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# Scientific Literacy of a Third Year Biology Student Teachers: Exploration Study

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## Abstract

The Department of Biology, Universitas Negeri Malang, manages undergraduate courses to prepare prospective teachers of Biology. Biology teachers have to know two important purposes of science education, that is, educating and motivating students to be involved in careers such as scientists and technologists, and providing students with the significant knowledge and understanding of science and social issues to enable them to become informed citizens. This research is conducted to investigate scientific literacy of the third year students of the department. Scientific literacy skill is measured by Multidimensional Literacy Test (MLT), a combination of multiple choice and essay test. The results showed that Scientific Literacy of the third year students is on the level of functional and structural dimension. The result of the interviews with the teachers about the teaching strategies showed that learning scientific writing, which is an important basis scientific literacy development, still needs to be improved. The results of the study can be used as a consideration in selecting and determining appropriate learning strategies to improve the literacy of prospective biology teachers.

**Keywords:** Scientific literacy, Biology Student Teachers

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## 1. Introduction

The main function of education is to educate students to prepare themselves for a successful life in the 21st century that is digital century and the era of knowledge-based economy. Knowledge-based economy driven by technologies based on knowledge and information production and dissemination [18]. According Partnership for 21st Century Skills students must be equipped to live in a multifaceted, multitasking, technology-driven world. Therefore, education institutions should be prepare students to live in the information age; empower students to be able to use the knowledge and skills they already had to use today's technology to discover new things in the future; prepares students to be able to think for themselves, make informed decisions, develop expertise, and continuous lifelong learning. Preparation of citizens and the workforce to live in the digital age depends on the excellence of the community, the quality of daily life, economic life, and the ability to compete; all of which can be developed through a good education.

Education is expected to educate students to become citizen literat which is a competence that is used in the workplace in the 21st century. According to [11] competence literat owned by generations of the 21st century include academic skills, thinking skills, reasoning, collaboration and technology competence. Partnership for 21st Century Skills formulate 21st century skills into three general skills, namely 1) the skills related to information and communication; 2) thinking and problem solving skills; and 3) interpersonal skills and self-regulating skills. In another reference Partnership for 21st Century Skills in collaboration with the National Science Teachers Association (NSTA) describes the necessary 21st century skills necessary learned to students in the context of science education. Such skills are creativity and innovation, critical thinking and problem solving, as well as literacy skills to communicate, collaborate, literat to information, literat to media, literat the information and communication technology, flexible and adaptive, initiative and capable of directing themselves, have the social skills of cross cultural, productive and accountable, as well as the attitudes of leadership and responsibility.

In science education, scientific literacy is a term known since the late 1950s, especially after Paul Hurd published his paper entitled Science Literacy: Its Meaning for American Schools [8]. Science literacy should also be defined as the ability to think scientifically and critically, and able to use scientific knowledge to develop decision-making skills [5]. Another opinion explains that science literacy is the knowledge associated with natural phenomena that must be owned by a person to apply to his life [2]. PISA [12] states that a scientifically literate person, therefore, is willing to engage in reasoned discourse about science and technology the which requires the competencies to explain phenomena scientifically, Evaluate and design scientific inquiry, and interpret the data and evidence scientifically.

The term "scientific literacy" has been much discussed in the discussion of education in Indonesia. Scientific literacy, especially relating to the inquiry into the purpose of education is important in Indonesia, as listed in the Graduate Competency Standards for Primary and Secondary Education Units [15] "formulate the problem, propose and test hypotheses, determine which variables, designing and assembling the instrument, using a variety of equipment to make observations and measurements are precise and meticulous, collect, process, interpret and present the data systematically, and draw conclusions consistent with the evidence obtained, and communicate scientific experiment results orally and in writing ". In the 2013 curriculum (Kurikulum, 2013) process of inquiry is develop as a learning process to achieve scientific literacy, especially with the use of a scientific approach in learning by using step of observation, questioning, collecting the data and information, association, communicating findings and ideas.

Competency-based curriculum has been applied in Indonesia start from level of primary, secondary and higher education based on the rules and regulations of the Indonesian Government Regulation [17]. Competency-based curriculum in biology aims to provide a learning experience to understand the concept of biology, science

process skills, and solve everyday biology problems [16]. In [20] says that implementing competency in biology aims to provide pupils with key conceptual and procedural knowledge for promoting scientific literacy.

In fact, the results of scientific literacy assessment by PISA showed the position of Indonesian students who are not encouraging. The [12] report showed that the ratings of scientific literacy Indonesian students in 2000 was ranked 38th (of 41 countries), 2003 order of the 38 th (of 40 countries), in 2006 the order to 53 (from 57 countries), 2009 order 38 th (of 40 countries), and in 2012 the order of the 64 th (of 65 countries).

With the belief that Indonesian children have similar potential with children from other countries, of course, can be suspected that the learning was done in our country is different from the demands of the generation. School curricula in our country is considered by many as less sensitive and less responsive to changes that occur in the community both locally, nationally and globally. Learning needs to be directed to creating scientific literacy community. In an effort to improve the competencies of students in literacy, the Ministry of Education and Culture of the Republic of Indonesia raises "School Literacy Movement" which aims to build a culture of literacy for all students [6].

In science education reform, according to [5] there are two views about literacy in science, namely "science literacy" and "scientific literacy". "Science literacy" considers that the main component of scientific literacy is an understanding of the basic concepts of science. Scientific literacy, looked as thinking and acting skills involving mastery of thinking and use scientific thinking in identifying and addressing social issues. Therefore, it is fair if scientific literacy is growing in line with the development of life skills [19], namely the need for skills of reasoning and scientific thinking in the social context and emphasized that science literacy is intended for everyone, not just to those who choose a career in science and technology.

PISA [12] explains that the competence of scientific literacy skills not just mastere the knowledge of the concepts and theories of science but also knowledge of common procedures and practical matters related to inkuri scientific and how to make science more advanced as described, "individuals who are scientifically literate have a knowledge of the major conceptions and ideas that form the foundation of scientific and technological thought; how such knowledge has been derived; and the degree to the which such knowledge is justified by evidence or theoretical explanations ".

According to PISA [12] to understand the issues of science and technology needed three domains of competence, (1) the ability to provide an explanation of natural phenomena, the evidence and technology and its implications for society, (2) conduct such an inquiry, the identification of questions that can be answered with scientific inquiry; identify the procedures used; and propose ways to solve problem, (3) the competence to interpret and evaluate the data and scientific evidence and evaluate whether a conclusion can be trusted.

Scientific inquiry as component of scientific literacy [24]. In [24] defining scientific inquiry is a learning activity that involves identifying a problem to be investigated, using induction to formulate hypothesis, using deduction to generate prediction, design experimental procedure, conduct a scientific experiment, collect meaningful data, organize, and analyze data accurately and precisely, and explain any unexpected results. In [24] use the inquiry stages as a framework to develop scientific inquiry as scientific literacy assessment. Other researcher, [3] develop Test of Scientific Literacy Skills (TOSLS) with two main indicators, i.e., understand methods of inquiry that lead to scientific knowledge; and Organize, analyze, and interpret quantitative data and scientific information. In [7] found that scientific inquiry determines scientific literacy, but not on the amount of experience doing scientific inquiry, but on the quality of experience of conducting scientific inquiry.

Student teachers should have a good ability to scientific literacy, so when they become teacher in the future, they can teach students become scientifically litterate learners. This study aims to describe the ability of scientific literacy of biology student teachers. The research was focus on third year students, which will carry out the teaching practice in the classroom. The third-year student will graduation for next year, so that they can low scientific literacy we can propose the chaning of learning process to improve the ability of scientific literacy. The scientific literacy of biology student teachers were assess by using two instruments, based on –characteristic and step inquiry according [3, 24], and the dimensions of scientific literacy by (Bybee, 2003) cited by [21].

## 2. Method

This is an exploration study to know the scientific literacy competence of third year biology student teachers in Biology Department of Universitas Negeri Malang.

The study was carried out with undergraduate students majoring in biology education in the Faculty of Mathematics and Natural Science, Universitas Negeri Malang, Indonesia, in the academic year of 2015/2016. Data were collected from one group, third year biologi student teachers, one year before graduation. The number of the third year was 81 students consisting of 6 male and 75 female students. The proportion of female higher than male in this group.

The assessment of the scientific literacy was done using 2 kinds of tests, i.e.: Scientific Inquiry Literacy Test (SILT) and Multidimensional Scientific Literacy Test (MSLT). Scientific Inquiry Literacy Test is a multiple choice test developed based on the indicators of scientific literacy inquiry competence. The indicators are as follows:

1. Identifying valid scientific opinions (for instance opinions/theories to support a hypothesis)

2. Conducting effective review of literature (for instance, identifying and evaluating the validity of the sources used)
3. Understanding elements of a research design
4. Analysis of data accurately
5. Developing accurate graphs based on relevant data
6. Solving problems using quantitative skills including basic statistics (such as finding average, probability, percentage, and frequency)
7. Understanding and interpreting the result of a statistical analysis
8. Drawing inference and making prediction based on quantitative data
9. Evaluating scientific information

The score of each item was 5 so that the total score of all correct answers was 100.

The Multidimensional Scientific Literacy Test (MSLT) was a multiple choice and essay type test that was developed into five levels, from illiterate, nominal, functional, conceptual to multidimensional scientific literacy level. The questions in MSLT measured the students' scientific literacy level around 4 popular issues like Illegal Logging, HIV-AID, Tropical Diseases, and Global Warming. Each correct answer was given a score starting from 1 for illiteracy, 2 for nominal literacy, 3 for functional literacy, 4 for conceptual literacy, and 5 for multidimensional literacy.

The two types of tests were tried out with second year students to know the validity and the reliability. The validity was determined as the item discrimination index, a correlation coeficient that represent a relationship between a particular item and the other item on the test. The try out resulted in 20 valid test items based on Pearson calculation 0.42-0.58. The reliability was obtained based on the calculation of internal consistecy of Cronbach's $\alpha$. The reliability of the test items was 0.78. The analysis used to compare the scientific literacy competence of the first and third year students was t test.

# 3. Findings and Discussion

## 3.1. Scientific Literacy Inquiry

The average result of SILT of the third year students was 57.2 (DV 12.8). The result of showed that the third year students' scientific literacy inquiry competence was low than compare with minimum requirement (minimum requirement is 75).

We analyze indicators of scientific inquiry literacy are poorly understood by third-year students (see Table 1). According to minimum classroom competence standar

| Indicator of scientific inquiry literacy | Percentage of true answer |
|---|---|
| 1. Identifying valid scientific opinions (for instance opinions/theories to support a hypothesis) | 45,8 |
| 2. Conducting effective review of literature (for instance, identifying and evaluating the validity of the sources used) | 53,7 |
| 3. Understanding elements of a research design | 64,6 |
| 4. Data analysis | 87,5 |
| 5. Developing accurate graphs based on relevant data | 25 |
| 6. Solving problems using quantitative skills including basic statistics (such as finding average, probability, percentage, and frequency) | 51,3 |
| 7. Understanding and interpreting the result of a statistical analysis | 23,7 |
| 8. Drawing inference and making prediction based on quantitative data | 70,63 |
| 9. Evaluating scientific information | 30 |

Table 1: Scientific literacy competence according to scientific inquiry literacy indicators.

(75%) we identify only one indicator was mastered by students, data analysis. Students have not competence on, identifying valid scientific opinions (for instance opinions/theories to support a hypothesis), conducting effective review of literature (for instance, identifying and evaluating the validity of the sources used), understanding elements of a research design, developing accurate graphs based on relevant data, solving problems using quantitative skills including basic statistics (such as finding average, probability, percentage, and frequency), understanding and interpreting the result of a statistical analysis, drawing inference and making prediction based on quantitative data, and evaluating scientific information.

## 3.2. Level of Scientific Literacy

The level of scientific literacy is determined using Multidimensional Scientific Literacy Test. This test was developed using four theme issues, illegal logging, HIV/AIDS, tropical diseases, and global warming. The four issues is occur in Indonesia. On every issue the test arranged by questions ranging from illiteration, nominal, functional, structural, and the highest was multidimensional of scientific literacy. The percentage of scientific literacy competence of students to show a downward trend at a higher level. The level of most students on the level of functional and structural. The reseach showed that the third year students' scientific literacy level was still not satisfactory because their competence only reached the functional and structural level.

Science and technology play a significant role in modern society. Education responsible to prepare students to understand science and technology. This understanding is a central to a young person's preparedness to survive in daily life. This understanding to science and technology empowers individuals to participate appropriately in

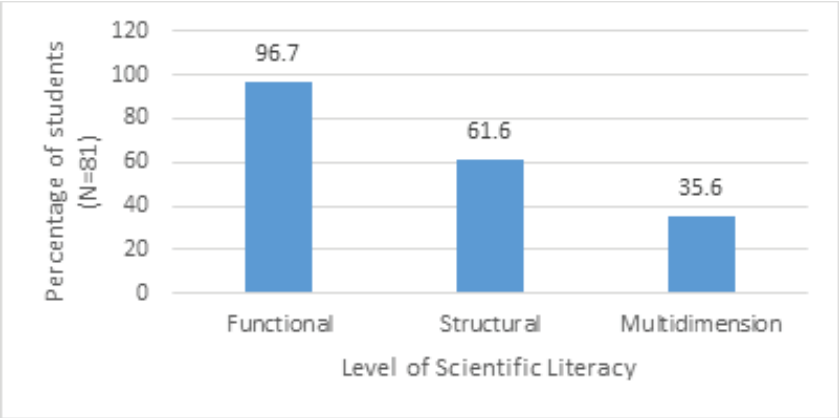


**Figure** 1: Percentage of students in upper three level of scientific literacy.

public policy where issues of science and technology impact on their lives, and contributes significantly to the personal, social, professional and cultural lives of everyone [23].

PISA [12] stated that the competence of literacy scientific not just explain knowledge of the concepts and theories of science but also knowledge of procedures and practical matters related to scientific inquiry. According to PISA scientific literacy domain refers to an individuals': ...scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, to explain scientific phenomena and to draw evidence-based conclusions about science related issues; their understanding of the characteristic features of science as a form of human knowledge and enquiry; their awareness of how science and technology shape our material, intellectual and cultural environments; and their willingness to engage with science-related issues, and with the ideas of science, as a reflective citizen. Based on the definition of scientific literacy in PISA then the core of the learning activities lead to scientific literacy is to do scientific inquiry. People who are scientifically literate are generally able to develop an understanding of concepts, principles, theories and processes of science and is aware of the complex relationship between science, technology and society.

Over the years there have been numerous models of curriculum and instruction designed to improve the quality of science teaching and learning. In the end, all of these models are related to the construct of scientific literacy [10]. An understanding of the nature of science established as one Characteristic expected for someone who has the scientific literacy [9]. Understanding of the nature of science and scientific inquiry is a way to get scientific literate [10].

The Government of the Republic of Indonesia has decided the implementation of Curriculum 2013. In the 2013 curriculum, teaching school biology strengthen students mastery of concepts, processes, and scientific attitude, which is contained in the core competencies (Kompetensi Inti) 3, Core Competence (KI) 4, and Core Competencies (KI) 2, respectively. Biology student teacher should know that learning biology developed a way of knowing (inquiry) of a systematic nature, so that biology is not only a mastery

of knowledge in the form of a collection of facts, concepts or principles, but also a process of discovery. Science education in secondary schools is expected to be a vehicle for students to learn about themselves and the environment, as well as prospects for further development in applying it in our daily lives. Science education emphasizes providing direct experience to develop the competencies that students explore and understand the universe scientifically. Science education is directed to seek out and doing, so can help learners to gain a deeper understanding of himself and the natural surroundings.

Teaching and learning strategy to achieve science literacy, needs to be applied in the classroom for student teachers of biology. The previous strategy in our isntitution that presented science as body of knowledge should be changed into a strategy that presents science as human endeavor to obtain solid knowledge about the universe based on internally empirical and consistent data although it is still not perfect. The knowledge gained through such activities is not only knowledge about facts but also facts which are interpreted and the interpretation relies on the principles of inquiry [22]. Without understanding the assumption built in NOS (Nature of Science) and the process of acquiring knowledge (scientific inquiry), students may build an image about science which only consists of isolated facts away from the contexts that make the knowledge relevant, up to date and meaningful [1].

In [4] suggests five principles of pedagogy in teaching science to encourage the growth of scientific literacy, (1) teach science contextually, inspiring, useful, simple, relating to their life, because scientific literacy calls for understanding, not for calculation ability, (2) teaching by dialogue and interactive, i.e brainstorming, provocative discussion questions, and verbal questions to the class, for examplein other words, use them all, to keep the class actively thinking, (3) trims the detail, and unify, and plan our course with no preconceptions about what "needs" to be "covered," decide on achievable general goals, and include only those topics that are really relevant to those goals, (4) develop modern learning of science, ruthlessly trim the older details, retaining only what is needed to understand today's view of the universe, (5) building a scientifically literate society by teaching science-related societal issues.

## 4. Conclusions and Suggestions

The purpose of new science curriculum in Indonesia is to educate students to be scientifically literate people. Scientifically literate will possess an understanding at least 5 major elements of scientific literacy: (1) science as inquiry process, (2) science content, (3) science and technology, (4) science in personal and social perspectives, and (5) nature of science. Since teachers have vital role in the learning process, preparing biology student teachers who will become scientifically literate biology/science teachers is needed to prepare scientifically literate students.

Investigation to the biology student teachers' level of scientific literacy is important, because the result will determine the teaching strategies that prepare them to be scientifically literate biology/science teachers. In this study, the biology student teachers' competence of scientific literacy was investigated. The results showed the third year students' competence of scientific literacy was not yet satisfactory. This unsatisfactory finding, thus, demands the changes of teaching learning strategies. In the teaching and learning process, science should be viewed not as body of knowledge but more as a process and attitude. Teaching and learning biology in our institution would based on three key areas, 1) what of science (concepts, principles and theories), 2) how of science (processes of science), and 3) applications of science (science, technology, society, and environment connections) which summarize the true nature of science.

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