CONNECTIVE LEARNING PEDAGOGY ENHANCES STUDENTS' ACADEMIC PERFORMANCES BY INFUSING CRITICAL THINKING AND PROBLEM-SOLVING SKILLS

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Abstract

This study is a descriptive analysis of a Connective Learning teaching technique that is based on visual intelligence infused with critical thinking skills. This technique helped students achieve higher performance in biology. Students scored 1.7 times higher grades than students who did not receive this supplemented instruction. Furthermore, students show enhanced retention and transfer of knowledge in their respective field of studies.

Keywords: Connective Learning, Critical Thinking, Teaching Modules, Active Learning

Introduction

Majority of higher learning institutions in USA expect that their undergraduate students are capable of tackling the challenges of 21st century. One of the main expectations is that graduates develop higher learning skills that would help them to become experts in their field of studies. Furthermore, they should be able to solve problems that are inherent in the technologically driven global economy. Many employers complain that their employees are not equipped with critical thinking skills and lack interpersonal communication skill that are essential for an enterprise where cohesiveness is an integral part of the business operation.So the question arise what is critical thinking skills?

According to Glaser (1941) "the ability to think critically involves three things: 1) an attitude of being disposed to consider in a thoughtful way the problems and subjects that come within the range of one's experiences, 2) knowledge of methods of logical inquiry, and 3) some skills in applying those methods. Recently, Paul and Elder (2008), fine-tuned Glaser's definition of critical thinking as "the intellectually disciplined process of

actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as guide to belief and action."

Various strategies have been developed and practiced to promote improvement of critical thinking abilities among students. Some of the strategies are described as follows: a) Cooperative learning encourages group learning environment that is based on active learning and it foster critical thinking among learners (Cooper, 1995); b) Ongoing classroom assessment helps to monitor and facilitate students' critical thinking abilities (Angelo, 1995); c) Concept mapping promotes critical thinking and problem solving abilities (Ausubel, 1963; Ausubel et al. 1978); d) Case study/ Discussion uses open ended case study environment which enhances critical thinking abilities (McDade, 1995); e) Problem-based learning (PBL) provides evidence that suggests it promotes critical thinking skills (Ball and Knobloch, 2004) and f) Writing assignments are an integral component for developing critical thinking skills (Wade, 1995).

Teachers who uses instructional platform to enhance critical thinking would be considered preferable instructors than those who follow the old traditional lecturing technique in the classroom. To maintain academic excellence, teachers who could deliver instruction that would encourage pupils to be innovative and creative in their thought processes, and challenge the fertile minds of our youth and foster their originality. Our college graduates must compete successfully and maintain our leadership position in business, sciences and bio-medical fields, in the global arena.

Instructions should be challenging to the students. It should be presented in a way where students will be thinking about the problem and how to solve that problem. Strategies that enhance the critical thinking abilities of our students include a new pedagogy known as "Connective Learning" was introduced twelve years ago (Sen, 2002). Connective Learning is a simple, effective teaching technique based on visual learning that incorporates the best ideas of problem-based learning, cooperative learning through concept mapping and delivers the learners the tools for higher order thinking, self-achievement and enhanced retention.

Connective Learning (CL) empowers students by providing an active learning platform, the freedom to access information on their own initiative and make students feel counted as the principal players in solving and/or explaining the topic at hand. Students are energized to learn and think that learning is a positive experience. This experience allows student learners to feel that they are directly a part of the whole process of learning and they are in control of their own intellectual development. A positive outcome directs

the students to fulfill their own goals and assures them that they can achieve anything if they desire to obtain it.

New knowledge could be learned through the integration with the prior knowledge. One of the most important elements for thinking process is the ability to ask meaningful questions because they raise issues, involve in active participation of the learners and develop analytical reasoning that enhance learning and encoding of knowledge. For this reason, we must encourage our students to ask questions. If our questions generate more questions in our student's mind, then we know that the process of critical thinking is proceeding forward for the solution of a particular problem and/or issue. This dynamic interaction is the essence of learning. If this process is stifled by the teachers then learning cannot occur in the classrooms.

In this paper the authors describe how to use Connective Learning (CL) technique in the classroom and provide data that supports their argument.

Methods

One way to raise the interest and curiosity of students is to take a topic they are familiar with or at least they have heard about it. Then ask each student to write some information about the topic that comes to his or her mind. Collect these ideas from each student and write them on a whiteboard. Next ask students to link each bit of information or fact that has a connection or relationship with the main topic. The main topic should be in the center. This will give us a concept map of the main topic. Then ask students to expand each subtopic through extensive library search and collect the students' work. Reports will be evaluated for individual efforts in this project. The teacher should divide the class into five or six groups. Each group can accommodate five to ten students. Representative of each group should present an oral presentation about their library findings on subtopics. Teacher should collect written group reports for evaluation of the group effort in this project. The teacher should lead the class by discussing the importance of each bits of information and try to put a unifying theme with analysis so that the students can "see" the whole problem. Teacher should ask students to work together to develop a main statement based on the information collected by the class. This statement is the central idea of this project. Each student must develop questions based on the central idea. The teacher should emphasize to the students about the importance of this critical process and ask students to answer each question and collect their written responses for evaluation. The teacher should provide a detailed summary of the whole topic and allow students to discuss the issue in the classroom.

Model for designing CL modules

Designing CL module involve stages such as: **G**ather information, **A**nalyze information, **D**esign gathered and analyzed data into a "form", **G**auge the efficacy of the product, **E**valuate critically the product and **T**est the product for final analysis (GADGET).

Example of a student developed Connective Learning Module

A picture about a woman sitting in the beach in daytime is shown in a PowerPoint slide in the class. Students were asked to write some information about the picture that comes to their mind. These ideas were collected from each student and placed on a whiteboard. Students were asked to link each bit of information or fact that has a connection or relationship with the main topic. Students generated a concept map which is presented below.

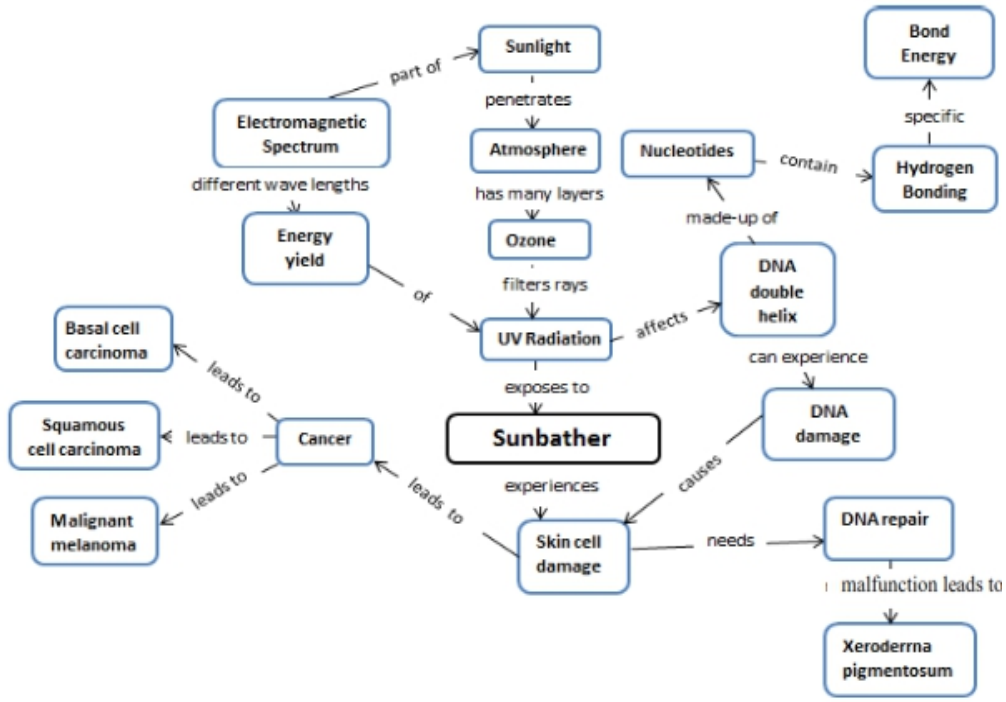

Fig.1. A concept map depicting the impact of the sunlight on sunbathing activities.

From this concept map, students developed a unifying theme as follows: The UV radiation from the sun has enough energy to damage DNA in human skin cells that can lead to various mutations, which subsequently can express themselves into various types of skin cancers, some of which are fatal. From this unifying theme, students formulated some important questions such as:

1) How much energy does UV radiation have at a particular wavelength?

2) How do you calculate the energy at a particular wavelength?

3) How much energy is needed to break bonds between nucleotide base pairs?

4) What types of photo-induced damage can be found in DNA?

5) Why does damaged DNA cause mutations?

6) Why are some UV damaged cells unable to be repaired by the DNA repair mechanism?

7) What are the types of cancers present in skin?

8) How does UV radiation penetrate the atmospheric layers?

9) Why is ozone layer depletion detrimental to skin cells?

A Connective Learning module on DNA was used to assess the impact of CL modules on student performance in cell biology class at Bethune-Cookman University in spring 2015.

Before the introduction of the module students were given a multiple choice pre-test containing 23 questions to assess their background knowledge on DNA and structural basis of cellular information. All students enrolled in this cell biology course were biology majors and representing the senior class. Immediately after the completion of the CL module, students were given post-test to see how well students performed on conceptual understanding and problem solving skills.

Electronic classroom response system (ECRS) allows teachers to assess and evaluate students' conceptual understanding immediately. This system also promotes retention and meaningful engagement of students in the classroom. In this study a low-tech approach was utilized to assess students' mastery of concepts. A simplified version of CL module on sunbathing was used to see how well freshman students master the concept that was presented in the classroom. After completion of the CL module, students were given a short quiz comprising ten multiple choice questions. Questions were presented to the students through PowerPoint slides and students wrote their answers on a piece of paper. Students' responses were collected and graded to assess how effective the CL module was.

Data Analysis

Pre- and Post –test data were matched for all students taking the both pre-and post-test. Student t test was used for data analysis. The "null hypothesis" was that there was no difference in mean pre-post test scores among student participants.

Results

When all questions generated through the construction of the concept map were answered a document emerged which showed the expertise, metacognitive skills and transfer of knowledge acquired by the students through this modular approach.

Cell biology course at Bethune-Cookman University is offered every spring semester. Biology seniors are required to take this 400-level course for graduation. Average class size is eighteen students per semester. The data described here represent spring semester 1997 through the spring semester 2014, a span of 17 years. Seventy nine (79) students enrolled in cell biology course during the years 1997 through 2007 and they did not receive instruction supplemented with CL technique, whereas, one hundred forty-six (146) students received instruction supplemented with CL technique during the year 2008 through 2014. During the years 2008 through 2014 fifty five percent students achieved 80% and above in the final grades in cell biology course when instruction was supplemented with CL technique. On the other hand, thirty-two percent students achieved similar levels of mastery in cell biology course during the years 1997 through 2007. This data indicate that CL technique enhanced student grades 1.7 times over the grades earned by the students who were not exposed to CL technique. Comparative analysis of students' performance with CL and without is depicted in Table 1.

Table 1. Grade distribution of students in Cell Biology supplemented with CL and without.

Final Grades	A	B	C	D	F	I
Years 2008-2014 (with CL)	38 (26%)	43 (29.4%)	48 (32.8%)	4 (2.74%)	3 (2%)	10 (6.8%)
Years 1997-2007 (without CL)	9 (11.4%)	17 (21.5%)	35 (44.3%)	16 (20.2%)	0	2 (2.53%)

Common biological knowledge assessed through the use of a comprehensive exit examination (required for graduating seniors) are given to biology majors every year. One hundred multiple choice questions were selected from all fields of biology such as ecology, evolution, genetics, metabolism, taxonomy, plant and animal physiology. All students must take the comprehensive examination to graduate with a bachelor degree in science with a major in biology. In 2010 the department raised the passing score to 70% so that graduates will be competitive with other colleges and universities. During the years 2000 through 2009, twenty-nine students took the exit examination and their average score was 49.44%, whereas, during the years 2011 through 2014, seventy-one students took the test and their average score was 70% indicating that students improved their conceptual understanding and retained information better than previous graduating seniors. Since all biology majors must take cell biology course to graduate, it could be suggested that CL based instruction might have influenced the improved performances of the students.

The result of the pre- and post-test on DNA and structural basis of cellular information module revealed that the paired t test gave the value of $t= 3.6977$, and $p= 0.0024$ indicating that a very small probability of this

result occurring by chance, under the null hypothesis of no difference between pre- and post-test scores. Thus the null hypothesis was rejected, since $p<0.05$.

Simulated classroom response system results showed sixty percent student scored 70% and above indicating that students were able to understand the concepts well and could apply acquired knowledge to answer questions correctly. Some examples of questions are given below: a)Why everyone, regardless of skin color, can get skin cancer? b) What are the factors that are responsible for rising skin cancer rate in USA? c) How many major types of skin cancer are there? d) What is the name of the most dangerous skin cancer found in humans; e) Can tanning salons damage your skin? and f) Why uv radiation is bad for your skin?

Personal interview of former graduates revealed that their experience with CL pedagogy helped them to become critical thinkers. They have mastered the concepts and know how to connect these information to develop, and synthesize new approach to solve problems. This metacognitive learning helped them to be successful in academic and professional life.

Conclusion

Connective Learning (CL) technique is an effective mode of instruction that enhances critical thinking and problem solving skills. This technique has been used for number of years with great success however, the technique needs to be evaluated through the scientific rigor and statistical analysis that it deserves. This process is under way. This limitation does not negate the validity and efficacy of this powerful instructional tool.

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