Development of an online-based instrument prior knowledge on the concept of cellular respiration

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Abstract. This research aims to produce valid and reliable prior knowledge questions on the concept of cellular respiration online by utilizing Google form media. The questions developed in this study are multiple choice questions with a four-tier test type. The sample in this study were students who took general biology courses at Faculty of Teacher Training and Education (FKIP) of Universitas Sriwijaya. Samples play a role in the evaluation process after prototype I was produced, at one-to-one (n = 13) and small group (n = 23) stages. The instrument used in the data collection process was a walkthrough, question readability questionnaire and questions. The questions given to the sample consisted of multiple choice questions on the grounds of open-ended questions (the development stage) and four-tiered multiple-choice test questions (the small-group evaluation stage). The use of the Goggle form in this study was carried out at the stage of giving open-ended question questions and the evaluation process at the one-to-one and small group stages. The results of this study indicate that the prior knowledge questions that have been developed are categorized as valid with an expert review rating of 80.5% and the reliability of the categorized questions is weak with a value of 0.37. The results of the expert review assessment revealed that the items developed were in accordance with the understanding of the concepts to be measured. Findings from the results of this study can be used as a reference for developing prior knowledge questions with the type of four-tier test to detect students' understanding before learning is done. Thus the teacher is expected to choose the right learning strategy before the learning process.

1. Introduction

Biology are one part of the Science in Middle School. Supposedly, Biology is taught in an integrated manner by teachers in junior high school with physics and chemistry lessons, but in its application, biology are still taught separately. One of the obstacles faced by teachers who teach science lessons is the qualifications of these teachers who are graduates in the majors of Biology, Chemistry or Physics Education. This was revealed at the Focus Discussion Group forum held by the Department of Biology in Lubuklinggau in 2018. The solution taken to overcome this problem is the application of the General Biology course for chemistry and physics education majors at FKIP Universitas Sriwijaya.

General biology lectures turned out to have obstacles in its implementation. These constraints are in the form of the extent of the content being taught with insufficient time allocation. The same thing was discovered by Cimer [1] through his research. Cimer explained that in such a situation, teachers tend to teach quickly, ask questions about many things, and choose learning strategies that are not
appropriate. In fact, to streamline time allocation, teachers must choose the right learning strategy so that the time allocation provided is sufficient for the delivery of content.

Determination of an appropriate learning strategy can be done in various ways, namely analysing lecture content and analysing prior knowledge for students before learning takes place. Prior knowledge is known to have advantages to be able to quickly detect weaknesses and strengths possessed by students [2]. The results of this prior knowledge analysis can categorize students' understanding of the concept into three groups, namely understanding, lack of knowledge, and misconception. This categorization can then be used as a reference in designing effective and more meaningful learning [3].

The ability of prior knowledge students can be done in many ways, one of which is by using questions. The types of questions used are also various and have their own weaknesses and strengths [3]. The form of questions that can be used to determine student prior knowledge is a four-tier test type. Four-tier test questions have fewer weaknesses compared to other types of questions. In addition, this type of four-tier test questions can better detect misconceptions in students without the possibility of error [4]. However, the four-tier test also has a weakness, namely the allocation of time used in data collection. Weaknesses of the four-tier test can be overcome by using online media in the application of the test.

Utilization of online media in the provision of tests has been recognized to have advantages in the aspects of efficiency of time, energy, and costs that might be incurred when compared with conventional tests (paper pencil test) [5]. Provision of tests through online media can also help teachers evaluate the results of student achievement and make it possible to provide various types of questions [6]. One of the media that can be used to provide prior knowledge tests online is to use Google form. Google form is very suitable to be used in giving test questions because this media is very easily applied by teachers and students [7]. Google form can also facilitate teachers to provide stimulus questions to students in the form of images so as to enable teachers to provide various types of questions to students.

2. Method
This research is a development research that aims to produce products in the form of online-based prior knowledge instruments on the concept of cellular respiration. The stages carried out in making this instrument consisted of the stages of developing the instrument that produced prototype I and continued with the instrument evaluation process to produce prototype II. The instrument development process is based on the modified Treagust framework. The instrument developed was a matter of multiple choice prior knowledge with a four-tier test type.

The instrument development process consists of four stages, including:

a. The planning stage consists of a concept analysis process based on the handbook used in learning and conducting a literature review relating to the results of research on prior knowledge on the concept of cellular respiration.

b. Stages of problem development, consisting of the process of making multiple choice questions based on open-ended questions from the concept analysis process that has been done before, giving open-ended questions, analysing the results of multiple choice questions based on open-ended questions and developing prior knowledge questions. MCQs on open-ended questions are provided online with the help of Google forms to facilitate researchers in the process of data collection and analysis of results. The development of prior knowledge questions is done by considering the results of analysis of sample answers from multiple choice questions based on open-ended questions. The four-tier test questions developed are first-tier and third-tier, whereas second-tier and fourth-tier questions are not specifically developed because they only ask the level of confidence of the research subjects when answering questions at the previous level. Both first-tier and third-tier are multiple-choice questions with two alternative answers in the first-tier and four alternative answers in the third-tier. The level of confidence is categorized as "sure" and "not sure".

c. Evaluation stages, consisting of self-assessment, expert-review, one-to-one, and small groups. The one-to-one and small group stages are carried out online with the help of Google forms.
Each evaluation stage allows revisions to be made to improve the questions developed based on the advice of the research evaluators.

The research subjects in this study were students taking general biology courses in the academic year 2019/2020. The research subjects played a role in the evaluation process at the one-to-one (n = 10) and small group (n = 23) stages. Research subjects came from Biology and Chemistry Education majors.

This study uses three data collection techniques, including documentation, walkthroughs and tests. 

a. Documentation is carried out at the planning stage. The documents collected are in the form of research literature and Handbook used in learning. All data collected will then be analysed descriptively.

b. The walkthrough is used to accommodate the suggestions given by the evaluator at the evaluation stage of the self-assessment, and expert review. All suggestions obtained from each of these stages serve as guidelines for revision. The walkthrough data are analysed quantitatively for expert review and descriptive for other stages. Expert review validation is done by considering three aspects, content, construction, and language. Each aspect validated has an assessment instrument with a rating scale of 1-5. The results of the assessment of each aspect are then calculated for the percentage of validation using the following formula (Table 1):

\[
\text{Validation Percentage} = \frac{\text{Score of each aspect}}{\text{Maximum score of each aspect}} \times 100\%
\]

| Criteria |
|---------|
| 76 ≤ NA < 100 |
| 56 ≤ NA < 76 |
| 40 ≤ NA < 56 |
| 0 ≤ NA < 40 |

Table 1. Achievements of expert review validation

| Percentage (%) | Criteria |
|----------------|----------|
| 76 ≤ NA < 100  | Valid    |
| 56 ≤ NA < 76   | Sufficient|
| 40 ≤ NA < 56   | Low      |
| 0 ≤ NA < 40    | Not valid|

c. Question readability questionnaire. Question readability questionnaire was used in the one-to-one stage evaluation process. This questionnaire aims to determine whether the sample can understand the sentence developed or not. Question readability questionnaires were analysed by calculating the percentage of the sample who could understand the problem sentences on each item developed.

d. Test. Giving test questions is done at the small group evaluation stage online with the help of Google form. Before it is given to the sample, questions are entered in Google form. The results of tests that have been carried out are then performed reliability analysis questions. The results of the reliability of the questions are further categorized based on Table 2, while the level of difficulty of the questions and distractors are known directly from Anates.

| Category   | Correlation value |
|------------|-------------------|
| Very high  | 0.800 – 1.000     |
| High       | 0.600 – 0.799     |
| Sufficient | 0.400 – 0.599     |
| Low        | 2.00 – 0.399      |
| Very low   | 0.00 – 0.199      |

Table 2. Reliability test category

3. Result and Discussion

3.1. Concept Identification
Identification of important concepts to be done before the process of developing prior knowledge questions is done. Concept identification is done by referring to the Handbook which will later be used
in the learning process [8]. The results of the identification of concepts that have been done show that there are five important concepts in cellular respiration material (Table 3). Each concept has sub-concepts which amount varies according to the depth of the material being studied by students.

Table 3. Important concepts relating to cellular respiration material.

| No. | Concept                                                                                                                                   | Sub-concept |
|-----|------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| 1.  | Metabolic reactions that produce energy from the breakdown of complex molecules into simpler molecules are called catabolism reactions         | 8           |
| 2.  | Glycolysis harvests chemical energy by oxidizing glucose to pyruvate                                                                      | 5           |
| 3.  | After pyruvate is oxidized, the citric acid cycle completes the harvesting of energy by oxidizing organic molecules.                         | 4           |
| 5.  | During the oxidative phosphorylation process, chemiosmosis attaches transport electrons to ATP synthase Fermentation and anaerobes enable cells to produce ATP without using oxygen | 4           |

Based on the results of the concept identification in Table 3, it is known that the most important concept that has sub-concepts is the concept of metabolic reactions which are metabolic reactions in general. Explanation of the concept of metabolic reactions becomes quite a lot because a general explanation of metabolic reactions including an explanation of aerobic respiration, anaerobes and a brief explanation of the stages of respiratory reaction are explained in this concept. Furthermore, in other concepts describe the steps of the reaction step in depth.

3.2. Relevant Research Study
At this stage a literature review is conducted in accordance with an assessment relevant to cellular respiration material. The study reviewed amounted to three studies [9, 10, 11]. The results of the literature review conducted show that some concepts are known to be still not well understood by students. These concepts include cellular respiration processes in the fermentation stage, the citric acid cycle, and electron transfer; the role of glucose, oxygen, water, ATP as a result of cellular respiration; and basic concepts regarding cellular respiration. The equation from the findings of these three studies shows that students do not understand well about anaerobic respiration and fermentation in living things.

3.3. Making Multiple Choice Questions has An Open-ended Question
The results of the concept analysis and the study of the results of previous studies are used as the basis for compiling multiple choice questions with an open ended question. Making multiple-choice questions based on open-ended questions is intended to capture data about possible variations in the reasons students choose answers to the questions given. Data collection in this evaluation process uses Google form (Figure 1) and student responses are directly captured on Google form.
Figure 1. display of the development of multiple choice questions based on open-ended questions and recapitulation of results

The results of this stage are used by researchers to help make alternative choices at the third level of the four developed levels.

3.4. Making Prototype Questions I
Questions developed to solicit student prior knowledge data on cellular respiration concepts are multiple choice questions with a four-tier type of test. Questions and alternative choice answers in the first-tier and third-tier are developed specifically from the results of the analysis of each step of development that has been done before. Whereas second-tier and fourth-tier are not specifically developed because they only ask the level of student confidence when answering questions in the first-tier and third-tier before. The number of questions developed at this stage is 20 questions with three main topics. The distribution of question numbers based on focus topics is presented in Table 4.

Table 4. Problem grid that has been developed.

| No. | Topic                                | Question Number |
|-----|--------------------------------------|-----------------|
| 1.  | Aerobic and anaerobic respiration     | 1, 2, 3, 11, 12, 13, 15, 17 |
| 2.  | Stages of cellular reaction          | 4, 5, 6, 7, 10, 14, 16, 18, 19, 20 |
| 3.  | Carbohydrate, protein, fat metabolism| 8, 9            |

3.5. Self-assessment
At this stage, the evaluation process is carried out by the researcher himself by reviewing the questions and answer choices that have been developed at all levels of the questions. Studies conducted by researchers include the appropriateness of the questions with the concepts to be explored, the use of language, and the appropriateness of the choice of answers both the choice of answers provided for the first and third levels. Some things that need to be improved from the questions that have been developed include the change in questions because it does not fit the concept of the question to which understanding is measured, changes in alternative sentence choice of answers used because the sentence is confusing or ambiguous, and changes in word / sentence structure due to writing errors.
3.6. Expert review

Evaluation by experts is done after prototype I has been revised from the self-evaluation stage. Validation is one of the categories that must be fulfilled by a test to be carried out, the validation process should be carried out on various aspects and involving many stakeholders [12]. The test validation process is a responsibility that must be carried out by the teacher before the test is carried out. Many types of validation that can be done by the teacher, including content validation, constructs and language.

Expert validation is carried out in three ways, namely content validation, construct validation, and language validation. Evaluation of each validation is done by experts by giving a minimum score of 1 and a maximum score of 4. A score of 4 is given if the validator assesses that the developed instrument is very good, a score of 3 is given if the instrument is good, a score of 2 if the instrument is not good, and a score of 1 if the instrument is not very good. The points are assessed by the validator for each validation which is based on the item development assessment instrument issued by the Ministry of Education. The results of expert assessments are presented in Table 5.

| No. | Validation          | Result | Category |
|-----|---------------------|--------|----------|
| 1.  | Content validation  | 85.5%  | Valid    |
| 2.  | Construct validation| 70%    | Valid    |
| 3.  | Language validation | 86%    | Valid    |
|     | Mean                | 86.1%  | Valid    |

3.7. One to one

The one-to-one phase is carried out aiming to find out whether the sample can understand the problem sentences and the alternative choice of answers developed or not. The number of samples in this study amounted to 13 students. The one-to-one evaluation process is done online with Google form media (Figure 2.). The process of collecting data is done by spreading Google form links to the samples for later answering. Data from the results of the one-to-one stage is directly obtained from Google form making it easier for researchers to conduct data analysis (Table 6).

![Figure 2](image_url)
Table 6. Result of the one-to-one stage evaluation

| Question Number | First tier | Third tier |
|-----------------|------------|------------|
| 1               | 53.8%      | 84.6%      |
| 2               | 76.9%      | 76.9%      |
| 3               | 84.6%      | 92.3%      |
| 4               | 100%       | 92.3%      |
| 5               | 92.3%      | 92.3%      |
| 6               | 69.2%      | 92.3%      |
| 7               | 92.3%      | 100%       |
| 8               | 76.9%      | 92.3%      |
| 9               | 61.5%      | 84.6%      |
| 10              | 69.2%      | 84.6%      |
| 11              | 84.6%      | 84.6%      |
| 12              | 84.6%      | 92.3%      |
| 13              | 69.2%      | 61.5%      |
| 14              | 76.9%      | 92.3%      |
| 15              | 100%       | 76.9%      |
| 16              | 100%       | 92.3%      |
| 17              | 84.6%      | 84.6%      |
| 18              | 76.9%      | 76.9%      |
| 19              | 92.3%      | 92.3%      |
| 20              | 92.3%      | 84.6%      |

3.8. Small group
The small group evaluation process is carried out by providing complete prior knowledge questions to the research sample. This small group data collection is also done online. Before the link is given to the sample, all questions are entered into the system. The researcher directly provides a link to the research sample and the questions are answered by the sample through its android device.

Figure 3. Display of prior knowledge questions that have been developed for small group evaluation.
The results of the small group stage evaluation are then entered into the Anates 4.0 program to calculate the reliability of the questions. The calculation of the reliability of the questions is done by entering one by one the students’ answers for each question that is tested. In the calculation of the reliability of the questions carried out focused on the first-tier only. The results of calculating the reliability of the questions with the help of Anates 4.0 is known that the reliability of the questions is 0.37. The amount of value is categorized in the low reliability group.

4. Conclusion
This research shows that the development of online-based prior knowledge questions on the concept of cellular respiration has been successfully carried out. The questions developed had fulfilled good test criteria with a validation value of 80.5%, even though the test reliability was still relatively low (0.37). The development of online-based prior knowledge questions is easier than conventional techniques. The process of evaluating questions becomes easier, faster, reduces costs, and time efficiency both the time of data collection and analysis of evaluation data. This is due to the Goggle form system which has facilitated researchers to obtain immediate data summaries without having to look at each incoming response.

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