Factors Affecting Students' Statistical Literacy Ability in Indonesia (Meta-Analysis)

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Abstract
Statistical literacy is an important skill needed by students to understand data and make decisions based on accurate information. This study uses meta-analysis to identify the factors influencing students' statistical literacy skills in Indonesia. Data were collected from 19 studies conducted between 2017 and 2024. The research results indicate that the learning model, major, and school quality play important roles. In addition, internal factors such as learning styles, statistical anxiety, and levels of mathematical thinking are also very influential. These findings are expected to assist teachers and policymakers in designing more effective learning strategies to enhance statistical literacy skills in the future.
Keywords: Statistical Literacy, Meta-Analysis, Learning Models, Majors, Learning Styles, School Quality

Introduction

Mathematics is a fundamental science used to solve various problems in everyday life. Sharma (2021) in his research revealed that “Mathematics is a strong instrument for worldwide knowledge and communication that helps to organise and prevent chaos in our life”. One of the most important branches of mathematics is statistics. Statistics function to collect, analyze, and interpret data so that we can make accurate decisions. In the research titled “why statistics” Davidian (2012) defines “Statistics is the science of learning from data, and of measuring, controlling, and communicating uncertainty; and it thereby provides the navigation essential for controlling the course of scientific and soci-etal advances”. In the current digital era, data is available in large quantities and has become an important part of various fields, such as education, business, health, and government.

Statistics play a very important role in modern life today and can even be easily found in everyday life, as well as being highly needed in scientific research. Nasution (2021), mentions that statistics can help find relationships between variables, signs of certain population distributions, samples so that the results align with the object being studied, group differences from the object being studied, predictions for the future, interpretation of the collected data, and making accurate decisions.

According to the Ministry of Education and Culture (2018), the digital era is when digital technology enables the rapid and easy acquisition and dissemination of information.

Statistical literacy is a very important component of statistics in the digital era due to the abundance of information that includes statistical data.

Statistical literacy is described as the ability to critically evaluate, communicate, and analyze data and statistical information (Gal, 2002). Generally, statistical literacy focuses on two components: (a) the ability to understand and critically evaluate statistical information, such as data or stochastic phenomena that can be presented in various appropriate contexts, and (b) the ability to discuss or communicate the presented information, such as understanding the meaning of the information, understanding its implications, or understanding the value to be gained (Gal, 2002).

Statistical literacy encompasses basic and essential skills that can be used in understanding statistical information or research results. These skills include the ability to organize data, create and display tables, and work with different data representations. Statistical literacy also includes understanding concepts, vocabulary, and symbols, as well as understanding probability as a measure of uncertainty (Ben-Zvi, 2004). There are 6 indicators of statistical literacy ability by delMas (2002), namely (1) identify, (2) describe, (3) translate, (4) interpret, (5) read, (6) compute.

The urgency of statistical literacy is increasing in the digital era filled with information. As the next generation, students must possess these skills so that they can compete and adapt to a constantly changing world. According to OECD (2021), statistical literacy is one of the important skills that supports mathematical reasoning in the modern era. Unfortunately, Indonesian students' statistical knowledge still needs to be improved. In the literacy survey conducted by the Program for International Student Assessment (PISA) in 2018 by the Organization for Economic Cooperation and Development (OECD), Indonesia ranked 72nd out of 78 countries. This indicates that school learning projects must be created to improve student statistics and literacy. (Widya, Sukoriyanto, 2023).

The literacy and statistical abilities of Madrasah Tsanawiyah students are very low, according to research conducted by Maryati & Pratna. (2018). This is evident in the data analysis, data collection process, and presentation of results, which leads to errors when answering questions. Students' thinking skills, which tend to vary, can affect their statistical literacy abilities. Amalia et al. (2020) state that thinking skills can influence their statistical literacy abilities. A strong desire to acquire knowledge and a strong sense of responsibility towards education and its requirements are important components that influence statistical literacy (Nishfani, 2017).

Factors that influence statistical literacy skills become important information for educators to create learning activities that can enhance statistical literacy skills. Therefore, this research aims to identify, understand, and delve deeper into the factors that influence the statistical literacy of students in Indonesia.

Method

This study used the meta-analysis method to identify and analyze the factors influencing the statistical literacy ability of students in Indonesia. Meta-analysis **was** chosen because it allowed researchers to combine and synthesize results from various relevant studies, thereby providing a more comprehensive and valid picture. Botella and Zamora (2017) stated that, regarding meta-analysis, "Nació con el impulso de tratar de mejorar la forma poco rigurosa como se hacían las revisiones clásicas, que desde entonces pasaron a llamarse revisiones narrativas" (*It emerged with the aim of improving the less rigorous way in which traditional reviews were conducted, which then came to be known as narrative reviews*, p. 20). Furthermore, Botella and Zamora (2017) highlighted the limitations of narrative reviews, which were considered to lack precision and objectivity, thereby restricting the replicability of their findings.

The data used in this research came from 19 articles and research journals published between 2017 and 2024. To identify relevant studies in this meta-analysis, a systematic literature search was conducted using several academic databases. The search was limited to articles published between 2015-2024, using a combination of keywords such as "statistical literacy," "statistics," "literacy," and "Indonesia." These studies were selected based on the following criteria:

- The focus of the research is on students' statistical literacy.
- The research was conducted in Indonesia.
- Including variables related to factors that may influence statistical literacy ability.

After the initial screening based on titles and abstracts, followed by a review of the full texts, 19 articles met the criteria and were included in the final meta-analysis.Here is a list of 19 articles reviewed by the researchers:

Table 1. Literatur Review

No.	Article Title	Author	Tahun
1.	Pengembangan Soal Matematika Model PISA Konten Statistika untuk Melatih Kemampuan Literasi Statistik Siswa di SMP	Yosti Andiyani Taneo, Uke Ralmugiz, Agustin Fatmawati	2023
2.	Hambatan Belajar Siswa Dikaji Dari Kemampuan Literasi Statistik di Sekolah Menengah Pertama	Mira Marlina, Sugiatno, Ahmad Yani T	2019
3.	Kemampuan literasi statistik dalam pembelajaran berbasis proyek yang dimodifikasi	Fitri nur oktiviani, St. Budi Waluya, Zaenuri	2021
4.	Analisis kemampuan literasi matematis siswa pada materi statistik di mts miftahussalam	Endang Rahayu Ningsih, Siti Nur Asmah, Riyanti Nurdiana	2024
5.	Literasi Statistik Siswa Berdasarkan Gaya Kognitif Field Dependent dan Field Independent	Fardatul Amalia, Junaidah Wildani, Mohamad Rifa'i	2020
6.	Analisis Literasi Statistik Siswa SMP dalam Menyelesaikan Soal Model PISA	Laurentcia Noviafta Widya, Sukoriyanto	2023
7.	Analisis Kemampuan Literasi Statistik Siswa MTs Ditinjau dari Gaya Belaja	Rizki Fitri, Khariani, dan Nuraini	2024
8.	*Literacy of Middle School Students in Solving TIMSS Problems*	Dwi Priyo Utomo.	2021
9.	Analisis Tingkat Kemampuan Literasi Statistik Siswa SMA Sederajat Berdasarkan Mutu Sekolah	Hadi Kusmanto	2017
10.	Analisis Kemampuan Literasi Statistik Siswa Sma Ditinjau Dari Jurusan IPA, IPS Dan Bahasa Kelas XI DI SMAN 4 Mataram Tahun Ajaran 2023/2024	Muhammad Diennis Dwi Mustika, Harry Soeprianto, Laila Hayati, Baidowi	2024
11.	Pengaruh Model PBL (Problem Based Learning) Terhadap Kemampuan Literasi Matematika Pada Pokok Bahasan Statistik Siswa Kelas XI TKR SMKN 3 Bojonegoro	Junarti, Novi Mayasari	2022
12.	Analisis Kemampuan Literasi Statistik Mahasiswa Dalam Berpikir Kritis Masalah Sosial	Novita, Fatkhurahman	2023
13.	Kemampuan Literasi Statistik Mahasiswa Calon Guru Ditinjau Dari Kemampuan Awal Matematika	Johannis Takaria, Melvie Talakua	2018
14.	Literasi statistik mahasiswa berdasarkan tingkatan berpikir matematika	Mahyudi, Endaryono, Rifki Ristiawan	2024
15.	Pengaruh Kecemasan Statistik Terhadap Berpikir Literasi Statistis Mahasiswa Stkip Pgri Jombang	Rengga Adi Setyabekti, . Nurwiani, Lia Budi Tristanti	2023
16.	Analisis Literasi Statistik Pada Calon Guru SD ditinjau dari Kecemasan Matematika	Ema Butsi Prihastari, Isti Hidayah, Masrukan,Bambang Eko Susilo, Nuriana Rachmani Dewi	2023
17.	Literasi Statistik Mahasiswa Pendidikan Matematika ditinjau dari Resiliensi Matematik	Anik Pujiati, Diah Oga Nusantari, Fatwa Patimah Nursa'adah	2023
18.	Pengaruh kecemasan statistika terhadap kemampuan literasi statistik	Risma Nurul Auliya, Munasiah Munasiah	2017
19.	Pengaruh Kecemasan Statistik Terhadap Berpikir Literasi Statistis Mahasiswa Bimbingan Konseling IAIN Batusangkar	Rizqon Halal Syah Aji	2020

Results and Discussion

Table 1 lists the 19 research publications that the researchers gathered and examined about statistical literacy at different educational levels in Indonesia. The findings of the research's meta-analysis are as follows:

Meta-Analysis Based on Educational Level

Based on a study of 19 research papers on statistical literacy, here is the data on the educational levels of the research sample:

Table 2. Educational Levels of Statistical Literacy Research

Educational Level	Frequency	Percentage
Junior high school/equivalent	8	42,1%
High school/equivalent	3	15,79%
Higher education/institutions of equivalent status	8	42,1%
Amount	19	100%

Based on Table 2, there are 8 articles that use samples from the junior high school level, with the same number at the higher education level

Meta-Analysis Based on The Year Of Research

Based on a study of 19 research papers on statistical literacy, here are the research year data:

Table 3. Statistical Literacy Research Year

Year	Frequency	Percentage
2017	2	10,53%
2018	1	5,26%
2019	1	5,26%
2020	2	10,53%
2021	2	10,53%
2022	1	5,26%
2023	6	31,58%
2024	4	21,05%
Total	19	100%

Based on Table 3, out of 19 research articles on statistical literacy, the highest number of research articles is in 2024, which is 21.05%.

Meta-Analysis Based on The Data Collection Method

Based on a study of 19 research papers on statistical literacy, data on research data collection method were obtained as follows:

Table 4. Statistical Literacy Research Data Collection Method

Method Of Collecting Data	Frequency	Percentage
Field trials	1	5,26%
Written test and interview	7	36,84
Pretest and posttest questions	2	10,53%
Questionnaire, written test, interview	2	10,53%
Questionnaire, written test	1	5,26%
Written test	3	15,79%
Survey or interview	1	5,26%
Statistical Anxiety Rating Scale) instrument	2	10,53%
Total	19	100%

Table 4 shows that research on statistical literacy uses a combination of written tests, interviews, and questionnaires, with the majority of studies using written tests and interviews, accounting for 36.84%.

Meta-Analysis Based on Data Analysis

Based on a study of 19 research papers on statistical literacy, the data regarding the types of data analysis used in the research are as follows:

Table 5. Data Anaysis in Statistical Literacy Research

Data Anaysis	Frequency	Percentage
Qualitative descriptive	8	42,1%
Quantitative descriptive	1	5,26%
One-way ANOVA	2	10,53%
Two-way ANOVA	1	5,26%
Simple linear regression analysis	3	15,79%
Multiple linear regression analysis	1	5,26%
T-Test	1	5,26%
N-gain test	2	10,53%
Total	19	100%

Based on Table 5, the most commonly used data analysis in the collected research on statistical literacy is qualitative descriptive, with 8 articles or 42.1%.

Meta-Analysis Based on External and Internal Factors

Based on a study of 19 research papers on statistical literacy, the data regarding external and internal factors that influence statistical literacy are as follows:

Table 6. External and internal factors in statistical literacy research

Factor	Frequency	Percentage
External	10	52,63%
Internal	9	47,37%
Total	19	100%

Based on Table 6, the dominating factor is the external factor, which amounts to 10 or 52.63%. Below is a more detailed explanation of the external and internal factors that can influence students' statistical literacy based on 19 studies on statistical literacy.

Table 7. details of external and internal factors

External/Internal	Factor	Frequency	Percentage
External	PISA model Mathematics Questions	3	15.79%
	Learning barriers	1	5.26%
	Modified PJBL model	1	5.26%
	TIMSS questions	1	5.26%
	School quality	1	5.26%
	Departments (Science, Social Sciences, and Language)	1	5.26%
	Problem based learning (PBL) model	1	5.26%
	Collaborative problem solving (CPS) model	1	5.26%
Internal	Field Dependent and Field Independent Cognitive Styles	1	5.26%
	Learning styles	1	5.26%
	Interest and Critical Thinking Ability	1	5.26%
	Levels of mathematical thinking (reproduction, connection, analysis)	1	5.26%
	Statistical anxiety	3	15.79%
	Math anxiety	1	5.26%
	Mathematical resilience	1	5.26%
Total		19	100%

In Table 7, it is shown that based on 19 studies on statistical literacy, the most prevalent external factor is the PISA model Mathematics Questions, accounting for 15.79%. Meanwhile, the most dominant internal factor is Statistical anxiety, also at 15.79%.

Based on the results of the meta-analysis shown in Table 2, the distribution of the sample in statistical literacy research in Indonesia indicates that there are 8 articles using samples at the junior high school level (SMP) and the same number at the higher education level. This indicates that research on statistical literacy in Indonesia focuses on middle school students and university students, suggesting that researchers and educators pay attention to the development of statistical literacy at the middle school and higher education levels, while conversely, there is a lack of attention from researchers and educators towards statistical literacy at the high school level.

In Table 3, the highest number of research articles was published in 2024, with a percentage of 21.05%. This indicates that research on statistical literacy in Indonesia has been increasing in recent years. The increase in the number of these studies may be due to the growing awareness of the importance of statistical literacy in supporting students' critical and analytical thinking skills.

The results of the meta-analysis in Table 4 show that research on statistical literacy uses various data collection methods, and the most commonly used method is written tests along with interviews, with a percentage of 26.84%. Written tests are one of the most common and systematic ways to collect information about students' behavior, abilities, and professional skills (EL Hasbi, 2024), while errors in data collection can be minimized as much as possible by conducting good interviews (Soegijono, 1993), where researchers can minimize errors in collecting students' statistical literacy data using the interview method.

In Table 5, the most commonly used data analysis method in statistical literacy research in Indonesia is qualitative descriptive, with 8 articles. The use of qualitative descriptive analysis indicates that many studies place greater emphasis on exploring how students understand and apply statistical literacy. This method, which has long been used in meta-analysis to synthesize data from various studies (Glass, 1976), can provide an in-depth picture of how students apply statistical knowledge in the context of learning.

The results of the meta-analysis show that external factors are more dominant in influencing statistical literacy skills compared to internal factors. Based on table 6, external factors have a percentage of 52.63% or 10 articles. Furthermore, the most dominant external factor is the PISA model math questions with a percentage of 15.79%. OECD (2019) in the

PISA 2018 Assessment and Analytical Framework document indeed emphasizes that the tasks in PISA are designed to assess students' ability to apply their mathematical knowledge in real-world contexts, including data analysis and critical problem-solving. This indicates that the use of PISA model statistics questions can train students to apply statistical knowledge in real-world contexts as well as conduct data analysis and problem-solving within a statistical context. PISA questions focus on literacy, which emphasizes the competencies and skills of students that can be used in everyday life acquired from school (Johar as cited in Mansur, 2018).

Another external factor that influences statistical literacy is school quality, as concluded by Nishfani et al. (2017). School quality is an external factor that can affect students' statistical literacy based on the data obtained. Schools with moderate quality have higher average statistical literacy scores compared to schools with low quality, while schools with high quality have higher average statistical literacy scores compared to schools with moderate and low quality. Then there is the modified project-based learning (PJBL) model that can enhance students' statistical literacy, in line with the statement by Oktiviani et al. (2021), that compared to students who receive conventional learning, students who receive modified project-based learning show a better improvement in statistical literacy. Next, there is the Problem-Based Learning (PBL) model, which can also enhance statistical literacy skills. Students have better mathematical literacy skills when using the PBL model compared to using the direct instruction model in statistics subjects (Junarti and Mayasari, 2022). Based on the research by Marlina et al. (2020), it was concluded that learning barriers, which consist of didactic barriers, epistemological barriers, and ontogenic barriers, affect the level of students' statistical literacy, where students with different levels of statistical literacy have varying amounts of learning barriers. There are also TIMSS (Trend In International Mathematics And Science Study) questions that can enhance statistical literacy because, as Utomo (2021), mentioned "The characteristic of TIMSS questions is that they are often related to everyday life contexts, and contextual content requires understanding, argumentation, and creativity in the problem-solving process," (thus TIMSS questions can improve statistical literacy like PISA questions). Next, there are the factors of science, social science, and language majors at the high school level obtained from the research of Mustika et al. (2024), which states, "Students from the science major show higher statistical literacy compared to students from the social science and language majors." There is also the CPS (Collaborative Problem Solving) model, as cited from the research by Takaria (2018), where

students who received instruction using the CPS model showed a higher increase in statistical literacy compared to students with expository learning models based on initial mathematical ability, with the increase in statistical literacy attributed to the effective use of the CPS model.

On the other hand, the most dominant internal factor is statistical anxiety, which also has a percentage of 15.79%. Statistical anxiety can hinder students' understanding of statistical material, leading to a lack of confidence in processing and analyzing data. Prihastari et al. (2023), state that anxiety in learning statistics negatively impacts students' ability to interpret data, thereby reducing the level of statistical literacy. This indicates that statistical anxiety contributes to the low ability of students to interpret statistical data.

Furthermore, based on Table 7, another internal factor that also influences statistical literacy is the cognitive style, specifically field-dependent and field-independent styles. According to the research by Amalia et al. (2020), it was found that students with a field-independent cognitive style performed better in solving the presented problems compared to students with a field-dependent cognitive style. Amalia's detailed explanation further indicates that students with a field-independent cognitive style have better statistical literacy skills than students with a field-dependent cognitive style. Furthermore, according to the research by Fitri et al. (2024), students with auditory, visual, or kinesthetic learning styles have different levels of statistical literacy, but it is not known which learning style has superior statistical literacy. The results of the study by Novita and Fatkhurahman (2023), state, "Of the five variables suspected to influence statistical literacy, only two variables were proven to affect students' statistical literacy abilities, namely interest factor and critical thinking ability factor." (both are internal factors that influence statistical literacy ability). The factor of math anxiety affects students' statistical knowledge as well as their statistical literacy abilities, where students with moderate and low statistical literacy categories have moderate levels of math anxiety, while students with high statistical literacy categories have low levels of math anxiety (Prihastari et al., 2023). Then there is the factor of mathematical thinking levels (reproduction, connection, analysis) where, according to Mahyudi et al. (2024), the main cause of the lack of statistical literacy among students is the low reasoning and critical thinking skills that are very much needed at the connection and analysis levels. Next, in the study by Pujiati et al. (2023), it is mentioned that "an appropriate learning approach can improve students' statistical literacy, but there are other factors that also

influence, such as students' mathematical resilience." A more detailed explanation in that study shows that mathematical resilience affects the improvement of statistical literacy skills.

The results of the meta-analysis on factors influencing statistical literacy also show that out of the total 19 articles analyzed, there are factors that positively affect statistical literacy ability or can enhance statistical literacy ability such as; PISA Model Mathematics Questions, Modified PJBL (Project-Based Learning) Model, TIMSS (Trends in International Mathematics and Science Study) Questions, PBL (Problem-Based Learning) Model, Collaborative Problem Solving (CPS) Model. There are also factors that negatively affect statistical literacy or can hinder statistical literacy, such as: Learning barriers, statistical anxiety, mathematical anxiety. In addition, there are also factors that can have both positive and negative effects, such as: mathematical resilience, levels of mathematical thinking (reproduction, connection, analysis), interest and critical thinking ability, cognitive styles (Field Dependent and Field Independent), major (Science, Social Science, and Language), as well as school quality.

Conclusion and Suggestion

The research results show that the factors that can influence statistical literacy can be external and internal factors. Based on 19 studies on statistical literacy, external factors that influence statistical literacy include learning barriers, the project-based learning (PJBL) model, TIMSS (Trends in International Mathematics and Science Study) questions, school quality, high school majors (Science, Social Science, and Language), the problem-based learning (PBL) model, the Collaborative Problem Solving (CPS) model, and most notably, PISA-style mathematics questions. Meanwhile, internal factors that can influence students' statistical literacy include cognitive styles such as Field Dependent and Field Independent, learning styles, interest and critical thinking ability, levels of mathematical thinking, math anxiety, mathematical resilience, and the most commonly encountered is statistical anxiety.

The results of this meta-analysis provide several important implications for the world of education. First, the use of PISA or TIMSS model questions can be considered as practice and assessment questions for statistics material in schools. Second, the need for the development of more contextual teaching methods to improve students' statistical literacy. Third, reducing statistical and mathematical anxiety through a more interactive and supportive learning approach can enhance students' understanding of statistical material.

Overall, this research highlights the external and internal factors that influence students' statistical literacy. By understanding these factors, educators can design more effective learning strategies to improve students' statistical literacy in Indonesia.

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