



Contained Testing: Comparison of Scientific Literacy Ability of Middle and High School Students Aged 15 Years Old

¹Aulya Nanda Prafitasari, ²Restasa Britan Pradhana

¹Biology Education, Universitas Muhammadiyah Jember

²State Senior High School 2 Situbondo

Email Correspondence: aulya.prafitasari@unmuhjember.ac.id

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Abstract

One of skills used as the basic of high order thinking skills is scientific literacy ability. This ability is evaluated by OECD in PISA program follow by students aged 15 years old from various countries. Therefore, this article is aimed to compare scientific literacy ability of middle and high school students aged 15 years old on a limited scale. Scientific literacy ability has 4 indicators which are nominal literacy, functional literacy, conceptual/procedural literacy, and multi-dimensional literacy. This research was designed in quantitative research that describe data were gained from the comparison between 25 students grade IX SMP Negeri 7 Jember and 25 students grade X SMA Negeri 2 Situbondo. The data were analyzed using Kruskal Wallis with SPSS program. The result showed that 3 among 4 indicators of scientific literacy test of middle and high school students aged 15 years old had sig >0.05 , which means there is no significant difference. Those 3 indicators are nominal literacy (0.204), functional literacy (0.107), and conceptual/procedural literacy (0.154). Meanwhile, for multi-dimensional literacy showed sig 0.04 or <0.05 , hence it can be concluded that there is significant difference of multi-dimensional literacy ability between middle and high school students aged 15 years old. So, from this limited research it can be seen that age is not a reference in the development of students' level of scientific literacy.

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INTRODUCTION

Scientific approach which is used as the basis for learning activities requires students to mobilize all of their potential analysis and understanding in the learning process, especially in problem solving. In the Kurikulum Merdeka, one of the learning targets is to increase student literacy and numeracy, including scientific literacy. Scientific literacy abilities are very important to measure and improve as a basis for selecting forms of learning according to the heterogeneous ability levels of students. Apart from that, a good level of scientific literacy will improve students' critical and analytical skills in understanding a concept. Not only high-level students but also students from elementary level are instructed to use their critical thinking. One of abilities which is used as the basic of high order thinking skill is scientific literacy ability. Scientific literacy is the skills to employ scientific knowledge, identify problems, and draw conclusions based on evidence in understanding and making decisions regarding nature and its changes because of human activities, Anjarsari (2014). According to Hernandez (2015)

scientific literacy ability of students is important to increase: 1) knowledge and research of natural science, 2) oral and written vocabularies needed to understand and communicate science, and 3) relation among science, technology, and society. Reading ability denotes an indicator of students literacy awareness in disclosing each problem based on science concepts.

Scientific literacy ability has 4 categories. Scientific literacy levels by Soobard & Rannikmäe (2011) are explained as follows:

a. Nominal Literacy:

Students agree with what people say without having their own ideas. Students use/utilize and write scientific terms, but they are not able to justify or having misconceptions.

b. Functional Literacy:

Students are able to keep in mind any information from the text books such as writing the basic facts, but they are not able to justify their own opinion based on the text or graphic given. Students even know interdisciplinary concepts, but they are not able to describe the relations between those concepts.

c. Conceptual/procedural Literacy:

Students take advantage of interdisciplinary concepts and show comprehension and interconnectedness. Students have understanding about the problem, justify the answer correctly through information from the text, chart, or table. Students are able to analyze the alternative solutions.

d. Multi-dimensional Literacy:

Students take advantage of any concepts and show an ability to connect those concepts with daily life. Students understand how science, society, and technology are interrelated and affect one another. Students also show an understanding about nature of science through their answers.

Various countries have taken scientific literacy test held by PISA (Programme for International Student Assessment), a student ability assessment program established by OECD (Organization for Economic Co-operation and Development) to evaluate education system of 72 countries around the world. PISA is the OECD's Programme for International Student Assessment. PISA measures 15-year-olds' ability to use their reading, mathematics and science knowledge and skills to meet real-life challenges by OECD (2018). According Puslitjak Kemdikbud (2021) from PISA 2018 show that Indonesia is in the bottom 10 of the 79 countries that Participate. Indonesian students' scientific ability is 37 points below the ASEAN average. But, based on Islami (2020) research shows that although there are science literacy differences of Thai had score slightly better than Indonesian, although is not statistically differences (Sig. 0.087). This provides an idea for the researcher to investigate the scientific literacy ability of 15 years old students from public schools with relatively balanced facilities and infrastructure qualifications but different in term of levels as applied to PISA activities. According Wuriyanto (2022), the age of 15 years was chosen because the OECD uses this reference to carry out the PISA Program tests, and most Indonesian students aged 15 years are in grades IX and X. Scientific literacy ability test was done using questions with the same natural science concept using Computer Based Test (CBT) system so that the result could be found out immediately. The questions of concepts used were questions about natural science in general on the basis of literacy science on reading material previously studied by both middle and high school students.

METHODS

This research is aimed to find out if there was significant difference or comparison of scientific literacy ability of middle and high school students aged 15 years old. This research was done in March 2022 on 25 students of SMP Negeri 7 Jember and 25 students of SMA Negeri 2 Situbondo aged 15 years old. At that age, there are students in grade IX and X. The selection of both schools and research samples was determined based on purposive sampling technique. There were 25 students selected to take the scientific literacy test from the two schools and through the help of the teacher, it was confirmed that the students were at the age of 15 years.

The previous scientific literacy questions are adapted from scientific literacy questions belongs to Fatmawati (2015) combined with literacy questions belongs to Pradhana (2017). Then, based on researcher's understanding, scientific Literacy indicators are divided into 4 categories. Those scientific Literacy indicators consist of the lowest category which is nominal literacy, functional literacy, conceptual literacy, to the highest category, that is multi-dimensional literacy. Simply, According Pradhana (2017) each scientific Literacy indicator is described as follows.

- a. Nominal Literacy
Nominal literacy indicator refers to that students are able to tell and know the identity of certain concept, but they are not able to comprehend the function of that concept.
- b. Functional Literacy
Functional literacy indicator can lead students to recognize a certain concept and function of it.
- c. Procedural/Conceptual Literacy
Conceptual literacy indicator aims more at students' understanding on more than 1 concept which has procedural relevance without knowing cause and effect aroused by those concepts.
- d. Multi-dimensional Literacy
Multi-dimensional literacy indicator causes students to maximize image media, chart, or educational product to comprehend the interrelations and causal relationships from several concepts, students are also encouraged to do a deeper analyse on condition changes of certain concept.

Scientific literacy skills were analyzed only based on the output data from the results of the tests carried out by students without giving any treatment or training beforehand to each sample group. This research was conducted using test application from the website platform kahoot.com. The questions in the scientific literacy test are in the form of multiple choice which are valid because they are the result of the application of scientific literacy test questions of Fatmawati (2015) which mixed with Pradhana's Physics literacy test (2017). By using Soobard & Rannikmäe scale, this test was designed by making contextual situations and questions of three subjects i.e. Biology, Physics and Chemistry was like Shahzadi,s Research (2020). Student answers are then analyzed through the results output that can be downloaded directly from the Kahoot! by 4 categories scientific literacy skills, namely nominal literacy, functional literacy, procedural literacy, and multidimensional literacy. This study used multiple choice instruments such as the results of Ni'mah's (2019) research which states that 65% of scientific

literacy researchers use a type of multiple choice instrument which includes measurement of content, context, and process. In this study, both class IX and X students used the same scientific literacy instruments, just like in the PISA program.

The results of the students' answers was analyzed using SPSS to determine whether there was a significant difference in the scientific literacy ability of 15 year old students in grades IX and X from SMP Negeri 7 Jember and SMA Negeri 2 Situbondo. The decision-making criteria were determined based on the significance value of the Kruskal Wallis-test indicated by the SPSS Outputs data. Because the tolerance level used is 5%, the null hypothesis (H_0) which is interpreted by the absence of a significant difference to the scientific literacy ability of 15 year old students will be accepted if the significance value is > 0.05 .

RESULTS AND DISCUSSION

The scientific literacy test questions consisted of 16 natural science questions with general concept previously studied by middle and high school students. Those test questions covered 4 indicators of scientific literacy ability with the same amount. Scientific Literacy questions were tested using computer based test, so that the result can be immediately found out. Application program used was game application or quiz tournament with platform *Kahoot!*. The test covers physics, chemistry and biology material which is integrated with environmental problems. Here are some examples of multiple choice questions used in scientific Literacy ability test.

If Reina turned off kitchen utensils when they were left behind. How much is the saving of CO2 emmissions?


 Go Full Screen

Skip

Aktivitas	Jumlah karbon dioksida (ton/tahun)	
	Keluarga Reina	Keluarga Aini
Memasak	2.8	0.6
Memasak air	2.4	2.2
Penerangan	0.6	0.8
Menggunakan alat-alat Dapur	1.6	2.0
Meninggalkan alat-alat dapur dalam keadaan hidup	0.5	0.3
Total	8.3	5.9

0
 Answers

▲ 0,3 ton/year

◆ 1,6 ton/year

● 1,1 ton/year

■ 0,5 ton/year

Pict 1. Nominal Literacy Indicator Question

What is the purpose of water purification in phase 2?

54

0 Answers

Kill bacteria and germs
 Filter water from small particles

Precipitate sand and mud
 Filter water from large particles

Pict 2. Functional Literacy Indicator Question

Which is included into criteria of clean drinking water?

No	Parameter	Sampel				
		1	2	3	4	5
1	bau	Tidak	Tidak	Tidak	Tidak	Tidak
2	keruh	Jernih	Jernih	Jernih	Scrub	Keruh
3	Rasa	Tidak	Tidak	Tidak	Hambur	Hambur
4	Warna	Jernih	klokningan	Jernih	Kekhitaman	Jernih
5	pH	7	5	8,7	10	9

55

0 Answers

Sample 1
 Sample 2

Sample 3
 Sample 4

Pict 3. Procedural/Conceptual Literacy Indicator Question

Based on the table, what affects the tree absorption of CO₂?

No	Pohon	Luas perhelai daun (cm ²)	Jumlah daun per pohon (helai)	Daya serap CO ₂ per pohon per tahun (ton)
1	Angonna (<i>Pterocarpus indicus</i>)	38,69	1.225.138,00	0,74
2	Hangar (<i>Leptorhemia purpurata</i>)	88,88	122.478,00	0,49
3	Daun (<i>Leucaena leucocena</i>)	93,43	974.846,00	31,31
5	Kembang merak (<i>Caesalpinia pulcherrima</i>)	0,85	182.676,00	0,01
7	Melati (<i>Strobilium macrophylla</i>)	48,02	1.075.816,00	7,42

52

0 Answers

Large area of each leaf of each tree
 Number of leaves of each tree

Large area of leaf and number of branches of each tree
 Large area of each leaf and number of leaves of each tree

Pict 4. Multidimensional Literacy Indicator Question

The result of scientific Literacy research on 25 students grade IX at SMP Negeri 7 Jember and 25 students grade X of SMA Negeri 2 Situbondo aged 15 years old then being analyzed based on each scientific Literacy indicator. The result is shown in the table below.

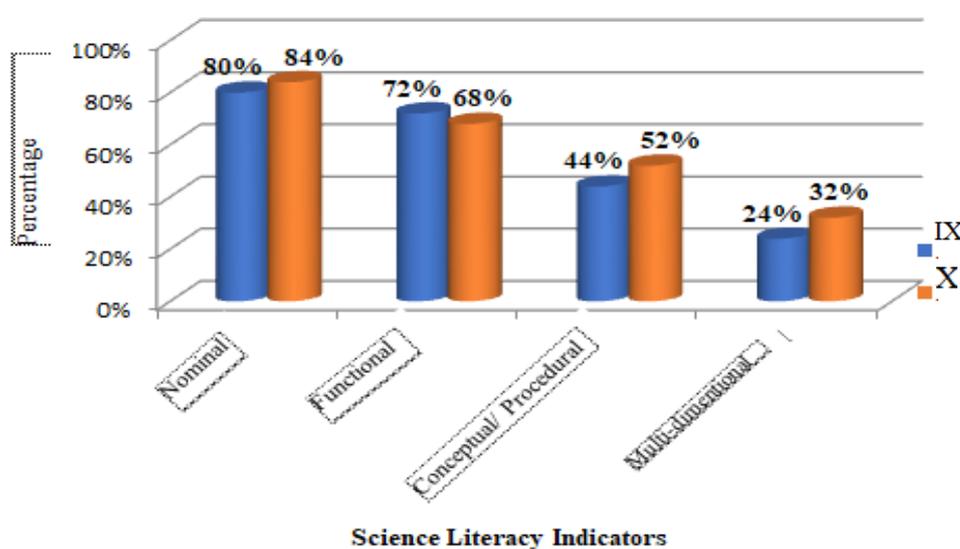
Table 1. The Percentage of Scientific Literacy Ability Indicator of Students Grade IX aged 15 Years Old

Scientific Literacy Ability Indicator	Total of Correct Answer	Percentage
Nominal Literacy	20	80%
Functional Literacy	18	72%
Conceptual/Procedural Literacy	11	44%
Multi-dimensional Literacy	6	24%

Table 2. The Percentage of Scientific Literacy Ability Indicator of Students Grade X aged 15

Scientific Literacy Ability Indicators	Total students with Correct Answer	Percentage
Nominal Literacy	21	84%
Functional Literacy	17	68%
Conceptual/Procedural Literacy	13	52%
Multi-dimensional Literacy	8	32%

The main purpose of this data analysis is to compare scientific Literacy ability between middle and high school students aged 15 years old. Here are the chart showing the result of the comparison.



Pict 5. Scientific Literacy Ability Chart Comparison of Middle and High School Students aged 15 Years Old

As it has been known, scientific Literacy ability has 4 level of understanding starting from the lowest which is nominal literacy, to the most complex one that is multi-dimensional literacy. Pict 5 shows that in general the largest percentage of students' scientific literacy abilities is in the nominal literacy and the lowest one is in the multidimensional indicator. This has also been shown by several previous studies such as Al – Momani’s (2016) which states that 20% of secondary students possessed in Nominal Scientific Literacy. There are 40 % of students were at Functional Scientific Literacy. Students with Procedural Scientific Literacy entailed 80%. Lastly, and only 5% students possessed Multidimensional Scientific Literacy. The scientific literacy test requires a lot of concentration, especially on multidimensional questions, but according to Purwani (2018) students stated that they were lazy to read questions on tests. We assume it can influence results.

In this Study, each of scientific Literacy indicator was analyzed using Kruskal Wallis to know if there was significant difference result of the correct answer between students grade IX and X. SPSS program used to evaluate the result of scientific Literacy was being set to have a significance limit 0,05. H_0 as hipothesis of this test was “There was no significant difference between scientific Literacy of middle and high school studnets aged 15 years old”. The significance level was used as a decision-making criterion with the provision if the significance value of the SPSS uotput showed more than 0.05, then the hypothesis H_0 was accepted, and if it less than hypothesis H_0 was rejected. The recapitulation result SPSS output for each scientific Literacy indicator is as follows.

Table 3. The Kruskal Wallis Test Comparison Result of Each Science iteracy Indicator of Middle and High School Students Aged 15 Years Old

No	Literacy Indicator	Output Sig- SPSS	H_0
1.	Nominal	0.204	Accepted
2.	Functional	0.107	Accepted
3.	Conceptual/Procedural	0.154	Accepted
4.	Multi-dimensional	0.04	Rejected

Based on Kruskal Wallis output result using SPSS above, it can be seen that 3 out of 4 scientific Literacy indicators of middle and high school students aged 15 years old is bigger that 0.05 so that H_0 is accepted. While for multi-dimensional literacy the SPSS output result is less than 0.05 which means H_0 is rejected. This shows that scientific Literacy ability for nominal, functional, and procedural indicators of middle and high school students aged 15 years old don not show any significant difference. But as shown in the tables, each grade only has about half that correct in answering the questions of conceptual/procedural literacy criteria. This level shows students' ability to understand the interrelationships and causal relationships between concepts. Walid (2021) mentioned that through understanding the concept of science students are expected to be able to better understand the concept or subject matter itself, the interrelationships between concepts, and use concepts in solving problems. Students should be

able to analyze and solve problems with quite complex data. According Prafitasari (2019) the lack of procedural literacy results is the impact of functional literacy needs. Therefore, students should get used to it problem solving based learning. On the other hand, scientific Literacy ability for multi-dimensional indicator shows that there is significant difference. This result can be evaluated from these factors, those are:

- a. Basic ability of middle and high school students aged 15 years old are relatively the same.
- b. The ability to define causal relationship between middle and high school students aged 15 years old are relatively the same.
- c. The structural accuracy level between middle and high school students aged 15 years old are relatively the same.
- d. Complex analysis ability between middle and high school students aged 15 years old are different.

Those factors can occur because at the age of 15 years, middle school students are already at the final level which is IX while high school students are still at the beginning level which is X grade with relatively the same development of mindset based on their age according to cognitive theory from Piaget, Fatimah (2015). On the other hand, multi-dimensional ability shows difference because the learning environment of high school students is different from middle school students. High school students are more accustomed to problem solving method in their learning so that they have a better analysis ability. Students' scientific literacy ability are influenced by many things as explained by Jannah (2020) that factors that influence students' scientific literacy include the learning process, students' science attitudes and students' reading interest. Meanwhile, De Moraes (2010) mention that curriculum, learning models, learning methods, learning media, schools infrastructure, and human resources influence on student's scientific literacy. This is supported by Zaini (2022) that there is a significant effect on the use of the PQ4R model assisted by e-book using the sway on the scientific literacy of students. Measurement of scientific literacy on a regular basis needs to be examined because according to Odja (2014), the result of scientific literacy study is expected to be a foundation for formulating efforts which are able to increase scientific literacy skills. This result is still lacking in some aspect, therefore continued research using sample with larger population is still needed.

CONCLUSION

This research proved whether there is significant difference or comparison on the result of scientific literacy ability test of middle and high school students aged 15 years old. The result shows that 3 out of 4 Scientific literacy test indicators of middle and high school students aged 15 years old has sig >0.05 , which means there is no significant difference. Those 3 indicators of Scientific literacy are nominal literacy (0.204), functional literacy (0.107), and procedural/conceptual literacy (0.154). Meanwhile, multi-dimensional literacy shows sig 0.04 or <0.05 , thus it can be concluded that there is significant difference of multi-dimensional literacy between middle and high school students aged 15 years old.

SUGGESTION

This research can be continued by comparing the Literacy and Numeracy abilities of middle class students according to the "Kurikulum Merdeka" that currently implemented.

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