Conceptual Biotechnology Measured by Using a Two-Tier Multiple Test

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Abstract: Biotechnology is a concept that combines biology and technology. The concept of Biotechnology in this research is divided into 4 based on the Rainbow Code of Biotechnology (RCB). This research aimed to measure the concept of biotechnology using a Two-Tier Multiple Test (TTMC). This research consists of two methods, namely qualitative and quantitative methods. TTMC was developed using a procedure defined by Borg and Gall. TTMC consists of 20 questions and tested to 137 students to collect data. Based on the research findings, it can be concluded that TTMC assessment instruments developed is feasible and meets the criteria as a good question with the content validity (CV) of 1.00, an average score of the reliability test of 0.92 of a very high category, the level of difficulty of 79.2% with a moderate category and 16.7% with a difficult category, and the discriminating power of 18.7% with a very good category and 39.6% with a good category. The TTMC instrument developed for measuring biotechnology material is sufficient to measure understanding of biotechnology with 41.6% of consistency. The research results show that the two-tier tests are effective in determining the students' conceptual understanding of biotechnology and can also be used as an alternative for evaluating student learning outcomes.

Keywords: *biotechnology, two tier multiple test*

INTRODUCTION

Biotechnology is a concept consisting of the basics of modern and conventional techniques based on science. One of the problems of Pre-Service Elementary Teacher (PSET) students is the existence of misconceptions in understanding and categorizing biotechnology. The concept used in biotechnology is RCB (Atmojo, 2018; Atmojo, 2019; Qalbina&Ahda, 2019). RCB is a Rainbow Code which consists of four categories including green biotechnology, red biotechnology, white biotechnology, and blue biotechnology. Green biotechnology focuses on solving food problems (Figueiredo, 2019. Red biotechnology deals with health. White biotechnology is about industry. This biotechnology uses living cells and/or enzymes to make industrial products such as the development and production of compounds and the generation of new energy (Riordon, 2019; Straathof, 2019). Meanwhile, blue biotechnology is used in the marine sector trying to restore the balance of the marine ecosystem (Subekti, 2018).

Biotechnology, in general, is a technique in using living organisms or a process to create or modify products with the aim of increasing the use of plants and animals or developing microorganisms for special purposes (Natadiwijaya, 2018). Based on the research, biotechnology has the ability to answer the challenges that will be faced in the future regarding various products from various fields of science (Qalbina & Ahda, 2019; Nurlaely, 2017; Adriani & Ahda, 2019).

An understanding of low biotechnology has influenced PEST's ability so that a higher level of understanding is required (Jacob, 2019). Therefore, efforts need to be made in measuring the concept of biotechnology using two-tier tests. TTMC offers alternative solutions in solving misconceptions in categorizing biotechnology. In addition, two-tier tests help solve problems in

the evaluation process (Kuether, 2019; Halim, 2018). It can be seen that the simulation framework reviewed in the literature combines the TTMC process which separates questions and answers with the two-tier questions (reason) (Liepetrz & Borowski, 2019; Andersen, 2018). TTMC used allows to identify weaknesses about understanding specific concepts and to overcome problems in the next stage by making improvements (Kuether, 2019; Series, 2019; Dai, 2018).

METHOD

The research design used is the qualitative-quantitative method. The researcher used a TTMC test and interview. The subjects consist of 137 pre-service elementary school teachers from elementary school teacher education department of Universitas Sebelas Maret in the 2017/2018 academic year. The population of this study were all 640 students of the Faculty of Teacher Training and Education of UNS. As for the sample from this study, it was selected using Cluster Random Sampling. The instruments used in the research are 20 items of TTMC accompanied by reasons for selecting answers. TTMC was developed using the procedures determined by Borg and Gall. Based on Borg & Gall's theory, this research is very helpful in developing problem solving in education and learning.

Table. 1 The Categories of RCB Conceptual Area

No	Conceptual Area	Question Numbers
1	Green Biotechnology (GB)	1, 2, 3, 4, 5
2	Red Biotechnology (RB)	6, 7, 8, 9, 10
3	White Biotechnology (WB))	11, 12, 13, 14, 15
4	Blue Biotechnology (BB)	16, 17, 18, 19, 20

RESULTS AND DISCUSSION

The findings show that TTMC is very effective for measuring PSET's ability to understand biotechnology material. The test instrument used consists of 20 multiple-choice questions accompanied by reasons. PSET analysed the answers and provided their reasons based on the answers chosen. Based on the research findings, it can be concluded that TTMC assessment instruments developed is feasible and meets the criteria as a good question with the content validity (CV) of 1.00, an average score of the reliability test of 0.92 with a very high category, the level of difficulty of 4.1% with a moderate category, 79.2% with a moderate category, and 16.7% with a difficult category, and the discriminating power of 18.7% with a very good category, 39.6% with a good category, 14.6% with a sufficient category, and 27.1% with a bad category. The TTMC instrument developed for measuring biotechnology material is sufficient to measure the high-order thinking skill with 41.6% of consistency. The guideline for assessing TTMC for biotechnology material can be seen in Table 2.

Table. 2 Guideline of TTMC Instrument Scoring

	Criteria	Scores
1	No answer	0
2	More than one answer	0
3	One correct answer in second tier	0
4	One correct answer in first tier	1
5	Two correct answers in the first and second tiers	2

Based on the RCB categories, an average of 62% (85 out of 137 PSETs) can answer TTMC about biotechnology correctly. The percentage of the number of PSETs that answer correctly in each RBC category is shown in Figure 1.

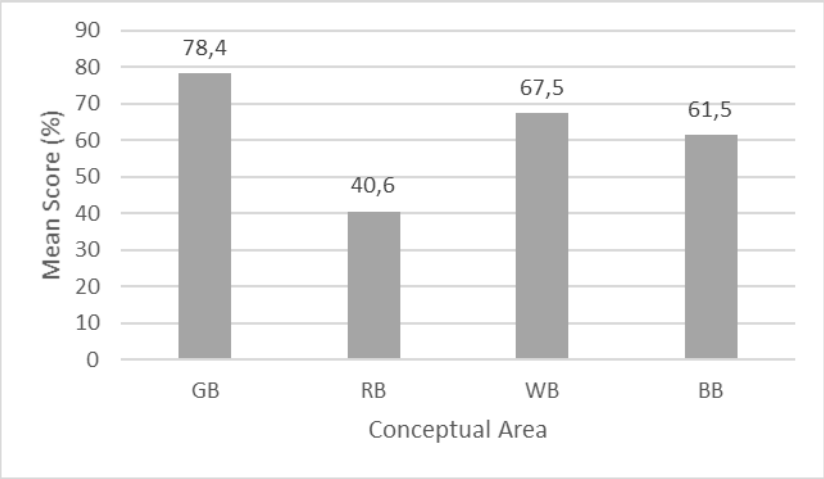

Figure 1. The Percentage of TTMC Scores Answered Correctly on Each RCB Conceptual Area

Based on Figure 1, the concept of biotechnology based on RCB which is the lowest and difficult to analyse and understand is the concept of RB (red biotechnology). Most PESTs answered question 8 incorrectly. The following is one example of the TTMC question (two tiers). Figure 2 shows that there are two-tier questions (first-tier and second-tier questions). First- and second-tier questions are closely related, so it can be said that question 1 is the basic understanding to answer question 2

Question 8:

First-tier question:
Diseases that attack humans can be cured with antibiotics because...
a. Antibiotics help suppress and stop the proliferation of bacteria
b. Antibiotics make the body stronger
c. Antibiotics increase endurance if given regularly
d. Antibiotics increase the body's immunity to viruses and fungi

Second-tier question:
The success of antibiotics in some diseases has decreased in recent years. Why? Because...
a. After produced, antibiotics gradually lose their activity.
b. Bacteria become resistant to antibiotics.
c. This antibiotic only helps fight puerperal fever, but does not fight other diseases.
d. This antibiotic need has been reduced because public health conditions have improved very deeply in the recent years.

Correct answer: Question 1: A, Question 2 (Reason): B

Figure 2. TTMC Question No. 8 Included in RCB of RB concept

Based on Figure 2, the most difficult question to analyse by PSET is about the RCB concept related to health problems. Question 8 is about how antibiotics work in the human body. To analyse PSETs' answers, we can use the Scoring Guideline of TTMC Instrument in Table 2. PSETs often misunderstand the concept of antibiotics that their answers are incorrect. Antibiotics work by creating an environment that can eradicate bacteria so we can be healthy. The correct answer is how antibiotics work by suppressing or breaking metabolic connections

so that bacteria cannot metabolize and eventually die. Then, we become healthy again. The concept of question 8 is the process of how antibiotics work in stages so that the administration of antibiotics is used until the bacteria that cause the disease disappear and patients recover (Murray, 2017; Yilmaz & Ozcengiz, 2017).

CONCLUSIONS

Based on the results of the analysis and discussion, it can be concluded that the implementation of TTMC is very effective in measuring the mastery of the concept of biotechnology based on RBC. TTMC can help educators (teachers/lecturers) to know and analyse biotechnology concepts consisting of four RCB categories. From the findings, 137 PSETs have an average correct answer of 62% (85 from 137 PSETs). The highest percentage is in the GB category of 78.4%. The lowest percentage is in the RB category. They have difficulty understanding the concept of biotechnology in the health sector, especially on antibiotics and vaccines with a percentage of 40.6%. Many PESTs have difficulty distinguishing how antibiotics work for health. Besides, this research offers an alternative solution in developing printed books, learning media, and science concept based learning methods that are suitable for learning biotechnology material.

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