Development of three-tier diagnostic test instruments for detecting students' conception

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Abstract. A research and developmental study about developing three tier test instrument was carried out to detect students' conception on cell concept. Students' pre-conception about cell concept, cell reproduction and gametogenesis are often not in line with scientific concepts. This preliminary study was conducted to analyze the profile of students' pre-conception about cell reproduction in senior high schools. Modified Borg and Gall's R&D research design used in this research. Instrument development resulted in three tier diagnostic test in the form of 30 multiple choice test items with its reason and certainty index. To validate the instrument, it was administered towards a number of senior high school students (XI and XII graders) in Bandung. Then the response of the students were quantitatively and qualitatively analyzed. Research findings show that the instrument as product is effective to determine students' conception, including their misconception. The percentage of misconception found in cell concepts mostly in gametogenesis (17.35%), compared to those who comprehend (27.83%), and not comprehend (54.82%). The results of this preliminary study will then be used for further study in preparing STEM based learning program which will facilitate 12th grade students on conceptual change in cell reproduction, as well as to prevent its misconception.

1. Introduction

The concept is an abstraction of the characteristics that facilitate human communication and enable humans to think [1]. A concept can be obtained through concepts that occur before receiving formal (school) lessons and through assimilation of concepts obtained at school. Concept assimilation is the main way to escape concepts, both during and after school [2].

In learning activities, students will build their own concepts depending on what students find. But sometimes the concepts built by students are not in accordance with the scientific concepts discovered by experts. These events can occur due to the limited knowledge of students in the material. In addition to factors from students, the role of the teacher is also very influential. Teachers who are not aware of the preconceptions that students have will try to generalize preconception. It does result in differences in knowledge obtained by students. Another factor, which is the answer to the error theory, is the method used by the teacher, which cannot be used for students who show false preconceptions [3,4].

According to Gabel, misconceptions can occur from observations of natural phenomena that use feelings and concepts that are not in accordance with students' mental development [5]. Misconceptions that are more complex can interfere with the formation of concepts in students' cognitive structures [5].
Therefore, the teacher should pay attention to the initial conception learned before giving a new concept because each student has their own conception based on their previous experience. In addition, misconceptions need to be detected so that the teacher can determine the learning that must be done.

One form of diagnostic tests is to use three-tier diagnostic test. A three-tier diagnostic test is a diagnostic test that contains three-tiered multiple choice questions. The first level contains questions about the concept being tested, the second level contains the reasons for each answer to question in the first level and the third level contains the level of confidence as a form of diagnostic test. By using this instrument, students are likely to guess the correct answer can be reduced to 4% [6]. In addition, the teacher can also know the conceptions made by students and categories of students' understanding (conceptual understanding, not understanding concepts / guessing and misconceptions).

Based on the results of interviews conducted by researchers for Biology teachers in one high school in Bandung, obtaining information that students still problematic in the concept of cell. In fact, this concept is one of the concepts discussed with a higher education. Cells are basic materials that must be mastered by students before studying biology. Because the basis of biology is cell.

Based on this description, we are interested in knowing more about the conceptions obtained by students in learning Biology. Whether the concept obtained is correct or deviates from the scientific conception. So this study aims to find out where misconceptions occur. To detect it first, the development of a three-tier diagnostic test instrument was carried out. By knowing the location of misconceptions, we hope that teachers can take appropriate steps to overcome these misconceptions.

2. Experimental method

This research is a research and development designed to produce a product, namely a three-tier diagnostic instrument testing cell misconceptions. The steps of research & development include four stages modified from Borg and Gall [7], these steps consist of preliminary studies, product draft design, development of product drafts and product trials.

The research subjects consisted of expert lecturers who were selected based on their experience and abilities in their fields. Class XI and XII students of one high school in the city of Bandung as many as 26 students as subjects of limited trials. Data collection instruments include: limited testing questions in the classroom to determine the effectiveness of the product being developed.

Data analysis techniques used in limited trials are calculating average values [8].

\[ X = \frac{\sum x}{n} \]

Information:
- \( X \) = Average score
- \( \sum x \) = Total score of correct answers
- \( n \) = Number of questions

Based on the values obtained from the calculation concluded the feasibility level of the product developed with reference to the eligibility criteria in Table 1.

| Average score | Description |
|---------------|-------------|
| 3.26 – 4.00   | Good (No revisions needed) |
| 2.51 – 3.25   | Good enough (need to be revised in part) |
| 1.76 – 2.50   | Poor (partial revision with review of content / material) |
| 1.00 – 1.75   | Not Good (Revised Total / replaced) |

Table 1. Criteria for product feasibility analysis.
Analysis of product development effectiveness was obtained from limited trial data conducted in 26 students from one high school in Bandung class XI and XII.

3. Results and discussion
The process of developing a three-tier diagnostic test instrument for cell reproduction misconceptions begins with a preliminary study. The preliminary study includes literature study and field observation. Literature study was carried out on some literature to examine the misconceptions that often occur in cell reproduction material. The results of the literature study were collected and analyzed to compile a three-tier diagnostic test instrument. Field observations were conducted by interviewing biology teachers in one of the high schools in Bandung and several students. He who is chosen is a student taught by the teacher. The results of the interview are as follows: 1) Material cell division is considered as material that is not easily understood by students; 2) most (> 70%) test scores on gametogenesis material are still below the minimum competency standard (SKM); 3) Learning on the material of cell concept is carried out by the teacher with the lecture method assisted by PowerPoint presentation slides; 4) Presentation of biological material in class conducted by the teacher has not been able to attract students to learn about cell division and gametogenesis; 5) Students assume that cell matter, cell division and gametogenesis have many biological terms that are difficult to memorize and understand.

The next step is to compile three-tier diagnostic test items in the form of multiple-tiered choices accompanied by reasons and confidence levels of 30 questions. These questions are prepared based on preliminary studies that have been carried out. Excerpt from the results of the development of the three-tier diagnostic test instrument is found in Table 2.

| Misconception                     | Number of question | Question                                                                 |
|-----------------------------------|--------------------|--------------------------------------------------------------------------|
| Record organelles and not cell organelles | 1                  | Below this which does not include cell organelles, namely                 |
|                                   |                    | a. Nucleus                                                              |
|                                   |                    | b. Plasma membrane                                                      |
|                                   |                    | c. Mitochondria                                                         |
|                                   |                    | d. Endoplasmic reticulum                                                |
|                                   |                    | e. Mesosome                                                             |
| **Reason:**                       |                    |                                                                          |
| a.                                |                    | The endoplasmic reticulum is where the ribosome attaches                 |
| b.                                |                    | Mesosomes are only found in bacterial cells                              |
| c.                                |                    | Plasma membranes are part of cell protectors                           |
| d.                                |                    | Mitochondria can produce energy with the help of oxygen                 |
| e.                                |                    | The nucleus is the core of a cell                                       |
| **Level of confidence:**         |                    |                                                                          |
| a.                                |                    | Sure                                                                    |
| b.                                |                    | Not sure                                                                |

The three-tier diagnostic test instrument that has been compiled is then validated by an expert lecturer using a validation sheet. This validation aims to find out whether the questions have been prepared in accordance with the learning indicators or not so that they can be said to be good. Based on the results of validation, the instruments developed are categorized as good and do not require significant revisions. The revision is done based on the advice of the validator so that the instrument that will be used can distinguish students who master the concept, misconceptions or guesses. Examples of revised instruments developed are listed in Table 3.
Table 3. Suggestions and results of the revision of the three-tier diagnostic test instrument.

| Suggestion                                                                 | Results of the revision                                                                 |
|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Answer questions using essays so that the creative process of students can be developed | This revision cannot be done because it is based on the experience of the researcher when the questions are presented in the form of essays, many student answers that don’t lead to the purpose of the question. |
| Using standard sentences                                                 | Some of the editorial questions are converted into standard sentences.                  |
| Readability of picture must be clear                                     | The image used is replaced so that the readability is clear.                            |

The revised three-tier diagnostic test instrument was then limited to 7 high school students to find out the quality. The results obtained were analyzed by calculating the average value. The results of limited trials can be seen in Figure 1.

![Figure 1. Limited trial results diagram.](image)

Based on the results of the trial, limited three-tier diagnostic test instruments were developed including good categories and did not need revision. This is shown in Figure 1 with values above 3.26. Based on the eligibility criteria that have been explained in the method, these values indicate that the development product is categorized as good and does not require revision.

The final stage of the development of the three-tier diagnostic test instrument is the improvement of the product so that it is better and more appropriate to be used in high school students. This stage includes rewriting so that the layout of the questions and drawings are more proportional, choosing the right editor so that it is easy to understand by students, binding instrument questions so as to further increase the attractiveness of students to read.

The three-tier diagnostic test instrument developed from the results was tested on students in class XI and XII of senior high school as many as 26 students. This test is conducted to determine the effectiveness of products developed in determining students who master the concept, misconception or guessing. The trial activity was conducted in April 2018. The results of the instrument development trial can be seen in Figure 2.
Figure 2. Diagram of instrument development test results.

Based on the percentage of the results of the development of the instrument, 27.83% of students understood the concept, 17.35% of students’ misconceptions and 54.82% of students didn’t understand the concept. The presentation of students experiencing misconceptions is quite high. Some misconceptions occur in the concept of cell organelles and gametogenesis. Students feel confused in differentiating between cell organelles and not cell organelles. Whereas in the concept of gametogenesis, students feel confident that gametogenesis is carried out by meiosis only when in fact gametogenesis is carried out in two stages: mitosis and meiosis.

The results of this study are in line with the research of Taslidere [9] and Milenković [10] who explained that three-tier diagnostic tests can detect misconceptions that occur in students. This can also be used to detect students’ conceptual understanding. The results of other studies also explain that three-tier diagnostic tests can detect alternative conceptions that can be developed by students [11]. Alternative conceptions arise when there are deviations from the concept of scientific concepts. It comes from students' personal experiences and social interactions.

The three-tier diagnostic test instrument that has been developed in this study not only can detect misconceptions on the cell concept but can measure and detect the conception possessed by students. So it can be used to facilitate 12th grade students on conceptual change in cell reproduction.

4. Conclusion
The final product of this research is the Three-tier diagnostic test instruments which will later be used in Science, Technology, Engineering and Mathematics (STEM) based learning in the high school environment. Three-tier diagnostic test instruments are made and developed in advance to see the initial conception of students. From the results of the instrument testing made, 27.83% of students understood the concept, 17.35% of students' misconceptions and 54.82% of students didn’t understand the concept. The presentation of students experiencing misconceptions is quite high. Some misconceptions occur in the concept of cell organelles and gametogenesis.

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