An Analysis of Student's Scientific Literacy Skills of Senior High School in Sungai Penuh City Based on Scientific Competence and Level of Science Literacy Questions

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ABSTRACT
21st century education aims to improve students' scientific literacy skills. The results of PISA study show that the scientific literacy of Indonesian students is in low category. The low scientific literacy of students is caused by several factors in education system, both from the curriculum, teachers, and students themselves. This study aims to analyze the ability of scientific literacy of Grade X SMA in Sungai Penuh City in terms of the competency aspect of science and the level of science literacy questions. This research is a descriptive research using mixed method and using sequential explanatory design. Sample in this research were 86 students who came from three high schools with high, medium and low categories taken by cluster random sampling technique. The instrument used was a scientific literacy test item and an interview guide sheet. Data analysis technique is done by giving a score for each of students answer then described into value and category of scientific literacy achievements and analyze the interview results. Based on the study results, it is known that the average value of each scientific competency is, 22.66 for competence to explain phenomena scientifically, 47.15 for evaluating and designing scientific investigations competence, and 28.44 for the competence to interpret scientific data and evidence. Based on the question level, the highest score was obtained at level 1 questions with an average value of 46.08 and the lowest was on level 6 questions with an average value of 7.17.
Keywords: *Scientific literacy, Scientific competence, level of science literacy questions.*

1. INTRODUCTION

Education now is in the 21st century and is also known as the industrial revolution 4.0 era which is marked by the rapid development of science and technology. Education in this 21st century aims to encourage students to have the supportskills to be responsive to changes along with the times. Wijaya, et al.[35] states that there needs for a change in mindset (mind set) from humans or students. NCRL and Metiri Group[14]state that the skill that must be have by students in the 21st century is literacy skill.

Science literacy is the ability to understand the concepts and processes of science and utilize science to solve the problems in everyday life. According to the PISA (Program for International Student Assessment) scientific literacy is the ability to use scientific knowledge, identify questions, and draw conclusions based on scientific evidence in order to understand and make decisions regarding to nature and its changes due to human activities[23] .

Science literacy is divided into four dimensions, namely science competencies / processes, science knowledge/ content, science application contexts, and scientific attitudes. Science competence consists of three aspects, they are explaining scientific phenomena, evaluating, and designing scientific investigations, also interpreting data and scientific evidence. Science knowledge consists of content knowledge, procedural knowledge, and epistemic knowledge. Context application of science includes health and disease, natural resources, environmental quality, hazards and the latest developments of science and technology. Whereas the attitude of science refers to the further development of science knowledge, pursuing career in science, and using scientific concepts and scientific methods in life[24] .

Science literacy is important for students so they not only understand science as a concept but can also apply science in their daily lives. According to the National Research Council (1996) in Ardianto and Rubbini[3]scientific literacy is important to develop because (1) it gives personal satisfaction and pleasure that arises after understanding and studying science; (2) everyone needs

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information and scientific thinking for making decision; (3) everyone needs to involve their abilities in public discourse and debate on important issues involving science and technology; and (4) scientific literacy is important in the world of work, thus requiring people to learn science, reasoning, think creatively, making decisions, and solve problems.

Science literacy can be measured through PISA studies conducted by OECD (Organization for Economic Cooperation and Development) once every three years. OECD is an international organization in cooperationfield and economic development, while PISA is a form of ability and knowledge evaluation in reading, mathematics, and science designed for 15 years old strudents. Indonesia began to join the PISA study since 2000. The results of PISA study for the ability of scientific literacy of Indonesian students from 2000 to 2015 can be seen in Table 1.

Table 1. PISA Study Results of Indonesian Students' Literacy Ability

Year	Indonesian Average Score	PISA Average Score	Ranking	Participants
2000	393	500	38	41
2003	395	500	38	40
2006	393	500	50	57
2009	385	500	60	65
2012	375	500	64	65
2015	403	500	62	70

Source: (OECD [18][19][20][21][22][23]).

Based on Table 1. it is known that the ability of Indonesian students for scientific literacy (science aware) from 2000 to 2015 is still in low category becaused of the scores obtained are below the average of PISA completeness score. This indicates that Indonesian students have not been able to understand the concepts and processes of science and have not been able to apply the science knowledge they have learned in their daily lives.

The low ability of scientific literacy of Indonesian students is generally caused by learning activities that are not yet oriented towards the development of science literacy. Ardianto and Rubbini[3] revealed that the low scientific literacy is caused by several factors, namely the state of school infrastructure, human resources of school, and school management. Kurnia[9]also revealed that the low scientific literacy ability of Indonesian students is influenced by the curriculum and education system, the selection of teaching methods and models by teachers, facilities and learning facilities, and teaching materials.

Angraini's[2] research results show that the scientific literacy ability of Grade X SMA students in Solok City is still relatively low due to the material being tested which has never been studied, students are not accustomed to working on questions that use discourse, and the learning process is not supportive for students in developing scientific literacy skills. The same thing was expressed by Rizkita[30]that the scientific literacy ability of Malang City SMA students is still low. The low ability of scientific literacy is due to the learning process that does not yet involve the science process. Nuraini, et al. [15] concluded that as much as 47.82% of students can answer questions level 1, 33.80% of students can answer questions level 2, 42.90% of students can answer questions level 3, 26.50% of students can answer level 4 questions, 21.73% of students can answer level 5 questions, and no students are able to answer level 6 questions. Based on science competence, 30.87% of students are able to explain phenomena scientifically, 40.42% of participants students are able to interpret data and scientific evidence, and 24.90% of students are able to evaluate and design scientific investigations.

Based on the interview results conducted by the author in October 2018 of four Biology teachers in SMA in Sungai Penuh City, it was obtained information thatin learning activities teachers find it difficult to teach students independently and actively because of students are accustomed to material given directly to them, It also causes students to be less active to explore their knowledge, students are less able to link one concept with other concepts that have been learned as proved by studentsinability to answer questions that demand analytical skills.

Based on the problems described above, it is known that information or data about the scientific literacy ability of Grade X SMA students in Sungai Penuh City is not yet known. Information about the ability of scientific literacy is important to know in order to provide appropriate solutions to the problems faced, especially in the field of scientific literacy. To that end, the authors have conducted research on the analysis of the ability of scientific literacy in SMA students in Grade X in Sungai Penuh City.

2. METHODS

This research is a descriptive study with a combination method (mixed method) with sequential explanatory design. The population in this study were all student of Grade X SMA in Sungai Penuh City who were registered in the 2018/2019 school year. The sample in this study was selected by cluster random sampling technique. The grades selected as research samples are grade X MIA1 SMAN 2 Sungai Penuh, garde X MIA2 SMAN 4 Sungai Penuh, and garde X MIA1 SMAN 5 Sungai Penuh. The total sample was 86 students. The instrument used in this study was a scientific literacy question paper developed by Miswati[11]in 2016, and an interview guide sheet for teachers and students. Data collection techniques in this study were by giving tests in the form of scientific literacy test questions and conducting interviews with students and teachers. Data analysis of scientific literacy skill is carried out with the following steps.

2.1. Scoring

The scoring system is in accordance with the scoring rules according to PISA, as follows:

1) for multiple choice questions, a score of 1 if true and 0 if false,
2) for compound questions, a score of 0.5 is given for each question item that is answered correctly and a score of 0 if the answer is wrong,

for essay questions, the correct answers were given a score of 2, partly correct score of 1, and all wrong were given a score of 0[22].

2.2. Tabulation

Tabulation is done by writing the student code and its scores into the table. The tabulation was made to describe the ability of biological science literacy from the results of scientific literacy tests of SMA students in Sungai Penuh City based on the following aspects.

1) The results of scientific literacy tests based on scientific competence.
2) The results of scientific literacy tests based on the level of questions.

2.3. Determination of Value

Data obtained from tests that have been given a score are then converted to value. Converting scores into value using the formula according to Arikunto[4].

$$\text{Value} = \frac{\text{Obtained Score}}{\text{Max Score}} \times 100$$

The scientific literacy achievement values obtained are then interpreted based on the criteria presented in Table 2.

Table 2. Criteria for Achievement of Science Literacy

No	Value Range	Criteria
1	67 – 100	High
2	33 – 66	Moderate
3	< 33	Low

(Hasan, at.al[8])

2.4. Analysis of Interview Results

The results of interviews with teachers and students obtained were then analyzed to deepen and broaden information about the achievement of science literacy abilities of grade X SMA students in Sungai Penuh City and to find out the factors that influence the scientific literacy abilities of students. To reduce errors in the process of acquiring research data, an examination of validity of data is done using triangulation techniques.

3. RESULT AND DISCUSSION

3.1. Result

3.1.1. Test Analysis Results Based on Science Competency

Test results based on science competency are grouped into three based on PISA science competence namely, explain phenomena scientifically; evaluating and designing scientific investigations; and interpret data and scientific evidence. The following is a brief analysis of the results of each scientific competency.

3.1.1.1. Competency of Explaining Phenomena Scientificly.

Test analysisresult of competencyof explaining phenomenascientificlyare presented in Table 3.

Table 3. Test Analysis Results Of Competency Of Explaining PhenomenaScientificly

No	Indicator	Average	Criteria
1	Remember and apply scientific knowledge appropriately.	32.55	Low
2	Identify, use, and produce clear and representative models.	25.58	Low
3	Make and justify correct predictions, provide clear hypotheses.	30.81	Low
4	Explain the potential implications of scientific knowledge for the community.	31.95	Low

3.1.1.2. Competence of Evaluating and Designing Scientific Investigations.

Test Analysis Results of evaluating and designing competency ofscientific investigations are presented in Table 4.

Table 4. Competency Test Results Evaluating and Designing Scientific Investigations

No	Indicator	Average	Criteria
1	Identifying questions explored in a scientific study	50.38	Moderate
2	Distinguish possible questions for scientific inquiry	37.59	Moderate
3	Propose and evaluate ways to explore the questions given scientifically	59.30	Moderate
4	Explain and evaluate various ways that scientists use to ensure data reliability and objectivity and the ability to generalize explanations	42.15	Moderate

3.1.1.3. Competence in Interpreting Scientific Data and Evidence.

Test analysis results of competency tests interpreting data and scientific evidence are presented in Table 5.

Table 5. Test Analysis Results of Interpreting Data and Scientific Evidence

No	Indicator	Average	Criteria
1	Analyze data and draw appropriate conclusions	31.78	Low
2	Identify assumptions, evidence, and reasoning in the context of related science	29.38	Low
3	Distinguish between arguments based on scientific evidence and theory	39.82	Moderate
4	Evaluate arguments and evidence from different sources	9.30	Low

3.1.2. Test Analysis Results Based on Question Levels

The results of scientific literacy tests of students at each level can be seen from the achievement of the average value of scientific literacy for each level of questions presented in Table 6.

Table 6. Results of Science Literacy Tests at Each Level of Questions

No	Level	Average	Criteria
1	1	45.08	Moderate
2	2	41.18	Moderate
3	3	33.37	Moderate
4	4	30.23	Low
5	5	10.65	Low
6	6	7.17	Low

3.2. Discussion

3.2.1. Science Literacy Ability Based on Science Competency

The scientific literacy abilities of the students analyzed in this study consisted of three scientific competencies according to PISA, namely competence to explain phenomena scientifically; evaluating data and designing scientific investigations; and interpret data and scientific evidence. The results of the test analysis show that students' scientific literacy skills for these three competencies are in low and medium categories. This can be seen from the average value obtained by students for each science competency.

The low ability of students to explain phenomena scientifically is caused by learning that is less related to the material being studied with the scientific phenomena that occur. Information obtained from the teacher, it is known that teacher only links the material with scientific phenomena at the end of the meeting. The scientific phenomenon was conveyed by the teacher in the delivery of lessons learned related to negative and positive impacts in life. Scientific phenomena should be conveyed in every concepts discussionso that students can relate the concepts of the material they are learning to the scientific phenomena that occur around them. Nadhifatuzzahro[12] revealed that science learning must be able to help students to explain phenomena in daily life using science concepts that he obtained including in answering the questions of scientific literacy provided.

Students’low scientific competence in explaining the phenomenon scientifically is also caused by the students’ tendency to memorize the material. The habit of memorizing the material also causes students to be unable to associate the material that has been studied with scientific phenomena in everyday life. In addition, the habit of memorizing the material also causes students to be unable to understand the concepts of the material they are learning. Sudijono[31] revealed that students who have understood the material are students who can provide a more detailed explanation in their own words about a concept. Yusup's[38]research results concluded that the success of students in learning science can be achieved if students have a good conceptual understanding.

The second competency analyzed in this study is evaluating and designing scientific investigations. The average value obtained by students for each indicator belongs to the medium category. This shows that students are starting to be able to master this competency. The ability possessed by students in mastering all the indicators on this competency is caused by learning initiated by the teacher by expressing scientific problems. In learning activities, teachers use problem-based learning models, discovery learning, and inquiry learning so that with these models students have sufficient ability to master this competency. Purwani[28] revealed that students scientific literacy competencies can be obtained if students are accustomed to learning with scientific problems. The results of Basam, et al.[6] revealed that learning that leads to scientific discovery or inquiry makes students not only dominated by conceptual abilities.

Learning model has an important role in the development of students' scientific literacy. Thus the learning model must be considered in implementing learning. Astuti[5]states that the Problem Based Learning (PBL) model can increase students' scientific literacy. The statement is in line with the results of Pujiastutik's[27] research, which concludes that PBL learning models can improve students' scientific literacy competencies. The model can increase students 'interest in scientific issues and increase students' scientific investigations.

Another learning model that can improve students' scientific literacy is the inquiry learning model. This statement is in line with the statement of Lederman, et al.[10] which revealed that the integration of inquiry learning models in science learning can increase students' scientific literacy. Puspitasari[29]research results conclude that learning with inquiry models can improve students' scientific literacy competence compared to traditional learning models or lectures on science learning.

In addition to the two models mentioned above, discovery learning model can also improve students' scientific literacy competencies. According to Nurhayati[16], discovery learning model can improve students' scientific literacy because this model involves students to gain direct learning experiences. Yaumi[37] research results conclude that learning with discovery learning models is effective in increasing the competence and level of scientific literacy of students.

According to Sujarwanta[32], learning science must be done like scientists, namely learning science using process skills so that students have a more complete learning experience and can develop their scientific literacy abilities. Science learning according to Yaumi, et al.[37]must be oriented towards achieving scientific literacy. In line with this statement, Pantiwati and Husamah[26] revealed that teachers need to implement science learning activities that are effective in enhancing students' scientific literacy abilities. The results of Puspitasari's[29] research conclude that learner-oriented learning is more effective in improving scientific literacy competence than learning by lecture method.

The third competency analyzed in this study is competence in interpreting data and scientific evidence. Based on the analysis of the test results for competence in analyzing data and scientific evidence, it is known that students are only able to master one indicator, namely to distinguish between arguments based on scientific evidence and theory. Two other indicators have not been able to be mastered by students.

The low competency of students in interpreting data and scientific evidence is due to the lack of students' learning experience in developing these competencies. According to Abdurrahman[1] science learning must provide learning experiences that develop the ability to interpret data and draw conclusions. These abilities can be developed by training and familiarizing students with solving evaluation questions in the form of discourse, pictures, graphics, and tables. The results of the writer's interview with the teacher and students are known that in evaluation of learning, the questions given by the teacher are questions that merely require students' memories of the material that has been learned as explaining a concept. Teacherrarely gives questions that demand students' analysis and understanding presented in discourse, pictures, graphs, and tables.

Evaluation of learning by teachers should not only give questions oriented to material knowledge, but also ask students to use their knowledge in connecting one concept with another concept. This opinion is supported by Pantiwati's[25] statement that science assessment is not only oriented to the mastery of the material, but also to the mastery of the ability to interpret data and draw conclusions. Utami's[33] research results conclude that to improve students' scientific literacy skills, teachers must create evaluation instruments based on scientific literacy. In line with this, the results of research Windyariani, et al.[36]also concludes that the use of scientific literacy assessment in evaluations will provide students the opportunity to explore the ability of scientific literacy.

3.2.2. Scientific Literacy Ability Based on Question Levels

Level 1, the average value obtained by students at this level is 45.08 and is in medium criteria. Achievement of the value shows that students are generally able to answer questions at level 1. That is, students already have scientific knowledge even though it is limited. In this case the students are able to apply their scientific knowledge to a number of familiar situations. Learners can also present a clear scientific explanation of the evidence provided.

Level 2, the average value obtained by students at this level is 41.18 and is in the medium criteria. Achievement of these values indicates that students generally have sufficient scientific ability to provide possible explanations in contexts that are already known or draw conclusions based on simple investigations, and students begin to be able to use reasoning and make conclusions correctly from the results of scientific investigations or solutions problem. Natrurasari, et al[13] state that level 2 is set as the basic level defining the level of achievement on the scale of

scientific literacy where students begin to demonstrate scientific competence that enables them to actively participate in life situations related to science and technology.

Level 3, the average value obtained by students at this level is 33.37 and is in the medium criteria. Achievement of these values shows that students have begun to have the ability to identify scientific problems clearly, although still not perfect. Students can choose facts and knowledge to explain phenomena and apply simple models or strategies of inquiry. Students also begin to be able to interpret and use scientific concepts from various disciplines and can apply them directly. Students have also begun to be able to develop concise statements using facts based on scientific knowledge they have.

Level 4, the average value obtained by students at this level is 30.23 and is in the low criteria. The acquisition of these values shows that students have not been able to work effectively with situations and problems that might involve explicit phenomena that require them to make conclusions about the role of science or technology. Students have not been able to choose and integrate explanations from various science concepts from science or technology and connect their explanations directly to aspects of life situations. Thus, students have not yet reached an action to be able to reflect and communicate conclusions using scientific knowledge and scientific evidence.

Level 5, the average value obtained by students at this level is 10.65 and classified as low criteria. The acquisition of these values indicates that students have not been able to identify the scientific component of many complex life situations, apply scientific concepts and knowledge about science to these situations, and students do not yet have the ability to compare, select, and evaluate appropriate scientific evidence to respond to lifesituation. Students have not been able to use and develop the ability of inquiry properly, students also have not been able to connect knowledge appropriately into life situations. Thus, students have not been able to build explanations based on their evidence and arguments and critical analysis.

Level 6, the average value obtained by students at this level is 7.17 and is classified as a low criteria. The acquisition of these values shows that students have consistently been unable to identify, explain and apply scientific knowledge and knowledge about science in various complex life situations. Learners do not yet have the ability to connect different sources of information, and use evidence from various sources to justify a decision. Learners have not demonstrated the thinking and reasoning of scientists and have not been able to use scientific reasoning in supporting solutions to scientific and technological situations that are less familiar. Thus, students cannot use scientific knowledge and develop arguments to support conclusions that are centered on personal, social or global situations.

Based on the explanation above, it is known that the ability of students in answering questions at the level of high questions is still low. This is caused by students not being accustomed to answering questions that demand the application of scientific knowledge in complex situations. Questions commonly asked by teachers in evaluations are questions at levels C1 to C3 that ask students just to recall the material being studied. Students should be accustomed to working on scientific literacy questions to develop knowledge and the ability to relate what they learn with their application to new situations. This is consistent with the statement of Gormally, et al.[7] that science assessments must be able to develop thinking skills and develop students' reasoning towards a given situation. Widiyanti's[34] research results conclude that there is a positive relationship between students who are accustomed to working on scientific literacy problems with scientific literacy abilities.

Each level of science literacy questions used in the study of students' scientific literacy ability analysis has a number of different questions and scores. The results showed that at low levels students are generally able to answer questions with a maximum score. At a high level (levels 5 and 6) only a small proportion of students get a maximum score even some questions cannot be answered by students. This is evident from the average values obtained by students at levels 5 and 6, namely 10.65 and 7.17. The results of this study are in line with the results of Sari and Nurwahyunani's[17] research (2016: 353) which concluded that the ability of students in the city of Semarang at a high level (levels 5 and 6) is still low with the average values obtained ie 12.36 and 6.28 .

The inability of students to get maximum scores or to answer questions at high level questions shows that the lack of scientific understanding of the material. According to the OECD[22] students who are in this condition cannot apply scientific knowledge and knowledge about science in various complex life situations and cannot connect various sources of information and explanations and use evidence from scientific sources to justify decisions.

level of questions it is known that the highest value obtained by students at level 1 questions with an average value of 46.08 and the lowest at level 6 questions with an average value of 7.17. Thus, it can be concluded that the scientific literacy ability of grade X SMAstudents in Sungai Penuh City is still low.

4. CONCLUSION

Science competencies that have been able to be mastered by students namely the competence of evaluating and designing scientific investigations with an average value of 47.15 in the medium category. Two other competencies, namely explaining phenomena scientifically and interpreting data and scientific evidence, cannot be mastered by students with an average score of 22.66 and 28.44, respectively, with low categories. Based on the

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