A Survey of High School Students’ Scientific Literacy Skills in Different Gender

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Abstract. Scientific literacy skills are one of the skills required by the students nowadays, especially in biology. Students should master these skills in order to be able to apply scientific knowledge to solve problems related to science. The aim of this study was to investigate male and female senior high school students’ scientific literacy skills. The current study employed a survey method. The samples of the study consisted of the eleventh graders from three public senior high schools (SMAN) in Malang: SMAN 8 Malang, SMAN 7 Malang, and SMAN 1 Malang. The research data were analysed using an independent-samples t-test. The analysis result showed that there was a significant difference between male and female students’ scientific literacy skills. Female students tend to perform better in scientific literacy skills than male students (p=0.002). Around 2.33% of the male students were on level 0, 23.26% on level 1, 51.16% on level 2, and 23.26% on level 3. On the other hand, 4.05% of the female students were found on level 1, 56.76% on level 2, and 39.19% on level 3. This condition suggests that an innovative learning to empower students’ scientific literacy skills needs to be introduced to biology learning.

1. Introduction
The rapid development of science and technology in the 21st century requires humans to continue to develop and become an expert in science and technology. Therefore, students’ mastery of science and technology in Indonesia must also be improved considering that there have been many obstacles found in the process of teaching science and technology to the students. One of the abilities that students need to possess in the 21st century is scientific literacy skills [1].

Science literacy is the application of scientific knowledge in identifying problems, seeking new knowledge, describing scientific phenomena, and formulating conclusions from the evidence collected from the surrounding environment [2]. Scientific literacy is the understanding of concepts and processes of science and the relationship of both the community [3]. Science literacy is associated with the preparation of students in dealing with life in society. Science literacy is needed by an individual to
make personal and collective decisions on socio-scientific issues [4]. Science literacy can be considered as the root of progressive change in science learning [5].

Science literacy plays a very important role in today’s human’s life. In the absence of scientific literacy skills, people are prone to mistakes, especially in understanding the facts and findings of science. Scientific reasoning is very useful for understanding causation and determining the solution to a problem; therefore, misunderstanding science concepts can lead to a bigger problem. On a broader scale, low literacy skills of the Americans could bring an impact to the competition in the global job market because more and more countries need highly qualified workers [3]. Science literacy is essential in science learning and scientific literacy skills are now used as one of the benchmarks for the success of international science learning [6].

Science literacy is a branch of information literacy. Information literacy ability is the basis of success in using the right to obtain information. The right to obtain information is then used to improve the ability of the community to process and evaluate information to generate appropriate decisions [7]. The right to obtain and use information also applies to information in the fields of science and technology.

Competencies needed in scientific literacy include explaining scientific phenomena, evaluating and designing scientific investigations, and interpreting data and findings scientifically. Scientific literacy refers to a set of knowledge of science and science-based technology and their distinctive goals, processes, and results. Scientific literacy not only contains knowledge of scientific concepts and theories but also the awareness of procedures and practices in scientific inquiries and the ways to develop science [8]. Scientific literacy is used in all matters related to science, starting from the basic ones to determining important decisions for the welfare of oneself, family, and society [9]. Scientific literacy focuses on the ability to apply scientific knowledge in dealing with everyday life situations. This ability is very important to be owned by people who actively participate in a community [10].

There are many benefits of mastering scientific literacy skills, especially in Biology learning. Scientific literacy ability is an important capital for someone to be able to process, evaluate, and make decisions based on their abilities, knowledge, and experiences [11]. Information learned and processed through high-level thinking will be remembered longer and clearer than those processed through low-level thinking. As a result, the learning outcomes of both male and female students can improve accordingly. The current scientific literacy skills should be developed in learning activities. Learning that can empower students’ scientific literacy skills can result in promoting the students’ self-potential and self-confidence [12].

Science education should develop students’ potentials in science and technology, particularly the potentials to be able to face challenges, make decisions, develop survival strategies, and learn to live effectively in a diverse global community in the 21st century [13]. However, some research reports a gender bias that benefits male students in tasks related to cognitive achievement and skills development [14, 15]. Providing an equal opportunity for all students can help improve their performance in scientific literacy regardless of gender differences [16].

Gender is determined based on a set of characteristics that distinguish between masculinity and femininity. One feature that is obvious is sex assignment, namely men and women. The differences in the psychological aspects of men and women are often associated with intelligence, attention span, interests, talents, motivation, maturity, and readiness factors. These factors or these gender differences will certainly affect students’ learning activities and social activities. Gender differences arise in several cognitive areas, such as metacognitive abilities [17] and critical thinking and problem-solving abilities [18].

Some studies have unveiled the effect of gender differences on students’ abilities, including scientific literacy skills [19]. Female students have better control over aspects of attitude, motivation, time
management, anxiety, self-testing strategies, and thus obtain a higher score on literary lessons. Male students are better at aspects of concentration, information processing, and strategy selection; therefore, they can achieve higher scores in mathematics lessons [20]. It was reported that female students in Finland, Greece, Latvia, and Slovenia had better scientific literacy skills and were more skilful in reading compared to male students [21].

Based on the exposure described, the present study aimed to investigate students' scientific literacy skills based on gender differences. The results of this study are expected to provide insight into the improvement of students' scientific literacy skills through innovative learning.

2. Research Method

The present study employed a survey method. The population of the study consisted of 23 public senior high schools (SMAN) in Malang. The participants were categorized as male and female students. The random sampling method was used to select 117 eleventh graders (43 males and 74 females) from SMAN 1, SMAN 3, SMAN 7, and SMAN 8.

The participants' scientific literacy skills were evaluated using an essay test which covered topics in Bacteria. The test was developed on three science literacy competencies suggested by OECD [8], that were explaining phenomena scientifically, designing and evaluating science investigations, and interpreting data and evidence scientifically. The content and construct validity of the instrument was evaluated thoroughly. The instrument’s validity ranged from 0.518 – 0.672 > 0.161 (R_table = 0.161) and the instrument’s reliability test result was 0.828.

Following is the example of an essay test item regarding household waste management.

Household waste is a type of waste mostly produced by humans. Wet waste or organic waste usually consists of decaying organic materials, such as food scraps, animal slices, and deciduous leaves. People commonly take these following actions to manage the household waste: (A) Processing the waste into biogas to reduce LPG consumption and (B) Turning the wet waste into compost.

1. As a community member who cares for the environment, which action will you consider doing to participate in household waste management? Explain your reasons!

2. What do you think is the fastest way to make compost?

The students’ responses were examined based on a scientific literacy rubric adopted from OECD [8]. The results were then analysed using an independent-samples t-test to investigate the difference between the male and female students’ scientific literacy skills. The same data were also used in determining the levels of the students’ scientific literacy skills.

3. Findings and Discussion

3.1 The Students’ Scientific Literacy Skills Based on the Scientific Literacy Indicators

The students’ scientific literacy skills based on the scientific literacy rubric were summarized in Table 1. Table 1 indicated that 2.33% of the male students were on level 0, 23.26% on level 1, 51.16% on level 2, and 23.26% on level 3. On the other hand, 4.05% of the female students were categorized into level 1, 56.76% were on level 2, and 39.19% were on level 3. It was obvious that compared to the female students, the male students showed bigger percentages in level 0 (2.33%) and level 1 (23.26%). The majority of the female students belonged to level 2 (56.76%) and level 3 (39.19%). These figures were higher than those of the male students. Most of the students were still categorized into level 2, indicating that the students’ scientific literacy skills were still at the “start to develop” stage.
Table 1. The Students’ Scientific Literacy Skills Based on the Rubric

| Level                        | Male      | Female     |
|------------------------------|-----------|------------|
| 0 (undeveloped)              | 2.33%     | 0%         |
| 1 (less developed)           | 23.26%    | 4.05%      |
| 2 (started to develop)       | 51.16%    | 56.76%     |
| 3 (well developed)           | 23.26%    | 39.19%     |
| 4 (very well developed)      | 0%        | 0%         |
| TOTAL                        | 100%      | 100%       |

Students’ poor performances in scientific literacy skills can be caused by several factors, including the lack of understanding of the concepts of science and technology and less effective science learning processes [13]. The students’ inability to express their opinions in dealing with the problems provided was also influenced by their inadequate language skills [22]. Following are the examples of the students’ answers which were categorized into level 1 of scientific literacy skills. Student SG believed that the biogas production from organic waste was the best solution to the household waste management issue.

**Student SG:**
1. **Number 1 (biogas), we need to reduce the usage of LPG**
2. **Processed in the correct way**

Unlike student SG, students MLH and MNA both agreed that the most appropriate way to manage the household waste was by producing compost.

**Student MLH:**
1. **Turning the waste into compost because this action can prevent the environment from pollution and it can help transform the waste into something useful (the compost).**
2. **Burning the garbage.**

**Student MNA:**
1. **The second option. Compost can replace the function of chemical fertilizers, thus can reduce the use of chemicals.**
2. **The action must be performed regularly. The compost should be taken care of and put in a damp place.**

The answers above indicate that the students were still unable to figure out the most appropriate and accurate solution to the household waste management issue. The students’ lack of linguistic skills was reflected in the superficial, unstructured, and minimal empirical sentences used to describe their opinions [23]. Student MLH even provided an alternative solution that may lead to a greater problem related to fire and air pollution.

More than half of the students possessed level 2 scientific literacy skills. The students’ responses showed a simple relationship between the way bacteria get nutrients and the organic composting process. The students were also able to evaluate the choice of organic waste treatment solutions by considering the pollution aspects and the long-term impact of the solution. Here are the examples of the students’ answers to level 2 scientific literacy.

**Student DP:**
1. **Because bacteria play an important role in decomposing the waste into compost.**
2. **I prefer the composting process to avoid air pollution if the waste is burnt.**

**Student ASA:**
1. The compost that has been processed from the household waste can be used in cultivating plants. More plants will be grown and more oxygen will be produced.

2. Using an organism such as the earthworm as the composting catalyst

There were 23.26% of the male students and 39.19% of the female students reaching level 3 scientific literacy. These students had begun to show a more complex relationship between the solution and the biological concept related to the way of how bacteria live and examine the relationship from various perspectives. The students were also able to provide several alternative solutions to accelerate the composting process. Followings are the instances of the students’ level 3 answers.

Student DD:
1. The second option. It is eco-friendly and cost saving. Compost can fertilize the soil.
2. Using a catalyst, performing an anaerobic composting process, mixing the materials

Student AMA:
1. I chose action 1 (processing the waste into biogas). It is more beneficial than action 2 which is commonly found in society. Compost can be made from dried leaves but in addition to cost-saving, action 1 can also support the conservation of the non-renewable resources such as LPG that is usually produced from petroleum.
2. The ingredients are piled up in warm soil and sprayed with water, this can facilitate methane bacteria to decompose waste. The garbage should be cut into small pieces and added with decomposing bacteria.

3.2 The Students’ Scientific Literacy Skills Based on Gender Differences

The results of the independent-samples t-test were presented in Table 2 while the average scores of the students’ scientific literacy skills were summarized in Table 3.

Table 2. The Independent-Samples t-Test Results.

| Levene's Test for Equality of Variances | t-test for Equality of Means |
|----------------------------------------|-----------------------------|
| F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |
| Sci. Lit. | 6.644 | .011 | -3.096 | 115 | .002 | -2.798 | .904 | -4.589 | -1.008 |

Table 3. The Average Scores of the Students’ Scientific Literacy Skills.

| GENDER | N | Mean | Std. Deviation | Std. Error Mean |
|--------|---|------|----------------|-----------------|
| Sci.   | Male | 43  | 15.6744        | 5.67669         |
| Lit.   | Female | 74  | 18.4730        | 4.05855         |

Table 2 and Table 3 indicated a statistically significant difference between the male and female students’ scientific literacy skills (p = 0.002). The female students’ average score (18.4730) was higher than that of the male students (15.6744). Female students tend to have better attitudes and motivation compared to male students [20] so that they were more serious in doing the essay test. Female students are normally equipped with more satisfactory reading abilities [21] compared to male students [24] [25]. Male and female students have a different brain structure and information processing system. Male students
process text and audio information in visual and auditory area, while female students process information in language area that connected to abstract thinking skills [26]. As a result, they can better understand the texts and are more skilful in connecting the information obtained from the texts to the real-life circumstances.

3.3 Promoting Students’ Scientific Literacy Skills through an Innovative Learning Strategy

Science learning needs innovations, such as the implementation of a constructivist instructional model, to empower students’ scientific literacy skills. This learning model can help create an interactive learning so that students are able to explore the surrounding environment, build knowledge, make critical questions, and seek answers to their problems [13]. Contextual learning that brings forth learning materials relevant to students’ everyday life can improve students’ active participation [27]. An inquiry and laboratory-based learning [28] is also able to promote the development of students’ scientific literacy skills.

Another innovation that can provide students with meaningful learning experiences is by implementing a problem solving-based learning. Problem-based learning with a simulation approach can help both male and female students to construct socio-scientific concepts and improve their writing skills on certain science topics [29]. Problem-based learning is contextual and meaningful both for teachers and students [30]. One of the problem-based learning models that can be applied in the classroom to empower students’ scientific literacy skills is RICOSRE [31].

4. Conclusions

The results of the current study indicated that the scientific literacy skills of the senior high school students in Malang were still at the “start to develop” stage. Female students who participated in this study reported higher scores in scientific literacy skills compared to the male students. Innovative learning such as constructivist, contextual, inquiry-based, and problem-based learning can be used to empower students’ scientific literacy skills.

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