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## Statistics literacy: what, why and how?

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**Abstract.** 21st Century learning directs human resources to become literate societies, where human resources can obtain information, organize, facilitate, communicate in various contexts. Statistical literacy and mathematical literacy are among the developed literacy. Statistics Literacy and mathematical literacy might be like literacy about the same discipline, but is that the case? What exactly is statistical literacy? How is the mindset designed to be built in statistical literacy? How to calculate the statistical literacy of a person? Why has it become an important competency for society today? This paper will try to explain it.

### 1. Introduction

In this era of globalization, the flow of information is increasingly difficult to stem. Information from various parts of the world can be obtained quickly. Under these conditions, people are required to be smart in responding to information so as not to be trapped in misleading information. In the world of statistics, data can be interpreted as a collection of information or all facts or information about something that can be used as material for organizing information. [1]. This information can be presented in various forms, such as distribution tables, graphs, curves, and diagrams. The data presentation is intended so that the data is more easily understood by the reader, as well as easy to interpret [1]. But the fact that there are some people has not been able to translate the data or information presented in a table or graph. A person's ability to interpret a data can be said as a literacy ability of statistics. Literacy includes basic and important skills that can be used in understanding statistical information or research results. These skills include being able to organize data, create and display tables, and work with different data representations. Statistical literacy also includes an understanding of concepts, vocabulary, and symbols, and includes an understanding of probability as a measure of uncertainty [2].

Wardhani, S & Rumiati [3] stated that "Statistical literacy is the ability of a person to formulate, apply and interpret mathematics in various contexts, including the ability to make reasoning statistically and use concepts, procedures, and facts to describe, explain or predict an event". The definition of statistical literacy is not merely focused on minimal knowledge in mathematics. Static literacy also includes doing mathematics and using statistical concepts in other fields and aspects of everyday life. From solving simple problems to complex problems. More broadly statistical literacy can be understood as an individual's capacity to recognize and understand the role that mathematics plays in real life, to be able to provide judgments and judgments appropriately, utilize statistical knowledge in everyday life [4]



Statistics is one of the mathematical literacy contents that is included in the data content with the key concept is the presentation and interpretation of data [5]. Kimura in Aoyama and Stephens [6] states that a key component of statistical literacy is the ability to process qualitative information from quantitative information and or create new information from both qualitative and quantitative information.

The purpose of this study is to examine statistical literacy. What is statistical literacy? What is the position of statistical literacy in terms of mathematical reasoning and statistical reasoning? Whether statistical literacy is part of mathematics or statistical literacy is something different from mathematics.

## 2. Method

This article was prepared using the literature review method. The literature review is a survey of scientific articles, books and other sources that are relevant to a particular problem, area of research, or theory, and as such, provides a description, summary, and critical evaluation of these works. Literature reviews are designed to provide an overview of sources to explore when researching a particular topic and to show the reader that the research carried out by the field [7] By using this method, the article is expected to present useful, in-depth and holistic information.

In this article discusses journals related to Statistics, Statistical Literacy and Mathematical Literacy. The journals consist of national journals and international journals. These international journals include Statistical Literacy: Meanings, Components, Responsibilities. The Challenge of Developing Statistical Literacy by Aoyama, K. & Stephens, K. (2003); Statistical Literacy, Reasoning, And Thinking: Goals, Definitions, And Challenges. The Challenge of Developing Statistical Literacy, Reasoning, and Thinking by Ben-Zvi, D. & Garfield, J. (2004); Statistical Literacy, Reasoning, and Learning: A Commentary. Journal of Statistics Education by delMas R. 92002); Statistical Literacy: Meanings, Components, Responsibilities. The Challenge of Developing Statistical Literacy, Reasoning and Thinking by Gal, I.(2004); New Pedagogy and New Content: The Case of Statistics. International Statistics Review by Moore, D. S. (1997); Enhancing Statistical Literacy: Enriching our Society, Journal of the American Statistical Association by Wallman, K. K. (1993); Assessing statistical literacy through the use of media surveys. In I. Gal & J. Garfield, (Eds.), The assessment challenge in statistics education by Watson, J. (1997).

National journals and proceedings discussed include: Profil Kemampuan Literasi Statistis Mahasiswa Jurusan Pendidikan Matematika Universitas Sultan Ageng Tirtayasa, Aksioma Jurnal Pendidikan Matematika FKIP Universitas Muhammadiyah Metro by Khaerunnisa, E.&Pamungkas, S.A. (2017); Literasi Matematika: Apa Mengapa dan Bagaimana? Proseeding Seminar Nasional Matematika Dan Pendidikan Matematika UNY by Sari, RHN. (2015); and Pendidikan Statistika untuk Generasi Lebih Baik. Proceeding Seminar Nasional Statistika VII, Bale Sawala Universitas Padjajaran by Tiro, M.A. (2018).

## 3. Discussion

In this section, we will examine statistical reasoning and mathematical reasoning and its relation to statistical literacy.

### *Statistical Reasoning and Mathematical Reasoning*

Moore [8] argues that statistics are mathematical science but are not a branch of mathematics, with more specific thinking characteristics compared to mathematical theories. Statistics and mathematics are like two things that are one entity. However, both have different ways of thinking. Statistical thinking is inductive-probabilistic while mathematical thinking is deterministic deductive [9]. Statistical reasoning is defined as a way of reasoning using statistical ideas and can be understood from statistical information. This reasoning includes data interpretation, a data representation of statistical summary data. John Wilder Tukey [10] argues that statistics is not a branch of mathematics or applied mathematics, but an integral part of science.

A similar view was expressed by Gal and Garfield [11] that statistical reasoning and mathematical reasoning are two different things. Here are some views:

1. In statistics, data is seen as numbers with a context. This context motivates to make the procedure and it becomes a source of meaning and a basis for an interpretation of the results of these activities.
2. The determination of data is a characteristic of statistical investigation, which distinguishes it from mathematical exploration which has a higher level of precision.
3. Mathematical concepts and procedures are used as part of solving statistical problems. However, the need for accurate calculation is required, and the use of technology to help the situation is normal and the intensity increases from time to time by the development of the technology itself.
4. Many statistical problems do not have a single mathematical solution, starting with questions and the results are opinions supported by findings and assumptions. The answers need to be evaluated about the quality of reasoning, the suitability of the proposed method, the nature and evidence of the data used.

In line with the previous opinion delMas [12] distinguishes the types of statistical reasoning and mathematical reasoning seen from the content of reasoning. Statistical reasoning content is in the form of objects that are contextual while mathematical reasoning objects are abstract. The construct of thinking and reasoning statistically as mentioned above is part of the statistical literacy of women

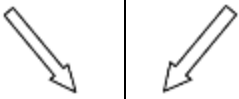
#### *Statistics Literacy*

Statistics can be seen as knowledge about variability and become a means to explain the phenomenon of uncertainty that always occurs in life, in the workplace, and in science itself. Whereas statistical literacy includes the ability to interpret, critically evaluate, and communicate information and statistical messages Gal [13]. Furthermore, delMas [12] states that basic statistical literacy refers to the competence of identification or recognition, computing, construction in handling statistical problems.

Wallman [14] defines statistical literacy as the ability to comprehend and critically evaluate the results of statistical analysis that permeates our daily lives - coupled with the ability to appreciate the contribution that statistical thinking can make in public and private, professional and personal decisions. Watson [15] presents a statistical literacy framework consisting of three levels with increasing sophistication: 1) a basic understanding of probability and statistical terminology; 2) understanding statistical languages and concepts when they are embedded in the context of broader social discussions; 3) questioning attitudes that can be assumed when applying concepts to oppose claims made without an appropriate statistical basis.

Wardhani, S., and Rumiati [3] transformed the principles of statistical literacy into three components namely content, process and context components. And the three components are translated in by Khaerunnisa, E., and Pamungkas, AB [4] include data uncertainty, to represent content components and process components including being able to formulate hypotheses, able to use concepts, facts, procedures, and reasoning to prove hypotheses, interpret (interpret ) problems in conclusions and context components, namely the context of science (scientific). Gal, I [13] models literacy statistics by involving two components, knowledge and dispositional. The knowledge component consists of five cognitive elements, namely: literacy skills, statistical knowledge, mathematical knowledge, context knowledge, and critical questions and while the disposition component consists of two elements, namely: critical attitude and beliefs and beliefs and attitudes.

**Table 1. Statistical Literacy**

<b>Knowledge elements</b>	<b>Dispositional elements</b>
Literacy skills Statistical knowledge Mathematical knowledge Context knowledge Critical Questions	Beliefs and Attitude Critical stance
	
<b>Statistical Literacy</b>	

Furthermore, Tiro, M.A. [16] describe the operational formulation of statistical literacy which includes five basic competencies: (1) understanding statistical concepts, (2) insight into the application of statistical concepts, (3) numeracy skills and making graphics, (4) interpretation skills, and (5) visualization skills and communication. The following is a brief explanation of the basic competencies in statistical literacy

1. Understanding statistical concepts.

For example, the concept of the mean (standard) and standard deviation (standard deviation) include the calculation formula and the information delivered. This conceptual understanding leads to the knowledge of the realm of application of the concept in real life.

2. Insights into the application of statistical concepts

Knowing the situation and conditions can be used statistical values and in what situations a certain statistical value has or has no meaning. For example, calculating the average age value of a group of people, of course, the results do not provide valid information. The average value of the group's income might provide useful information to illustrate the level of welfare of the group.

3. Counting and charting skills.

Calculating skills such as average and other statistical values, as well as making graphics or drawings, have been easily obtained with the statistical package on a computer. However, after calculating certain statistical values, the concept and application of these values must be known.

4. The ability of interpretation.

The results of the calculation of statistical values do not give meaning if they cannot be interpreted correctly. Likewise explaining information from a graphic or image is an important capability that must be possessed in the information age today.

5. Visualization and communication skills

Visualization can be in the form of tables or graphs. Communication is successful if it gives influence to the person who is given information. The influence referred to here is a change in knowledge, attitudes, and behaviors that are getting better.

Khaerunnisa, E. and Pamungkas, AB. [4] formulated an indicator of statistical literacy ability which includes 3 things such as being able to formulate problems, able to use concepts, facts, procedures and reasoning, interpreting (interpreting) problems to solve problems PISA

### *Statistical Literacy and Mathematical Literacy*

In discussing statistical and mathematical reasoning, different things appear. In the realm of reasoning that distinguishes between statistics and mathematics is the event to think. How to think statistically is inductive-probabilistic while the way of mathematical thinking is deductive deterministic. The object of statistical study is the real thing while the object of the study of mathematics is abstract. However, the realm of mathematical thinking will be different when it is associated with literacy.

In PISA mathematical literacy is interpreted as follows: "Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens"[17].

This understanding implies mathematical literacy not only in the mastery of the material but also in the use of reasoning, concepts, facts and mathematical tools in solving everyday problems. Also, mathematical literacy requires a person to communicate and explain the phenomena he faces with mathematical concepts. [9].

Mathematical Literacy is an attempt to recognize the role of mathematics so that it can provide meaning and benefit for everyday life. Ojese, B [18] argues that mathematics literacy is knowledge to know and use the basis of mathematics in everyday life. Adding the previous opinion Steen, Turner & Burkhard interpreted mathematical literacy as an ability to use mathematical knowledge and understanding effectively in facing the challenges of everyday life.

From the above definition, in general, mathematical literacy is directed to use mathematics in life to solve everyday problems better and more effectively. In the process of solving this problem, someone who has mathematical literacy will realize or understand which mathematical concepts are relevant to the problem at hand. This process includes activities of exploring, linking, formulating, determining, reasoning, and other mathematical thinking processes. This thought process can be categorized into 3 main processes namely formulating, using and interpreting. [9]

Review the definition of statistical literacy that was discussed earlier. The process of thinking in statistical literacy also includes understanding statistical concepts, applying statistical concepts, interpretation skills, and visualization and communication skills [16] Strengthened by Khaerunnisa, E. and Pamungkas, AB. [4] which formulates indicators of statistical literacy capabilities which include 3 things, namely being able to formulate problems, being able to use concepts, facts, procedures and reasoning, interpreting (interpreting) problems to solve problems. PISA

From this study it can be concluded that statistical literacy and mathematical literacy have in common, which can be interpreted as an effort to use concepts, facts and procedures, conduct reasoning, and interpret an object in various contexts of solving problems in daily life. What distinguishes between the two is the object of study? The scope of mathematics studies is broader than statistics.

### *The urgency of Statistics Literacy*

Our society has entered the era of Industrial Revolution 4.0 where people need to be literate in statistics not only in school, work but also in daily life. The explosion of information that is happening right now encourages the public to have an understanding of statistics so that the available information can be well absorbed and can communicate the information to the public correctly and accurately. There is a growing recognition of the importance of statistical literacy in various aspects of daily life. In recent years, statistics educators have emphasized the place of statistical literacy [16].

The issue of the importance of statistical literacy has been raised several years ago, such as Moore's statement [8], in his speech as president of the American Statistics Association (ASA) stated that it is

difficult to think of policy questions that have no statistical component, and argue that statistics are a common method and fundamental because data, variations, and opportunities are everywhere in modern life. Wallman [14], in a 1992 ASA president's speech, stressed the importance of strengthening statistical understanding and statistical thinking among all sectors of the population, partly due to various misunderstandings, misconceptions, mistrust, and doubts that people have about values. statistics in public and private choices.

Some facts on the ground illustrate the need for statistical competence in modern society, including:

1. Headline news often presents graphics or data on the front page. From this presentation, the general public is expected to understand and appreciate the compacted information. Based on the results of the study, it has been shown that interpreting information that is presented in graphical form is still something that is considered difficult for some circles [19]
2. Large companies that set policies for almost all of their employees to teach about some basic concepts of statistics. In a company, statistics can be used as an instrument for an economic success value. [19]
3. Political and economic policies involve statistical information in the process. Denzen [20] gives an example of how fishermen negotiate with the government and environmentalists about fish quotas, all of which are based on data and statistical models. In this case, statistics are used as a language of strength

As a consequence, if the community is expected to have adequate statistical literacy skills, we need to teach students statistical data analysis as early as possible. Both through formal education and training. Research shows that statistical training can help in solving certain types of daily problems [21]. Industrial trainers and educational planners have pointed to the important role of statistical understanding and mathematical competence as a component of the skills needed by workers in various industries [22].

#### 4. Conclusion

Statistical reasoning has a different way of thinking than mathematical reasoning. The way of statistical thinking is inductive-probabilistic while the mathematical way of thinking is deductive deterministic. However, in the context of literacy, statistical literacy, and mathematical literacy have in common, which can be interpreted as an effort to use concepts, facts, and procedures, conduct reasoning, and interpret an object in various contexts of solving problems in daily life. There are two distinguishes between the two is the scope of the study. The scope of mathematics studies is broader than statistics. The ability of statistical literacy is an important thing for the community to have, so as not to get lost and get caught amid the current information explosion.

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