The Problem-Solving Skills of Senior High School Students on Biology in Temanggung

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Abstract. The study aimed to determine the level of Senior High school students’ problem-solving skills and to identify students’ problem-solving skills based on gender. This study was a descriptive study by using survey method. The population of this study was all of the eleventh-grade students from mathematics and natural science class in SMA N 1 Temanggung, SMA N 3 Temanggung, and SMA N 1 Pringsurat, with 191 students as the sample. The sampling technique was cluster sampling. Data collection was conducted by providing a question in the form of problem-solving essays. The score category level to analyze student’s problem-solving skills level and inferential statistics with independent sample t-test to analyze problem-solving skills based on gender. The result of the study showed that (1) the problem-solving skills level of Senior High school students in Temanggung mostly in the moderate category, (2) there is a significant difference of problem-solving skills in students based on gender. Female students have higher problem-solving skills than male students.

Keywords: Biology, Gender, Problem-Solving Skills

1. Introduction
The twenty-first century demands human resources on each state to master various forms of life skill. The skill which highly required in 21st century is Higher Order Thinking Skills (HOTS). Higher order thinking has to be definitely owned by students, especially Senior High School students because thinking in higher order in a proper context taught the students the habit of in-depth thinking, the behavior to run life with smart, balanced, and responsible approaches [1].

Partnership for 21st-century skills identifies that one of the skills in the 21st century is the problem-solving skills. Problem-solving ability is a part of life skills (life skills which have been integrated into education curriculum which demand the students implement higher order thinking. Higher order thinking in the term of problem-solving is learning through understanding, think critically in
evaluating ideas, formulating problem-solving alternative in a creative manner and communicating them effectively \[2\]. Problem-solving skills are perceived as necessary to conceive by students, especially Senior High School students because these abilities could support students to make a proper, systematic, rational decision as well as considering various perspectives \[3\]. Biology as one of the learning subjects in Senior High School studies about topics contained with problems or issues in daily life, therefore, problem-solving skills are crucial to being owned.

The results or learning process which until present have been running in the effort to improve problem-solving skills need to be evaluated through authentic assessment. Casey \[4\] concludes that “Learning is affected by many factors; personal, situational, and cultural”. Due to that matter, personal, situational and cultural factors generate influence towards learning results, thus, it is important to discover how far those factors affect the problem-solving skills. One of the elements associated with personality is gender. There has been no information associated with problem-solving skills on students in the area based on gender, due to that matter this research is conducted.

2. Materials and Methods

2.1. Materials

2.1.1. Problem-Solving Skills

Engel \[5\] states that “problem-solving is the process used to solve a problem”. In addition, Wilfork \[6\] defines problem-solving skills like an ability of students in using their thinking process to solve problems.

Problem-solving is an ability to solve the problem with non-automatic process \[7\]. Crebert et al. \[8\] reveals that effective problem-solving demands students to identify, determine, and solve the problem through logic as well as lateral and creative thoughts. In this process, students arrive at a deeper understanding of the type of topic and establish new knowledge and comprehension, therefore, they are able to create a decision. Peng \[9\] states that problem-solving has several stages which include explaining the description of the problem, analyzing the cause, recognizing and finding an alternative solution, judging each alternative solution, selecting one of the best alternative solutions, attempting to solve the problem through the selected solution, and judging whether the problem is truly solved.

2.1.2. Factor of Gender

Gender shows different behaviors of women and men that include physical, emotional, intellectual, and the other differences of ability \[10\]. The terms of gender and sex are frequently considered as similar, however, sex is actually indicating a biological difference between men and women, while gender shows the psychosocial difference between men and women \[11\].

The men and women have physiological differences in internal and substantial natures. For example, men and women have a different level of hormone which determines the variation of biological characteristics, namely fertilization. Men and women indeed look different and have different organs and sexual hormones, and due to the perception that men and women surely have differences in the ways of thinking, acting, and, feeling something \[12\]. Frederick et al. \[13\], explains that the brains of both women and men have structural, chemical, and functional differences. These differences cause the difference in the way of thinking between men and women, especially in facing a problem. Aside from that, the area of parietal lobe which functioned for visuospatial ability is bigger in men compared to women.

Men have tendencies in logic, reason, mechanical designing ability, abstraction direction determination, and manipulation of physical objects, while women are more dominant in using the
feeling as well as having more tenacious skill in studying \[14\]. Men have spatial, mathematics, and more aggressive skills, while women are better in verbal skill \[11\]. In that order, gender is highly contributing to the problem-solving skills of students, these skills require logical thinking which tends to be conceived by men.

2.2. Methods
2.2.1. Research Design
This research is a descriptive type of research through the implementation of a survey method to obtain the data of students’ problem-solving skills. The population of this research is the entire XI grade students of Senior High School in Mathematics and Natural Science major at 3 schools (SMAN 1 Temanggung, SMAN 2 Temanggung, and SMAN 1 Pringsurat). Sample collecting technique used in this research is cluster sampling, therefore, two classes of each school are required which amounted to 191 students. This research was conducted in May-June 2018.

2.2.2. Research Instrument
The data collecting of problem-solving skills was conducted through problem-solving-based essay test in biology subject. The data of test results were converted into quantitative data by performing a scoring from 0-4 of score category. Each score of question item is accumulated until the single score is acquired. The research instrument is a set of test in the essay from based on problem-solving which consists of test clues, test items, and answer key. The instrument that used has been determined as valid and reliable. The instrument was determined as valid because the value of Pearson product-moment correlation > r table (0.344) and determined as reliable with the 0.702 results of Alpha value.

2.2.3. Data Analysis
The collected data were analyzed in descriptive statistic and inferential statistic manners through SPSS 16 program. Descriptive analysis is used to provide short descriptions associated with the level of problem-solving skills on students which measured by inspecting the score of achievement percentage rate of value categories (mean, minimum score, maximum score, deviation standard) as well as by inspecting the score of achievement percentage level of value categories to analyse the level of problem-solving skills on students. Inferential statistical analysis is used to test the difference of problem-solving skills on students based on the gender of student parametrically through t-test of the independent sample. This is the table of criteria of score range of problem-solving skills level and criteria of score level of each problem-solving skills.

Table 1. Criteria of score range of problem-solving skills level

| Score Range   | Category   |
|---------------|------------|
| 60 < X ≤ 80   | High       |
| 40 < X ≤ 60   | Moderate   |
| 20 < X ≤ 40   | Low        |
| X ≤ 20        | Very Low   |
Table 2. Criteria of score range of each aspect of problem-solving skills

| Score Range     | Category |
|-----------------|----------|
| 15 < X ≤ 20     | High     |
| 10 < X ≤ 15     | Moderate |
| 5 < X ≤ 10      | Low      |
| X ≤ 5           | Very Low |

3. Result and Discussion

3.1 Results

3.1.1. The Level of Students’ Problem-Solving Skills

The entire problem-solving skills of students are categorized into four categories, namely high, moderate, low, and very low. This is the grouping of the score of problem-solving skills of Senior High School students on Biology subject.

Table 3. The level of problem-solving skills of Senior High School students in Temanggung

| Score Range     | Category | Frequency | Percentage |
|-----------------|----------|-----------|------------|
| 60 < X ≤ 80     | High     | 3         | 1.57%      |
| 40 < X ≤ 60     | Moderate | 119       | 62.31%     |
| 20 < X ≤ 40     | Low      | 69        | 36.12%     |
| X ≤ 20          | Very Low | 0         | 0.00%      |
| Total           |          | 191       | 100%       |

The problem-solving skills of Senior High School students in Temanggung on each indicator of problem-solving skills are described throughout the table as follows.

Table 4. Problem-solving skills of Senior High School students on each Indicator

| Problem-solving Aspect                        | N   | Min | Max | Mean  | Std.dev | Value Category |
|----------------------------------------------|-----|-----|-----|-------|---------|----------------|
| Analyzing problem                            | 191 | 6   | 15  | 10.08 | 1.91    | Moderate       |
| Analyzing the cause of problem               | 191 | 8   | 18  | 12.47 | 2.20    | Moderate       |
| Analyzing and discovering alternative solution | 191 | 7   | 17  | 11.31 | 1.98    | Moderate       |
| Selecting one alternative solution/the best solution | 191 | 4   | 14  | 8.47  | 2.54    | Low            |

*Maximum total score of each skill aspect = 20*
3.1.2 Gender-Based Problem-Solving Skills

The descriptive analysis of problem-solving skills on male and female students is presented in the table below.

Table 5. Gender-based problem-solving skills of students

| Gender | N   | Min | Max | Mean  | Std. dev | Value Category |
|--------|-----|-----|-----|-------|----------|----------------|
| Men    | 75  | 33  | 62  | 41.25 | 5.89     | Moderate       |
| Women  | 116 | 30  | 55  | 44.79 | 6.00     | Moderate       |

The results of gender-based problem-solving skills are studied in further through inferential statistic method to see whether the existing differences are significant or not which described as follows.

Table 6. The results of a t-test of an independent sample of problem-solving skills based on gender

| Gender | N   | Mean    | Std. dev  | Sig. (2-Tailed) |
|--------|-----|---------|-----------|-----------------|
| Men    | 75  | 41.25   | 5.89174   | 0.000           |
| Women  | 116 | 44.79   | 6.00767   |                 |

3.2. Discussion

According to the results of the survey, it is known that in general, the problem-solving skills of students are at a moderate level. These good problem-solving skills result from the research sample that consists of students in 15-18 years of age who might have conceived problem-solving skills. The cognitive development level of students has entered the formal operational stage. The characteristics on this stage are Senior High School students have abilities to think abstractly, logical reasoning, and drawing conclusions from the available information [15]. The quality of abstract thinking during the formal operational stage is proven on the ability to solve the problem in a verbal manner performed by students [16]. According to cognitive development, Senior High School students are supposed to have problem-solving skills by capable of properly mastering the four cognitive aspects of problem-solving test items of the problem-solving skills.

According to the occurring facts, there are some students who still acquire results of problem-solving in low category and have yet to master the entire problem-solving aspects which are measured. This condition is possibly caused by a lack of practice regarding the development of problem-solving skills on a student in the learning process. The success of students in the solving problem is facilitated through the availability of practices that frequently conducted [17]. The development of problem-solving skills in learning needs to be implemented since the previous level of education, namely in elementary and middle schools. If the foundation of basic skills is not developed during the childhood period, critical thinking to solve the problem will not have gone through maturity in teenage. Due to that matter, students whose problem-solving skills were not developed since elementary school towards middle school will tend to have no improvement on their thinking potential in the effort to solve the problem inappropriate manner [18].

The problem-solving skills on students, namely the skills aspects of analyzing the problem, analyzing the cause of the problem, and formulating alternative solution are at moderate category while the skills aspect of selecting the best solution is still in the low category. The low value in selecting the best solution from several alternative solutions which has been described in prior is
caused by most of the students who able to select a solution, but not the best one, in addition, the proposed reasons are less rational, and less supporting the selected solution as the best solution. There are some students who also mention the solution which not in accordance with the context of a problem from the biology perspective presented in the essay. This stage is the most difficult one because the skills of properly selecting and sorting the solution or strategy are required [17]. This aspect of skill is categorized as a convergent stage which requires logical, rational, and structured thinking skills. Thinking in rational and convergent manners are required in the problem-solving stage to determine the best solution [19].

According to the mean value (see table 5) which supported by inferential statistic test (see table 6), a significant mean difference of problem-solving skills between men and women is obtained. Women have higher problem-solving skills compared to men. This result is different with the initial assumption in which rational thinking skills of men are higher compared to women, thus, men tend to have higher problem-solving skills compared to women. This condition is caused by the type of problem-solving skills test which delivered through essay with long sentences. The test questions which were used mostly examine the verbal skills that more mastered by female students. The solution to this type of question will require high verbal skills. According to Fennema et al. [20], there are problems that can be solved through verbal method. Verbal skills are highly associated with problem-solving skills. Men are having spatial and mathematics skills which also more aggressive while women are better in verbal skills [11]. The factor of motivation also has a contribution to the result of this assessment. The skilled students in solving problem will instead find difficulty in using the skills if they have no motivation to use the skills [20].

In addition, differences in chemical structure and function of the brain can also affect problem-solving skills [20]. The men think with their grey material which fulls with the active neuron. Women think with a white material that contained with more connection between neurons. In this way, the brain of women is little more complicated in setting, but the setting allows the brain of women to work faster than men [21]. The parts of frontal lobe which responsible for problem-solving and decision making, as well as limbic cortex that responsible to manage emotion, are bigger on women. This condition allows women to process and responding information more quickly. In addition, women have bigger corpus callosum than men. Corpus callosum is functioned as the main nerve that connects two parts of the brain, namely right and left brains [22]. These differences have made women become capable of using their two brain parts in balance and optimizing the cognitive function better than men [23].

4. Conclusion
The conclusion of this research is the level of problem-solving skills of Senior High School student on biology subject is mostly categorized in the moderate category. Problem-solving skills of a student based on students’ gender have a significant difference, namely, the female students have higher problem-solving skills compared to men. This research was conducted only to measure the problem-solving skills on students regarding their cognitive aspects, such as analyzing a problem, analyzing the cause of the problem, formulating an alternative solution, and selecting one best solution. Therefore, for the following research should be conducted to measure the problem-solving skills on the entire aspects, started from analyzing the problem in assessing whether the problem is truly solved. The following researcher should be able to study the other factors which able to influence the problem-solving skills on students.
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