



Excretory system learning in senior high school: comparative analysis of students' problem-solving skills

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ABSTRACT

Problem-solving skills are the essential skills that should be owned by students. This research aimed to analyze the problem-solving skills of senior high school students in biology learning of excretory system topics. The method used was descriptive-quantitative. The data were collected using a problem-solving essay test. The subjects were the eleventh-grade students of senior high schools in Surakarta, who were divided into A category (high level) and B category (low level). Based on the analysis result, it can be seen that the problem-solving skill achievement of the eleventh grade of A group includes: defining the problem (50.78%), examining the problem (40.62%), planning a solution (19.53%), implementing the solution (37.50%), and evaluating (40.62%); while B category includes: Defining the problem (46.35%), examining the issue (34.67%), planning a solution (18.54%), implementing the solution (20.96%), and evaluating (32.25%). The lowest percentage in both categories was found in planning the solution and evaluating. Based on the result, the average problem-solving skills in A group was 37.81% and B Category was 32,26%. Based on the data, it can be concluded that students' problem-solving skills in A and B categories are still low. The skills can be improved by conducting problem-solving based learning and familiarizing students to solve problems according to problem-solving stages.

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INTRODUCTION

Knowledge era requires intellectual capital in the form of High-order thinking skills (HOTS) (Brookhart, 2010). HOTS is related to the seven skills needed in the 21st century, as follows: 1) critical thinking and problem-solving, 2) creativity and innovation, 3) collaboration and teamwork, 4) cross-cultural understanding, 5) communication and media literature, 6) computers and ICT 7) careers and independence (Redhana, 2019; Yen, & Halili, 2015). One of the HOTS needed in the 21st century is critical thinking and problem-solving skill, as explained by Dewey in point one. This study focused deeper on problem-solving skills. Problem-solving skills are one of the essential abilities that should be owned by students. Problem-solving, according to (Anderson, 2014) is life skills that involve the process of analyzing, interpreting, reasoning, predicting, evaluating, and reflecting. Thus, problem-solving skills are the skills to apply prior knowledge into new situations involving high-order thinking processes (Yavuz, Arslan, & Gulten, 2010).

Problem-solving skills are viewed as a fundamental part of science learning (Lamanepa & Panis, 2018; Daniel, 2015). They can be applied to the excretory system topic in biology learning as it has high complexity and is very carefully related to the phenomena encountered in real life. The concept of the excretory system topic is quite abstract and complex which is not enough to memorize the theory (Zikra, 2016). The biological concept of the excretory system topic is not simple. It requires students to have problem-solving skills to be able to understand theories and compare them to the everyday life phenomena (Rusdi, Evriani, Dwi, 2016). Complex excretory system materials demand teachers to use appropriate learning strategies as Isnaini's research on the use effect of Mind Map on student's understanding concept in excretory system materials (Isnaini, Aini, & Angraini, 2016).

Problem-solving skills are abilities that can eliminate the gap between conditions and reality (Fakhriyah, 2014; Patnani, 2013). According to Gagne in (Tan & Siti Hajar, 2015), high-order intellectual skills can be developed through problem-solving. This is similar to students' high-order thinking skills, which will provide a more effective problem solving (Duman & Bilal Duman, 2010). Every student has skills to solve problems which is different from one to another. This is consistent with the statement of (Sapitri, Utami, & Mariyam, 2019), which states that the skills to solve problems are the students' skills to use available information to determine what to do in certain situations. Problem-solving skills refer to the efforts needed by students in determining solutions to the problems they face (Ince, 2018).

Yenice, Ozden, & Evren (2012), the levels of problem-solving are divided into 5, namely: 1) Facing problems, getting difficulties. This process can include the awareness of unknown things in complex situations. 2) Defining the problem, explaining the characteristics of the situation. This stage includes activities to identify what is known and unknown, to find goals, and to identify standard and extreme conditions. 3) Discovery solutions (provision of multiple solutions), which found a solution. This stage includes activities of observing patterns, identifying steps in planning, and choosing or finding algorithms. 4) Consequences of hypothetical solutions, which are carrying out plans based on hypothetical solutions, such as using existing algorithms, collecting additional data, conducting a needs analysis, formulating problems, trials for the same situation, and getting results (answers). 5) Consequence test, which is testing whether the problem definition matches the situation or not. This stage can include an evaluation process to find out whether the hypothesis is appropriate or not; whether the data used are accurate or not; whether the analysis used is correct or not; whether this analysis matches the type or not; whether the result is reasonable or not; and whether the plan used can be applied to other problems or not (Martinsen & Furnham, 2019; Woolley, Huang, & Rabinowitz, 2019).

However, these skills have not yet been developed. They are still categorized as low among senior high school students in Surakarta. It is because they still cannot write and formulate problems relevant to the provided discourse, which is in line with the idea of (Mbekwa & Govender, 2014) and (Sumartini, 2016). The students also have not been able to provide the best solutions related to

the problems previously formulated. The students' low problem-solving skills need to be studied further (Kao, 2014). Based on the observations through classroom observations and student interviews, it can be concluded that the students' problem-solving skills are still low because learning tends to be teacher-centered. Therefore, the students are less active in learning, have a lack of interest in learning, and have low abilities to understand story questions.

Based on the below background, the research that analyzed the problem-solving skills of senior high school students in biology learning, especially in the excretory system topic. Problem-solving skills can be improved with the right learning strategies as done by the previous researchers above or can use teaching materials in the form of problem-solving based modules that are adjusted between indicators of problem-solving and excretory system material so that low problem-solving abilities are expected to increase.

METHODS

Design of the Study

This research was descriptive research using a quantitative approach. The quantitative approach used in this research was the analysis that focused on numerical data processed using statistical techniques. The research procedure was conducted by providing problem-solving-based test instruments adapted to the excretory system topics, in which there were problems in the form of real cases that might be encountered in everyday life with the aim of students being able to respond and solve problems given and provide solutions for solving them.

Participant

The research population was 126 eleventh-grade students of senior high schools in Surakarta, and the sample was 63 students categorized as A category (high class/students who have high academic scores) and B category (low class/students who have low academic scores). The division of high and low classes was based on the problem-solving pretest average scores.

Instrument

This descriptive research used instruments developed based on the stages of problem-solving skills, according to Mourtos et al., (2004) which include identifying problems, examining problems, planning solutions, implementing plans that have been made, and evaluating (Mourtos, Okamoto, & Rhee, 2004). The test used was an essay test with excretory system materials divided into three sub-materials, i.e., human excretory system, human excretory organ abnormalities and diseases, and animal excretory system. The material divisions aimed to distribute the materials and reached the problem-solving indicators thoroughly. Each problem-solving indicator of the question instrument given had three essay questions, each of which was the excretory system sub-material. The problem used was to display a real problem or case that often occurs in the excretory system.

Table 1.

Problem solving stages

Problem-Solving Stages	Indicators
Recognizing the problem	- Determining facts related to the problem. - Determining the concept/category.
Examining the problem	- Identifying the root of the problem. - Examining causal relationship.
Planning a solution	- Developing the problem-solving plan based on the root of the problem. - Mapping sub-problems and sub-solutions.
Implementing the solution/plan	- Making the sequence of problems to be solved.
Evaluation	- Examining the solution feasibility. - Making assumptions about the solution.

Source: (Mourtos et al., 2004)

Data Analysis

The sample was selected purposively, and the data obtained were based on the analysis of the students' answers by coding each answer based on the calculation of the score percentages of the problem-solving stages the score percentages of problem-solving stages were calculated using Formula (1), and After obtaining the percentage of problem-solving skills, the students were categorized according to [Table 2](#).

$$\text{Percentages} = \frac{\text{score obtained}}{\text{maximum score}} \times 100\% \quad (1)$$

Tabel 2.

Problem-solving Category Percentages

Percentages (%)	Category
80-100	Very high
60-79	High
40-59	Medium
20-39	Low
0-19	Very low

Source: (Rahmawati, Amin & Lestari, 2016)

RESULTS AND DISCUSSION

The research data were obtained by giving a score of each problem-solving skill indicator based on the Mourtos achieved. The results were categorized in percentages based on Arikunto Comparisons between the obtained scores and categories were displayed in percentages. The percentages explain the students' problem-solving in the biology learning of the excretory system topic. The excretory system material requires students to understand the existing concepts that exist instead of memorizing the theory. Therefore, the students can understand the processes that occur in an excretory system as a whole (Nuroifah, 2014). By understanding the concept of excretory systems, the students are expected to be able to solve problems and cases that exist in everyday life, especially in diseases and disorders in the kidneys, liver, lungs, and skin.

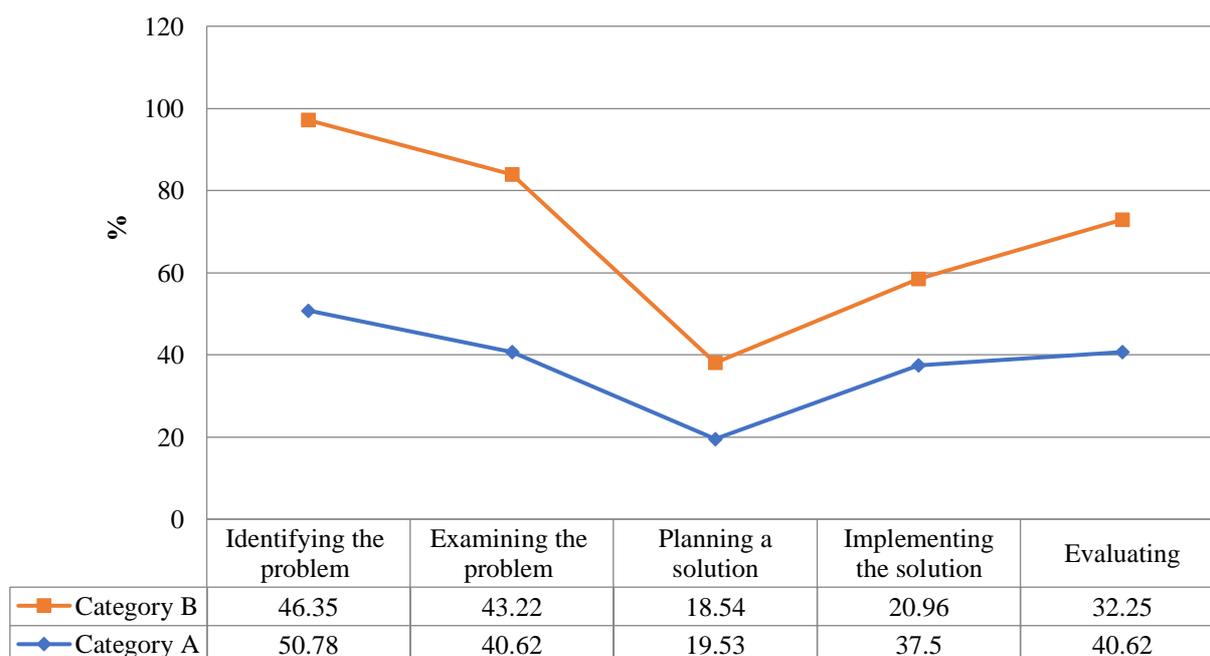


Figure 1. Comparison of stages of problem-solving different category

Table 3.

The activity of problem-solving stages

Problem-solving Stages	Material	Activity	Percentages (Criteria)
Identifying the problem	Human excretory system, human excretory organ abnormalities and diseases, and animal excretory system.	<ul style="list-style-type: none"> • Understand problems in general. • Look at aspects related to the problem. • Develop/analyze problems develop a hypothesis. 	48,5 (Medium)
Examining the problem	human excretory system, human excretory organ abnormalities and diseases, and animal excretory system.	<ul style="list-style-type: none"> • Look at data/variables that are known or unknown. • Search and browse various information from various sources. • Screen various information that has been collected. • Formulate problems. 	41,92 (Medium)
Planning a solution	human excretory system, human excretory organ abnormalities and diseases, and animal excretory system.	<ul style="list-style-type: none"> • Find various alternative solutions to various problems. • Conduct studies on each alternative problem solving from various perspectives. • Decide to have one alternative solution to the most appropriate problem. 	19,93 (Very Low)
Implementing the solution	human excretory system, human excretory organ abnormalities and diseases, and animal excretory system.	<ul style="list-style-type: none"> • Perform problem-solving in stages. 	29,23 (Low)
Evaluating	human excretory system, human excretory organ abnormalities and diseases, and animal excretory system.	<ul style="list-style-type: none"> • Correct the problem-solving methods. 	36,43 (Medium)

The result showed that of the 63 samples taken, the average result showed that the senior high school students in Surakarta had low problem-solving skills. This can be seen in [Table 3](#) and [4](#), which indicate that A and B categories have low problem-solving skills, although students with high academics have higher average scores than students who have low academic. This can be seen from the result that all the students have not been able to master all stages of problem-solving skills yet. Based on the research result, the students' problem-solving skills vary in each of the five stages in this research.

In the first stage, identifying the problem, students with high academic obtained 50.78%, and student with low academic 46.35%, which showed that some participants were quite able to define the problem with fair criteria, at the stage of identifying problems students with the category of high academic are able to identify problems better than students with low academic categories who tend to be less careful in understanding the problem so that the problem is not well identified.

In the second stage, examining the problem, students who have high academic scores obtained 40.62% and students who have low academic scores category is 43.22%, meaning that the students were less able to examine the problem. At this stage, the students lacked in determining a reciprocal or causal relationship.

Table 4.

Percentages of Problem-solving stages of Class A and Class B Category

Problem-solving stages	Percentages (%)	Percentages (%)
	A Class Category	B Class Category
Identifying the problem	50.78	46.35
Examining the problem	40.62	43.22
Planning a solution	19.53	18.54
Implementing the solution	37.50	20.96
Evaluating	40.62	32.25

In the third stage, planning a solution, students who have high academic obtained 19.53% and students who have low academic scores is 18.54%. At this stage, all the students have not been able to form an action plan by chosen alternative solution and think about the form of the plan so that it can be implemented. The research result of analyzing biological concept and problem solving based on critical thinking skills of eleventh-grade students of senior high school that the percentage of indicators for developing action strategies is 84% (Khoiriyah & Husamah, 2018). In this indicator, the students have not been able to determine a good and appropriate strategy in implementing the solution.

In the fourth stage, implementing the plan made students who have high academic scores obtained 37.50% and students who have low academic scores 20.96%. At this stage, the students still cannot implement a solution that has been made well. The fifth stage evaluation that students who have high academic scores obtained 40.62%, and students who have low academic scores is 32.25%.

Only in the problem identification were the students in the medium category. It is because they are quite capable of determining the relevant problem and evaluating it. Meanwhile, in planning the solution, they have not been able to master the problem formulation (Rahmawati 2018; Sugiyanto, 2018). Each teacher needs to apply problem-based learning to their students. It is expected that the students are trained to think, analyze, receive information, process data actively, and conclude. Even though the data above show that scores of the students who have high academic abilities are better than those of students with low academic abilities. However, both groups fall into the category of low problem-solving. Therefore, for students with high academic and low academic levels, they still need the right learning strategies to improve the ability of the two groups. Besides using appropriate learning strategies, learning modules can also be provided to the students who have low academic abilities by providing problem-based modules leading them to solve problems in a guided manner so that the ability to understand problems will increase.

It is in line with (Carson, 2007) that problem-solving skills are essential to be applied in order to see how well students' abilities to think, analyze, and act to implement the solution (Ijirana & Supriadi, 2018). Most students have difficulties applying the solution due to several factors, such as the hesitation in doing analysis. Even though they are able to pass the five problem-solving stages, most of them have not been convinced with their answers. Thus, their problem-solving skills are less on specific indicators.

Problem-solving skills are needed in science learning, considering that biology learning is not limited to concepts and facts, but also procedural and metacognitive biology learning processes. According to Afandi, Sajidan, Akhyar, & Suryani, (2018), biology learning is a reflection of thinking skills that use logical principles accompanied by empirical evidence combined with scientific methods to obtain new knowledge about nature about social life, especially in the excretory system. It is a complex material that requires not only memorizing theories, but also analysis skills to solve a problem commonly happening in daily life.

It is as explained by the National Science Teachers Association (Bodzin, Klein, & Weaver, 2010) that biology learning is a learning process that emphasizes the students' experience combined with their thinking skills to solve problems. Based on that opinion, we can conclude that problem-solving skills are needed in biology learning, especially in the excretory system that, indeed, requires

problem-solving skills which are essential for social lives and the future — developed a student worksheet on the excretory system with a problem-solving learning method, where she believes that excretory systems require students to be able to solve the problem in some instances of the excretory system material (Hikmah, 2015). Other research concerning the understanding of excretory systems is that of Fajarinda and Widi that applied other learning methods (Nurulita, 2015; Astuti, Prasetyo, & Rahayu, 2012).

Low problem-solving skills, especially in excretory system materials, need to be empowered because according to Christiyoda (2016) and Selçuk (2010), students' problem-solving skills have significant advantages including being innovative people, becoming people who are ready to compete and to change, changing behavior, increasing creativity, and improving thinking skills. Students with problem-solving skill will be ready for challenges.

CONCLUSION

Based on the data, it can be concluded that the students' problem-solving skills in both A and B categories are still low, especially at the stage of solution implementation in class A and B, categorized as low. Complex excretory system materials require not only memorize subject material but also appropriate problem-solving strategies. The skills can be improved by implementing problem-solving learning by providing case studies to stimulate students to solve problems according to the problem-solving stages.

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