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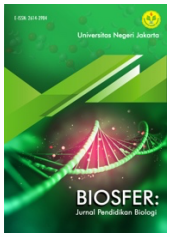

# The correlation of higher order thinking skills and scientific literacy of public high school students

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**ABSTRACT**

Various studies show that the scientific literacy of Indonesian students is still in a very low category, based on a review of the literature several factors are thought to be involved, namely related to the thinking ability of students who have not reached higher cognitive abilities in this case higher order thinking skills. So, this study aims to determine the relationship between higher order thinking skills and scientific literacy in public high school students in Bulukumba Regency, this research is a correlational type with a quantitative approach. The population in this study were all XII grade students at public high schools in Bulukumba Regency. The samples in this study were XII grade students at SMAN A, SMAN B, SMAN C, SMAN D, SMAN E, SMAN F, SMAN G, and SMAN H. Data collection techniques in this study used multiple choice tests that tested the C4-C6 level and scientific literacy tests tested in the PISA Program. Data analysis in this study was conducted using simple correlation test with Product Moment correlation method. The results showed that there is a relationship between higher order thinking skills and scientific literacy of high school students in Bulukumba Regency. This is based on the results of the analysis obtained showing that the significance value of learning is smaller than 0.05, namely (0.001 <0.05).

## INTRODUCTION

Education is currently growing and developing in line with efforts to create human resources in the Society 5.0 era as a response to the development of the Industrial Revolution 4.0, humans work in harmony with the performance of information and communication technology. Daud & Saenab, (2017) revealed that the spread of information from around the world is easily accessed quickly by anyone and anywhere. This development is intended to obtain solutions and find new innovations to solve various life problems faced by modern humans through special skills. Ariyana, Pudjiastuti, Bestary, & Zamroni, (2018) revealed that the design of improving learning qualifications is part of efforts to improve the quality of students which ultimately leads to improving the quality of Indonesian education.

Science understanding is knowledge gained through the scientific process of investigation, observation and deduction. Students are expected to grow and develop analytical, inductive, and deductive thinking skills in solving everyday problems. Cahyana, Kadir, & Gherardini, (2017) stated that science education or Natural Sciences (IPA) has a strategic role in forming students who can think critically, creatively, and logically and have the initiative to respond to societal issues. Several problem-solving skills develop in individuals who have scientific literacy. Scientific literacy is interpreted as the power of students in processing, reasoning and being able to relate the knowledge learned to the concrete realm of everyday life.

Septiani, Junaidi, & Purwoko, (2019) further explained that literacy is not limited to reading and writing, but involves thinking skills that make them a literate generation in learning, including in science learning. Rudini, Ruslan, & Daud, (2021) also revealed that quality education can produce quality and productive human resources. Several surveys that have been conducted to assess the quality of human resources, especially in Indonesia, in facing the challenges of the 21st century, one of which was carried out by PISA, found that Indonesian students in terms of their level of literacy in understanding science presented in the 2022 PISA results show that the scientific literacy of Indonesian students is ranked 67th out of 81 countries participating in the survey. This finding explains again that the scientific literacy of Indonesian students is still at the lowest position.

It has been explained from various opinions that students who have good scientific literacy are not only remembering and memorizing material content but also found in individuals who are able to think analytically, reflectively, and creatively in responding to a problem found. All of these characteristics can also indicate the ability of students to think at a higher complex level. Students' literacy skills expressed a similar statement are closely related to higher-order thinking skills. The opinion is based on the opinion conveyed by Khoiriah, Jalmo, & Abdurrahman, (2020) that higher-level thinking skills invite students to be able to apply knowledge concepts to new implications or new things that have never been taught.

Angraini & Sriyati, (2019) stated that higher-order thinking skills emphasize application skills and students must be able to construct their knowledge. This skill implies evaluating the ability to reason, justify, analyze, process, and evaluate information. The similarities that can be identified in the characteristics of these two competencies, both scientific literacy competencies and high-order thinking skills, do not solely rely on the process of remembering students but rather interpret science conceptually in everyday life to a problem presented. So, the link between students' higher-order thinking skills and scientific literacy can be observed in the higher-order thinking skills themselves.

The findings of several surveys conducted, become material for Indonesia's reflection on the existence of homework development on the quality of Indonesian education that is more challenging. When referring to these results, it is explained that the scientific literacy of Indonesian students is influenced by several determinant factors, one of which is the higher-order thinking skills of the students themselves. The findings obtained by Yuriza, Adisyahputra, & Sigit, (2018) it show that there is a positive relationship between higher-order thinking skills and students' scientific literacy with a correlation strength that is categorized as quite strong. Based on these findings, it is concluded through analysis and review that there is a relationship between higher-order thinking skills and the scientific literacy competence of students, especially those in public high schools in Bulukumba Regency, Indonesia.

## METHODS

### Research Design

This research is a correlational type with a quantitative approach that aims to identify and understand the nature of the relationship between higher-order thinking skills and student scientific literacy. This research is intended to find causes that allow changes in behavior, symptoms, or phenomena caused by an event, behavior or things that cause changes in independent variables that have occurred. This research was conducted from September 2023 to October 2023 with the research subject of students, especially class XII of Public High School. The selection of this sample is considered because at this level students are represented as having achieved competence in several concepts of material in the biology class at the previous level. The collected data will be analyzed quantitatively to conclude the research hypothesis testing and then described.

### Population and Samples

The population of this study was all XII-grade students in 19 public high schools in Bulukumba Regency, South Sulawesi, Indonesia. The sample was taken by using the Cluster Random Sampling method by mapping the sampling of school areas located in several regions in Bulukumba Regency, with the division of the North region represented by SMAN A and SMAN B, SMAN C and SMAN D representing the East region sample, SMAN E and SMAN F representing the South region sample, and SMAN G and SMAN H representing the West region sample and SMAN G with SMAN H represented the sample of the West region. The individual samples were taken using a sampling formula based on the opinion of Arikunto (2016) that due to the limitations of the researcher, 15% of the total population was taken. Due to the limitations of the researcher, 15% of the total population was taken, thus obtaining 303 research samples from the sample schools that had been determined. That has been determined. Individual samples in this study were taken randomly from the school sample.

### Instrument

Research data on both variables were collected using tests that test cognitive abilities in the form of multiple choice with four answer choices that focus on Biology content questions. The test technique tested to measure higher-order thinking skills amounted to 20 questions containing questions at the C4 cognitive level as many as one item, C5 level as many as six items and C6 level as many as three items. These higher-order thinking questions are adapted from the tests tested in the Provincial Achievement Tests (PATs) program implemented by the regional government of Alberta, Canada. Then, for the scientific literacy variable, students are measured using tests adapted from tests tested in the Program for International Student Assessment (PISA). The scientific literacy test was given based on the scientific literacy indicators issued by PISA in the process dimension, namely: 1) Interpret data and evidence scientifically, which has seven items; 2) Interpreting data and evidence scientifically, which has ten items; and indicator 3) Evaluating and designing scientific questions based on scientific evidence, which has three items. Both tests on this variable have been translated into Bahasa Indonesia. The validity and reliability tests carried out on the higher order thinking skills test refer to the comparison of the Sig value < 0.05, which shows that out of 23 items there are 20 items that meet the requirements, with a Cronbach's Alpha reliability value of 0.816 > 0.60, it can be concluded that the 20 items are reliable. The instrument for collecting data on scientific literacy shows that of the 20 items tested, 20 items were declared valid, while the Cronbach's Alpha reliability test value is 0.876 > 0.60, so it can be concluded that the 20 items are reliable.

### Procedure

This research begins with the adaptation of questions based on higher order thinking skills and questions that test scientific literacy that focus on questions containing Biology content. Then this research instrument went through the validation stage. Data were collected by administering tests using instruments in the form of questions in secondary schools selected through the Cluster Random Sampling technique for regional samples, while individual samples were taken randomly. Furthermore, research was carried out by giving tests conducted by researchers as students of the Biology Education Postgraduate Study Program at Universitas Negeri Makassar. After implementation, then the processing of data that has been collected to be examined and analyzed using statistical

testing. on the SPSS version 22 application and Microsoft Excel, as for the test method used in this study, namely simple correlation.

**Data Analysis Techniques**

The data obtained then went through the analysis stage to obtain conclusions. The analysis was carried out using two techniques, namely descriptive and inferential statistical analysis. Descriptive statistical analysis consists of the categories and percentage values from data collection of two variables. In this study, to present the desired data acquisition, the scores that have been obtained are then converted into guidelines for the value category of higher-order thinking skills described by Kusumah (2010) and the scientific literacy of students according to Purwanto (2009).

Inferential tests are intended to test the research hypothesis. In this study, the hypothesis was tested using a simple correlation with the Pearson Product Moment Correlation method using the SPSS version 22.0 application. Before being able to test the hypothesis the data collected needs to go through a basic assumption test, namely the normality test and linearity test. The normality test serves to determine whether the data distribution is normally distributed or not, the basis for decision-making is that the data is said to be normally distributed if Sig > α (0.05). Meanwhile, the Linearity test is intended to determine whether the two variables to be tested have a linear relationship or not significantly, with the basis of the decision if the significance result > 0.05, it is said that the two variables have a linear relationship.

**RESULTS AND DISCUSSION**

The correlation between the two variables is tried to be explained in this study, considering that both higher-order thinking skills and scientific literacy are two of the life skills of the Industrial Revolution 4.0 society. Descriptive findings in this study can be explained in the following Table 1

**Table 1.**
Category distribution of higher-order thinking skills of Public high school students in Bulukumba

| Interval | Category | Frequency | Percentage (%) |
|---|---|---|---|
| 85.00 – 100 | Very Good | 0 | 0% |
| 70.00 – 84.00 | Good | 0 | 0% |
| 55.00 – 69.00 | Fair | 3 | 1% |
| 40.00 – 54.00 | Enough | 57 | 19% |
| < 40.00 | Poor | 243 | 80% |
| **Total** | | 303 | |

Based on the ability of students in Bulukumba Regency to solve high-level problems from the table above 80% are in the poor category. Referring to the data above, it is known that higher-order thinking skills in 303 samples of class XII students in public high schools in Bulukumba Regency are mostly classified in the poor category. In addition, it was found that there were no samples in the high or very high categories.

The findings in this study are similar to the previous study which revealed that the average score of students' higher-order thinking skills was around 53.52% in the very poor category (Putri, Sikumbang, & Rakhmawati, 2020). Different test findings show that 60% of students fail to solve questions with a high cognitive level (Sabu, 2018). The weakness of students' higher-order thinking skills is caused by several determinant factors, one of which is their lack of familiarity with solving HOT-type problems. It is explained that students are used to working on problems that tend to be convergent, which causes some of them to experience epistemological obstacles when faced with problems containing new concepts whose solutions require other points of view (Pirmanto, Anwar, & Bernard, 2020). Whereas the task demands high-level questions and expects students to answer questions by applying, analyzing, synthesizing, and evaluating information rather than remembering facts (Muhibbuddin, Artika, & Nurmaliah, 2023)

An outline representation is carried out with the percentage of competency attainment of the sample of class Sample class XII students per indicators in Bulukumba regency can be seen in the following Table 2.

**Table 2.**
Percentage per indicator of higher-order thinking skills

| Indicator | Percentage (%) | Category |
|---|---|---|
| Analysis | 26.79% | Poor |
| Evaluation | 32.89% | Poor |
| Creation | 27.28% | Poor |

The percentage per indicator that was successfully analyzed shows that the highest level of students' high-level thinking skills was found in the Evaluating indicator but was in the poor category, then the lowest percentage was achieved by students in the Analyzing indicator. These findings show that overall the majority of students at Public High Schools in Bulukumba Regency are in the poor category so they are declared to not have high-level thinking skills in all indicators.

The low level of students' higher-order thinking skills is explained by previous research including the lack of quality of the learning process in terms of learning activities and students' understanding based on basic competencies and indicators that must be achieved (Putri et al., 2020). Some of the reasons for previous research revealed that the lack of quality of the learning process can be seen from the learning activities and understanding of students based on basic competencies and indicators that must be achieved (Thahir, Magfirah, & Anisa, 2021)

Descriptively, the science literacy skills of the entire accumulated sample have been analyzed starting from categorizing to calculating percentages. The description of the scores, and determination of intervals to the frequency distribution can be observed in the following Table 3.

**Table 3.**
Category distribution of scientific literacy of Public high school students in Bulukumba

| Interval | Category | Frequency | Percentage (%) |
|---|---|---|---|
| $N \geq 86$ | Very Good | 0 | 0% |
| $76 \leq N < 86$ | Good | 0 | 0% |
| $60 \leq N < 76$ | Fair | 13 | 4% |
| $55 \leq N < 60$ | Enough | 20 | 7% |
| $N \leq 54$ | Poor | 270 | 89% |
| **Total** | | 303 | |

The scientific literacy variable in the sample in this study is explained in Table 3, there are around 89% of the 303 samples whose scientific literacy competency scores are in the poor category. From these findings, it can be concluded that the scientific literacy competency of State High School students in Bulukumba Regency is in the poor category. Furthermore, the overall analysis of percentages is based on indicators that determine scientific literacy abilities, these percentages are shown in the following table.

This finding is slightly different from that obtained by other researchers in different regions but in the same province with the results of the analysis showing that 50% of students' scientific literacy is in the middle category (Zuhri, Adnan, & Saparuddin, 2023). Adnan, Mulbar, Sugiarti, & Bahri, (2021) explains further that the ability to organize, understand the inquiry method, and interpret data and information in Biology subjects is still low. However, another study shows that it is not much different from the researcher, namely the scientific literacy of students around 72% are in the percentage of the poor category (Angraini & Sriyati, 2019; Bagasta, Rahmawati, M, Wahyuni, & Prayitno, 2018). Various representations of scientific literacy conducted by researchers and other studies show similar results, namely the need for improvement in science learning. Some of the factors causing this are explained as students not having an understanding of the basic science concepts taught by the teacher; lack of ability to interpret tables or graphs; and neglect of the importance of reading/literacy and writing skills (Yusmar & Fadilah, 2023).

Analysis of the overall score that has been done is continued by evaluating the achievement of each of the 3 indicators on science literacy skills on the whole sample. The achievement of each indicator is presented in the form of a percentage as attached in Table 4.

**Table 4.**
Percentage per indicator of scientific literacy competency

| Indicator | Percentage (%) | Category |
|---|---|---|
| Interpret data and evidence scientifically. | 35.03% | Poor |
| Explain phenomena scientifically. | 35.87% | Poor |
| Evaluate and design scientific questions based on scientific evidence. | 72.81% | Good |

Based on Table 4 it is known that students' scientific literacy skills for each indicator, interpreting data and evidence scientifically and explaining phenomena scientifically, show a very low percentage. The data analysis presented in the table above explains further which indicators students have difficulty in solving science-based problems/issues. When looking at previous studies, there is a diversity of results. The conclusion of the analysis is similar to the research conducted Permatasari, (2022) , which also found that the indicators of Explaining phenomena scientifically and Interpreting data and evidence scientifically were still very low. Meanwhile, the indicator of evaluating and designing scientific questions based on scientific evidence was the highest achievement at 38.46%, although it remained in the very poor category. This is different from the research Wulandari & Sholihin, (2022) that managed to conclude from the results of the study showing that the average achievement of scientific literacy in the knowledge aspect was 66.45%, so their abilities were classified as good.

The analysis continues by carrying out inferential data analysis. Hypothesis testing is carried out using the simple correlation method. Before you can carry out a hypothesis test, you must first test the basic assumptions of normality and linearity. Based on the normality test carried out, it was found that Kolmogorov Smirnov significance in both variable data showed Sig > α (0.05), namely for high-level thinking skills it was 0.058, while the scientific literacy competency variable was 0.053. Apart from that, the linearity test that was carried out showed a value of 0.489 > 0.05, which means there is a significant linear correlation of the two variables in this study. After testing the basic assumptions, the analysis continued with hypothesis testing with the results in Table 5.

**Table 5.**
Hypothesis Testing with Simple Correlation

| Model | Sig. (1-tailed) |
|---|---|
| Higher order thinking skills | 0.001 |

**. Correlation is significant at the 0.01 level (1-tailed).

The correlation test that has been carried out shows a significance value that explains there is a relationship between higher-order thinking skills and the scientific literacy competence of public high school students in Bulukumba Regency, Indonesia. This finding reaffirms the findings of research conducted by Susiati, Adisyahputra, & Miarsyah, (2018) which concluded that there was a significant relationship between higher-order thinking skills and scientific literacy skills with a criterion score for the strength of the data relationship was weak. Thahir, Magfirah, & Anisa, (2021) also explained a similar thing not much different from the researcher's findings, namely that there is a positive relationship between the two variables, but the level of correlation is weak.

Field findings show that students of class XII SMAN in Bulukumba Regency, Indonesia, have very low higher-order thinking skills which have implications for their scientific literacy skills. Students still have difficulty in solving problems in the form of questions that require complex thinking skills such as decomposing material, formulating appropriate conclusions, forming representations of the analysis process, and finding relationships between concepts. The greatest difficulty is found in testing their ability to break down material into small parts and determine the relationship between one group of information (facts). This opinion is reinforced by the statement delivered Primasari, Miarsyah, & Rusdi, (2020) that scientific literacy involves the ability to analyze, interpret data/information, draw conclusions and find solutions.

Learners have not been able to achieve indicators of achieving science literacy competencies in fulfilling the characteristics of the tasks contained in the (Organisation for Economic Cooperation and Development, 2015) namely to be able to explain phenomena scientifically Interpret data and evidence scientifically and provide justification for their choices and the ability of the sample group to

evaluate how to explore due to limitations in the interpretation of data sets including the source and impact of the accuracy of scientific data. This weakness is explained Miyata, (2020) that students are only able to write facts when explaining evidence due to a lack of understanding of various cause-and-effect relationships based on evidence and difficulty utilizing abstract knowledge to identify descriptions to explain contextual processes or phenomena. The low achievement of students in this study cannot be separated from the weak ability of students in critical thinking.

Forming thinking skills is one of the cores of the learning program. Critical thinking is represented in the form of self-capability in thinking reflectively and systematically which is needed when wanting to determine the right decision in this case the decision/solution of science problems, which in the end this competence is owned by individuals with high-level thinking skills. As the findings (Listiani & Susilo, 2022) concluded the relationship between science literacy and critical thinking. The difficulties faced by students were explained Fakhriyah, Masfuah, & Mardapi, (2019) because students have not been able to connect with environmental phenomena, causing students to have difficulty in solving complex problems until it is difficult to relate science concepts appropriately. Empowering higher-order thinking skills is tantamount to developing science literacy skills.

Although the scores are still in the low category, the relationship between higher-order thinking skills and scientific literacy competence on the indicator Evaluate and design scientific questions based on scientific evidence as explained by (Organisation for Economic Cooperation and Development, 2015), this ability relates to the competence of students to be able to utilize various interrelated scientific ideas and concepts to offer hypothesized explanations of phenomena to make predictions. As in the indicators, the highest percentage was found in higher-order thinking skills, especially the ability to determine the value/consideration of an object/information based on criteria. Niate & Djulia, (2022) Describing the reasons for the low ability of students in this indicator indicates the low content, procedural, and epistemic knowledge of students. Improving this competency can be pursued through active learning activities involving students in science processes such as stimulation support, inquiry, or projects. Through research Wen et al., (2020) Inferring the benefits of this kind of active learning on scientific literacy skills suggests higher scientific literacy skills are more capable of making more differentiated inferences, and will have better scientific literacy performance.

Yuriza et al., (2018) explain that students' scientific literacy is closely related to higher-order thinking skills. This ability requires not only the ability to remember, but also a higher and deeper level of understanding, such as the ability to analyze, synthesize, and evaluate (Yuriza, Adisyahputra, & Sigit, 2018). The statement forms a straight line regarding the formation of 21st-century student competencies in using scientific knowledge, defining problems/questions, and drawing conclusions based on evidence that becomes the basis for decision-making related to natural phenomena and symptoms. To face the challenges of these various competencies, more complex thinking skills are needed, in this case, higher-order thinking skills in students. Fatmawati & Khotimah, (2023) describes the fundamental principle of scientific literacy as teaching how to think and act by engaging in higher-order thinking.

The similarity of the characteristics of the challenges in achieving scientific literacy and higher order thinking skills of students is that the demands of the thinking process are not limited to memorization patterns, but also being able to apply and express science in everyday life as a problem solver. As stated by Thomas & Thorme (2009), HOTS requires making connections between facts, categorizing them, manipulating them, placing them in a new context, and being able to apply them to find new solutions to problems. However, the low achievement in these two variables was revealed by Utami, Marwoto, & Sumarni, (2023) related to the dynamics of the habitual teaching process in schools such as the completion of teaching materials by teachers according to curriculum targets in each school, which contributes to many biology concepts being misunderstood or merely memorized so that they have low retention and are easily forgotten. The implication is that students will not be able to contribute constructively and engage their higher levels of cognition (Oluwaseun & Ademola, 2020).

Nugroho, (2021) explains that in the content process, the application of science is still not as expected, because the material presented is only rote which only trains the short-term memory domain which causes students to have the ability to think only by remembering, restating, or reciting without any processing (recite). As Suhadi, Ristanto, Sigit, & Supriyatin, (2023) found from results of the research conducted showed that 50% of students had low biological literacy skills. These statements and findings imply that efforts are needed to accustom students to dealing with the

complexity of problems, encourage them to formulate deductions, solve problems rationally, formulate conclusions from evidence or facts from the ability to examine the relationship between scientific concepts and situations presented in their environment, as science literacy evaluation is aimed at. Luzyawati, Hamidah, Fauzan, & Husamah, (2025) revealed that the assessment of students' science literacy is intended to improve students' intellectual capacity so that they have adequate thinking skills to perform their roles.

Septiani, Junaidi, & Purwoko, (2019) explaining that literacy is not just the ability to read and write, it is also explained that this competence is related to skills in understanding information analytically, critically, and reflectively in the case study at hand. This assumption represents the extent to which higher-order thinking skills can explain their relationship with scientific literacy, which can be seen as an indication of individuals who are able to make decisions, analyze assumptions that arise, conduct investigations based on the data/information obtained to produce new information or conclusions themselves. As the scientific literacy character described by Hernawati, Amin, Muhdhar, & Indriwati, (2019) from his study the achievement of scientific literacy refers to the process of science which is the mental process involved when answering questions or solving problems.

HOTs are able to connect, manipulate, and transform existing knowledge and experience to think critically and creatively in an effort to solve problems in new situations, with the hope that students will be able to solve a variety of scientific problems that require higher cognitive processes (Putranta & Supahar, 2019). Other learning developments Fauzi & Wicaksono, (2021) explained that there is a significant influence between student grades and students' HOTS levels. Satriani, Taiyeb, & Mu'nisa, (2018)) also expressed a similar opinion that low science process skills will ultimately lead to low student science learning outcomes. From a process point of view, higher-order thinking skills also have an influence on other competencies as found by Naimnule & Corebima, (2018) that There is a correlation between metacognitive skills and critical thinking skills towards the process skills. The view expressed Kola, (2020) that students are required to have science literacy skills necessary for them to function effectively after graduation in society.

## CONCLUSION.

Based on the hypothesis testing that has been carried out, this research concludes that there is a correlation of higher-order thinking skills and scientific literacy competence in students at State High Schools in Bulukumba Regency, Indonesia. In order to improve and perfect similar research, the researcher suggests testing the level of difficulty of the questions in the validation of the questions, as well as trying to ensure the same number of questions between the variable indicators being tested. As well as managing the time for conducting research properly in accordance with the limitations of time, energy and materials owned by the researcher.

The limitation in this study lies in the data collection instrument which is only in the form of multiple choices due to limited time, material and energy, for variables such as in this study should use varied forms of questions such as Essay combined with multiple choices. So that what is measured can be represented convincingly. As for the obstacles during the research, namely the research locations that are far apart from each other so that it makes it difficult to access to be able to conduct research in the near future, but this problem is resolved by time management and good communication with the research schedule with the parties involved in the research location.

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