Exploring gender-based biological concepts: an analysis of bilingual secondary school students

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A R T I C L E I N F O

A B S T R A C T

The purpose of this study was to analyze gender-based biological concepts understanding at secondary school students of bilingual programs. 6 (sixth) problems, according to Bloom's taxonomy categorization, were designed consisted of: understanding, applying, analyzing, evaluating, and creating. The topics included cell, classification of the organism, ecology, plant anatomy and physiology, and human anatomy and physiology. Samples were 47 students from grade nine (secondary school) from one of bilingual secondary schools in Jakarta, Indonesia. Data obtained were analyzed quantitatively and qualitatively. The analysis showed that the average value of the concept comprehension test was 55.07, which was below the Minimum Criteria of Completeness score of 73. The average value of male students was 57.29, and the average value of female students was 52.85. There was no significant difference between the learning outcomes of male and female students. Some male students have higher achievements because they have more engagement in science than others. Students' low ability to understand the biology concept makes them unable to perform their competency at the stages of applying, analyzing, evaluating, and creating. Overall, data showed that the average level of understanding of biological concepts for secondary school of bilingual programs still tends to be low and needs to be continuously improved in the learning process. Hopefully, further studies can be conducted to develop the most appropriate learning method to improve biological concepts.

INTRODUCTION

Biology is a subject related to various fields of work, including medicine, pharmacy, environment, and agriculture. Understanding biological concepts encourage students' awareness about environment; enhance positive attitudes and thinking abilities in science (Chavan & Patankar, 2018). Through a high understanding of biological concepts, students would be prepared to engage in various fields of work related to biology, have a great understanding of maintaining health, protecting the environment, and having a positive attitude and good scientific ability.

Bilingual school program began with the emergence of government regulations regarding the implementation of Pioneer International Standard School (Fitriati, 2015; Hendarman, 2011). The regulation was Law No. 20 of 2003 (Department of National Education, Republic of Indonesia, 2003) and strengthened by Minister of National Education Regulation No.78 of 2009 (Ministry of National Education, 2009). The purpose of bilingual school is to strengthen students' English competency, especially in Mathematics and Science. Through bilingual school, students are expected to have foreign language skills that apply throughout the world (Baker, 2011) and following the needs of the 21st century industry. In the bilingual program, biology lesson is carried out with English.

Biology is one of the difficult subjects for the students at secondary school (C. W. Anderson, Sheldon, & Dubay, 1990; Bahar, Johnstone, & Hansell, 1999; Lazarowitz & Penso, 1992; Seymour & Lonaden, 1991) even in higher education (Lestari, Ristanto, & Miarsyah, 2019). Students have difficulty in learning biology because of numbers of concepts that need to be understood, biological events that cannot be seen with the unaided eye, abstract concepts and many foreign terms (Chavan & Patankar, 2018; Tekkaya, Özkan, & Sungur, 2001; Wardyaningrum & Suyanto, 2019). Too many biology topics in the curriculum make it difficult for students to do meaningful learning; they are more motivated to simply memorize the material (Chiappetta & Fittman, 1998). Another challenge for students of the bilingual program is the demand to understand biology using English terms. In contrast, the English proficiency of students in a class is uneven because of different primary school backgrounds (students from regular schools use the Indonesian language of instruction in science lessons).

Difficulties in understanding biological material causes a decrease in motivation and learning outcomes (Çimer, 2012) as well as students' interest (Zeidan, 2010). Difficulties in understanding the terms also decrease students' achievement (Lestari et al., 2019). Student science competence in Indonesia is still low, as evidenced by Indonesia's achievements in PISA 2015, Indonesia has an average value below the average of the OECD (Organization for Economic Cooperation and Development) country. A low average score is shown in the value of trust, attachment, and motivation to science (OEDC, 2018).

Conceptual understanding is one of the essential goals in learning, especially science, at all levels of education (Konicek-Moran & Keeley, 2015; Phanphech, Tanitteerapan, & Murphy, 2019). Indicator of understanding concepts is the ability of students to answer questions according to Bloom's taxonomic level remembering, understanding, applying, analyzing, evaluating, and creating (L. W. Anderson & Krathwohl, 2001; Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). The level of Bloom's taxonomy is shown in Figure 1.

Embedding the concept of material in appropriate ways will make a material embedded in a child's long term memory (Gabel, 2003; Schunk, 2012). The development of conceptual change approaches through active learning has also been carried out to gain a deep understanding of a science concept in students (Yenilmez & Tekkaya, 2006). However, various learning approaches are still needed to improve the understanding of concepts and students' interest in learning biology. CirGi was one of the learning designs developed to improve conceptual understanding in Indonesia (Ristanto, Zubaidah, Amin, & Rohman, 2018). Learning

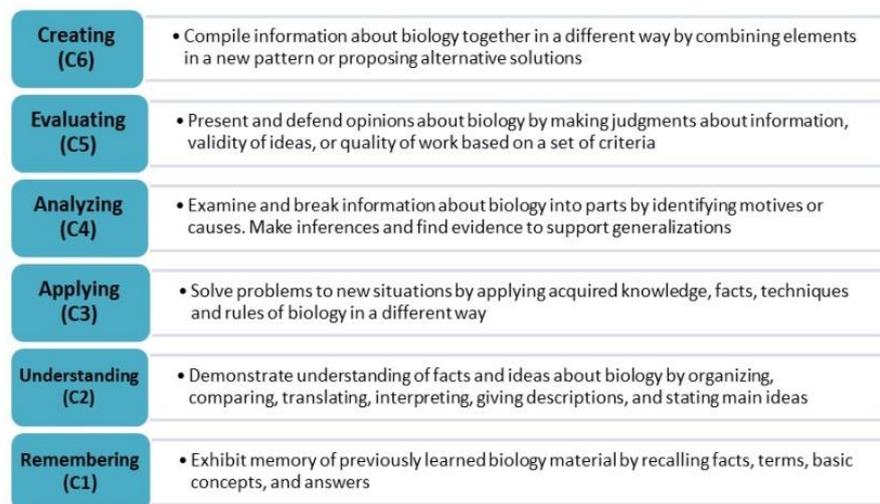media and type of learning method also affect the student's knowledge in biology (Ristanto et al., 2018).

Figure 1. Bloom's Taxonomy revised (L. W. Anderson & Krathwohl, 2001)

Male and female students have the same level in connecting various biological concepts (Yadav & Singh, 2015). There were no significant differences between male and female students in the achievement of science learning outcomes and attitudes toward science (Olasehinde & Olatoye, 2014) and results in the international biology Olympiad (Steegh, Höffler, Keller, & Parchmann, 2019). Courses of science in universities such as engineering, health, computer science, pure science, and physics are not exclusively for males (Tambaya, Sabitu, & Matazu, 2016). However, there is a difference between career interests. Females prefer careers in the field of biology, while males in the fields of physics and chemistry (Kang, Hense, Scheersoi, & Keinonen, 2018). Research on understanding biological concepts and learning biology in bilingual program schools, especially in Indonesia, is still minimal.

Meanwhile, the potential of students in terms of intelligence and economics is quite high. Students who choose a bilingual program primarily in the Penabur Christian Educational Institution (Badan Pendidikan Kristen Penabur) must pass special tests for English, Science, and Mathematics. Students who choose to study in bilingual schools are ready to compete because they choose schools with a dense national curriculum load but use the language of instruction in foreign languages. Therefore it is crucial to develop the learning process and students' understanding.

The existence of hopes and various facts drives the need to improve biology learning, especially in secondary school bilingual programs. The purpose of this research is to analyze the biological concepts achievement of bilingual school students. This systematic review is needed to help us understand the level of bilingual students' conceptual understanding of biology topics. This research is the background for further research to find appropriate learning methods to improve students' understanding, students' engagement, and students' achievement in biology and maximize the potential of bilingual program students.

METHODS

Research Design

This research was survey research (Sugiyono, 2013) with a quantitative descriptive analysis approach. This approach describes or provides a systematic, factual, and accurate description of the facts, nature, and phenomena of biological concepts achievement of secondary school students from the bilingual program.

Population and Samples

The study population was all students from grade IX (nine) Secondary School bilingual program of Jakarta Penabur Christian Educational Institution (SMP BPK Penabur Jakarta) in the Academic Year 2019/2020. The sample was selected using purposive sampling (Sugiyono, 2010) and got 47 Secondary School students of Kelapa Gading Penabur Christian Educational Institution (SMP BPK Penabur Kelapa Gading Jakarta) consisted of 28 male students and 19 female students. All students have completed studies in the same program, which are grade VII and VIII bilingual programs.

Instrument

Participants were given 6 problems to be answered. The type of problem was an essay test. Topics in the problems contain cell, classification of living things, ecology, plant anatomy and physiology, and human anatomy and physiology. Those are the core topics in biology (Brownell, Freeman, Wenderoth, & Crowe, 2014) that the participants have learned. All instruments measure students' competency according to Bloom's taxonomy categorization (L. W. Anderson & Krathwohl, 2001). The instrument was validated by expert lecturers from Universitas Negeri Jakarta. The assessment scheme is shown in Table 1.

Table 1
Assessment Scheme of Biological Concepts for data collection

Basic Competence	Topic	Number of problem	Bloom taxonomy/ cognitive level
Identify the organization of life from the cellular level to the organisms and the main composition of the cell	Cell	1	Applying
Classify living things and objects based on characteristics	Classification of organism	2	Understanding
Analyze the interactions between organisms and their environment and population dynamics due to the interactions	Ecology	3	Analyzing
Analyze the environmental pollution and its impact on the ecosystem	Pollution	4	Evaluating
Analyze the relationship between the structure of plant and their functions, and technology inspired by plant structures	Plant anatomy and physiology	5	Creating
Analyze the human digestive system and understand the disorders related to the digestive system, and efforts to maintain the health of the digestive system	Human anatomy and physiology	6	Creating

The validation result of the questions is shown in Table 2. Assessment validation contains the validation of content and language. Content validation was assessed based on the suitability of the question with the Basic Competence or indicator, the formulation of the short and clear question, and explicit instruction in the question. Language validation was assessed based on the grammar; it was communicative, easy to understand, and does not lead to multiple interpretation questions.

Table 2
The validation result of questions

Question number	Content	Language
1	Valid	Valid
2	Valid	Valid

3			Valid				Valid			
4			Valid				Valid			
5			Valid				Valid			
6			Valid				Valid			

Procedure

We applied the instrument to the participants in the form of the test. Participants were informed about the day and the topics several days before the test. They prepared by studying the topics according to the materials received in grade VII and VIII. They were informed about the purpose of the research and the types of problems in the test.

Before the participants did the test, teacher reminded them about the materials, type of the problems (essay), the rules, and the time of the test. The test was done in 60 minutes (one meeting). The result was collected to be analyzed. Figure 2 shows a diagram of the research procedure.
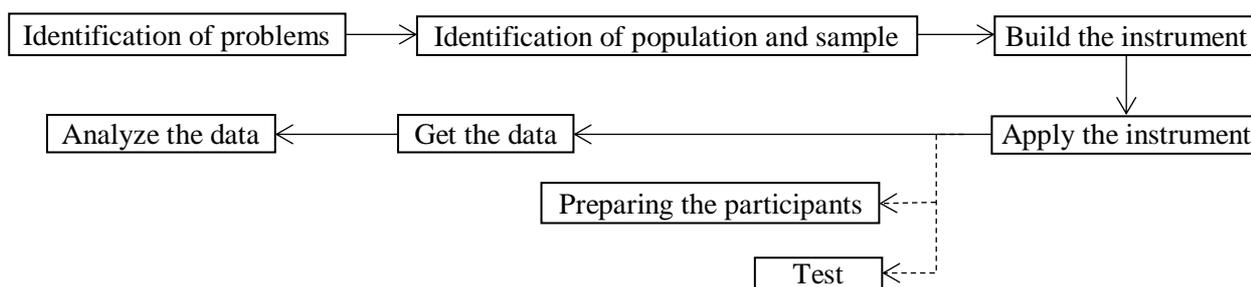
Figure 2. Research procedure

Data Analysis Techniques

The data were analyzed according to a maximum value, minimum value, standard deviation, and the average value of student achievement based on the instruments used. The analysis was also taken descriptively based on the cognitive (Bloom's taxonomy) level.

RESULTS AND DISCUSSION

The average value of the students' test was 55.07. This average score was below the Minimum Criteria for Completeness (Kriteria Ketuntasan Minimal), which was 73. From 47 students, only 9% achieved above 73, and all of them were male students. The result of the conceptual understanding test is shown in Table 3.

Table 3
The Results of Gender-Based Biological Concepts Test

Bloom's level	Problem number	Topic	N		Min		Max		SD		Average	
			M	F	M	F	M	F	M	F	M	F
C2	2	Classification of Organism	28.00	19.00	50.00	50.00	100.00	100.00	22.57	20.50	75.00	67.11
C3	1	Cell	28.00	19.00	25.00	25.00	100.00	100.00	25.51	25.36	58.04	53.95
C4	3	Ecology	28.00	19.00	25.00	25.00	100.00	75.00	29.70	11.47	41.96	27.63
C5	4	Pollution	28.00	19.00	25.00	25.00	100.00	75.00	23.06	10.12	61.61	48.68
C6	5	Plant Anatomy and Physiology	28.00	19.00	0.00	25.00	100.00	100.00	27.26	28.93	54.46	57.89
C6	6	Human Anatomy and Physiology	28.00	19.00	25.00	0.00	100.00	100.00	26.65	28.10	52.68	61.84

Based on Table 3, the average value of conceptual understanding in all topics is below 73, except the average value of male students on the topic of classification of the organism with

Bloom's taxonomic level understanding. The average value of the classification of the organism is the highest average value, and this is because the questions on this material are at the lowest Bloom taxonomy level tested, which is the understanding level. Most male students were able to record differences between living things based on the data presented. However, female students' average ability at the understanding (C2) level cannot pass through the minimum completeness value. Ecology is the topic with the lowest average value. Based on the data, the participant students have not been able to answer questions at level applying, analyzing evaluating, and creating.

The average value of all topics for male students was 57.29, while the average value of all topics for female students was 52.85. The final average value was not significantly different. Some male students have joined the extracurricular science club and several science competitions. They have a greater interest in science than female students; male students obtain therefore higher average tests on several topics than female students (Gunuc, 2014; Karabıyık, 2019; Konold, Cornell, Jia, & Malone, 2018).

Understanding the concept is achieved when students can think using the concept, apply it in other fields, make their definitions of the concept, able to make analogies about the concept, and build a mental or physical model of the concept (Konicek-Moran & Keeley, 2015; Trilipi, Subali, Anwar, & Santoso, 2019). Test results under Minimum Criteria for Completeness show that students have not reached the understanding of biological concepts. Biology lesson is difficult for students.

The following (Table 4, 5, 6, 7, 8, and 9) are the problems and examples of student's answers, according to Bloom's taxonomy categorizations. We put our analysis below each table.

Table 4
Problem and student's answer, topic: classification of organism

Problem's level: understanding	Answer – Student A

See the following dichotomous key to answer the question below.
1 a. Has backbone……….....................................……… 2
   b. No backbone……....................................……… 5
2 a. Internal fertilization..… 3
   b. External fertilization..… 4
3 a. The body is covered by fur..................................… Aves
   b. The body is covered by hair..............................… Mammalia
4 a. The body is covered by scales............................ Pisces
   b. The body is covered by slimy and moist skin. Amphibia
5 a. Has long and segmented body .... Annelida
   b. The body has pores.. Porifera
	A. • No Backbone
	   • Body has pores
	   • It is a Porifera
	   • External fertilization
	   • The body is covered by slimy and moist skin
	
	B. • Has backbone
	   • Internal fertilization
	   • The body is covered by hair
	   • It is a Mammalia

Explain the differences between animals A and B based on the dichotomous key above.
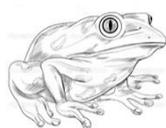
A   B

According to the level of this problem – understanding – students had to demonstrate the understanding of an organism's classification by organizing and interpreting the dichotomous key and stating the differences of organisms based on the key (L. W. Anderson & Krathwohl, 2001). This student (student A) failed to show his/her understanding of classification,

particularly the characteristics of frogs. He/she could not interpret and organize the critical difference of Amphibian and compare Amphibian (frog) and Mammalia (rabbit) using the dichotomous key provided.

Table 5
Problem and student's answer, topic: cell

Problem's level: applying	Answer – Student B
Rani was experimenting with human cheek cells. She took the cells from the inner side of her cheek. Those cells were colored by methylene blue and then observed using a microscope. The picture beside is the image shown under the microscope. Rani has the same physical characteristics as her parents. Which part of the cell (A or B or C) is that connected to that statement? Explain.	Part B. B is called the cytoplasm, which contains organelle. Organelle contains mitochondria and many else. So, Rani's cytoplasm must have the same physical characteristics as her parents.

Students failed to apply the concept of the cell. He/she can identify parts of the cell (cytoplasm) in the image from the actual cell shape observed under a microscope. However, He/she could not identify the cell nucleus as part of the cell where genetic material plays a role in inheritance. Student only memorized parts of cells in the diagram and has not been able to apply and relate them to the process of inheritance.

Table 6
Problem and student's answer, topic: ecology

Problem's level: analyzing	Answer – Student C
The following are the type of interactions between organisms U, X, and Y: U and X is living together. U gets nutrition from the waste of X and gets better water circulation from the movement of X. Organism X gets protection from getting eat by Y. X is prey of Y. A. Name those organisms (U, X, and Y). B. Name and explain each type of interaction according to the description above.	A. U: sea anemone X: clownfish Y: shark B. U and X will form commensalism because U gets benefit by eating X's waste, and X is neither benefit nor disadvantage. X and Y will form predation because X is prey of Y

The student was able to examine, break the information, and identify the organisms that interact. He/she was able to conclude and determine one of the interactions (predation) but failed to determine the other form of interaction based on the concepts described in the problem. He failed to determine the symbiotic mutualism interaction.

Table 7
Problem and the student's answer. Topic: pollution.

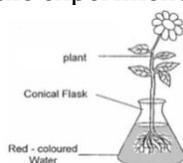| Problem's level: evaluating	Answer – Student D
Some of the freshwater ecosystems (river, dam, lake) in Indonesia, such as Lake Sunter, Jakarta get damage like the picture below. A B In picture A, several people have to clean the water and make the barrier to prevent the spreading of water hyacinth. In picture B, almost all the surface of the water is covered by water hyacinth. What is the effect of that condition on the environment? What should we do to prevent and solve that environmental damage?	Fish in the water will die. Sunlight is blocked, and the water will be covered by water hyacinth. Fish cannot go to the surface of the water to breathe. Do not throw detergent waste into the river because detergent contains a substance that can increase the growth of water hyacinth. When the river surface is blocked, sunlight can't penetrate to the river, so aquatic plants in the river can't grow, so the fish inside will be lacked food, and plants inside the river can't produce oxygen, so fish also can't breathe. As a result, the fish can't survive.

According to this problem, students have to present and defend opinions by making judgments about water pollution (eutrophication). He/she knew about the theory but failed to connect the available information and present it in a correct flow because she only memorized the material without understanding the presented biology concept.

Table 8
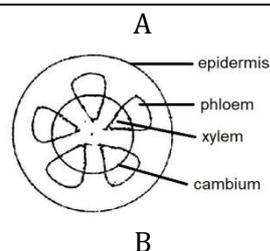Problem and student's answer, topic: plant anatomy and physiology

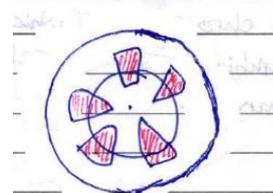| Problem's level: creating	Answer – Student E
See the diagram of the experiment below. plant Conical Flask Red - coloured Water	The flower in picture A will turn red because inside the flower, and there's xylem that carries water to the whole plant. So the xylem carries the red water to the whole flower, turning the flower into the red. Meanwhile, in picture B, the xylem will turn red after

A

epidermis
phloem
xylem
cambium

B

What will happen with the flower in picture A, after one day? Why does it happen?

Picture B is a stem cross-section of plant A. What will happen in the tissue, as shown in picture B, according to the activity on picture A? Explain why.

Draw the diagram of the stem cross-section after the experiment.

carrying water to the whole plant. Diagram of stem after the experiment.

The student was able to compile the information through the diagrams and combine the concepts of transportation in plants unique in the tissue that transport colored-water from the root and its impact on plant parts (flowers and xylem on the stem). He/she mentioned, "the xylem will turn red" at his/her explanation, but he/she cannot represent it into a correct diagram. Students have to shade xylem, but he/she shaded phloem and xylem.

Table 9
Problem and student's answer, topic: human anatomy and physiology

Problem's level: creating	Answer – Student F
Caitlyn was sick with the following symptoms: nausea, abdominal pain, abdominal bloating, vomiting, and burning feeling in the abdomen. Name the sickness. What are the suitable treatments for that sickness?	Caitlyn gets sick with the following symptoms: nausea, abdominal pain, bloating, vomiting, and burning feeling in the abdomen. Based on the symptoms, I think Caitlyn may have retinitis, inflammation in the kidney. The treatment for the sickness is to go to the doctor and get medicine or get surgery.

Students failed to compile information about the symptoms in the human body and relate it to a correct disease (gastritis), including proposing solutions to overcome health problems per the intended disease. Understanding the concept covers dimensions such as factual and procedural knowledge, connecting, transferring knowledge, and metacognitive (Mills, 2016; Musyaddad & Suyanto, 2019). Learn about a concept is the process of learning to organize information into a form of logical thinking and strengthen conceptual understanding by improving the thinking process (Giddens & Brady, 2017). Understanding concepts is influenced by meaningful learning, misconceptions, and the process of remembering (Mills, 2016; Sele, 2019). Understanding a concept involves the ability to define, interpret, and explain everything related to the concept in question (Anderson & Krathwohl, 2001). Critical thinking also influences cognitive learning (Miharja, Hindun, & Fauzi, 2019). The analysis of students' answers using Bloom's taxonomic cognitive level shows that students are still at the stage of memorizing the material. Students have not been able to redefine the concepts. Students have not been able to connect the concepts and arrange them into logical forms of thinking.

CONCLUSION

The data obtained proves that biology competencies in secondary school students, especially students of the bilingual program (sample), are low. The average value of the concept comprehension test was 55.07, which is below the Minimum Criteria of Completeness score 73.

Students have not been able to redefine a concept, interpret a concept, connect various concepts, and apply concepts they were accepted. The topic that is so dense in the curriculum and demand of understanding in English for bilingual program students causes them to memorize more than trying to understand a concept. The ability to understand a low concept makes the students unable to continue their competency to the stages of applying, analyzing, evaluating, and creating. The average value of all topics for male students was 57.29, while the average value for female students was 52.85. There is no significant difference between the learning outcomes of male and female students. Some male students have higher achievements than females because they have joined the extracurricular science club and several science competitions while none of the female students were involved. They have higher engagement than other students. This study is an overview of the level of understanding of biological concepts in secondary school students' bilingual programs. Research can be continued to find appropriate learning methods, so students are motivated to gain a higher understanding, increase their interest in studying biology. Hopefully, the learning outcomes obtained are high. We also need to research how to get students' high engagement in biology to apply biology in their daily lives eventually.

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