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The Need for Creativity in Teaching Higher Order Thinking Skills in Biology

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Abstract

The objectives of this study are to know the students' opinion on the difficulty level of the topic of Nutrition in the form four Biology and to identify the students' level of thinking skills in the topic. This study uses a quantitative study design through a survey approach. A questionnaire and a formative test were administered to 196 pure Science stream students in four secondary schools in Perak. Respondents were selected through group sampling method. It was found that the mean of difficulty level of the topic of Nutrition is 1.94 which shows the students' opinion on this topic as a difficult topic. The findings of the formative test show that the students' higher order thinking skills in the topic of Nutrition are low because over 60% of the respondents fail to solve questions of high cognitive level in 7 out of 10 subtopics. The findings of the formative test are compatible with the students' opinion on the difficulty level of the topic of Nutrition. The overall findings show that students understand but cannot apply basic concepts in the whole topic of Nutrition. Hence, teachers need to be creative by integrating technology in their teaching aids to help students visualize and integrate microscopic concepts in a complex system.

Keywords: Higher Order Thinking Skills, Nutrition, Biology, Technology Integration, Difficulty Level, Creative Teacher

Introduction

Enhancing student achievement is one of the six National Key Result Areas targeted by the Malaysian government in the Government Transformation Programme (Performance Management & Delivery Unit, 2010). Among the reactions are the Ministry of Education Malaysia has developed the Malaysian Education Development Plan to be implemented in pre-school education to secondary education from 2013 to 2025 (Ministry of Education, 2013). Of course, teachers are the main backbone of the Ministry of Education to realize the transformation of the country's education. Hence, teachers' responsibilities are now more challenging as their creativity and commitment are needed to achieve learning goals in the 21st century.

According to Education Performance and Delivery Unit (2015), learning in the 21st century aims to produce highly productive and proficient students in communication, higher order thinking skills and in information and communication technology (ICT). Collins (2014) emphasizes on teachers and school administrators to be aware of the importance of teaching higher order thinking skills to students to provide them with life in the 21st century. Anderson et al. (2001) categorizes higher order thinking skills as information transfer while lower order thinking skills as perceived information. If both of the transferring and remembering activities occur, meaningful learning is said to take place (Collins, 2014). This means that teachers in the 21st century should not only master the curriculum content in any subject taught but must also be proficient in pedagogy and use the latest technology in teaching (Education Performance and Delivery Unit, 2015). This is to ensure meaningful learning takes place on students.

Higher order thinking skills are needed to solve many questions of Science and Mathematics so that students can apply, analyze, synthesize and evaluate information rather than restating facts (Ministry of Education, 2012). In Biology, higher order thinking skills are needed to solve many questions in real life (Cimer, Timucin & Kokoc, 2006). Examples for decision making, problem solving, experimentation, conducting investigations, classifying organisms and comparing different organisms (Marzano, 2007). Higher order thinking skills in Biology can also help students to solve new problems (Janssen & Waarlo, 2010) not only in the examination but also in their daily lives.

Background of the Study

The researcher chose Biology which is an elective subject for secondary students in the pure Science stream as a studied subject by focusing on the topic of Nutrition. Biology is a subject which studies living things scientifically (Campbell, 2015). Biology is extensive and contains many abstract and microscopic Science concepts and processes that make it difficult to learn effectively in a short period of time. Students also have problems to visualize and think at molecular levels (Friedler, Amir & Tamir, 1987; Westbrook & Marek, 1991; She, 2004). As a result, misconceptions can occur in students if they are only taught based on information and rigid diagrams in the textbooks (Swain, 2012). Therefore, teaching aids based on the latest technology such as computer animation is needed to visualize processes that are not visible to the naked eyes or difficult to explain to students in the classroom (Barak, Ashkar & Dori, 2011).

Nutrition is the sixth topic in the form four Biology subject and it contains one of the biological fields which is physiology for animals and plants. Since the content of this topic is extensive, the researcher only focuses on Nutrition For Animals. This topic is interesting to be learnt as it relates directly to human life. However, abstract and microscopic concepts such as absorption, osmosis and enzyme activity which consist in the topic of Nutrition cause this topic difficult to be learnt and to teach. According to Gan, Manoharan and Azmah (2005), absorption concepts can be seen in the absorption process of digestive molecules such as glucose, amino acids, water-soluble vitamins and minerals in the arteries of the small intestine, while the absorption of fatty acids, glycerol and fat soluble vitamins occurs in the lacteals of small intestine. Osmosis of water molecules occurs in the colon during the formation of faeces while enzyme activity occurs during the process of food digestion in the mouth to the small intestine.

Hence, this study is conducted to identify the higher order thinking skills of students who have studied the topic of Nutrition through the common learning method. Is the common learning

method that uses teaching aids just as textbooks, reference books, whiteboards and PowerPoint presentations able to generate higher order thinking skills of students? The findings from the unstructured interviews and the formative test will be examined whether they are compatible with the students' opinion on the difficulty level of this topic or not. Furthermore, suggestions on improvement of the teachers' teaching methods will be made so that students' higher order thinking skills can be generated. Higher order thinking skills are not impossible to be possessed because they are the skills that can be taught and learned (Yee et al., 2011) by all students regardless of low or high achievement (Zohar & Dori, 2003).

Research Questions

1. What are the students' opinions on the difficulty level of the topic of Nutrition?
2. What are the level of students' skills to solve higher order thinking questions according to the subtopics in the topic of Nutrition?

Methodology

This study uses a quantitative study design through a survey method approach. This survey involves respondents to answer the questionnaires of difficulty level of the topic of Nutrition and a formative test of the topic of Nutrition which contains 15 multiple choice items. 196 form four pure Science stream students from four secondary schools in Perak were chosen as a sample of the study to answer both instruments. Respondents selection was made by three level of group sampling because it consisted of three times random selection. The data from the questionnaires of Difficulty Level of the topic of Nutrition and a formative test of the topic of Nutrition were analyzed descriptively using Statistical Package of Social Science (SPSS) version 21. The values of mean, standard deviation and percentages were calculated.

The questionnaires of Difficulty Level of the Topic of Nutrition contains a list of 10 subtopics in the topic of Nutrition. The respondents indicated the difficulty level according to the four level of Likert scale which is 1 = not difficult, 2 = quite difficult, 3 = difficult and 4 = very difficult for each subtopic. The aim of the questionnaire was to know the subtopics that the students could not understand based on their opinion after studying the topic of Nutrition. The mean value obtained is compared to the scale of the difficulty level as shown in Table 1.

Table 1. Scale of the difficulty level

Mean value	Difficulty level	Interpretation
1.33	Not difficult	Understand and able to apply basic concepts
1.33 – 2.66	Difficult	Understand but not able to apply basic concepts
2.67 – 4.00	Very difficult	Do not understand and not able to apply basic concepts

The formative test of the topic of Nutrition consists of 15 multiple choice items that represent the subtopics contained in the Nutrition For Animals. According to the Revised Bloom Taxonomy, the items consist of 2 questions of low cognitive level which from the understanding level and 13 questions of high cognitive level which from the analysis level and evaluation level. In social science research, multiple choice items can be used to evaluate higher order thinking skills (Zheng, Lawhorn, Lumley & Freeman, 2008) and lower order thinking skills in various ways

(Killiran, 1992). Students need to master at least the understanding level of the relevant concepts to answer questions of high cognitive level.

Results

(i) Difficulty level of the topic of Nutrition

Analysis of the difficulty level of the topic of Nutrition is shown in Table 2. The results show that 9 out of 10 subtopics are selected by respondents as difficult while 1 subtopic which is the Assimilation of Digested Food is selected as very difficult. 5 Subtopics which are the Food Digestion, Absorption of Digested Food, Assimilation of Digested Food, Formation of Faeces and Defaecation involves abstract and microscopic concepts of absorption, osmosis and enzyme activity that require visualization and thinking skills at molecular levels. In addition, almost all subtopics require the skill of applying concepts into daily activities. The overall mean of difficulty level of the topic of Nutrition is 1.94 which also clearly proves that the whole content in this topic is considered as difficult by the students.

Table 2. Students' opinion towards the difficulty level of the topic of Nutrition

No.	Subtopics in the topic of Nutrition For Animals	Mean	Standard deviation	Difficulty level
1	Types of nutrition	1.61	.769	Difficult
2	Balanced diet	1.35	.665	Difficult
3	Malnutrition	1.78	.763	Difficult
4	Food digestion	2.31	.712	Difficult
5	Absorption of digested food	2.43	.721	Difficult
6	Assimilation of digested food	2.76	.690	Very difficult
7	Formation of faeces	2.22	.824	Difficult
8	Defaecation	2.06	.868	Difficult
9	Evaluating eating habits	1.39	.716	Difficult
10	The importance of a healthy digestive system	1.50	.850	Difficult
Mean		1.94		

In addition, the researcher also conducted unstructured interviews to several form four Biology students to obtain triangulation of students' opinion to the data of the difficulty level of the topic of Nutrition. Selection of students was made randomly. Here are some of the extraction from the interviews.

- Student A : The diagram must be interesting, cheerful and real to see the movement of food in the animal digestive tract. My teacher reads and refers to the textbook completely. The content in my teacher's PowerPoint slides are same as in the textbook. The diagrams are also as in the textbook. I cannot imagine how it works.
- Student B : It is better to make a computer animation so that the flow of food in humans from the mouth until the formation of faeces can be seen.
- Student C : The diagrams in the textbook are not big enough. I do not see what's going on in the villus. Need to show the molecules around the villus and absorption of the molecules into the villus. There is no arrows to show molecular movement either.
- Student D : In this Nutrition topic ... the assimilation is hard to understand. So change the diagrams to better understand. Which I think animation can do better. We point out from the heart to the cell ... then back to the blood.

The findings of the interview illustrate students' complaints on the teaching method of the topic of Nutrition by their teachers. They also commented on the weakness of the diagrams in the textbook. Even with confidence, they provide suggestions to improve the quality of teacher teaching and the quality of diagrammatic presentation in the textbooks. Overall, the students expressed the difficulty of understanding the whole process from eating food in the mouth to the process of absorption in the colon, the absorption of food molecules in the small intestine and the assimilation of digested food that occurs in the liver and body cells. As conclusion, the findings from the interviews were compatible with the data from the difficulty level of the topic of Nutrition.

(ii) Formative test of the topic of Nutrition

The results for the formative test of the topic of Nutrition shown in Table 3 reinforce the findings of the difficulty level of the topic of Nutrition. Based on the results which showed that over 60% of the respondents failed to answer a question, it was found that the students were difficult to answer the questions from the subtopics of Balanced Nutrition, Malnutrition, Food Digestion, Assimilation of Digested Food, Evaluating Nutrition Habits and The Importance of Healthy Digestive System. These subtopics either contain abstract and microscopic concepts such as absorption concept, osmosis and enzyme activity or need skills in applying these concepts to daily activities. All subtopics showing low of higher order thinking skills are found to be parallel to the student's opinion on the difficulty level of the subtopics in the topic of Nutrition.

Table 3. Result for the formative test of the topic of Nutrition

Question number	Subtopic	Cognitive level of Bloom Taxonomy	Revised	Wrong respondents' answer (%)
1	Types of nutrition	Understand		84
2	Balanced diet	Analyze		62
3	Balanced diet	Apply		66
4	Balanced diet	Analyze		69
5	Malnutrition	Analyze		70
Table 3 continue				
6	Food digestion	Analyze		69
7	Food digestion	Understand		73
8	Absorption of digested food	Analyze		38
9	Assimilation of digested food	Analyze		63
10	Assimilation of digested food	Analyze		87
11	Formation of faeces	Analyze		41
12	Defaecation	Analyze		23
13	Evaluating eating habits	Analyze		67
14	Evaluating eating habits	Evaluate		39
15	The importance of a healthy digestive system	Analyze		70

Discussion

The most common misconception in absorption and osmosis concepts is also acknowledged by previous researchers such as Odom and Barrow (1995) and Meir et al. (2005). However, misconceptions in both concepts can be avoided if the students are able to visualize and think of chemical processes at the molecular level as suggested by Friedler, Amir and Tamir (1987) and Westbrook and Marek (1991). Failure to understand the concept of absorption, osmosis and enzyme activity will be difficult for students to understand the whole process that occurs in the digestive system in the human body. Yet, understanding a concept with depth will be able to generate higher order thinking skills among students (Zoller, 1993).

Thus, researcher thinks that it is a requirement for teachers to diversify technology as the auxiliary materials in teaching and learning. Integration of the technology will help students understand difficult science concepts (Barak, Ashkar & Dori, 2011). For example, meaningful learning occurs through the use of computer-based multimedia elements because students must

actively process information that they integrate from both pictures and words into a structured teaching (Wittrock, 1989). Furthermore, learning through multimedia presentations will increase the thinking level of students as said by Mayer (2001, 2003). Thus for the topic of Nutrition, researcher proposes to integrate technology through the development of a stand -alone interactive software to help teaching and learning of this topic.

Inside the courseware, it may include videos of mangroves and paddy fields to show how the living organisms in the ecosystems are classified according to the subtopic Types of Nutrition. The videos of eating humans, cows and rabbits can also be screened as stimulants before animations of the digestion of food in all of the organisms are shown. Students will be excited to watch animations that will explain the digestion of food from the mouth to the absorption of digested food in the small intestine or the release of undigested food as faeces. The addition of pedagogical agent elements such as the animation character of a teacher can serve as a knowledge conveyer, mentors, motivators and friends to learn and to complete the learning (Kim & Baylor, 2008). In addition, the stand-alone software promotes self-directed learning according to the students' ability. Besides, the use of exercises through games which repeatedly playable can induce higher order thinking skills indirectly.

Information and communication technology (ICT) which is creative and innovative is found to have high potential to support the development of higher order thinking skills. Hence, in the Wave 3 of the implementation of PPPM, the Ministry of Education Malaysia is committed to fully integrate ICT throughout the implementation of pedagogy and curriculum. Teachers will be trained with alternative teaching and assessment approaches such as project-based learning and ICT-based assessments to teach higher order thinking skills. The goal of the Ministry of Education Malaysia by the end of 2015, all teachers are at least at the minimum level of ICT literacy in accordance with the competency rubric by the International Society for Technology in Education (ISTE) (Ministry of Education, 2013). Commitment of the Ministry of Education Malaysia has prompted UNESCO to recognize Malaysia as the first country in the world to pioneer ICT strategic plans for the education system (Ministry of Education, 2013).

Conclusion

Science teachers like Biology teachers need to be creative to diversify teaching aids based on the latest technology. For example by using animation and video or animation based learning software to explain abstract and microscopic concepts. Stand-alone learning utilities allow students to study at their own pace either in or out of school hours and gain knowledge beyond the textbook content. This pedagogical practice should be practised from the pre-school or primary school level. What a good thing if the science teachers master in the technology and multimedia is they themselves can develop animation-based learning utilities to help them to teach. The learning software can be used over and over again in subsequent classes with minimal customization if necessary.

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