Development of Cell Cognitive Diagnostic Assessment Instrument: Small Group Review

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ABSTRACT

This study aims to obtain an overview of the cell cognitive diagnostic assessment (CCDA) instrument that has been developed from a small group testing point of view. There are 20 multiple choice questions that have been developed with five alternative answer choices. These questions consist of four topics, namely the structure and function of cells, cell membranes and molecular transport, cell reproduction, and cell communication. This research was conducted through a survey research method with a total sample of 45 students from the Biology Education Study Program. The instruments provided in this study were questions that had been developed previously to determine the effectiveness of the answer choices used and questionnaires to determine the level of readability of the questions and answer choices. Data collection was carried out online with the help of Google Form media. The results showed that several answer choices for each question had to be revised because they did not function effectively, apart from that, of the 20 questions tested there was 1 question whose answer choices could not be understood by the sample so it had to be revised while the sentence questions could be understood well by the sample.

Keywords: *Cognitive diagnostic assessment, Readability, Distractor, Prior knowledge*

1. INTRODUCTION

The curriculum that applies at the Faculty of Teacher Training and Education states that all students in the department of Chemistry Education, Physics Education and Biology Education must take general biology courses in the first semester of their studies. This is intended to provide competency to science teacher candidates on science materials if one day FKIP graduates of these majors must become teachers at the junior high school level. The challenge faced in the General Biology course is how lecturers can package all the topics discussed in this General Biology course that can be presented in effective and efficient learning. In fact, the available time allocation is very limited.

The obstacles faced by this have been stated by Cimer [1] in the results of his research which stated that one of the factors that makes biology difficult to study is due to the unbalanced time availability with the amount of material that must be studied. Many things can be done to make learning time more effective and efficient, one of which is by providing diagnostic tests before the

learning process takes place [2-6]. One of the diagnostic tests that can be given is the cognitive diagnostic assessment which can increase the effectiveness of the learning process in the classroom [7, 8]. This CDA can provide an overview of detailed information related to the strengths and weaknesses of students and provide effective feedback to improve the learning process.

The results of observations that have been made on students who have taken General Biology courses previously found that the concept that is difficult to understand is the concept of the cell. This is because this concept is very abstract and has a lot of detail and many important terms that are difficult to understand. The concept of the cell is one of the most important terms and has a very abstract concept.

Increasing the effectiveness of learning on the concept of cells can be done by carrying out tests to find out students' prior knowledge, one method that can be done is by using the Cell Cognitive Diagnostic Assessment (CDA) instrument. The data from the CCDA instrument testing is expected to help streamline

the allocation of learning time and in accordance with the desired learning objectives.

2. METHOD

2.1. Method and research subject

This research is a survey research to determine the effectiveness of the distractor function and the effectiveness of the readability of the questions and answer choices that have been developed [9]. This CCDA instrument has previously been validated by experts for the validity of content and constructs (86.42% -valid) and has been revised according to the input provided by the validator. The development of this question is based on the analysis of literature studies by referring to the handbook and the results of research on student misconceptions related to the concept of cells and by considering the learning objectives of the expected course material. The subjects of this study were students majoring in Biology Education (n = 45). The data was collected online by providing a Google Form media link to the sample to be filled in by the sample.

2.2. Data collection and analysis

This study used two instruments in the data collection process, namely giving tests in the form of CCDA questions and questionnaires.

a. Test. The questions given are questions that have been validated by previous experts and have been revised. There are 20 questions with five alternative answer choices. Giving questions was done online by sharing the Google Form link with the research sample. Giving this question aims to determine the effectiveness of the answer choices used. If the choice of answer is not deceptive, then the choice of answer should be revised. The topics tested on the CCDA instrument consist of cell structure and function, cell membrane and molecular transport, cell reproduction and cell communication. The distribution of the questions based on the topics tested is presented in Table 1.

Table 1. Distribution of CDA questions developed by topic

No.	Topic	Styles
1.	Cells structure and function	1, 2, 3, 4, 5, 7, 16, 19, 20
2.	Membrane cells and molecule transport	8, 10, 11, 12
3.	Cell reproduction	6, 9 13, 14, 15
4	Cell communication	17, 18

Each of the answer choices in the CCDA questions that were tested was calculated the effectiveness of deceiving them by calculating the percentage of each of the answer choices. The choice of answer is considered

to be deceptive if at least 5% of the total number of research samples is chosen. However, if it does not reach 5% then the choice of answers must be revised.

Furthermore, the results of the distractor function calculation are analyzed based on the level of effectiveness of the distractor used by referring to table 2 [10, 11].

Table 2. Distractor effectiveness

NFD	DE
0	100%
1	75%
2	50%
3	25%
4	0%

a. Questionnaire. Giving the questionnaire aims to determine the legibility of the questions and answer choices that have been developed. This questionnaire is integrated with the test questions to minimize the forgetfulness of the research sample in the given question sentences and answer choice sentences. The calculation of the readability of the questions and the choice of answers is done by calculating the percentage of the number of samples that can understand the question sentences and the choice of answers or not. If 50% of the sample cannot understand the sentence and answer choices, then the questions and answer choices must be revised.

b. Questionnaire. Giving the questionnaire aims to determine the legibility of the questions and answer choices that have been developed. This questionnaire is integrated with the test questions to minimize the forgetfulness of the research sample in the given question sentences and answer choice sentences. The calculation of the readability of the questions and the choice of answers is done by calculating the percentage of the number of samples that can understand the question sentences and the choice of answers or not. If 50% of the sample cannot understand the sentence and answer choices, then the questions and answer choices must be revised.

3. RESULT AND DISCUSSION

This study aims to obtain an overview of the CCDA instruments that have been developed. Data collection was carried out online by providing a Google Form link to the sample. The CCDA instrument provided is a multiple-choice question with five alternative answer choices. In this study, the number of correct answers is 20 with the distracting answers totaling 80 answer choices.

The CCDA instrument developed consists of four main topics, namely cell structure and function, cell

membrane and molecular transport, cell reproduction, and cell communication. The data collected at this stage include the effectiveness of each answer choice for each question and the readability of the questions and the answer choices that have been developed. The research data are presented in Table 3.

Table 3. Distractor and readability Cell Cognitive Diagnostic Assessment (item test)

Que. No.	Distractor					Readability	
	A	B	C	D	E	Understand	Cant Understand
1	84,4	8,9	6,7	-*	-*	84,4	16,6
2.	13,3	64,4	4,4*	-*	17,8	86,7	13,3
3.	40	13,3	4,4*	17,8	24,4	62,2	37,8
4.	71,1	6,7	6,7	13,3	2,2*	66,7	33,3
5.	35,6	4,4*	17,8	26,7	15,6	64,4	35,6
6.	17,8	24,4	22,2	6,7	28,9	62,2	37,8
7.	20	13,3	4,4*	13,3	48,9	75,6	24,4
8	37,8	24,4	6,7	2,2*	28,9	66,7	33,3
9	20	22,2	13,3	24,4	20	68,9	31,1
10	77,8	2,2*	8,9	2,2*	8,9	75,6	24,4
11	57,8	13,3	2,2*	24,4	2,2*	60	40
12	37,8	13,3	20	8,9	20	66,7	33,3
13	37,8	6,7	6,7	8,9	40	68,9	31,1
14	24,4	17,8	13,3	4,4*	40	60	40
15	17,8	13,3	8,9	35,6	24,4	66,7	33,3
16	31,1	24,4	20	13,3	11,1	62,2	37,8
17	22,2	31,1	17,8	24,4	4,4*	46,7*	53,3
18	13,3	20	28,9	17,8	20	62,2	37,8
19	8,9	57,8	8,9	22,2	2,2*	80	20
20	13,3	40	2,2*	17,8	26,7	60	40

*=need revision

Analysis of the developed items needs to be analyzed to determine the quality of the questions that will be tested on students. One of the item analyses that needs to be done is the distractor function which aims to see the efficiency level of the developed answer choices [12].

The development of alternative answer choices used in this study comes from various literature on the results of previous studies that examine misconceptions related to the concepts being tested [9]. Distractor function analysis is important to do to improve the quality of the multiple-choice test used to test students' cognitive abilities [10]. The results showed that some number of questions were still not selected by the sample and the choice of answers selected was less than 5% of the total number of research samples. This indicates that the choice of answer cannot function properly to outwit the sample so that a revision must be made to the answer choice. Modifying or replacing answer choices that cannot function effectively aims to increase the effectiveness of the answer choices used [10, 11].

Replacement of the overall answer choices is made if the DE value is 0, while DE with varying values must be modified so that the answer choices used are more effective [13]. The DE value from the results of data analysis obtained will affect the difficulty index of the questions and the index of distinguishing power of the developed questions. The more functional the distractor is used, the more difficult the questions developed will be for the research sample to predict. In addition, the function of the distractor will also show the distinguishing power of these questions to differentiate between upper and lower group students. This means that only smart students can answer the questions being tested because they have understood the concepts being tested well. Of course, questions with a distractor with a high DE value can be used in the next test [14].

Table 4. Percentage of NFD and DE

NFD.	Precentage (%)	DE
0	30%	100%
1	5%	75%
2	35%	50%
3	20%	25%
4	10%	0%

The readability of the sample to the questions being tested shows a good understanding. The readability of the questions is one of the determinants of whether the questions being developed can be continued or revised before use. This is so that the results of the tests carried out are completely free of errors in the interpretation and ambiguity of the questions being tested [15]. The legibility of the questions developed will also affect the performance of the research sample. Questions that are easy to understand will make it easier to measure the abilities possessed by students [16]. The results of the research that have been done show that in general the sample has been able to understand the questions well. Even if the level of readability of the

questions being tested was low, the incomprehension was more due to students not understanding the answer choices used.

A very low readability level is shown in question number 17. This problem emphasizes the topic of cell communication. In this question, students find it difficult to understand the answer choices used. This is because the answer choices contain many terms that are difficult for students to understand, such as endocrine terms, receptors, and Na molecules. The difficulty of students in understanding the sentence questions and the choice of answers used can be caused by the length or shortness of the sentence. However, even short sentences may also be difficult to understand if the terms used are terms that are rarely used by students [17]. This is also supported by Wary & Janan [18] who stated that several factors resulted in the low percentage of readability of the developed questions, including the use of terminology that was rarely used by students.

The difficulty of the students who were the research sample in understanding question number 17 being tested could also be caused by the timing of the questions. This CCDA problem requires that it be given to the research sample before the concept is given, thus, the research sample must try to recall cell concepts (including the terms used in the concept) that they have studied previously over a long period of time. The ability of students to understand the sentences or words contained in the questions being developed also affects the initial understanding of a concept that the student has [19]. Students who have a good initial understanding of a concept will certainly find it easier to understand the sentences being tested, but students who have a bad initial understanding of the concept will show difficulties in understanding the answer choices.

The results showed that question number 17 was not the one that showed the lowest achievement in this small group test. In addition, this problem shows the effectiveness of a distractor with an NFD value of 1/75% DE. This means that even though students do not understand the answer choices, the distractor can function properly.

A very good level of readability is seen in questions 1 and 2. This is directly proportional to the achievement of these two questions which also show the best performance when compared to other questions. This illustration shows that the higher the question readability percentage, the better the results will be [20].

This high level of readability also resulted in the research sample being able to answer questions very well so that two of the five answer choices provided were not chosen at all or the percentage of choice of distracting answers was very low (<5%). This means that students easily know the correct answer, both students in the top group and students in the lower group. This incident will also threaten the distinguishing power of the questions so that it is difficult to distinguish between students in the upper group and those in the lower group.

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4. CONCLUSION

The results show that there is still a need to revise the CCDA instrument being developed. The most revisions that have to be made are the alternative revision of answer choices. Some of the answer choices for a certain number of questions were not chosen by the sample at all or the answer choices were very few chosen by the sample. This shows that the choice of answers has not been effective in outwitting the sample when answering the questions given.

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REFERENCES

[1] Çimer, A., What Makes Biology Learning Difficult and Effective: Students' Views. *Educational Research and Reviews*, *7*(3), 2012 61–71. https://doi.org/10.5897/ERR11.205

[2] Ozcan, T., Ozgur, S., Kat, A., & Elgun, S. Identifiying and Comparing the Degree of Difficulties Biology Subjects by Adjusting it is Reasons in Elemantary and Secondary Education. *Procedia - Social and Behavioral Sciences*, *116,* 2014, pp. 113–122. https://doi.org/10.1016/j.sbspro.2014.01.177

[3] Binder, T., Sandmann, A., Sures, B., Friege, G., Theyssen, H., & Schmiemann, P., Assessing prior knowledge types as predictors of academic achievement in the introductory phase of biology and physics study programmes using logistic regression. *International Journal of STEM*

Education, *6*(1), 2019. https://doi.org/10.1186/s40594-019-0189-9

[4] Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, Supplement*, *14*(1), 2013, pp. 4–58. https://doi.org/10.1177/1529100612453266

[5] Lee, J. Y., Donkers, J., Jarodzka, H., & van Merriënboer, J. J. G., How prior knowledge affects problem-solving performance in a medical simulation game: Using game-logs and eye-tracking. *Computers in Human Behavior*, *99*(April), 1999, pp. 268–277. https://doi.org/10.1016/j.chb.2019.05.035

[6] Rodrigo, M. M. T., Ong, A., Bringula, R., Basa, R. S., Dela Cruz, C., & Matsuda, N., Impact of prior knowledge and teaching strategies on learning by teaching. *CEUR Workshop Proceedings*, *1009*, 2013, pp. 71–80.

[7] Sun, Y., & Suzuki, M. Diagnostic Assessment for Improving Teaching Practice. *International Journal of Information and Education Technology*, *3*(6), 2013. pp. 607–610. https://doi.org/10.7763/ijiet.2013.v3.345

[8] Etobro, A. B., & Fabinu, O. E. Students' perceptions of difficult concepts in biology in senior secondary schools in Lagos state. *Global Journal of Educational Research*, *16*(2), 2017, pp. 139. https://doi.org/10.4314/gjedr.v16i2.8

[9] Cresswell, J. W., & Cresswell, J. D. Research design: Qualitative, quantitative and mixed methods approaches (5th Edition). Thousand Oaks, CA: Sage, 2018.

[10] Musa, A., Shaheen, S., & Ahmed, A. Distractor analysis of multiple choice questions : A descriptive study of physiology examinations at the Faculty of Medicine , University of Khartoum. *Khartoum Medical Journal*, *11*(1), 2018, pp. 1444–1453.

[11] Abdul, R., Ayesha, A., & Syed Hammad, H. Item Analysis of Multiple Choice Questions. *Pakistan Oral & Dental Journal*, *38*(2), 2018, pp. 291–293.

[12] Burud, I., Nagandla, K., & Agarwal, P. Impact of distractors in item analysis of multiple choice questions. *International Journal of Research in Medical Sciences*, *7*(4), 2019, pp. 1136. https://doi.org/10.18203/2320-6012.ijrms20191313

[13] Vyas, R., & Supe, A.. Multiple choice questions: A literature review on the optimal number of options. *National Medical Journal of India*, *21*(3), 2018, pp. 130–133.

[14] Hingorjo, M. R., & Jaleel, F. Analysis of one-best MCQs: The difficulty index, discrimination index and distractor efficiency. *Journal of the Pakistan Medical Association*, *62*(2), 2012, pp. 142–147.

[15] Shahzad Ahmad, Naveed Sultana, & Sadia Jamil. Considerations for Constructing and Validating Biology Achievement Test at Secondary Level. *US-China Education Review B*, *10*(1), 2020, pp. 13–25. https://doi.org/10.17265/2161-6248/2020.01.002

[16] Maizeli, A., Nerita, S., & Afza, A. An analysis of cognitive assessment readability toward biology learning outcome and process evaluation course. *Journal of Physics: Conference Series*, *1521* (4), 2020, https://doi.org/10.1088/1742-6596/1521/4/042014

[17] Wissing, G.-J., Blignaut, A. S., & Van den Berg, K. Using Readability, Comprehensibility and Lexical Coverage To Evaluate the Suitability of an Introductory Accountancy Textbook To Its Readership. *Stellenbosch Papers in Linguistics*, *46*(0), 2016, pp. 155–179. https://doi.org/10.5774/46-0-205

[18] Wray, D., & Dahlia, J. Exploring the Readability of Assessment Tasks: The Influence of Text and Reader Factors. *REMIE: Multidisciplinary Journal of Educational Research*, *3*(1), 2013, pp. 69–95. https://doi.org/10.4471/remie.2013.04

[19] DuBay, W. The Principles of Readability. *Online Submission*, January 2004.

[20] Hewitt, M. A., & Homan, S. P. Readability level of standardized test items and student performance: The forgotten validity variable. *Reading Research and Instruction*, *43*(2), 2003, pp. 1–16. https://doi.org/10.1080/19388070409558403