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THE USE OF BLOOM'S TAXONOMY TO ASSESS STUDENTS' PERFORMANCE EFFECTIVELY IN WRITTEN EXAMINATIONS

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Abstract

Bloom's Taxonomy is widely used, to bring out thinking ability in students, as an assessment method. In this article we emphasize four types of methods generally used in evaluating the intended learning outcomes in written examinations. How questions should be structured in each level of cognitive domain is discussed with an example in multiple choice questions (MCQ), short answer question (SAQ), structured type questions (STQ) and essay type questions (ETQ). Common biological applications were used as example questions. The questions were developed to show how students' thinking ability was brought out when questions were structured in line with the levels of cognitive domain in Bloom's Taxonomy. In conclusion, this paper defines how the application of Bloom's Taxonomy helps in developing complete answers which come out not from the students' memory but from applying, analyzing, synthesizing and evaluating.

Keywords

Bloom's Taxonomy; Multiple Choice, Short Answer, Structured, Essay

Introduction

One of the main objectives in teaching is to promote thinking ability in learners. When a theory is taught targeting to further thinking leading to the development of new knowledge, the educational process is highly effective. In order to encourage this, Benjamin Bloom and his co-workers (1956) introduced Bloom's Taxonomy. Using Bloom's Taxonomy the concepts, processes, procedures and principles are analyzed and evaluated at the stage of contents design of the educational programmes (Nobel, 2004). Bloom's Taxonomy uses multi-tiered scales in three aspects to describe the level of knowledge required to achieve each measurable student outcome. It will allow assessment techniques to be undertaken for the designated course learning outcomes by organizing it according to the Bloom's Taxonomy. It mainly deals with the learning which takes place in multiple domains such as cognitive (knowledge and mental skills), psychomotor (motor skills), and affective (feelings, values, dispositions, attitudes) (Haq Nawaz Anwar, Malik Muhammad Sohail 2014). In 2001 Lorin Anderson introduced changes into a cognitive domain in Bloom's taxonomy based on findings of cognitive science following the original publication. In the later version, the levels are designated as *remember, understand, apply, analyze, evaluate, and create* (O'Neill and Murphy, 2010). This paper was written with the objective of describing how levels of cognitive do-

main can be used to construct different types of questions to bring out the thinking ability of students in written examinations.

Cognitive Domain

The structure of this domain as introduced by Bloom and his collaborators (Bloom, et.al,1956) consisted of six major categories: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. The categories after Knowledge were presented as “skills and abilities,” having the knowledge as the base for putting these skills and abilities into practice. When it is organized in a triangle the knowledge is the bottom most level and it rises with six levels becoming more complex.

Affective Domain

Unlike cognitive domain the affective domain deals with a person’s emotions. Studying this domain, students normal and abnormal behavior can be identified and the necessary actions can be taken.

Psychomotor Domain

This domain addresses the physical abilities of a student such as coordination, and motor-skill usage. As this has a lot of physical inputs, thus developing the skills necessary in practice. (<https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/>).

The Cognitive Domain

Categories and steps of the Cognitive Domain are Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation.

This domain implies memory recollections, understanding of the information, application of the gained knowledge, division of the knowledge into sections and thinking further, creating new ideas and new knowledge (<https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/>).

Cognitive domain and assessing performances

Students performance is assessed in a variety of ways including exams, evaluation portfolios (Wickramasinghe and Peiris, 2015), assignments, oral presentations, theses defenses either in the middle or at the end of the semester. The examinations are designed to evaluate the achievements of the intended learning outcomes. The evaluations appear within the frame of cognitive domain. The lower part of the pyramid evaluate students’ memory and when propelling further the evaluation will rather focus on applications, analysis and creativity. Questions in written examinations can be referred to one of the methods for evaluating students’ performances and can be addressed very effectively if the questions are compiled bearing in mind the categories of the Bloom’s Taxonomy. In the most common way of written examinations several types of questions are included to evaluate the achievement of intended learning outcomes of students. This includes multiple choice questions (MCQ) short answer questions (SAQ), structured type questions (STQ) and essay type questions (ETQ). In this paper we would like to elaborate on these four types of questions, which will appear in a written exam paper.

Multiple Choice Questions

We would like to use some information about spider monkeys as an example to develop the MCQ questions.

Tropical rain forests in Central and South America up to Mexico are the habitat of Spider monkeys (of several species). They have long, limbs and the most prominent feature on the spider monkey's body is its long, prehensile tail that enables them to move easily from tree to tree. Tail facilitates movement through the dense vegetation. Spider monkeys are named that way because they hang from the trees by holding different branches with their limbs and long tails, "shaped" like spiders. Spider monkeys do not have a thumb. Their four fingers are in different sizes and curved to look like a hook, which is specially adapted to the life in the forest. (<http://animals.nationalgeographic.com/animals/mammals/spider-monkey/>)

Knowledge

Question: How many fingers do spider monkeys have on one hand?

- a. Two
- b. Three

- c. Four
- d. Five

Here only memory is tested which is appropriate for the level of knowledge in the cognitive domain.

Comprehension

Question: What statement explains a spider monkey's fingers in one hand?

Answers:

- a. They have 4 fingers and all are of the same size.
- b. They have 4 fingers and all in of different sizes.
- c. They have 5 fingers and all are of the same size.
- d. They have 5 fingers and two of them are different in size.

In the level of comprehension the same knowledge can be tested in order to find out whether a student comprehends the material. Students have to give the number of fingers and their disparity or similarity. If the teacher has just talked about the number of fingers, the students may not remember. However, if the teacher had described the size of fingers comparing all four fingers, there is a higher possibility to give a correct answer as students comprehend the sizes of fingers and their disparity in size.

Application

Question: Spider monkeys use their hands in a similar way like human beings do. However, there is a difference between the **anatomies of hands**. Select the correct answer which describes the **disparity**.

Answers:

- a. Spider monkeys' limbs are longer than humans' limbs.
- b. Spider monkeys have no thumbs whereas humans have thumbs.
- c. Human fingers and toes are of difference sizes, whereas a spider monkey's fingers and toes are of the same size
- d. Spider monkeys use their tails to hold on to things, whereas humans do not have tails.

Students should be able to apply the knowledge gathered about spider monkey fingers in the classroom. It can be tested using the above question. Answering this question they will think about the anatomy of the hand of both spider monkeys and their own. They apply the knowledge gathered in real life situation.

Analysis

Question: Select the correct answer which emphasizes the use of fingers special to spider monkeys.

Answers:

- a. As the fingers are curved they can hold the branches very firmly.
- b. They use the toes but not fingers to hold when swinging to jump long distances.
- c. As the fingers are long and slender they facilitate fishing out food from water sources.
- d. Their fingers are used to dig holes in trees to find food.

Students should be able analyze a situation in order to answer this question. They can use the information gathered in the classroom about the spider monkeys and analyze it accordingly. In this question it is not just the number of fingers they should know. They should know for what purposes they use fingers effectively. Students have to analyze the use of fingers.

Synthesis

Question: What is the feature of their fingers which shows adaptation to the life in the forest?

Answers:

- a. Use of a tail to hold branches.
- b. Their four fingers are curved and look like a hook.
- c. Lack of thumb on hands.
- d. Fingers can be used to grab things very easily.

This MCQ question will allow students to think about the structure of fingers. Just the memory will not be enough to answer the question. Answer to this question should come out after thinking for sometime. Even if they know from their memory that spider monkeys lack a thumb and they have four fingers they should synthesize a situation how the monkey's fingers help them adapt to the forest environment.

Evaluation

The benefits of adaptations of their fingers lead to:

- a. grabbing tree branches in a situation where predators are chasing.
- b. eating fruits and leaves well without dropping much.
- c. scratching the enemy quickly and escaping for survival .
- d. grabbing many items in one hand such as branches and fruits at one time.

Students have to analyze the situations, thinking about the structure of the hand and the fingers and their use and evaluate the most beneficial use.

Short Answer Questions

Short answer questions require answers which are concise, accurate, aiming directly at the question. Students should read the question carefully to answer the short answer questions accurately. It is possible that students wrote answers which are irrelevant if the questions are not properly understood. However, the answers can be in higher order of the cognitive domain as they are in descriptive form even it is short (Clay and Root, 2001).

Some knowledge about photosynthesis is used to compile short answers questions as an example.

Knowledge

Question: Define photosynthesis.

Here it is only necessary to write what photosynthesis is. Which can be done by recalling the information from the memory.

Comprehension

Question: Explain why photosynthesis does not take place during night time.

This needs some comprehension. A teacher explains the whole procedure of photosynthesis but never says that it does not occur during night time. However, a teacher's description of photosynthesis is enough to comprehend and answer correctly.

Application

Question: Explain how the plants, which do not have green colour prominently, photosynthesize?

This answer has application of other situations which a teacher might not have directly talked about. But a teacher may have talked about the pigments involved in photosynthesis. Hence students can apply that knowledge.

Analysis

Question: Explain the relationship of temperature on accumulation of photosynthate in relation to the rate of respiration.

The answer should include the analysis of situations such as high and low temperature and what happened to carbon assimilation and how respiration is involved in this.

Synthesis

Question: Describe why crop yield in a given land area in tropical countries is lower when compared to temperate counties.

In order to give the answer students have to synthesize reasons from the familiar facts such as high night time temperature, respiration rate and their relationships etc.

Evaluation

Question: Briefly explain photosynthesis systems which reduce photorespiration.

Students have to evaluate other photosynthesis systems such as C₄ and CAM in order to give a successful answer. In that context, further thinking on comparison of three photosynthesis systems is required. This indeed needs evaluation of the photosynthesis process and its differences among the three systems with the basic knowledge.

Structured Type Questions

In structured type questions all the steps of cognitive domain can be used. The structured questions should be similar to essay type questions in contents but with four or five sections. The first few sub-questions in one question are simple, so the quick answers are expected. These questions can be memory recalling in the category of knowledge of the cognitive domain. Gradually descriptive answers can be expected and questions can be elaborated bearing in mind the levels of cognitive domain. However, the questions should be designed appropriately within ILOs to get the expected level of answer. When the answers are put together they should make up a single story, as if it is one essay type question.

We would like to provide an example of plant tissue culture technique to demonstrate the structured type question.

Plant tissue culture was first introduced by Gottlieb Haberlandt in 1892, is known as the father of plant tissue culture. This technology is based on the unique ability of plant cells, to regenerate a whole plant from a single cell, known as 'totipotency' In order to regenerate, grow and multiply plant parts should be grown in an artificial medium which contains all required elements, water, vitamins, sugar and growth regulators. By manipulating growth regulators such as cytokinins and auxins in the medium plants parts can regenerate embryos, shoots and roots. Cytokinin, Benzyl Amino Purine (BAP) in particular multiply true to type shoots in large numbers through sub culture. Auxins can be applied to get callus and roots. This can be applied to produce large numbers of true-to-type uniform saleable plants within a short period of time continuously.

Knowledge

Question: Who is the father of plant tissue culture.

Just by recalling the name students can answer.

Comprehension

Question: Describe totipotency.

Students have to think about it little more by comprehending the ability of plant cells.

Application

Question: Discuss the difference between the growing medium of plants in *in-vivo* (normal condition) and the plants growing *in vitro* (inside glass).

Students have to apply their knowledge in growing plants outside. As outside plants undertake photosynthesis and vitamin synthesis they are not given sugar and vitamin. Students have to first indicate the differences and discuss the reasons in order to get full marks.

Analysis

Question: Describe the effects of plant tissue culture medium on regeneration of plants.

The students should include the requirements of the medium, specially the plant growth regulators and how they are manipulated to get callus followed by embryos, adventitious shoots and adventitious roots. This would be a quite comprehensive answer with analyzing the situation of requirements of plant growth regulators, their types, concentrations and at what stage these growth regulators should be applied so on. This cannot be done just by memory recalling or comprehending on what teacher has said in the class. They have to have a thorough knowledge on how plant growth regulators affect embryogenesis and organogenesis.

Evaluation

Question: Explain how plant growth regulators can manipulate the target number of saleable plants. This is a question where they have to show the output. In order to get a target output a certain plant growth regulators (cytokinins- BAP) should be applied in the medium for shoot multiplication. They have to discuss the performances of cytokinin, a particular type, and how the concentration affects the multiplication. If too much is added for too long it can have disorders and plants will not be saleable. Hence they should show when to stop growth regulators and when to add the rooting growth regulators.

The answer for this question is quite lengthy and a lot of evaluations of different situations are involved.

Essay Type Questions

Essay type questions are unstructured questions that are open and students have to construct the answer using some or all the levels of cognitive domain. Hence these answers have an appeal of quality. They do not require pre-defined categories and they allow students expressing their views openly. However, this openness can be advantageous as well as disadvantageous. Open-ended questions, produce a higher cognitive load in the sense that the students have to contribute more cognitive efforts to produce an answer. This can result in a lower response rate and sometimes lower quality answers. On the other hand, they can produce rich insights that provide in depth meaning to structured questions.

We would like to provide the same example as with structured type question, which is related to plant tissue culture.

Question: Discuss the role of growth regulators in plant tissue culture when a targeted amount of plants are to be sold during the designated time period. You can select any fruit crop to develop your answer.

In this question students have to have a thorough knowledge about the basics of growth regulator effect in plant tissue culture. They also have to apply knowledge gathered on how plants are multiplied and rooted using growth regulators. Also they should know the correct amount to be applied and the short term and long term repercussions for the particular crop. They have to synthesize the answer targeting an amount to be sold and the time period required. They can describe how the time period can be manipulated with the growth regulator concentration. Evaluations should also be done with the quality of plants and its relationship to reducing growth regulators in correct time.

Conclusions

Application of Bloom's Taxonomy should be in line with the learning outcomes of the module being tested. The Bloom's Taxonomy principles serve as guidelines for the staff involved in the development of question papers, but it is largely up to the teachers to produce a balanced question paper as the final outcome. Bloom's Taxonomy can be applied to all common types of questions for written examinations in order to stimulate students' effective and analytical cognition and develop their creativity.

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