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Science Literacy Support for Improving Students' Argumentation Skills

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Abstract: This study explores the impact of science literacy on improving students' argumentation skills at SMA Negeri 21 Surabaya during the 2023/2024 academic year, within the context of the "Merdeka Belajar" initiative and 21st-century competencies. This quantitative correlational research involved 60 students from classes XI-2 and XI-10, selected using purposive sampling techniques. Based on Toulmin's argument model and the PISA science literacy framework, data was collected through science literacy tests and argumentation skill assessments. Data analysis using Minitab 18 revealed a significant positive correlation between science literacy and argumentation skills, with $p < 0.05$ and correlation coefficients of 0.710 for class XI-2 and 0.926 for class XI-10. These findings support the hypothesis that enhancing science literacy can improve students' argumentation skills. This study highlights the importance of integrating argumentation skills into science education to enhance science literacy and recommends developing a curriculum that supports argumentation practices to improve students' critical thinking and problem-solving skills.

Keywords: Argumentation; Correlation of Science Literacy and Argumentation; Science Literacy.

Introduction

In the Industrial Revolution 4.0 era, the quality of human resources with intelligence and character is needed to face challenges and intense global competition [1]. The Industrial Revolution 4.0, which began in 2011, demands innovative learning systems and 21st-century competencies to drive the nation's economic growth and competitiveness. Indonesia has been working to improve education and social quality, which are interrelated with the "Merdeka Belajar" initiative promoted by the Minister of Education, Culture, Research, and Technology, Nadiem Makarim [2]. The US-based Partnership for 21st Century Skills (P21) identifies critical thinking, creative thinking, communication, and collaboration skills as competencies needed in the 21st century. These competencies are known as 4C competencies [3].

Wagner, in 2010, stated that students need to master effective ways of communicating, both orally and in writing [4]. The way a person expresses an idea can show reasoning ability. Based on PISA (Program for International Student Assessment) 2015 data, students are still unable to solve questions that require reasoning; the science literacy ranking of Indonesian students is still low and ranks 64th out of 72 participating countries with a score of 403 below the score set by the OECD Institute [5].

One of the right ways to improve science literacy skills is to provide opportunities for students to understand science in everyday life and argue about dealing with everyday problems. This argument will be used to deal with various problems and knowledge issues that exist in everyday life [6].

Research conducted by Djohar Maknun concluded that students' improvement in science literacy is directly proportional to their improvement in argumentation skills. Thus, argumentation skills can be developed during learning to strengthen students' science literacy [7].

Learners' argumentation skills are essential because they identify activities to be applied in learning to improve understanding and achievement of cognitive levels. Argumentation can also restore the goals of science education in a balanced manner [8].

Nowadays, the world of education requires learners to develop argumentation skills [9]. Jimenez Aleixandre and Erduran state that argumentation is the solution to almost all problems in science education, as it helps learners learn complex things, such as evidence evaluation, and assists teachers in understanding and supporting the learning process in science classrooms [10]. Science principles are used to address problems and make decisions in everyday life. Relevant learning can increase learners' awareness of the importance of science in determining their careers and roles as members of society [11]. This aligns with the goal of science learning, which is to emphasise the importance of science in current and future society. With sound science literacy and argumentation skills, learners are expected to compete globally and improve Indonesia's education quality [6].

This background is used as a basis for research entitled "Science Literacy Support for Improving Learners' Argumentation Skills." This study aims to assess the improvement of students' argumentation skills through the application of science literacy strategies in learning.

In the study titled "Science Literacy Support for Improving Learners' Argumentation Skills," two main variables were analysed. The independent variable is science literacy, defined as an individual's ability to understand, apply and evaluate scientific information in

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everyday life. Science literacy is essential in preparing learners to become knowledgeable citizens and able to argue well about science issues [12]. Meanwhile, the dependent variable is argumentation skills, which include the ability to put forward, support, and respond to arguments effectively. Argumentation skills are essential in science education as they encourage critical thinking and the ability to examine multiple perspectives [13]. In addition, this study also considered control variables such as demographic factors (age, gender, educational background), learning environment, and teaching methods used. With this framework, the main hypothesis proposed is that science literacy support has a significant favourable influence on improving students' argumentation skills. Measuring science literacy can be done through standardised test instruments, while argumentation skills can be assessed using rubrics that evaluate the quality of arguments and engagement in discussions.

Research Methods

Type of Research and Sample Determination

This research is a quantitative study with a correlational design. Correlational research aims to determine the relationship between two or more variables, such as science literacy and students' argumentation skills. The quantitative method was chosen because it allows objective measurement and statistical analysis to provide empirical evidence of the relationship between these variables. This research was conducted in May 2024. The determination of the sample in this study was carried out through a purposive sampling technique. The population in this study were all grade XI students at SMA Negeri 21 Surabaya in the 2023/2024 school year. The research subjects were students from classes XI-2 and XI-10, with 30 people in each class. Samples were taken from two classes (XI-2 and XI-10) to ensure variation and obtain more comprehensive data. It is also possible to see if the relationship between science literacy and argumentation skills is consistent across different grade groups.

Research Procedure

This research procedure includes planning, implementation, and data processing stages. The planning stage includes identifying research variables, preparing research instruments such as science literacy tests and argumentation assessment rubrics, and obtaining permission from the school. Furthermore, the implementation stage involved determining samples from classes XI-2 and XI-10, conducting science literacy tests where students worked on the tests and assessing argumentation based on specific scientific cases. The final stage is data processing, where the students' science literacy and argumentation test results are evaluated and analysed.

Research Instruments

The research instrument used is a description test consisting of 12 questions to measure argumentation skills based on Toulmin's indicators and four questions to measure science literacy skills based on PISA [14].

Data Analysis

Data processing was carried out using Minitab 18 software. For the prerequisite test, the data normality test was carried out using the Ryan-Joiner test, while for hypothesis testing, the Pearson Product Moment correlation test was used.

Results and Discussion

The prerequisite test in this study used a normality test using the Ryan-Joiner test with the help of Minitab 18 tools. The results of the normality test for the argumentation skills of class XI-2 can be seen in the following figure.

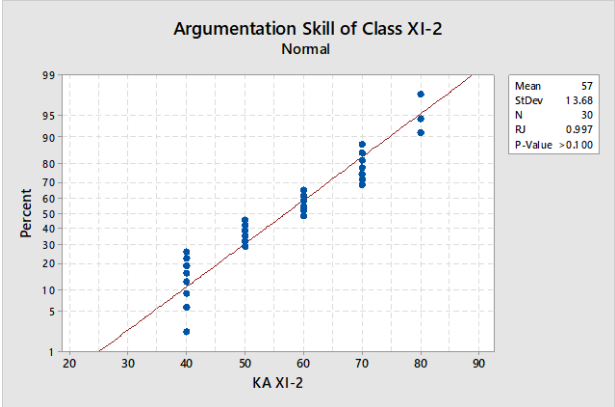

Figure 1. Normality Test of Argumentation Skills of Class XI-2

The normality test results for argumentation skills of class XI-10 can be seen in the following figure.

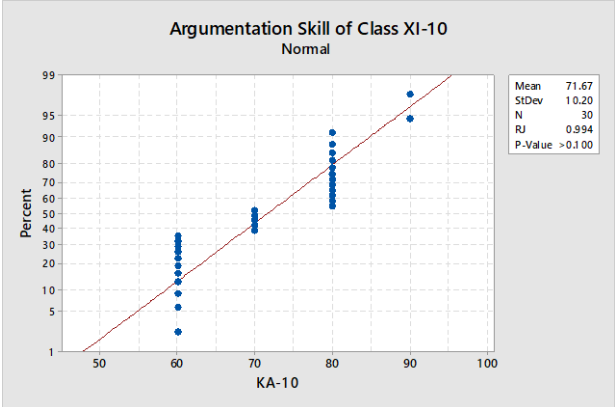

Figure 2. Normality Test of Argumentation Skills of Class XI-10

The normality test results for the science literacy skills of class XI-2 can be seen in the following figure. Based on the results of the normality test with the Ryan-Joiner method in Figure 1, Figure 2, Figure 3, and Figure 4, the p-value is more significant than 0.1, which is greater than the error rate (α) used, namely 0.05. So, it can be concluded that the data on argumentation and science literacy skills in classes XI-2 and XI-10 are normally distributed and can be analysed using parametric statistical methods.

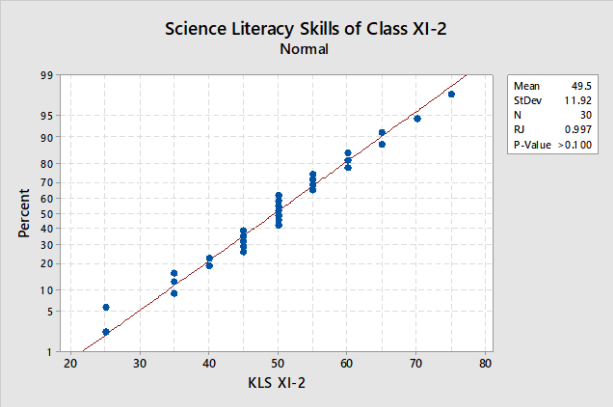

Figure 3. Normality Test of Science Literacy Skills of Class XI-2

The normality test results for the science literacy skills of class XI-10 can be seen in the following figure.

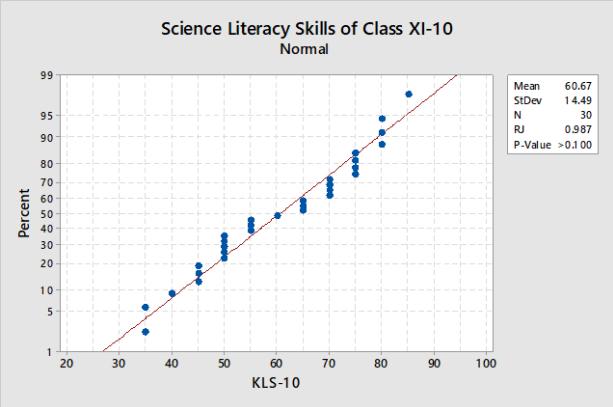

Figure 4. Normality Test of Science Literacy Skills of Class XI-2

After the prerequisite test, the hypothesis test is carried out. The relationship between argumentation skills and science literacy was tested using the Pearson Product Moment correlation test. This is because, based on the normality test, the data on argumentation skills and science literacy skills are both normally distributed. The correlation test results are presented in Figure 5, with the hypothesis formulation below.

The hypothesis in this study consists of two formulations, namely H0, which states that argumentation skills do not have a significant positive relationship to science literacy skills, and H1, which states that argumentation skills have a considerable positive relationship to science literacy skills. The test criteria used are if the P value <0.05, then H0 is rejected and H1 is accepted, while if the P value >0.05, then H0 is accepted and H1 is rejected.

The correlation test results show a significant relationship between argumentation and science literacy skills in class XI-2. The p-value of 0.000 indicates this result is significant (usually $p < 0.05$ is considered significant), and the Pearson correlation value of 0.710 indicates a strong positive correlation.

The correlation test results you mentioned show a very strong relationship between argumentation skills and science literacy skills in class XI-10. The p-value of 0.000 indicates that the results are highly statistically significant, meaning there is a minimal chance that this relationship occurred by chance. The Pearson correlation coefficient of 0.926 indicates a very strong positive relationship, meaning that the better the students' argumentation skills, the better their science literacy skills. This could be the basis for developing teaching strategies that integrate both skills.

This is in line with existing research that states that if science literacy skills increase, argumentation skills increase as well. Therefore, argumentation skills need to be presented in learning so that students' science literacy skills increase. This research also states a positive relationship between argumentation and science literacy skills.

Science literacy can enhance argumentation skills by providing the foundational knowledge and critical thinking abilities to construct and evaluate arguments effectively. Students with a strong understanding of scientific concepts and methods can better analyse evidence, identify logical fallacies, and build coherent arguments. Additionally, science literacy encourages a questioning mindset and an appreciation for evidence-based reasoning, which is crucial for effective argumentation. A solid understanding of scientific principles allows students to draw information from various factual sources when constructing arguments. This depth of knowledge helps them make more accurate and persuasive points. Science Literacy involves the ability to evaluate data, identify biases, and understand the reliability of sources. These skills are directly applied in argumentation, where assessing the strength and relevance of evidence is essential. Science literacy also teaches students to base their conclusions on empirical evidence rather than assumptions or unsupported claims. This practice is fundamental to constructing robust arguments. Scientific inquiry often involves solving complex problems through systematic investigation. These problem-solving skills can be transferred to the context of argumentation, enabling students to tackle complex issues logically and systematically. Science education frequently requires students to explain their findings and reasoning clearly. This practice enhances their ability to articulate arguments effectively.

A study by Kuhn and Udell (2003) found that teaching students to engage in scientific argumentation significantly improved their overall argumentation skills [16]. The researchers concluded that constructing and defending scientific arguments helped students develop a more structured approach to argumentation, which could be applied to other domains. Another study by Osborne, Erduran, and Simon (2004) emphasised incorporating. Argumentation in science education helps students better understand the nature of science [17]. This understanding, in turn, enhances their ability to engage in meaningful discourse about scientific and non-scientific issues.

Furthermore, a meta-analysis by Sampson and Clark (2008) revealed that interventions aimed at improving science literacy also positively impacted students' argumentation skills [18]. The analysis showed that students who participated in science literacy programs were more adept at constructing and evaluating arguments, supporting the fact that science literacy and argumentation skills are closely linked. Overall, the enhancement of argumentation skills through science literacy is well-supported by existing research. The foundational knowledge, critical thinking abilities, and evidence-based reasoning skills developed through science literacy are

essential to effective argumentation. This relationship underscores integrating argumentation practices into science education to foster scientific understanding and argumentation proficiency.

According to PISA 2018, a person who has science literacy is someone willing to engage regarding science and technology and is required to have the ability of the first three competencies, namely explaining scientific phenomena by recognising, offering and evaluating explanations for sharing natural and technological phenomena, the second competency is evaluating and designing scientific investigations by describing and assessing scientific investigations and offering ways to handle scientific questions, and the third is interpreting scientific data and evidence by analysing and evaluating data, claims, and arguments can vary repetition and draw scientific conclusions appropriately [14].

One of the characteristics of science-literate students is being able to apply science concepts in problem-solving to design and evaluate scientific investigations and collect valid data or evidence [25]. Competencies in assessing and designing investigations and procedural knowledge enable learners to conduct scientific investigations in ways that produce reliable data. This data is then used to support scientific claims in learners' argumentation. Thus, developing good science literacy improves argumentation skills, as learners can better design valid experiments and gather evidence that supports their claims scientifically.

The ability to interpret scientific data and evidence is closely related to stating evidence in arguments. Learners who interpret data identify evidence supporting their scientific claims [27]. Evidence is an essential component in building strong and valid arguments.

Epistemic knowledge enables learners to understand and explain why the evidence they gather supports the claim (warrant) and to provide additional support (backing) for the claim. Learners must know how the evidence was generated and its validity.

The ability to interpret data also helps learners to state qualifiers, which show the extent to which the data supports the claim, and rebuttals, which address potential counter-arguments. A deep understanding of data and the scientific method enables learners to recognise the limitations of their evidence and make more balanced and credible arguments [28].

Hubungan antara literasi sains dan keterampilan argumentasi terlihat jelas dalam cara peserta didik menggunakan data dan bukti ilmiah untuk mendukung klaim mereka. Kompetensi menafsirkan data dan bukti ilmiah serta pengetahuan epistemik mendukung kemampuan mereka dalam menyatakan *evidence, warrant, backing, qualifier*, dan *rebuttal* [29]. Dengan mengembangkan literasi sains, peserta didik tidak hanya memahami konten ilmiah tetapi juga bagaimana menggunakan bukti secara efektif untuk membangun argumen yang kuat dan valid.

Conclusion

This study shows a positive significant relationship between argumentation skills and science literacy in class XI-2 and XI-10 students, with normally distributed data allowing parametric statistical analysis. The Pearson Product Moment correlation test revealed that the improvement in science literacy was in line with the improved argumentation skills, with the correlation coefficient showing a strong to very strong relationship. These results confirm the importance of science literacy development in improving students' argumentation skills, enabling them to make valid scientific claims and participate in evidence-based scientific discussions.

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