Fostering Critical Thinking and Student Participation in Biological Sciences

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Recommended Citation
Ribot, Emeline J. (2011) "Fostering Critical Thinking and Student Participation in Biological Sciences," Teaching Innovation Projects: Vol. 1: Iss. 1, Article 10.
Fostering Critical Thinking and Student Participation in Biological Sciences

Summary
Instead of giving a lecture that can discourage both students and teachers, let’s try a different way of teaching Biological Sciences by using student participation and critical thinking techniques. Science professors usually perform power point presentations that include hundreds of slides in regards to a specific topic lasting about 2 hours without a break or interruption by student questions. Studies have demonstrated that students, when they participate in class, will memorize information for a longer period of time and develop critical thinking skills. Thus, an interesting approach would be to make students more involved in the course by having interactions between teacher(s) and the student body. To achieve this, analyzing experiments that have been published in international journals would make the course more realistic, and would also allow the students to understand what clinical and academic research has benefited our progress and knowledge base in the field of interest.

Keywords
critical thinking, analyzing research, active learning

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Objectives

The main objective of this course is to demonstrate that student participation in class induces a better learning base. From a student’s point of view, this type of teaching process will enhance their maturity when learning while inducing a more active and positive way to apply their newly acquired knowledge. The benefit for the teacher would be to interact more with their students by becoming a guide or mentor instead of plainly talking and not getting the feedback desired.

Summary of Relevant References


It is explained in this paper that the main purpose of education is to allow students to become independent from their teachers. The purpose of the teacher is to teach the basics and thus allow the student to “go beyond what is currently known and make their own contributions to the field.” Critical thinking can be defined as the “opposite of illogical/irrational thinking.” You require several skills to become a critical thinker such as:

1. Interpretation: to clarify and decode the significance of events, data, etc.
2. Analysis: to examine ideas/data and find relationships among them
3. Evaluation: to assess the credibility and the logic of statements/data
4. Inference: to build hypothesis, find relevant information, and draw conclusions
5. Explanation: to present and describe in a coherent way the results to make them understandable

To be a scientific researcher, a person needs to possess all of these skills. Critical thinking can be used in many different situations but there are two specific examples of its’ use. The first example is when an immediate decision or action has to be taken or decided upon. While the second situation, involves not having the time to consider all of the possible options before making a judgment.

Reynolds KC and Nunn CE. Engaging classrooms: Student participation and the instructional factors that shape it. Annual Meeting of the Association for the study of higher education 1997.

Although student participation in the classroom doesn’t affect the ability to learn specific information compared to a lecture, it has been related to an increase in critical thinking, problem solving, and the perceived value of the course.

Teacher behavior has also proven to affect student participation in the classroom. A more efficient learning system for students has been shown in many studies by eliciting the students to answer questions, make comments, do classroom activities, and attempt to get the student body interested in the subject matter. To encourage participation, students confess that they need “praise and humor [from the instructor] with a supportive classroom atmosphere”. For younger, freshmen students, there is more willingness and interest in having more interaction time during class compared to that of graduate students who would prefer no more than 20% of class spent in participation. This style of teaching is not as popular among teachers because they often have a
hard time tolerating different opinions and fear the students will talk amongst themselves while spreading opinions/rumors about their work. Graduate students are more focused on test scores and graduating numbers whereas younger students need social affirmation and validation.

Barrows HS. Problem-Based Learning in Medicine and beyond: a brief overview. New Directions for Teaching and Learning 1996; 68:3-12

Barrows took the example of medical schools to point out that students become bored because there is too much information to learn with little relevance to their future career path. It was also shown that the students had usually forgotten what they learned the year before. However, the same students were extremely interested in their practical courses, when they were working with patients in a more “hands on” and interactive environment. So, from this information, Barrows deduced that a new method to improve the clinical reasoning and problem-solving process should be designed.

The method described is based on several principles such as:

1. Learning is student-centered.
2. Teachers are guides that ask students questions to better understand and manage the problem.
3. Problems are vehicles for the development of problem-solving skills meaning that the problem will be introduced to the students in the same way that it occurs in the real world providing the relevance and motivation for learning.
4. New information is acquired through self-directed learning implicating that students work together, discuss, compare, review and debate what they have learned.

The educational objectives of this method are:

1. The acquisition of an integrated knowledge base, which allows the skills and information acquired to stay within long-term memory.
2. The development of an effective and efficient problem-solving process by presenting students problems that contain most of the information needed to analyze and resolve the issue.
3. The development of effective self-directed learning skills.
4. The development of team skills.

One advantage of this method is that students were more interested in the subject matter and they went deeper into the course material than the teacher had anticipated. A second advantage for the teacher was that they could follow the student learning process, adapt their courses during the semester, had time to intervene with students who were having troubles with the subject, and able to work with the more motivated students.

This method has already convinced teachers and students of its validity.

In this paper, the author pointed out that students usually learn word by word in a given lesson. This induces 3 drawbacks: they don’t recognize what is important, the learned material is only stored within the students short-memory and they are not able to apply what they have learned in a different context. The psychologist explained how learning by means of memorization led to failure for the student to transfer information, whereas to learn by understanding led to success in the transfer of knowledge to a different context. This is called “meaningful learning” which includes “knowledge acquisition” and “knowledge understanding”.

To make students learn efficiently, teachers have to assimilate students as “sense makers” where the students are active participants in the classroom. The students need to use the information the teacher provides them, use their previous knowledge, and then use cognitive processes to understand and solve a problem.

The author described a selection-organization-integration (SOI) model. To help explain, “sensory-memory” briefly stores incoming information, “short-term memory” stores information for a short period of time and “long-term memory” is permanent storage. Between “sensory-memory” and “short-term memory”, there is a step of “selecting” which is necessary to achieve the described model. This process consists of selecting relevant information within a classroom setting. For students to process information for a short period of time, they have to organize it by creating a coherent structure linking all the information together. Then, an “integrating step” is necessary to hold the information permanently, which then allows the student to link the information to previous knowledge.

Teachers can help to achieve this in 3 steps:

1. It has been shown that “discussing choices and methods used by students and teachers for selecting important elements” is essential. This was shown by Bloom and Broder (1950) by allowing students to model the cognitive process of experts, for example teachers, by listening to experts describe their cognitive processes while performing academic tasks.
2. Students can be asked to build a coherent cause-and-effect explanation for a problem they are facing, and compare their outcome with problem solutions derived by experts in the field of study. This step will improve their information-organizing process.
3. It has been shown that explaining something of a specific nature has been recognized as a critical learning strategy, teachers can encourage the process of integration by asking students to make elaborations or to generate self-explanations.

Content and organization

**Introduction**: Why increase student participation in the classroom? (15 minutes)

Introduce myself (where I work, how to reach me by phone and email, my university background, etc.)

Give the learning objectives: Make teachers realize that student participation will benefit student learning and allow them to enjoy teaching. Furthermore, show them that adding student participation in the classroom is easy to apply to what they have already prepared for their course.

Cite Facione: “Teach people to make good decisions and you equip them to improve their own futures and become contributing members of society, rather than burdens on society”.

Published by Scholarship@Western, 2011
Cite Reynolds et al: “Approximately 25 years of research has supported the premise of a positive relationship between college students’ verbal participation in class, motivation, satisfaction, learning, and problem solving ability”. Explain the article.
Cite Mayer: “Many students can remember much of the information in the passage but cannot use the information adequately to solve problems”.
Cite Barrows: “The Gestalt psychologists provided numerous examples of how learning by memorizing led to failure to transfer, whereas learning by understanding led to success in transfer learned material to different contexts”. Explain the article.

**Body of Presentation:** How to increase participation in the classroom? (25 minutes)
Explain the SOI model by Mayer
From the same paper, explain the teachers’ role.

**Example in biology:** The Cancer Stem Cell (30 minutes)

Cf Microteaching number 1
In a few slides, give an introduction of cancer, metastasis and the hypothesis of the role of Cancer Stem Cells in metastasis formation.
Then, show main figures from international papers, explain the experiment and ask for the conclusions from the students.

The first time, I will give the conclusion myself in order for the students to understand what I want them to do. I want them to select/find the main results, organize it in the Cancer Stem Cell hypothesis and integrate the results in cancer/metastasis context.
This step should needs to be done as it was found by Bloom and Broder (1950) that “an effective method of promoting transfer was to allow novices to model the cognitive process of experts by listening to experts describe their cognitive processes while performing academic tasks”.

Repeat that several times, give clues to the students in order to help them find the process of how to “read” an experiment and find the main conclusion.

Example of one slide from my presentation:
I will explain the research performed by Naumov et al in 2002. In this study, they injected human breast cancer cells that express a fluorescent marker, in mouse mammary fat. After 2 weeks, they found fluorescent cells in other organs of the body, for example, the liver. They took these fluorescent cells from the liver at different time points after injection, and assayed the samples to measure cellular viability, the presence of death markers, and the cell proliferative state.

At this point I would ask “What do these experiment show?” This will allow for student interaction.

The answer I would be anticipating would be something like: the researchers found that some cancer cells can disseminate in the body and travel to other more distant organs compared to where the cells were primarily injected. From the assay data, the students should draw the conclusion that the cells that disseminate are viable but are not proliferative.

I would have them draw more conclusions for this experiment. The primary conclusion is that some cancer cells can stay dormant for a month. This could be a clue that Cancer Stem Cells are involved in metastasis formation years after the primary tumor has developed. Finally, allow for the discussion of all the experimental conclusions provided by the students that lead to explain why Cancer Stem Cells might be necessary in metastasis formation. As an example, a student could say that the research showed that the cells have the ability to disseminate and stay dormant.

**Conclusion:** (10 minutes)
The most effective method for teaching students how to make sense of expository text is to allow them to participate in selecting, organizing, and integrating information within the context of authentic academic texts.

**Bibliography**

**Questions/comments:** from the audience (10 minutes)

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**Presentation Strategies**

**Learning styles:**  
Concrete experience by personal involvement  
Reflective observation by brainstorming, sharing ideas  
Abstract experimentation by a resume at the end of the course

**Teaching styles:**  
Transmission of knowledge about the CSC  
Nurturing by inducing a discussion between students and the teacher  
Social reform by saying that Research is always running, new discoveries will be made, that Research will affect future therapies.