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Assessment of Genetic Literacy for Biology Pre-Service Teacher

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ABSTRACT

Genetic literacy is the capacity to obtain, process, understand, and use genetic information. Genetic literacy is a supportive thing in understanding science as a theory, process, and application. Genetic literacy that is empowered in learning can develop cognitive and affective aspects in pre-service teachers. This study aims to measure genetic literacy skills as a preliminary study for further research on the genetic literacy skills of students in genetics courses. This research design refers to descriptive research. The research subjects in this study were Universitas PGRI Ronggolawe biology education students who took genetics courses for the 2019/2020 academic year. The genetic literacy skill instrument was validated through product-moment correlation analysis. There are 15 genetic literacy questions with right and wrong answer choice and multiple choice questions. Scores will be interpreted into percentages and grouped into high, satisfactory, under-satisfactory, and unsatisfactory categories. The results showed that genetic literacy tests on 25 college students showed that the highest score was 93 and the lowest score was 73. The average genetic literacy score of students was 82.7. Based on genetic literacy test questions, it shows that the concept of student understanding is in the excellent category. This phenomenon is influenced by various factors, including the learning design and teaching materials used. The concept of good student knowledge showed high results in genetic literacy skills in this study.

Keywords: affective, cognitive, genetic learning, genetic literacy

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Introduction

Genetic literacy is acquiring, processing, understanding, and using genetic information. Genetic literacy is supportive of understanding science as theory, process, and application. Genetic literacy can empower the ability to understand the nature of genetics and scientific knowledge and its applications while interacting with aspects of science in a way consistent with the values involved. In addition, understanding and appreciating the interconnectedness between genetics, technology, and society enables individuals to solve genetic problems and make modern decisions relating to themselves (Silawati et al., 2021).

Genetic literacy that is empowered in learning can develop cognitive and affective aspects in students (Little et al., 2022; Maryuningsih et al., 2022). Cognitive aspects include students' knowledge and capacity to use knowledge effectively and involve cognitive processes characteristic of science in personal, social, and global fields. Affective aspects relate to problems that can be solved by scientific knowledge and form students who can make decisions in the present and the future (OCDE, 2009).

Genetic literacy is essential to be empowered in biology learning because one's level of genetic literacy knowledge will influence one's decision-making and attitude toward genetic issues. In addition, genetic literacy can also influence one's attitude towards genetic-based services and technologies. For example, gene-based technologies or genetic screening. This technology makes detecting a person's risk of several genetic disorders possible. In addition, genetic screening can also identify genetically inherited conditions in fetuses or newborns so that patients can know if there are abnormalities in the fetus and can make plans or seek more information about the issue. Therefore, when someone has high literacy knowledge, they will be wiser in making decisions (Goltz et al., 2016).

Genetic literacy can be measured using questionnaires that assess knowledge and understanding of genetic concepts and issues. Measurement of genetic literacy can involve categorizing individuals into adequate or inadequate levels based on their performance on the questionnaire and is limited to the genetic topics measured. In measuring genetic literacy, it is essential to consider cultural and contextual factors, as attitudes and understanding may vary across different research subjects (Maghfiroh et al., 2023; Rujito et al., 2020).

According to Boerwinkel et al. (2017), biology learning should be aligned with research on microbiology, neurobiology, genetics, genomics, cell and molecular biology, ecology, evolution, and physiology to support learning. Based on this, one of the literacy that needs to be empowered is genetic literacy. Studies at PGRI Ronggolawe University of Tuban show that genetics learning contains various topics such as Mendelian inheritance, gene regulation, gene expression, and the nature of genetic material. However, the learning that takes place has never measured the level of genetic literacy in students who take genetics courses. The results of the initial preference analysis on pre-service teachers of the Biology Education study program at PGRI Ronggolawe University conducted in June 2019 showed scores in the recommended category for further study in developing genetic literacy. Genetic literacy is vital to be developed in students as a provision to face genetic challenges and issues that develop along with the development of the 21st century. This study aims to measure the genetic literacy of prospective biology teachers at PGRI Ronggolawe University of Tuban.

Methods

Research Design

This research is based on descriptive research that focuses on independent variables and does not involve comparing or linking variables.

Subject Research

The subject of this study consisted of 25 students of the Biology Education study program at PGRI Ronggolawe University for the 2019/2020 academic year.

Instrument

This study used a test instrument that included tests with proper and incorrect answer choices (5 items) and multiple choice (10 items). The problem of genetic literacy was adapted by Bowling et al. (2008). GLAI initially included 31 multiple-choice items that assessed core concepts of genetic literacy such as gene regulation (4 items), trait of genetic material (8 items), gene expression (6 items), transmission (4 items), evolution (10 items), and genetics &; society (7 items).

Test items were translated and adapted into Indonesian, and unsuitable items were replaced with materials used in the study. The topic of genetic literacy consists of The Substance of Genetic Material, Gene Expression, Gene Regulation, and Mendelian Inheritance.

The genetic literacy instrument problem is tested for validity through moment product correlation analysis (Table 1).

Table 1. Test Validation questions based on moment product correlation analysis

Item No	Topic	r_{xy}	r_{tabel}	Information
1	Gene Regulation	0.566	0.444	Valid
2	Nature of Genetic material	0.454	0.444	Valid
3	Gene Regulation	0.643	0.444	Valid
4	Gene Expression	0.862	0.444	Valid
5	Gene Expression	0.569	0.444	Valid
6	Mendelian Inheritance	0.587	0.444	Valid
7	Mendelian Inheritance	0.804	0.444	Valid
8	Nature of Genetic material	0.618	0.444	Valid
9	Nature of Genetic material	0.789	0.444	Valid
10	Mendelian Inheritance	0.576	0.444	Valid
11	Mendelian Inheritance	0.942	0.444	Valid
12	Mendelian Inheritance	0.888	0.444	Valid
13	Mendelian Inheritance	0.972	0.444	Valid
14	Mendelian Inheritance	0.583	0.444	Valid
15	Nature of Genetic material	0.485	0.444	Valid

Procedure

The research procedure was conducted on students of the PGRI Ronggolawe University, Biology Education study program with as many as 25 respondents. Students are given a question exam with true and false answers and multiple choice (PG) as many as 15 questions for 45 minutes. The instrument is validated by moment product correlation analysis after the instrument is tested on students.

Data Analysis

Data analysis in this study used percentage techniques. The data to be analyzed are the value of students' genetic literacy ability and genetic literacy on each indicator. There are 15 genetic literacy questions with the purpose of the test, mainly a multiple-choice model, with scores based on scores of 1 for correct answers and 0 for incorrect ones. Scores will be interpreted into percentages and grouped into high, satisfactory, unsatisfactory, and unsatisfactory categories.

Results and Discussion

The result of this study includes the interpretation of the value of students' genetic literacy skills. The analysis of genetic literacy test data on 25 college students showed that the highest score was 93 and the lowest score was 73. The average genetic literacy score of students was 82.7. The results of genetic literacy skills are described in Table 2.

Table 2. student genetic literacy outcomes

Range of value	**F. absolute**	**F. Relatif**	**Category**
83.33-100	9	46%	High
66.67-83.33	16	64%	Satisfactory
50-66.67	0	0%	Less than satisfactory
0-50	0	0%	Low

Figure 1 shows that most students have good genetic literacy. This result is evidenced by as many as 46% of students' genetic literacy offers a high category and 64% a satisfactory category. The following is an exception to genetic literacy. The genetic literacy questions consist of right and wrong answer choices and multiple-choice questions. The following data shows the students' genetic literacy scores based on each topic in Figure 1.

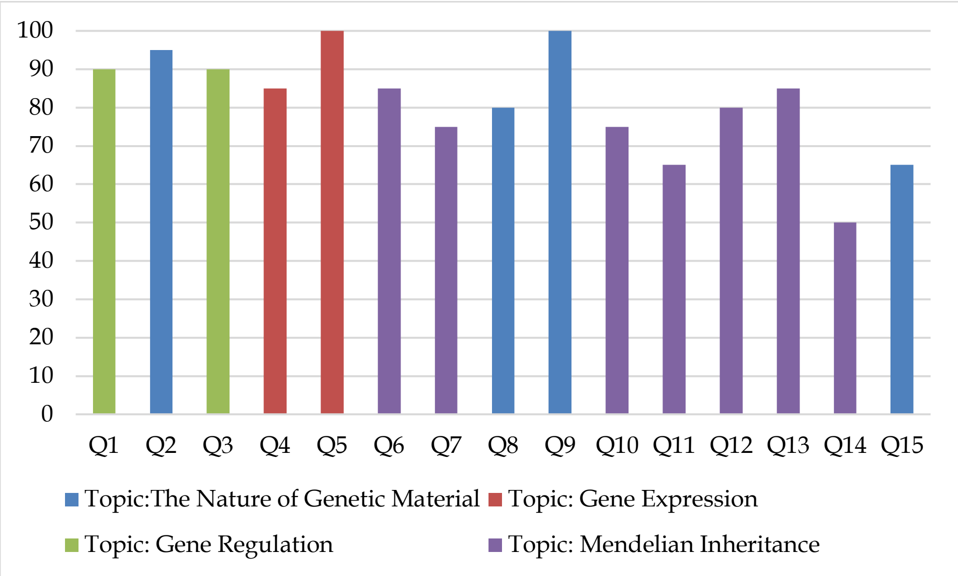

Figure 1. Score of Genetic Literacy

The data in Figure 1 shows that each question from the 4 topics has shown relatively good results, with the highest score of 100 and the lowest score of 50. The lowest score on the topic of Mendelian inheritance. Based on this question, shows that the concept of student understanding is in the excellent category. This is influenced by various factors, including the learning design and teaching materials used. Faize et al. (2018) stated that learning activities through conventional classes (face-to-face) and virtual classes have disadvantages and advantages, so if the two are combined, they will complement each other to support genetic knowledge.

The concept of student knowledge can improve student literacy; the results of this study show that students have a high level of genetic literacy. These findings differ from previous studies by Acra (2006) and Bowling et al. (2008), who report relatively low levels of genetic literacy, indicating a limited understanding of basic genetic concepts at the College level. Despite the high value of genetic literacy, increased knowledge of genetics was not associated with improved attitudes towards genetics. Cebesoy & Oztekin (2018) reported that teachers' genetic literacy in secondary schools obtained an average score of 15.16 (SD = 4.06), which indicated a low level of genetic literacy. This result means that attitudes in dealing with genetic issues are essential to the success of obtaining genetic knowledge.

Genetic literacy is vital to be empowered because, as emphasized, it is necessary for conscious societies that understand and accept responsibility for their own decisions in genetics-related issues (Jennings, 2004). Tsui & Treagust (2010) emphasize the importance of having knowledge of DNA, genes, and their relationship with humans to deal with the controversial issues of genetic discovery ethically and socially. Thus, an understanding of genetics is necessary not only to make fully informed decisions about socio-scientific issues such as cloning, genetic screening, gene therapy, and genetically modified foods, but also their ethical, legal, and social implications (Fowler, S. R., & Zeidler, 2010; Freidenreich et al., 2011). Therefore, modern society needs to increase genetic knowledge in making judgments and decisions on scientific and technological issues by utilizing their genetic knowledge (Maghfiroh et al., 2023b).

Universities are the best place to evaluate, assess, and improve genetic literacy. Teacher education programs must find ways to improve student literacy regarding genetics; in this context, universities are essential to train prospective Biology teachers who mastering the science of genetics and are responsible for improving genetic literacy (B. Ü. Cebesoy & Tekkaya, 2012).

Research by Little et al. (2022) also revealed that overall, genetic literacy outcomes have improved over time, with higher familiarity with genetic concepts in the 2021 sample. However, there is still room for improvement in certain areas, such as familiarity with the term "genome" and genetics-related skills. In addition, a limitation of genetic literacy is that it is assessed through surveys, which may need to capture individuals' understanding of the full concept of genetics. The study focused on a specific population (individuals enrolled in genetic research studies) and specific topics, which may limit the generalizability of the findings to other populations.

Recommendations for improving genetic literacy in schools or universities are to focus on increasing familiarization with genetic concepts, terms, and cases. In addition, genetic literacy needs to be implemented in the science curriculum so that it can be taught effectively. Explore innovative technologies like online platforms and mobile apps to deliver genetic literacy resources and interventions to a broader audience. This technology can help overcome barriers associated with access and reach of genetic literacy. Genetic learning should also include current problems and issues in genetics (Bottema-Beutel et al., 2021; Kenny et al., 2016; Krakow et al., 2018).

Conclusion

Based on the study results, it can be concluded that the genetic literacy rate of students of the Unirow Biology Education study program is in the high category, as much as 46%, and the satisfactory category is 64%. The increase in genetic literacy shows that students have succeeded in understanding material about Genetic Material Substance, Gene Expression, Gene Regulation, and Mendelian Inheritance. The suggestion for the sustainability of this research is to apply the material on biotechnology, microbiology, neurobiology, genetics, genomics, cell and molecular biology, ecology, evolution, and physiology in biology as material for genetic literacy problems. It is hoped that genetic literacy problems that cover all biological studies can be found. A suggestion for future research is to conduct a longitudinal study to track changes in genetic literacy over time to determine the improvement of genetic literacy.

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