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PROMOTING CRITICAL THINKING THROUGH BLOOM'S TAXONOMY IN BIOLOGY 1101 PEER-LED WORKSHOPS

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In Spring 2012, Associate Provost Pamela Brown and Professor Juanita But established a novel initiative called Reading Effectively Across the Disciplines (READ) at New York City College of Technology (CityTech). Having established through General Education assessments that students at CityTech struggled with reading, one of the aims of the program was to teach reading strategies to students and faculty alike andto assess to what extent these strategies were affecting student reading. One additional component was to implement Peer-Led Team Learning (PLTL) as a means to mentor students in reading (Gosser et al., 2001). These Peer Leaders would be recruited from the Biological Sciences Department and being senior students, they would have excelled in the target courses and have excellent reading skills.

As part of the training of the peer leaders, they are expected to engage in research in the area of PLTL. This paper details how PLTL can be used as a means to deliver these reading strategies via affective reading assignment design and how they can be designed to assess critical thinking. This paper discusses how reading strategies can be designed in the context of Blooms taxonomy, a framework of learning objectives designed in 1956.

Introduction to Bloom's Taxonomy

Bloom's Taxonomy of Learning Objectives was developed by educational psychologist Benjamin Bloom and colleagues to promote higher forms of thinking in education. It consists of three domains, one of which focuses on cognitive skills. Skills in cognition enable students to know, understand, apply, analyze, synthesize, and evaluate basic concepts. The other two created targeted affective (emotional) and psychomotor (manual/physical) skills (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956). Bloom's Taxonomy has helped educators to match questions they ask with the type of thinking skills they are trying to develop and to formulate their instructional objectives (Allen & Tanner, 2002).

Within the cognitive domain, there is a hierarchy of six categories or stages:

1. Knowledge: recall information from long-term memory.
2. Comprehension: focus on understanding facts presented in lectures or by reading the texts.
3. Application: make use of prior knowledge by answering questions in a different scenario ("Non-Traditional Teaching & Learning Strategies - Faculty Excellence at MSU | Montana State University," n.d.).

The first three levels are commonly known as *lower-order cognitive skills* (LOCS). The last three categories are also considered *higher-order cognitive skills* (HOCS) that require critical thinking.

4. Analysis: break information into sub-parts and determines how they relate to one another to create an overall picture.
5. Synthesis: combine information in new patterns.
6. Evaluation: make judgments based on criteria and standards.

Using these skills requires both knowledge and comprehension of the content, so all levels of thinking should be encouraged ("A New Method for Assessing Critical Thinking in the Classroom," n.d.).

In the 1990's "Bloom's Taxonomy" was revised, applying action verbs to identify the six learning categories. The categories are now called Remembering, Understanding, Applying, Analyzing, Evaluating and Creating ("Anderson and Krathwohl - Bloom's Taxonomy Revised," n.d.).

Use of Bloom's Taxonomy in Science Courses

To promote higher-order thinking in college students, an assessment of critical thinking skills in introductory biology course was conducted at Duke University. They developed a process by which (a) questions are prepared with both content and critical-thinking skills in mind, and (b) grading rubrics are prepared for evaluation in advance. This methodology improved student metacognition, and exposed a number of student misconceptionsabout the course content ("A New Method for Assessing Critical Thinking in the Classroom," n.d.).

A longitudinal study (10 semesters) in an introductory level biology course at New Mexico State University, NM, applied Bloom's Taxonomy in Peer-led workshops. Three lectures per week were replaced with two lectures and one peer-led workshop. The results showed grade improvement for all students, especially for undergraduate minority students and for females (Preszler, 2009). The scores increased on the questions that required critical-thinking skills.

In an introductory-level psychology course at St. John's University, Queens, NY, action verbs based on Bloom's Taxonomy were used in exams; questions used the following verbs: *Identify, Define or Describe, Evaluate and Explain,* and *Apply.* The questions were formatted to engage students in critical thinking and to answer more complex questions. The results showed that evaluating theoretical concepts is the most difficult of skills and required better knowledge acquisition skills (Nevid & McClelland, 2013).

Blooming Biology Tool (BBT), an assessment tool, was developed by a team of faculty members at the University of Washington and Evergreen State College, WA in 2008 to diagnose students' aptitude and to create new assignments to test critical thinking skills. The tool applied **B**loom's **L**earning **A**ctivities for **St**udents (BLASt) system to strengthen the study skills at each level of Bloom's Taxonomy. BLASt and BBT were applied in (1) a laboratory course that required students to write an NIH grant proposal for research, (2) in a higher-level undergraduate biology course (like cell biology)and (3) in an introductory level biology workshop at a liberal arts college. The students enhanced their study skills and metacognitive due to variation in course content (Crowe, Dirks, & Wenderoth, 2008).

In a study conducted by Lemons et al. (2013) aimed at logically analyzing questions, biologists used Bloom's Taxonomy to create HOCS-level questions. A framework was generated that provides an interpretation of participants' ideas about higher order questions and a model of the relationships among these ideas. Two hypotheses emerge from this framework. The first is that biologists intuitively look for

ways to measure difficulty when evaluating potential HOCS questions, by observing time required and student experience. The second is that biologists' assumptions about the role of questions in student learning influence the types of HOCS questions they write and even their comfort with HOCS questioning (Lemons & Lemons, 2013).

Application of Bloom's Taxonomy in Biology 1101 Workshops at CityTech

Our research has shown that Bloom's Taxonomy of Learning Objectives could be instrumental in designing biology workshop sessions that help to improve critical thinking skills of the workshop participants and to improve their reading and knowledge acquisition skills by utilizing the assigned course textbook.As part of READ, the biological sciences faculty designed reading assignments that were applied both in class and during Peer-Led Team Learning workshops. These strategies have been presented at workshops and conferences to instruct both peer leaders and the faculty.

Several Peer-Led Team Learning workshops were held each week, each accommodating a small number of students according to their schedules. Peer Leaders met with the biology instructor for guidance and to gain instruction in implementing the reading strategies. In the second semester, peer leaders were able to modify and design their own assignments.

The following is the summary of reading strategies that were applied to accommodate each level of Bloom's Taxonomy in the workshops:

1. Knowledge: Read aloud and text annotation. Each student defined segments of scientific theory by going around the room in turn (round robin). They recalled facts learned from reading the assigned section in textbook and from notes made on post-its.
2. Comprehension: Text annotation and concept maps. Students were asked to read about one biomolecule each (such as carbohydrates, proteins and lipids). During one session they read and annotated their section in textbook and wrote important facts on the post-its. During next workshop session, they arranged their post-its on the white board and created a map of molecules by categorizing them according to their characteristics and formation (Jigsaw technique).
3. Application: Through anticipation guides, students were asked to demonstrate their abilities in completing and identifying redox reactions used in respiration and photosynthesis. They were also tested on synthesis and utilization of ATP molecules in various biological processes.
4. Analysis: students prepared compare and contrast charts to study and analyze various stages of mitosis and meiosis. Words maps were also developed to practice basic vocabulary terms in topics such as metabolism, cell division, oxidation, reduction and DNA replication.
5. Synthesis: This level of taxonomy was useful in understanding complex topics such electron transport chain and photosynthesis. Students were judged on basic knowledge of the topics by filling in the blanks. They worked in pairs to explain how protons, ATP and kinetic energy are transferred from one step of the chain to other. In the end, they re-created the cycle and explained the light-dependent reactions of photosynthesis.
6. Evaluation: The workshops for introductory biology course were not advanced enough to teach techniques that would help in critiquing a topic and form reasonable judgment about it. This

stage is said to be more helpful in critical appraisal of research papers, especially when results are controversial or inconsistent.

Conclusions

Although certain levels of Blooms Taxonomy were addressed in the workshops, the upper levels, "Evaluating" and "Creating," were not. Those levels are necessary to develop higher order cognitive skills in order to improve critical thinking and knowledge acquisition skills (Nevid & McClelland, 2013). The higher order cognitive skills depend on students' willingness to think critically about the material, and the primarily freshmen students may not yet have understood the importance of designing their own questions. Future workshops will introduce critical thinking assignments designed on the basis on the research presented.

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