Preparing students for the transition from a teacher-centered to a student-centered learning environment

Active learning exercises that work at the university level

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Several authors have shown that an active learning environment using student centered activities promotes knowledge and interest in the subject (Lord, 1999; Penick, 1995; Yager, 1991). Constructivist education through scenarios, open-ended questions, debates, cooperative learning are among various teaching strategies that have proven effective in increasing students understanding and ability to apply concepts (Bybee, 1993; Lord, 1998; Modell & Michael, 1993). However, the passive learning environment of the teacher-centered lecture remains the predominant setting encountered by students. Puerto Rico is not the exception to this trend. Efforts to improve science education at the K-12 levels were initiated by the Resource Center for Science and Engineering (RCSE) at the University of Puerto Rico in 1990. Programs such as Science Sequence and Coordination (SSC) followed by a State-wide Systemic Initiative (SSI) have impacted teachers and students in approximately 25 % of our public schools. In addition, the Alliance for Minority Participation (AMP) at the University of Puerto Rico funded by the National Science Foundation (NSF), has promoted curriculum changes in most introductory science and math courses including General Biology. Despite all these efforts, there are two problems that persist at the university level: (1) Science professors are mostly researchers and need training and motivation to implant the new teaching methodologies; and (2) Professors that have already made changes to a more student-centered environment, still receive students that have not been exposed to innovative teaching methods. Recently, Puerto Rico was granted a Collaborative for Excellence in Teacher Preparation (CETP) grant from NSF. This project has a strong professional development component for professors in Education, Science and Mathematics. Hopefully these efforts will help us resolve the first problem mentioned above. In order to deal with the second problem, we must realize that both faculty and students need to make adjustments from their respective 'traditional' roles in the classroom (Modell, 1996). Thus, we focused our attention in the development of activities that helped make the transition to a more student-centered learning environment. The purpose of this paper is to describe some of the activities that proved effective in facilitating this transition.

Activities that engage

As part of the learning cycle, Bybee (1993) suggests the use of an "engage phase" to motivate students about the topic to be discussed in class that day. Engage activities that have proven particularly useful to us are those that make reference to a topic that is relevant to our students. For example: Puerto Rico suffered an unusual period of drought from May to December of 1994. Household's water supply in the Island was limited to 6 hours every two days during most of this period. Within this context, students were presented with the following situation at the beginning of a class on Ecology:

> Upon this period of drought in Puerto Rico, the coqui (common tree frog) populations declined drastically, while mosquitos and grasshoppers increased significantly; however, lizards did not show population changes. Why would a drought cause a decrease in the coqui populations, but not affect lizards? What might have caused the drastic increase in mosquitos? in grasshoppers? Mention 5 possible biological consequences of these changes on the ecosystem.

Students discuss this scenario in cooperative-learning groups for 10 minutes. Then, one group is called to present its answers to the rest of the class, and other groups are encouraged to comment, critique and expand on the subject. Throughout this exercise, students engage in higher level thinking skills such as analysis of a case, application of biological concepts to a real situation, and the exercise of verbalizing and writing an outcome of their discussion.

Activities that increase conceptual understanding

There are several processes in Biology that require thorough understanding of basic concepts before students can apply them and acquire further knowledge. Thus, we have developed cooperative learning activities to facilitate the learning of these processes.

1. One that has proven very effective is a game denominated "Exquisite corpses" in response to practices of the surrealistic movement in the early 1900's (Breton, 1974; Kaplan,1988). The name of the activity, though grotesque, responds to the very first sentence originated during this practice. One of the authors (Nazario) adapted this exercise as a teaching strategy in our Biology classes. Students are provided with an envelope containing four to five words that are related to a biological process under discussion. Each student within a cooperative group takes one of the words. One of the students makes a sentence that ends with the word he obtained; then moving clockwise within the group, each member writes a sentence that starts with the word that concluded the previous sentence, but ends with the word that he obtained. However, students only get to see the last word of the sentence. For example

if the words given to a group are: *chromosomes, centromeres, alleles, crossing over,* and *gametes,* a possible outcome of an "exquisite corpse" could be:

> The genetic material is contained within the chromosomes. Chromosomes after being replicated, are united in a region known as the centromere. Centromeres have the same position in homologous chromosomes, but homologous chromosomes may differ in their alleles. Alleles are interchanged between non-homologous chromosomes during crossing over. Crossing over is one of the events in meiosis that provide variation among resulting gametes.

Upon completion of their "exquisite corpse" the group discusses the logic and scientific accuracy of their outcomes. Two or three volunteers share their work with the rest of the class, and further discussion guided by the professor takes place. This activity provides an opportunity for students to synthesize and make connections between the important steps in a biological process. Simultaneously, the professor is able to evaluate the level of comprehension present among the students, and has the chance to explain difficulties or erroneous conceptions that would have not been obvious otherwise.

2. Another type of activity that promotes understanding of complex concepts is asking students to draw a graph that illustrates a trend. It is useful to select a graph that is not found in the textbook, although we have found that our students generally do not read before coming to class. After discussing the structure and function of the human kidney, students are invited to join their usual cooperative learning groups. They are asked to make a graph that illustrates the change in the salt concentration of the glomerular filtrate from the moment it enters the Bowman capsule, until it is excreted. Groups are provided with markers and overhead transparencies. After 10 minutes two volunteers with different outcomes, are invited to share their results with the rest of the class. This activity provides an excellent opportunity for professors to identify misconceptions, and to suggest ways to improve a graph. In addition, it lends a chance to demonstrate that there are several correct ways to represent a relationship graphically. Figure 1 illustrates two of the graphs made by students in the class.

Activities that promote active learning

The study of the diversity of organisms from monerans to animals requires a great deal of memorization. If professors are not ingenious, the wonders of the evolution of biodiversity could appear boring to our students. To use a student-centered hands-on approach to what could have been a descriptive lecture on animal diversity, we designed an activity that we named "Discover the Animal". Students join their cooperative learning groups, and each group receives a handout that contains four clues to each of the animal phyla. They can consult their textbooks, as well as other resources that the professor may bring to class that day. An example of Mollusca was:

> This phylum includes animals that...
> may occur in oceans, fresh water or land.most have an exoskeleton made of calcium carbonate. Some are considered gourmet food in France. Some of them have the anus located above their head.
> Once they discover the phylum, they must answer the following questions:
> Mention two important evolutionary advances present in this group. Mention three distinctive characteristics that are not shared with other phyla. Type of circulatory system. Type of digestive system. Mention all the taxonomic classes described for this phylum, and give a common name of a representative of each class.

This activity requires a class period of 90 minutes. After the groups work for 45 minutes, the professor may assign a phylum to each group, provide them with 2–3 over-head transparencies of the phylum (those provided by the textbook's publishing house), and ask them to present it to the rest of the class, emphasizing the points they discussed. Upon completion of this exercise, students document that they feel they "discovered the animals" on their own, instead of being told about them, and that it helped them synthesize the great amount of information provided by the text.

Activities that encourage creativity

Once students have been exposed to content material, and have had an opportunity to discuss it with the professor and/or other students in cooperative groups, you can provide activities to encourage their creativity. These activities require the ability to integrate concepts.

1. Plant reproduction in general, and in particular, Angiosperm's double fertilization appears to be very difficult for students to comprehend. The alternation of generations which does not occur in animals, may be one of the reasons for this. Generally, students memorize this type of information but do not necessarily understand it. After several descriptive lectures, students are challenged with the following activity:

> They are provided with several sheets of different colored construction paper, tape, glue, magic markers, and boards, and they are asked to create a model of the flower showing all the structures involved in reproduction such as: external morphology, mature male and female gametophytes, microsporangia, megasporangia, pollen tube, pollen grain, pollen tube cell, sperms, egg, polar nuclei, micropyle, ovary, ovule and integuments.

This activity provides an excellent opportunity for all students to get involved in applying concepts they learned in lectures. The process of creating images of the structures and labeling them with the proper name, allows students to assess their understanding on the topic. With the aid of the professor (who walks around helping and encouraging groups), they identify misconceptions and have a chance to correct them on site. Figure 2 shows one outcome of this exercise.

2. Many contemporary teaching studies advise educators to move beyond teaching the facts, and towards teaching to think about them (Eisen 1998). Ecological concepts such as population, community, and ecosystem have emergent properties, and involve many interactions. It is important that students understand how these interactions work, and how they may change under different biotic and abiotic conditions. Following several lectures on ecological topics, students perform the following activity in cooperative-learning groups.

"Describe an animal or plant **population** of your choice.
Specifically describe and justify the following points:

biome where it occurs
population density
dispersion
type of intra-specific competition that takes place, and why?
main predators
three types of defense mechanisms they may use
if it is an animal, main prey items

How does an increase in the population density, affect the population density of their prey? their predators?
mention three density independent factors that may affect this population, and how?"

Once students select a population, they realize that all other factors mentioned above are connected, and that they must transport themselves to the geographical area where the species occurs in order to provide scientifically correct answers. This activity fosters understanding of concepts such as dispersion, competition and predator-prey interactions in the context of the biology of a particular species.

Activities to review material

Whether it is after a difficult class discussion, or before an exam, students always benefit from the opportunity to review mayor concepts with their classmates. We provide a variety of activities for this purpose:

1. **Biology Bees** - we elaborate a long list of numbered questions that incide straight forward content answers, as well as those that require higher level thinking. The class is divided in two groups, they pick a name for the

group, and organize themselves in circles to be able to interact better. A student from one of the groups is called out at random from the roster and draws a number that corresponds to a question in the list. The professor reads the question out loud, the group discusses for the next minute, but the student that was called out is responsible for deciding and providing an answer. If the response is incorrect, a student from the other group gets called out from the roster and gets an opportunity to answer the same question immediately. The process is repeated in sequence, making sure that every student in the class is given the chance to answer a question. Points are given for correct answers and tabulated in the board. Although competition has been discouraged from the classroom settings, students seem to enjoy this activity because it does not single-out individuals, but emphasizes the group effort. At the end of the exercise, all students receive a written copy of all the questions.

2. **Fill-in jamborees** - These are handouts with lots of fill-in-the blanks that are prepared for different purposes. Word puzzles, cross-word puzzles and half-done flow charts serve this purpose. These activities are particularly helpful to exercise the use of biological jargon that students need to learn and apply, and to master definitions of key terms. An example is provided in Figure 3.

Discussion

During the process of developing and implementing these activities, we realized their value not only as a transition tool to a more student-centered environment, but also as a source of professional development of our teaching careers. We learned how to design these activities so that they will serve a specific purpose: engaging, increasing conceptual understanding, promoting active learning, encouraging creativity and reviewing content material. In addition, we learned that it was feasible to do this, with a large group of students that had not been exposed to this type of teaching before. This increased our confidence as professors, and convinced us that this methodology, although time consuming, is worth the extra effort. Assessment instruments revealed that these activities: (1) promote biological literacy in students, (2) increase students confidence with respect to biology, (3) increase conceptual understanding and applicability, and (4) provide an opportunity to show that science can be fun. This was evidenced through student evaluation forms, oral and written presentations by the groups, one-to-one discussions between professor and groups and the quizzes offered to evaluate knowledge gained from the activity. Furthermore, the enthusiasm expressed by our students aroused curiosity among: (1) other students who would audit our classes, and (2) other faculty members in our Department, who were eager to learn about what we were doing.

Our experience has empowered us to make further changes in the way we teach. We are in the process of preparing classes in Botany and

Zoology, as well as in General Biology that will strictly focus on constructivist-based cooperative learning. We have received the administrative support of our Department to make these changes, and in the near future we expect to impact a larger number of science students, prospective teachers and researchers. In addition, we are willing to serve as mentors and trainers to other faculty members that are determined to modify the way they educate.

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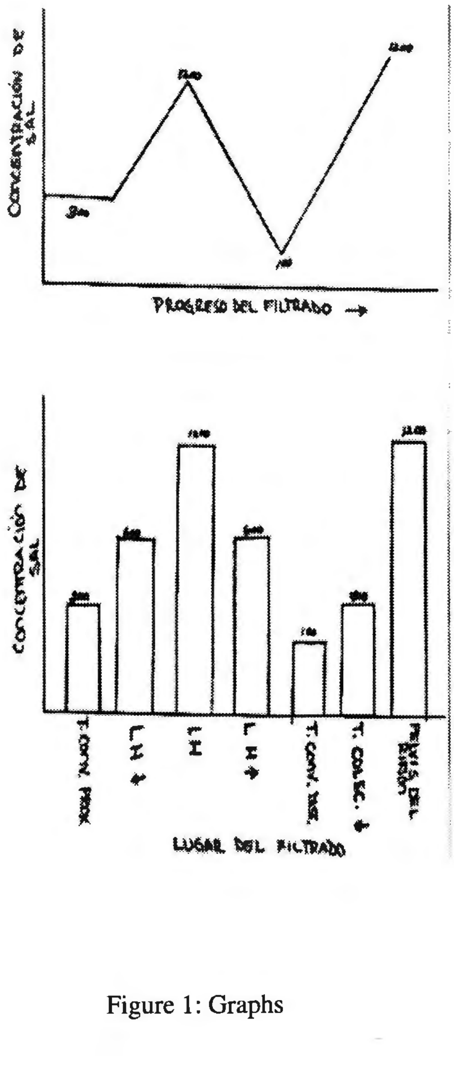

Figure 1: Graphs

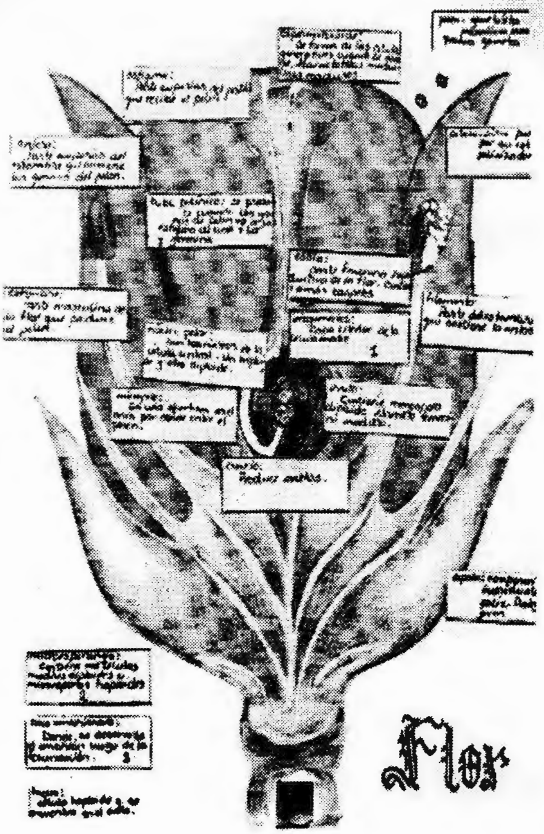

Figure 2: Flower

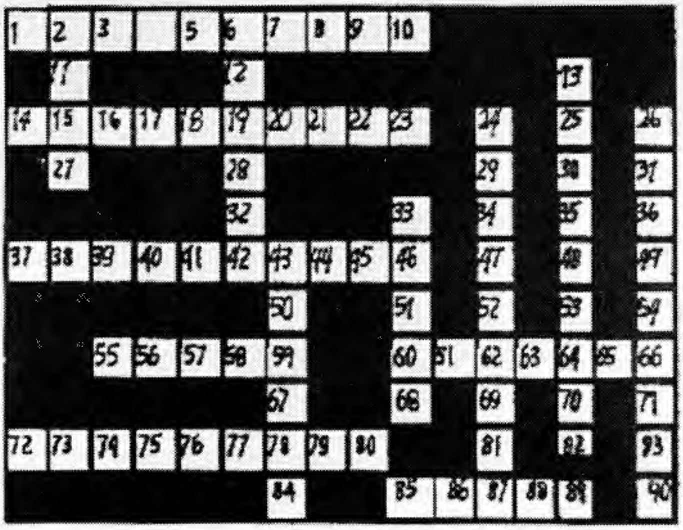

Figure 3: Cross-word puzzle