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Science Literacy among Students of Madrasah Ibtidaiyah Based on Gender and Academic Ability

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Abstract:
The lack of portraits of science literacy in elementary school students has become the main reason for this study. In addition, the latest literature review shows that not all factors suspected of influencing science literacy have been studied empirically. Therefore, this study aims to describe and analyze the differences in science literacy abilities of elementary school students based on academic ability. Participants involved in this study were 88 students from a number of elementary schools in Ternate City who were selected using stratified cluster sampling. Two research instruments were used, namely the academic ability test designed to be equivalent to final semester assessment questions (PAS) that focused on science content and a set of questions to measure science literacy abilities, most of which were adapted from Xiaoping Gu. The Two-Way ANOVA was used to analyze the hypothesis, which began with normality and homogeneity tests. The findings show that partially there are differences in the science literacy abilities of elementary school students in Ternate City based on gender (Sig.0.02<0.05) and academic ability (Sig.0.001<0.05). However, the interaction of the two factors was not confirmed to determine students' science literacy abilities (Sig.0.147>0.05). This means that changes in science literacy abilities influenced by gender do not depend on the level of student's academic abilities. Likewise, the increase in science literacy scores caused by academic abilities does not depend on gender.

Keywords: Academic Ability; Gender; Madrasah Ibtidaiyah; Science Literacy

Introduction

The development of the global world is facing a renewal called the era of Society 5.0, where people's lives are predominantly based on the use of science and technology(Agustina & Rahmawati, 2021; Narvaez Rojas et al., 2021) so that mastery of science and technology in the 21st century has become a real challenge for all humans living in this era. In response, the Indonesian government encourages science literacy to become a basic element in the education curriculum from elementary to secondary levels.

In many pieces of literature, science literacy is defined differently but has the same meaning. The OECD defines *science literacy* as a person's ability to apply their knowledge to identify questions, construct new knowledge, provide science explanations, draw conclusions based on science evidence, and the ability to develop a reflective mindset in understanding the characteristics of science, awareness of science and technology shaping the natural, intellectual, and cultural environment, to be able to participate in addressing issues and ideas related to science(OECD, 2019a). Some scholars also add complementary aspects to the definition of science literacy, namely the ability to use evidence and data to evaluate the quality of information and arguments presented by scientists and the mass media(OECD, 2019b).

Therefore, in simple terms, science literacy can be interpreted as the ability needed to understand science and apply it in everyday life concepts.

In the primary education system in Indonesia, science literacy is also included in the knowledge achievements that must be built continuously(Safrizal, 2021). Even now, the science literacy skills of elementary school students have become a concern for many countries because they are considered the key to success in facing the challenges of the 21st century(Deehan et al., 2024; Rukoyah et al., 2020). However, the PISA (Program for International Students Assessment) survey sponsored by the OECD (Organization for Economic Cooperation and Development) shows that until 2022, students' science literacy in Indonesia still needs to improve compared to the international average(OECD, 2022).

Some previous researchers have reported the results of their studies on science literacy in Elementary Schools and Madrasah Ibtidaiyah, which aim to map science literacy skills in a certain scope. From a number of these research reports, some studies examine the profile of science literacy in the context of the Covid-19 pandemic(Wibowo, 2021), define the science literacy skills of fifth-grade students in Integrated Science Learning in Elementary Schools(Dwisetiarezi & Fitria, 2021), and descriptions of science literacy in a specific context(Vivanti et al., 2016).

An in-depth literature review found a gap that can be used as a basis for further research. First, the results of the PISA survey cannot comprehensively describe the science literacy of students in certain areas in Indonesia because the sample size is relatively small, while the number of elementary school students in Indonesia is very large. It can be considered less representative. In addition, the variables of the gap in the quality of education and access to education in Indonesia(Aditomo & Felicia, 2018) are also considered not to have been included in the survey, so the map of the profile of science literacy skills in certain areas, especially in Eastern Indonesia, cannot be known. The literature study also revealed that the portrait of literacy in elementary school students is also very minimal.

In addition, the literature has not revealed many studies on gender and academic ability and their relationship with the science literacy skills of elementary school and elementary school students. Referring to the limitations of the survey results on the portrait of science literacy and the gaps found from the literature study results, it shows that a study of the science literacy skills of elementary school students using gender and academic ability as factors is important.

Literature Study

Previous studies on science literacy in both Elementary Schools and Madrasah Ibtidaiyah education can be categorized into five groups, including studies on 1) the application of certain strategies, approaches, and learning models to improve science literacy skills, 2) the development of learning models, modules, worksheets based on science literacy, 3) the relationship between science literacy and several variables, 4) Analysis of textbooks on science literacy content and 5) profiles and descriptions of students' science literacy.

Studies on applying learning methods or models to improve science literacy are dominant. As an illustration, Tuti et al. found that through a science approach, students can have science process skills and science attitudes and communicate them scienceally(Siregar et al., 2020). In addition, other researchers have found that problem-based learning can improve science literacy skills at all levels of elementary school(Mundzir et al., 2017) and academic groups (low, middle, and high)(Rizky et al., 2017). Likewise, research on the development of teaching materials to improve science literacy has also been widely carried out, such as research from Nurmala(2021), who succeeded in developing valid, practical, and

effective multimodal text-based science teaching materials that can improve students' science literacy. Learning media design, such as videos(Supardi & Azizah, 2022) and the development of Student Worksheets based on problem-solving, were used to improve students' science literacy regarding competence and knowledge(Susanti, Ardian Asyhari, 2019).

Several variables have been confirmed to correlate with elementary school students' science literacy. Rosmalah et al. (2020) revealed in their research report through path analysis that reading habits, learning motivation, and learning achievement affect science literacy. Kusumastuti(2019) identified that critical thinking skills positively affect science literacy skills. In addition, in the context of science learning, previous studies have found a linear relationship between science literacy skills and science process skills (Danianty & Sari, 2022) and science learning outcomes (Nugraha, 2022).

The next research group will study textbook analysis on science literacy content. Several studies have revealed different results related to analyzing references containing science literacy. In her study, Nurfaidah(2017) found that each chapter produced a different presentation of science literacy, such as science as a way of thinking and the interaction of science, technology, and society. Similar research was conducted by Utami et al. (2021), namely conducting a content analysis of elementary school student textbooks, and found that the book emphasized aspects of science as the body of knowledge and did not emphasize mastery of processes, attitudes, and technology.

Many scholars have successfully conducted studies describing elementary school students' science literacy skills. Utami et al.(2022) (analyzed science literacy skills based on aspects of content, process, and context and then found that the average achievement of science literacy aspects (content, process, and context) was relatively low. By using different measurement aspects, including science interest, science approach, and environmental awareness, Nadawiyah (2020) showed that the science literacy skills of elementary school students were categorized as quite high.

Research Method

This study used a comparative causal design that begins with a noted difference between two groups and seeks possible causes or consequences of the difference. The researcher attempted to determine the causes or consequences of the differences that exist in a number of groups, particularly related to science literacy skills.

The target population in this study were all students of Madrasah Ibtidaiyah in Ternate City, and sampling was carried out using the cluster stratified sampling technique. The clusters in this study were each Madrasah Ibtidaiyah in Ternate City. Meanwhile, the stratum in this study was based on gender (male and female) and academic ability (low, medium, high). Determination of the strata of academic ability was carried out using a test designed to be equivalent to the Final Semester Assessment test that focused on science content. This instrument consisted of 20 questions, including 10 multiple choice questions, 5 short answer questions, and 5 essay questions. Simple or systematic random sampling techniques were used to select students in each stratum that had been identified. So, from this process, the number of participants involved in this study was 88 students.

The instruments used to measure scientific literacy skills are mostly adapted from Xiaoqing Gu's research (Gu et al., 2019), which contains several aspects or dimensions: facts, concepts, scientific methods and processes, and attitudes toward science. The fact dimension, namely the basic scientific construct, consists of two subdimensions: understanding of scientific concepts (4 multiple choice questions) and

understanding of scientific views (10 true/false questions). The subdimension of the scientific method is about understanding the nature of scientific research, experiments, and trials (3 multiple-choice questions). Furthermore, in the aspect of attitudes towards science, there are two subdimensions, namely the rejection of superstition as part of a scientific attitude (3 descriptive questions with a maximum of 5 points) and involvement with popular scientific problems in society (3 questions with points using a Likert scale of 1-5). The validity test of the instrument in this study consists of a content validity test and a construct validity test, and the Cronbach Alfa coefficient test will be chosen as a method for testing the instrument's reliability, as well as both academic ability and scientific literacy ability.

Academic ability will be categorized into three, namely low academic ability (KR), medium academic ability (KS), and high academic ability (KT), with the following criteria(Suhandri et al., 2017) that presented in Table 1:

Table 1. The category of Academic Ability

Criteria	Interval Value
High	$X \geq \overline{X} + \sigma$
Middle	$\overline{X} - \sigma < X < \overline{X} + \sigma$
Low	$X \leq \overline{X} - \sigma$

Explanation of Symbols
X : Final Score
$\bar{X}$: Average
σ: Standar Deviation

The data will be analyzed using a two-way analysis of variance (ANOVA). However, a normality and homogeneity test analysis will be carried out as a prerequisite test.

Result

Description of Academic Ability and Science Literacy Score

The results of the descriptive analysis showed that from the 88 students, it was found that the average value of students' academic ability was 56.35 with a standard deviation of 12.213. The highest score obtained was 86, and the lowest score was 17. Afterward, the sample was then divided into three categories: high-ability students ($score > \bar{X} + SD = 56{,}35 + 12{,}213 = 68{,}563$), which were 12 students; students with moderate ability ($68{,}563 > score > 56{,}35 - 12{,}213 = 44{,}137$) which were 63 students and students with low ability ($score < 44{,}137$) which were 13 students. Thus, it can be concluded that the sample is dominated by students with moderate ability.

In general, the science literacy scores of 88 students are quite low. It can be seen from the average score of 54.70, with a standard deviation of 16.644. In addition, the maximum score obtained by students is 84, while the minimum score is 11. In general, the Science literacy ability scores of 88 students are quite low. It can be seen from the average score of 54.70, with a standard deviation of 16.644. In addition, the maximum score obtained by students is 84, while the minimum score is 11. Visually, the description of science literacy score distribution can be seen in Figure 1.

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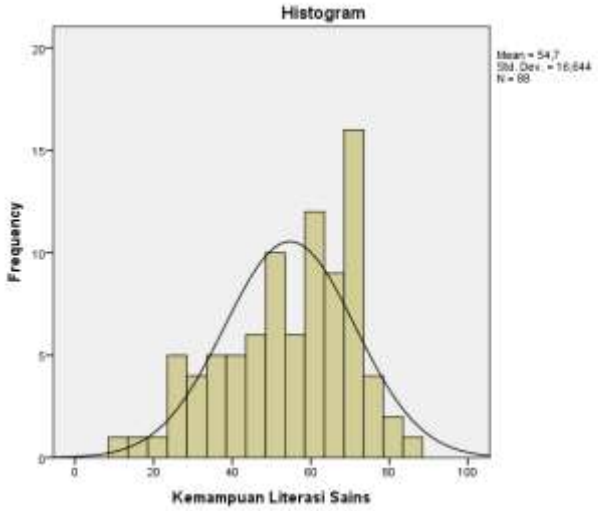

Figure 1. Histogram of Science literacy Score

The output of descriptive analysis also shows that the average difference in the Science literacy ability of male and female students is 5.43, with the average score of female students being greater than that of male students. In contrast to the Science literacy ability scores grouped by gender, Science literacy ability based on academic ability shows a significant distinction where there is an average difference of 16.43 between the low and medium academic ability groups. Meanwhile, the medium and high academic ability groups have an average difference of 9.69.

Normality and Homogeneity Test

The normality test results with Shapiro-Wilk in Table 2 show that the Sig. Value is >0.05, meaning that the data is normally distributed. Similarly, Figure 2, which results from the Q_Q plot analysis, also emphasizes that the science literacy ability score is normally distributed.

Table 2. The normality test result

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Science Literacy Ability Score	,113	88	,077	,959	88	,077

a. Lilliefors Significance Correction

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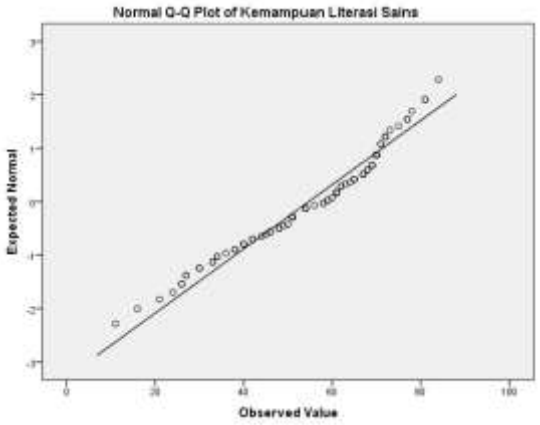

Figure 2. The Q-Q plot diagram of Science Literacy

Table 3 shows the result of the homogeneity test conducted using Levene's Test of Equality of Error Variance, which is based on gender, academic ability, and gender*academic ability. It is known that the Sig.>0.05 value means that the variance of the science literacy ability variable is homogeneous.

Table 3. The Homogeinity test result

Levene's Test of Equality of Error Variances[a]

Dependent Variable: Kemampuan Literasi Sains

F	df1	df2	Sig.
,585	5	82	,711

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Gender + Kemampuan_Akademik + Gender * Kemampuan_Akademik

Hypothesis Test Result

The output of the Two-Way ANOVA analysis in Table 4 shows that the Sig. Values for the gender factor and the academic ability factor are (0.020) and (0.001) respectively, which are less than 0.05. It means that H_0 can be accepted, meaning that partially, there is a difference in students' scientific literacy abilities based on gender, and there is a difference in students' scientific literacy abilities based on academic ability groups. However, interestingly, the hypothesis that there is an interaction between gender and academic ability in determining scientific literacy abilities must be rejected because Sig. 0.147>0.05. The Estimated Marginal Means diagram in Figure 3 also exhibits an intersection of literacy ability lines between students with medium and low abilities, indicating an interaction between the two.

Table 4. The Output of Two-Way Anova Analysis

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Tests of Between-Subjects Effects

Dependent Variable: Kemampuan Literasi Sains

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5848,358[a]	5	1169,672	5,254	,000
Intercept	133714,544	1	133714,544	600,669	,000
Gender	1245,498	1	1245,498	5,595	,020
Kemampuan_Akademik	3587,551	2	1793,776	8,058	,001
Gender * Kemampuan_Akademik	875,342	2	437,671	1,966	,147
Error	18253,960	82	222,609		
Total	287450,000	88			
Corrected Total	24102,318	87			

a. R Squared = ,243 (Adjusted R Squared = ,196)

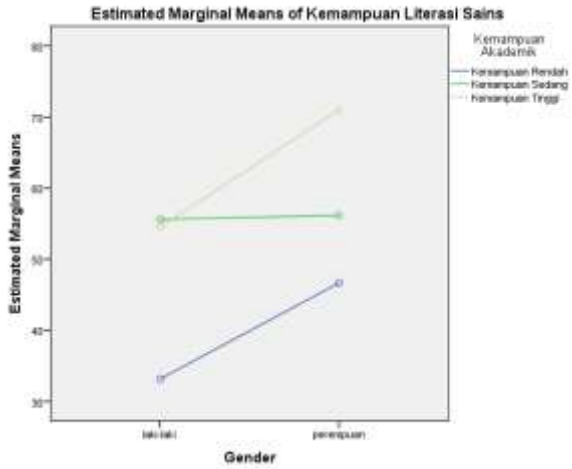

Figure 3. Marginal Means diagram

Disscussion

Gender can affect science literacy since it is driven by social and cultural factors that ultimately impact learning opportunities and experiences. In general, gender differences in science, engineering, technology, and mathematics (STEM) include areas such as participation, achievement, and interest. Several studies show that women tend to be less interested in science and less involved in science education compared to men(Esclamado & Rodrigo, 2024; Miller & Blessing, 2006). Social and cultural factors, such as gender stereotypes, traditional gender roles, and the lack of female role models in science, can influence women's interest and participation in science education (Chan, 2022; Dimitriadi, 2013).

In addition, gender distinctions in scientific literacy abilities can also be influenced by biological factors, such as differences in spatial and verbal abilities. Research shows that men tend to have better spatial abilities, while women tend to be superior in verbal abilities(Yilmaz, 2017). However, it is important to

note that these differences are not the primary determining factor in science literacy abilities and can be overcome with appropriate education and training(Trumper, 2006).

Several factors can influence scientific literacy abilities from a gender perspective. The first is gender stereotypes, which can influence students' interests and perceptions of science and technology. Gender stereotypes can place women and men into traditional gender roles, affecting career choices and interest in studying science (Ma, 2008). The next factor is the role of the model. As an illustration, the lack of female role models in science can influence women's interest and participation in science education. Women whom successful female role models inspire in science tend to be more interested and motivated in studying science(Dasgupta & Stout, 2014). The most important factor is education and training. Education and training tailored to gender differences can help strengthen students' science literacy skills. Boys and girls may have different learning styles, so different approaches can aid in improving their science literacy(Wang & Degol, 2017).

By increasing awareness of the factors that influence science literacy abilities from a gender perspective, action can be taken to increase students of all genders' participation and literacy abilities. Although gender differences in science literacy are not always consistent across countries and educational contexts, in many cases, social and cultural factors can play a large role in gender differences in science literacy, and these factors can be overcome with appropriate efforts, such as by making classrooms or science education programs more inclusive and based on gender equality.

Academic abilities contribute to students' scientific literacy abilities because they help students understand, interpret, and build broader scientific knowledge. Academic abilities such as reading, writing, mathematics, critical thinking, and reading and listening abilities can influence students' scientific literacy. Prior researchers have explained the rationale for this influence. Xie(2023) states that reading well can help students understand complex science texts, identify important information, and make conclusions. Patricia (2014) and Lestari(2020) wrote in their paper that students with good writing skills can help them express their understanding of scientific concepts, make arguments based on evidence, and make conclusions based on evidence. Apart from that, understanding scientific concepts related to numbers, such as calculation, measurement, and statistics, can be supported by good mathematical skills(Clements & Sarama, 2016; Maass et al., 2019). Finally, Dwikoranto(2011) and Beth(2018) revealed that good speaking and listening skills can help students participate in science discussions, convey ideas clearly, and understand other people's perspectives.

Therefore, elementary school students' academic abilities, such as reading, writing, mathematics, critical thinking, and problem-solving, have a positive relationship with their science literacy. Therefore, a practical science education program must pay attention to developing students' academic abilities and provide different approaches to strengthen these academic abilities.

Conclusion

This research confirms that partially, the differences in the scientific literacy abilities of Mardasah Ibtidaiyah students based on gender and academic ability exist. However, the interaction of these two factors has yet to be confirmed to determine students' scientific literacy abilities. Some studies are known to have confirmed the findings of this research. Gender stereotypes, lack of models in the fields of science, education, and training, and different biological characteristics between men and women are the rationale of this phenomenon. However, this factor can be reduced with more inclusive efforts based on gender equality in science classrooms and learning programs.

The similar thing also happens to the academic ability factor, where differences in academic ability groups (low, medium, and high) also contribute to differences in scientific literacy abilities. According to theories, students with good academic abilities have better reading, writing, communication, and critical thinking abilities, which will support their scientific literacy abilities.

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