results based on classes and basic competency of probability literacy.

Table 6. Average grades according to students' competencies and classes

No	Competencies	MIA-2	MIA-3	MIA-4
1.	understanding concept of probability	3.7500	2.2500	3.0968
2.	insight into the application of the probability concept	4.5714	2.6667	2.6129
3.	skills in calculating the value of probability	3.0714	2.5833	2.8065
4.	careful interpretation of the probability value	4.7143	3.6250	4.0000
5.	visualization and communication skills for information from the probability values	4.6429	4.1250	4.2581

The maximum score for every competency is 6.0

Results of two-way variance analysis can be seen in Table 7. These results indicated that there are differences among competence, the value of $F = 8.545$ with $df = 4$ and $p = 0.005$. There was also a significant difference between classes (the value of $F = 10.148$ with $df = 2$ and $p = 0.006$). Visualization of the differences can be seen in Figure 2. From Table 7 and Figure 2, it can be

concluded that the morning class (MIA-2) are seen significantly higher level of achievement than the afternoon classes (MIA-3 and MIA-4) for all five competencies of probability literacy.

Table 7. Results of two-way variance analysis

Dependent Variable: Achievement

Source	Type III Ss	df	Mean Square	<i>F</i>	<i>p</i>
Corrected Model	8.657 ^a	6	1.443	9.079	0.003
Intercept	185.675	1	185.675	1168.391	<0.001
Competence	5.432	4	1.358	8.545	0.005
Classes	3.225	2	1.613	10.148	0.006
Error	1.271	8	0.159		
Total	195.604	15			
Corrected Total	9.928	14			

a. R Squared = .872 (Adjusted R Squared = .776)

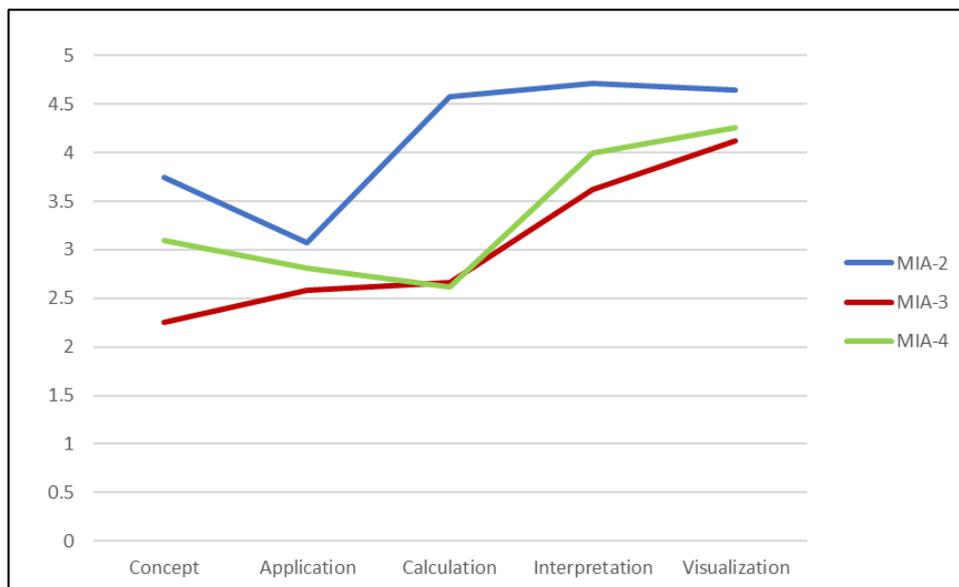


Figure 2. Achievement diagram according to competency and class

To conclude this section, we can refer to the ideas of Leavy and Hourigan [17] who design simple activities to provide exercises in noting probabilities, reviewing language uncertainty, and involving students in discussions relating to the results of random events. Students are placed in small groups. Bags with six marbles are displayed: 3 yellow and 3 red. The teacher mixed marbles in a basket and said he would choose one marble. He then asked a series of questions:

- What are the possible outcomes? What color is the counter?
- What is the probability of choosing yellow marbles? Why?
- Do you think this is a fair game? Is there a probability of getting yellow or red?
- Let's agree that this is a fair game and the chance to choose yellow marbles is 50:50 or 0.5 of the number of shots.
- If I played the game the same way 6 times, how many times do you think I would choose the yellow marble?

Learners discuss questions in their groups and record their answers. They then played the game 6 times. Each time they were instructed to shake the bag, take it without looking at a marble and record the color on their tape, and then put the marble back in the bag.

When students have played the game 6 times, they add a total of red and yellow marbles. The following discussion occurs with one group:

- Teacher: If I take marbles six times, how many yellow marbles do you expect?
- Andis: Three yellow. Because there are 3 yellow marbles from 6 marbles in total.
- Cian: You might get 3 yellow marbles. But you, it doesn't have to happen. You can get 4 red and 2 yellow. Of course, this game can be upgraded to other contexts.

Learners are involved in play activities for the high school level. It can even start from the elementary school level.

4. Conclusions

Based on the results of data analysis, it can be concluded that overall student achievement is categorized as medium (47% - 72%). Learning strategies still need to be improved in every statistical teaching, especially the topic of probability in schools. The probability literacy assessment model for high school students that has been developed can be widely used after some problems are revised. As probability literacy is an important aspect of learning in school, the following points are suggested. Every probability material taught in school needs to emphasize five competencies as follows: (1) understanding the concept of probability; (2) ability to apply probability concepts in relevant contexts; (3) skills in calculating the value of probability; (4) careful interpretation of the probability value; (5) the skill of visualization and communication of the results of statistical analysis involving the concept of probability and policy implications that can be taken based on these results. The development of instruments to measure the literacy competencies of students' probability needs to be further investigated in a special study. Besides, the morning class is a significantly higher level of achievement than the afternoon classes for all five competencies of probability literacy.

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