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Analysis of the Relationship Between Concept Mastery and Problem-Solving Skills of Pre-Service Biology Teachers in Human Physiology Courses

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Abstract. 21st century learning focuses on problem-solving skills. A higher level of education requires an understanding of a more systematic concept to elaborate problems. Problem-solving skill is one of the fundamental cognitive processes. It involves higher order thinking to discover solutions or ideas. This research aims to analyze the relationship between concept mastery and problem-solving skill of pre-service biology teacher in human physiology courses. This is descriptive correlational research conducted in Sulthan Thaha Saifuddin State Islamic University Jambi. The sample was selected using the purposive sampling technique. Respondents in this study were 33 students in semester VI. The instrument used in the study was an essay test of concept mastery integrated with problem-solving. The results showed that the average scores of the students' concept mastery and problem-solving were 56.8 and 58.0, respectively. Both included in the poor category. It also showed that there was a relationship between students' concept mastery and problem-solving skill. The correlation value was 0.76, with a significance value of $p<0.05$; therefore, it included in the strong category.
Keywords: concept mastery, human physiology, problem-solving

Introduction

The development of science and technology in the 21st century is increasingly advanced. It requires the improvement of human resources qualities that possess the habits of thinking, researching, and problem-solving skills (Rahman, 2019; Joweli, 2018). As the individuals who take higher education at the undergraduate and diploma level, university students are required to apply the knowledge they have learned to solve the problems (Kemenristekdikti, 2016).

A prospective Biology teacher is required to build or combine previously learned understanding to attain a solution (Nurita, et al., 2017). The use of material that involves

problem-solving in student learning activities can develop higher cognitive processes (Rahmawati et al., 2018). Problem-solving leads to mastery of concepts and is a way that can be used as evaluation in learning (Bahtiyar & Can, 2016).

Mastery of concepts, especially in science, is students' cognitive ability to understand and master the concept of science through phenomena, events, objects, or activities related to science material (Roslina, et al., 2020). Prospective teachers, especially in biology, need concept mastery to solve increasingly complex modern life problems (Fatmawati & Fauzi, 2019). As biology is one of the scientific fields, pre-service biology teachers need to build a capacity for concept mastery that is more than just remembering and memorizing (Etobro & Fabinu, 2017). Concept mastery can be developed from learning activities and experiences to promote students' thinking skills in solving problems. Concept mastery in biology learning is essential because it enables students to understand the problems they face in life and leads them to problem-solving abilities (Aritia & Suyanto, 2019).

Problem-solving skills are essential skills required by undergraduate students (Bahtiyar & Can, 2016), particularly for those prepared to become teachers. The purpose of problem-solving skills training for prospective teachers is to improve science learning quality (Subekt, et al., 2017). Future biology teachers' preparation aims to create professional teachers and support their future job (Akben, 2020). Problem-solving skills help university students to make decisions that are correct, careful, systematic, logical, and with consideration to various points of view (Lee, et al., 2016).

Problem-solving skills also encourage students to implement higher-order thinking skills (Setyarini, et al., 2018) so they can connect facts and relate them to pre-existing concepts to produce several problem-solving ideas (Toharudin, 2017). Higher-order thinking skills contribute to the effectiveness of problem-solving (Yurniwati & Soleh, 2020). According to international education thinkers, higher-order thinking and problem-solving skills are considered essential to prospective teachers in the 21st century.

Students in the biology education department should take some courses to achieve the expected competencies. Human physiology is one of the compulsory courses the students must complete. The essence of the human physiology course aims to equip prospective teachers with knowledge and concepts related to biological insights, especially the physiological structure of human organs and systems. This study aims to determine the level of students' concept mastery & problem-solving skills and analyze the relationship between concept mastery & problem-solving abilities in human physiology courses.

Methods

This research is a descriptive correlational study that applies a quantitative approach to analyze the relationship between concept mastery and problem-solving skills. The research was conducted at the Sulthan Thaha Saifuddin State Islamic University Jambi with a total sample of 33 students in the sixth semester who had completed the human physiology course. Data were collected using an essay test consisting of 10 validated questions by physiology experts. The test was conducted to measure the level of concept mastery and problem-solving skills and analyze the relationship between concept mastery and problem-solving skills in human physiology.

Concept mastery is assessed based on indicators proposed by Anderson & Krathwohl (2001), namely the ability to remember (C1), understand (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6). Students' problem-solving skills are assessed based on indicators created by Pólya & Conway (2004), namely 1) understanding the problem, (2) devising a plan, (3) carrying out the plan, (4) examining the solution obtained. Data of concept mastery and problem-solving were gained from students' answers and analyzed with categories in Table 1.

Table 1. Categories of concept mastery and problem-solving

Learning Outcome Score	Category
86-100	Very Good
76-85	Good
60-75	Fair
55-59	Poor
≤ 54	Very Poor

(Source: Purwanto, 2010)

Data analysis performed to obtain a correlation coefficient was product-moment correlation formula carried out using the SPSS (Statistical Products and Solution Services) program version 25. The prerequisite for the product-moment correlation test was that the data were normally distributed and linear between variables. The normality test performed in this study was the Shapiro-Wilk normality test with a sample size of less than fifty. The data would be considered normal if the significance value (sig.) was >0.05. If the significant (sig.) value of deviation from linearity was >0.05, then there was a linear relationship between concept mastery and problem-solving skills. The guideline for the degree of relationship for the interpretation of the correlation coefficient obtained from the calculation results that calculated the person correlation value is presented in Table 2.

Table 2. Degree of correlation category

Coefficient Interval	Degree of Correlation
0.00 – 0.199	Very Low
0.20 – 0.399	Low
0.40 – 0.599	Medium
0.60 – 0.799	Strong
0.80 – 1.000	Very Strong

(Source: Sugiyono, 2011)

Results and Discussion

Data of the students' concept mastery in the human physiology course are presented in Table 3.

Table 3. Data of students' concept mastery

No	Cognitive Dimension	Skor (%)	Category
1	Remembering	78.0	Good
2	Understanding	68.9	Fair
3	Applying	59.8	Poor
4	Analyzing	37.1	Very Poor
5	Evaluating	55.3	Poor
6	Creating	41.7	Very Poor
	Average	56.8	Poor

The average percentage of students' concept mastery was 56.8% which was categorized as poor. The top three cognitive dimensions of students' concept mastery were remembering, understanding, and applying. The dimension of remembering gained 78.0%, which included in the good category. The dimension of understanding gained 68.9%, which sits in the fair category. The dimension of applying gained 59.8%, which was in the poor category. The bottom three cognitive dimensions in students' concept mastery were evaluating, creating, and analyzing. The dimension of evaluating gained 55.3%, which included in the poor category. The dimension of creating gained 41.7%, which was in the very poor category. The dimension of analyzing gained 37.1%, which also was in the very poor category.

The results of observations in the human physiology course show that the learning process used conventional learning. Students still rely on the explanation of the material provided by the lecturer and the learning resources provided in the human physiology course are still limited. This causes the students' mastery of concepts to be low (Mulyani, et al., 2020). In order to improve students' mastery of concepts, lecturers must prepare as much learning as possible (Shi, 2011; Mutawah, et al., 2019). Students who have mastery of deep concepts will have the ability to 1) identify problems, 2) analyze and evaluate data or events, 3) design research, 4) use and manipulate tools, materials or procedures; and 5) solving problems in order to understand facts about nature and the changes that occur in life (Pantiwati, et al., 2020; Surif, et al., 2012).

The results showed that the problem solving ability of each aspect can be seen in Table 4.

Table 4. Data of Students' problem-solving skills

No	Problem-Solving Aspect	Skor(%)	Category
1	Understanding the problem	78.3	Good
2	Devising a plan	66.7	Fair
3	Carrying out the plan	50.9	Very Poor
4	Examining the solution obtained	36.4	Very Poor
	Average	58.0	Poor

The average score of students' problem-solving skills was 58.0%, which was in the poor category. The aspect of understanding the problem gained the highest percentage of

78.3%, which included in the good category. The aspect of devising a plan gained 66.7%, which sits in the fair category. In comparison, the aspects of carrying out the plan and examining the solution obtained were in the very poor category with a percentage of 50.9% and 36.4%, respectively.

These findings indicate that when students are faced with questions in the form of real problems, students are less able to analyze the problems presented. The impact is that the solutions to the problems given are not logical and cannot be applied in everyday life. Giving questions in the form of real problems in the student environment will train critical thinking skills so that they can produce a solution that can be applied in everyday life (Lieto, et al., 2019). Problem solving activities, especially in the aspect of considering solutions, require students to produce systematic and logical thinking (Chua, et al., 2014). The ability to solve problems is supported by cognitive abilities, especially in the dimensions of analysis and evaluation (Tawfik, et al., 2018).

The data then were tested with normality and linearity test as a prerequisite for the correlation test. The normality test and linearity test results are presented in Table 5 and Table 6, respectively.

Table 5. Normality Test Results

Variable	Statistic	Df	Sig.
Concept Mastery	0.97	33	0.64
Problem-Solving Skills	0.965	33	0.35

Table 6. Linearity Test Results

			Df	Mean Square	f	Sig.
Problem-Solving Skills*Concept Mastery	Between Groups	Combined	21	86.16	0.86	0.62
		Liniearity	1	802.06	8.06	0.01
		Deviation from Linearity	20	50.34	0.50	0.91

The significance value gained from the normality test results on the variables of concept mastery was 0.64 and the variable of problem-solving skills was 0.35, so it could be concluded that the variables were normally distributed. The significance value of the linearity test analysis gained a deviation of 0.91, and it could be concluded that the conceptual mastery and problem-solving skills were linearly correlated. The results of the product-moment correlation test analysis are presented in Table 7 as follows.

Table 7. Correlation Analysis Results

		Concept Mastery	Problem-Solving Skills
Concept Mastery	Person correlation	1	0.76
	Sig (2-tailed)		0.00
	N	33	33
Problem-Solving Skills	Person correlation	0.76	1
	Sig (2-tailed)	0.00	
	N	33	33

The results of data analysis about the relationship between concept mastery and student problem-solving abilities, there was a correlation between concept mastery and problem-solving abilities in the Human Physiology course ($p = 0.00$). The correlation value obtained is 0.76, so the level of the relationship between concept mastery and problem-solving abilities of biology teacher candidate students in the Human Physiology course is in the strong category.

Based on the presented results, the cognitive dimension of remembering was in a good category. This had an impact on problem-solving skills, particularly in the aspect of understanding the problem. The ability to remember allows the students to recognize what is known from the existing problems. Students can write down information about what is known and what is being asked in the questions. Students are said to have a good memory if all the information in the questions is rewritten when working on the questions (Wandari, et al., 2018).

Students 'cognitive abilities in problem solving based on logical intelligence obtained the results of indicators considering that they had an effect on students' ability to understand problems in the given problem solving problems (Susanti, 2018). The cognitive dimension of understanding is in a fair category, which impacts problem-solving skills on planning. The cognitive dimension of understanding involves cognitive processes such as interpretation, classification and comparison of information which are all categorized under the level of understanding (Anderson & Krathwohl, 2001; Lin, et al., 2018). A good understanding of the concept stimulates the brain to constantly develop ideas so that various ideas will emerge (Trianggono, 2017).

Students' cognitive dimension in the applying category was in a poor category and this affected their problem-solving abilities, particularly on the indicator of carrying out the plan which was in the very poor category. Students' concept mastery in cognitive dimensions of applying that included in the poor category makes them experience difficulty in carrying out the plans (Husamah, et al., 2018). Students' concept mastery in the aspects of analyzing and creating was in the very poor category, causing the acquisition of small scores on problem-solving skills in the aspects of carrying out the plan and examine the solution obtained. Analytical skills are a person's ability to process further information (Lin, et al., 2013). It was found that students had not been able to explain or describe in detail problem-solving using the basic concepts of human physiology theory.

Students' concept mastery in the cognitive dimension of evaluating is in the poor category, which affects the concept of mastery in the cognitive dimension of analyzing which is in a very poor category. The students' ability in processing and analyzing the information seems inadequate. This results in the ability to evaluate problems to test solutions with empirical data that is in a poor category. The ability to analyze and evaluating is an important supporting component in problem-solving (Aliyah, et al., 2018). It takes students' readiness to understand and analyze the problem so that the correct theory supports the problem-solving solution to achieve a very good percentage in evaluating (Lestari, et al., 2017).

Concept mastery in the dimension of analyzing, evaluating, and creating is higher-order thinking skills for the students who are prepared to be a teacher (Puspitasari & Nugroho, 2020). It takes more than just memorizing the facts. Higher-order thinking uses complex thinking to complete a task, some are unpredictable, and it uses a different approach from existing tasks and is different from the examples (Tambunan, 2019).

Indicators used to measure higher-order thinking skills consist of analyzing, evaluating, and creating (Susetyarini & Fauzi, 2020; Putri, et al., 2020). This is in line with Dungsungnoen (2016) who stated that the ability to solve problems is related to the accuracy of the solutions obtained and the ability to recognize problems, find alternative solutions, choose one alternative as a solution, and evaluate the data gathered.

Correlation analysis shows the degree of relationship between students' concept mastery and problem-solving that is in the strong category because concept mastery plays an important role in finding solutions in problem-solving (Puspitawati, et al., 2018). Concept mastery the students possess would be very helpful for the problem-solving process, particularly in understanding the existing problems (Prevost & Lemons, 2016; Fajarianingtyas & Hidayat, 2020). One of the goals of learning science, especially biology, is to make students capable of solving complex problems by applying the knowledge and concept mastery in everyday situations (Greca & de Ataíde, 2016).

The students' problem-solving skill was in the low or poor category. It indicated that they had not been able to use their learning experience to solve existing problems. Lack of ability to analyze problems is influenced by several factors, namely 1) lack of problem understanding, 2) low ability to identify problems, 3) low ability to analyze, 4) low concept mastery (Cheng, et al., 2018). The participants of this study possessed weak high-level thinking skills which resulted in poor problem-solving skills. Problem-solving skills must be supported by a cognitive system that controls focus and interference in information processing (Mairing, 2017). Any obstacle at the cognitive level can create difficulties in the problem-solving process (Pacheco & Herrera, 2021).

Problem-solving focuses on the user's previous experience and knowledge to think deeply and utilize cognitive abilities to solve new problems (Gunawan, et al., 2018). This is in line with Levin et al (2021) that claimed students in the problem-solving group possessed better conceptual knowledge performance. The learning process should provide benefits for students to fully develop their capabilities (Skuballa, et al., 2018). Science is a substantial component to improve a critical thinking society (Perconti & Plebe, 2020). Students who master the concept of biology will always support the problem-solving efforts in their surrounding environment since concept mastery is the foundation for a network of ideas that guides someone's way of thinking (Chen, et al., 2020).

The scope of biological problems is about the complexity of the relationship between concepts, so it is necessary to master good concepts in solving biological problems (Gilpin, et al., 2020). Problem-solving skills are considered the most complex intellectual functions, including thinking and reasoning, including metacognitive and critical thinking skills (Li, et al., 2021).

Conclusion

Concept mastery in the remembering dimension had the highest percentage of 78.0% and was in a good category, whereas the analyzing dimension had the lowest percentage of 37.1% and was included in the very poor category. In the problem-solving skills, the highest aspect was understanding the problems with a percentage of 78.3%, which was in the good category, whereas the rechecking aspect was in the very poor category with a percentage of 36.4%. The relationship between conceptual understanding and problem-solving was in a strong category with Pearson's correlation value of 0.76.

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