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BIOLOGY STUDENTS' SCIENCE LITERACY LEVEL ON GENETIC CONCEPTS

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ABSTRACT

Scientific literacy is one's scientific knowledge to apply based on scientific problems. It is important for shaping generational readiness to face the challenges of the 21st century. Scientific literacy is necessary for learning Biology because it can support skills in identifying, explaining scientific phenomena, and generalizing scientific facts. However, the scientific literacy level of students in Indonesia is still relatively low, ranking 70th out of 79 countries with an average achievement of 396. Therefore, this study aims to precisely determine the scientific literacy ability of Biology students and its correlation with the scientific learning model that lecturers apply. The data collection technique was carried out by providing 15 multiple-choice Scientific Literacy questions in the field of Genetics issued by the Program for International Student Assessment (PISA). The research data were analyzed descriptively and qualitatively using the Miles and Huberman approach, which consisted of three processing steps: data reduction, data presentation, and data conclusion. The results showed that the level of students' genetic scientific literacy was still relatively low, with scores of each class being observed at 32.63%, 42.97%, and 43.06%. Factors that indicate students' low scientific literacy are the use of textual teaching materials, students' misconceptions about the genetic material being studied, non-contextual learning, and low student reading power. Thus, improving the quality of teaching materials on integrated genetic material on scientific literacy and learning innovations that emphasize contextual learning and students' reading power is necessary to increase scientific literacy as a form of competency needed in 21st-century learning.

Keywords: biology students; genetics; science literacy

INTRODUCTION

Scientific literacy refers to one's scientific understanding and skills to apply that information to detect problems, learn new things, explain scientific phenomena, and interpret scientific evidence based on scientific issues (Roberts & Bybee, 2014). Scientific literacy trains students' ability to use natural science, identify questions, and conclude based on concrete evidence that aims to assist someone in making decisions about the natural environment and its changes through human activity (Jarman & Billy, 2007; Wahyu et al., 2020). Scientific literacy concerns students' ability to apply science concepts meaningfully, think critically, and make sound judgments to find the right solutions to solve problems relevant to students' lives (Mayer, 2014; Snow, 2016).

In learning biology, scientific literacy is needed to develop an attitude of science in Biology learning and apply it in life, have a scientific attitude and use it to solve problems in Biology

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that have an impact on life and develop creativity to dig deeper into the role of science in Biology (Nwagbo, 2006; Berman & Kuden, 2017; Mahanal et al., 2020). Scientific literacy also facilitates mastery of the concept of knowledge in a systematic way to study natural phenomena and make the right decisions according to the knowledge they have. Thus, scientific literacy aims to develop knowledge and investigations of natural sciences and understand scientific concepts and principles related to the context of community and individual life (Rubini et al., 2018; Wen et al., 2020).

Scientific literacy is a competency requirement that must be mastered in the industry. It encourages the world of education to integrate scientific literacy practices to sustainably create a character education system (Leichenko & O'Brien, 2020; Bahtiar et al., 2022). Furthermore, it is also essential to have scientific literacy to explore the concept of modernity, which is full of modern digital technology, as an effort to apply science. These values must be applied as attributes to prepare generations who are competent and ready to compete in a global world (Ait et al., 2015; Hu et al., 2018; Widodo et al., 2020).

In the 21st century, scientific literacy plays a vital role in creating quality human resources and mastering reliable knowledge and technology so that they are ready to compete in the global era. It follows the characteristics of the 21st century, which is experiencing rapid development of science and technology, so that in the 21st century it requires human resources who master competence and qualified skills in applying a scientific attitude to solving knowledge and technology-based problems (Van Laar et al., 2019; Al Sultan et al., 2021). In practice, scientific literacy in learning in the 21st century has implications for mastering scientific attitudes in identifying questions, acquiring new knowledge, interpreting scientific events, drawing conclusions based on facts, mastering the characteristics of science and implementing them in various scientific and technological phenomena needed in the 21st century (Hernawati et al., 2019; Haug et al., 2021).

Genetics, as a field of study in Biology, contains the inheritance of traits stored in the genetic information of living things. The depth of study of genetic material is primarily determined by the construction of knowledge attributes in understanding the concept of the genetic code, mechanisms of inheritance, molecular breakdown to build genetic structures, and DNA sequences outside of genes (Unsunnidhal et al., 2021; Fourzali et al., 2021). Because the study is very comprehensive, scientific literacy skills are needed in genetic concepts to help students master principles and interpret genetic concepts appropriately and functionally and can develop skills to solve problems in the field of genetics (Donovan et al., 2021; Yangin et al., 2022).

However, the facts show that students' scientific literacy level in Indonesia is still relatively low. That fact is consistent with the results of PISA research (2018), which shows that students' scientific literacy level in Indonesia ranks 74th out of 78 participating countries (OECD, 2018). TIMSS research results (2019) also show that Indonesia is in the bottom ten positions for scientific and mathematical literacy skills. (Mullis et al., 2020). The survey results indicate that students' scientific literacy skills in Indonesia still need to be improved to support the realization of quality learning.

Research on students' scientific literacy level in Indonesia has been revealed by the results of research by PISA (2018) and TIMSS (2019). Widodo (2021) also reports that the initial ability of students' scientific literacy in Indonesia is relatively low. Only around 20% of students can answer questions based on scientific literacy correctly. However, an analysis of the scientific literacy level of students specifically studied genetic concepts as any researcher has never carried out one of the competencies needed to learn this concept. Therefore, this study aims to examine in depth the scientific literacy level of students in the subject of Genetics so that students have an ideal pattern of understanding based on scientific literacy in studying the material. This study only refers to analyzing students' scientific literacy levels in genetic concepts according to the topic indicators set for testing. This research is expected to improve students' critical reasoning skills and abilities applied to genetic material based on scientific literacy.

METHODS

This research was conducted at the Tadris Biology Department, Faculty of Tariyah and Teacher Training, Universitas Islam Negeri Sumatra Utara, in September 2022. This research is classified as descriptive research, which describes a situation systematically to provide information relevant to the problem (Hanneman et al., 2013). In this case, the situation in question describes the state of the students' scientific literacy level in genetics. The population and research sample were all third-semester students in three classes, with 27, 35, and 31 students in each class.

The research procedure was carried out according to descriptive research steps: determining the problems to be explored, determining the examination and classification of data, tabulating the data findings, and interpreting the data obtained (Mishra & Shashi, 2011; Banta & Catherine, 2015). Determination of the problem begins with analyzing the importance of the ability of scientific literacy level in learning, especially genetics. Determination of this problem is done through analysis of literature sources and giving questions based on scientific literacy to students. From the results of the student's answers, the classification and tabulation of the answers given were carried out to be interpreted descriptively (Nakagawa et al., 2019; Mangist et al., 2020; Abdelrahman, 2020).

The problem revealed was the level of students' scientific literacy skills in Genetics material. Students are asked to answer scientific literacy questions on Genetics material issued by the OECD (2018). Furthermore, students' answers were analyzed according to the percentage level and the criteria presented to determine students' scientific literacy level in Genetics material (Bennich et al., 2020; Kwangmuang et al., 2021; Li et al., 2021).

The data collection technique used the Genetics question instrument issued by the OECD (2018) in 15 multiple-choice items. The instrument was validated according to the PISA standard (2018). The grid and the number of questions are presented in Table 1.

Table 1. The Genetic Material Grid Tested in Scientific Literacy

Material	Number of Questions
Genetic material	3
Mitosis	3
Inheritance pattern	3
Hardy-Weinberg law	1
Protein synthesis	3
Genetic disorders	2

Data analysis was conducted by calculating the percentage of students' correct answers, then interpreted with the following provisions.

Table 2. Category of Student Scientific literacy Level

Category	Provision
High	$M + SD \leq$ Score
Medium	$M + SD >$ Score $> M - SD$
Low	$M + SD \geq$ Score

(Pahrudin, et al., 2019)

RESULTS AND DISCUSSION

The following are the research data obtained. Based on Table 3, students' scientific literacy level in genetics material is still relatively low. Bauer & Booth (2019) emphasized that four factors can cause the low level of student scientific literacy: inappropriate use of textbooks, students' misconceptions about science-based material, out-of-context learning, and an unconducive learning environment.

Table 3. Student Scientific Literacy Level

Classes	M + SD	Score (%)	Category
TBio 1	48,82	32,63	Low
TBio 2	54,10	42,97	Low
TBio 3	51,78	43,06	Low

It is in line with the PISA survey (2018), which indicates that the use of textual textbooks can trigger students' low scientific literacy, students' misunderstandings of the material being studied, learning that is difficult to understand, and low ability to interpret reading content.

Inadequate selection of teaching resources can significantly reduce literacy levels. Learning allocations focusing only on textbooks have not fully enabled students to master the material. As a result, students feel bored, which reduces the essence of students' understanding of the material being studied in the context of life (Alivernini & Manganelli, 2015; Bellová et al., 2018). It is in line with Chen et al. (2021) that using textbooks that only refer to textual material can reduce the competence and skills of students in participating effectively according to their life situations. The research instrument can identify the scientific literacy level in genetic concepts because the questions are standardized according to the ability scientific literacy level in genetics issued by PISA (2018). As stated by Jufrida et al. (2019), the basic concept of scientific literacy is standardized internationally by PISA (2018) to measure the level of students' scientific literacy ability.

Misconceptions in the material can occur due to students' misunderstood in connecting genetic concepts material to the basic concepts that already exist in students' minds. The lecturer imposes a learning rhythm that is too fast, causing students not to understand the material being studied thoroughly. It has implications for students' low mastery of material concepts (Mun et al., 2015). The same thing was also expressed by Demir (2016). There is a tendency for educators not to relate material concepts to students' real life, causing students to have difficulty correlating theoretical concepts with scientific problems presented in the context of life. It also causes misunderstandings in examining the material concept in a given scientific literacy context.

Uncontextual learning tends to affect students' assumptions that the relation of material in everyday life is difficult to understand. Altun and Kalkan (2021) also expressed that the key to success in understanding scientific literacy is an emphasis on the context of the application of science in life. Guo (2022) adds that students who study scientific knowledge can connect certain phenomena in the context of understanding corresponding to actual reality. According to Pownall et al. (2022), science is very relevant to the processes that occur in society. Thus, in studying science, it is necessary to have an application context systematically and rationally linked to learning. Based on this explanation, students' low scientific literacy level in genetic material is indicated due to the lack of the role of the genetics lecturer in correlating genetic concepts in the context of life. Thus, students experience difficulties when asked to provide answers related to the connection between genetic concepts and complex problems that are relevant to the study.

The following reason for the low level of students' scientific literacy in genetics material is due to the low literacy of students in the context of the reading material in the questions. Students are invited to look at the reading material that introduces the problem. However, due to the low ability of students to read and process the information provided, students cannot determine the correct answer for each item presented. Renwick et al. (2022) also expressed that reading power is a fundamental skill for uncovering various facts and information contained in readings. These skills guide accessing important essences that are applied in learning. In line with this, Julia and Isrokatun (2019) also explained that reading ability is important for students to understand and investigate scientific concepts, the basic foundation for solving various scientific problems tested. Suitable reading activities direct students to understand the entire content being tested and be able to apply it in predicting certain phenomena. Thus, low reading power can be an obstacle for students to understand the science context given.

Furthermore, Greenhow et al. (2015) also added that students' low scientific literacy skills were caused by low student appreciation of science, development of personal attributes towards science, and acquisition of socioscientific value skills. Odell et al. (2021) also emphasized that low literacy skills indicate a lack of student knowledge in science and technology. It is a sign of weak mastery of good scientific knowledge and its application in using the latest technology. It is in line with Güneş and Bahçivan (2018), who said that low scientific literacy skills indicate a decrease in scientific literacy skills at the functional level. Thus, students are less able to interpret the importance of scientific literacy in learning.

In principle, the low ability of scientific literacy in genetics will impact various essential things in learning. It is stated by Schumm and Bogner (2016) that the belief system of teaching science in genetic concepts will decrease along with the low quality of students' scientific literacy. Aladağ et al. (2021) also explained that low scientific literacy skills impact the tendency of negative constructivist conceptions in applying science to learning and affect their scientific literacy beliefs and skills in digital learning. Chen and Zhao (2021) also added that low scientific literacy skills impact all vital aspects of the demand for fundamental skills students need to face global challenges. From this position, scientific literacy positively influences problem-solving skills in scientific investigations.

Students' low scientific literacy in genetics indicates they must improve their scientific literacy skills in genetics material. This research is important because previous research has not explicitly examined and concretely the level of students' scientific literacy skills in genetic concepts. The findings in this study stimulate the importance of increasing scientific literacy skills in genetic material. It is in line with Dragoş and Mih (2015) that scientific literacy plays a vital role in analyzing and organizing scientific investigations and their implementation in initiating scientific concepts and decisions. Britt et al. (2014) also added that scientific literacy is needed to study, understand, and critically evaluate scientific content to achieve one's needs. Thus, the analysis of the scientific literacy level in genetic concepts, which have never been studied, is expected to improve the order and system of learning Genetics that is more oriented towards issues and scientific information in aspects of genetics material critically and comprehensively to increase students' scientific literacy skills in genetics concept.

CONCLUSION

Based on the research results, the scientific literacy level of students in genetics is still relatively low. It is an obstacle to developing life skills based on scientific literacy in genetics. Therefore, it is necessary to use teaching materials that are more integrated explicitly with scientific literacy. Implementing more innovative and contextual genetic learning is also essential to increase student literacy in solving genetics-related problems in the scientific context.

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