HANDS-ON PHYSICAL SCIENCE COURSE AT RADFORD UNIVERSITY

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Most students in our introductory physical science course are elementary education majors. We are faced with several obstacles in teaching basic science to these students. For example, they lack interest in science, logical thinking, and necessary data gathering and analysis skills, among others. Many of those obstacles could be traced back to the science courses they had taken in the past. Those courses put more emphasis on memorizing scientific facts than understanding natural phenomena or experiencing scientific methods. As a result, the students tend to have a negative attitude toward science in general.

In order to reverse this attitude, we have been developing a hands-on, experience based physical science course. In each class students are asked to perform several experiments which require observation, data gathering, and analysis. The instructor provides necessary scientific background and explanation on the experiments as they go. One of the experiments the students enjoyed a lot is the measurement of average speeds of cars. They actually go out on the street and take data. Through this course students can experience how science works and learn that science could be more exciting than just memorizing.

Physical Science 350 at Radford University is an introductory science course that covers a broad range of subjects including physics, chemistry, astronomy, and biology. There is no prerequisite to take this course. About 90% of students taking the course are elementary education majors. It is a part of their degree requirement to take at least three science courses. Teaching basic physical science to these students poses several obstacles to us.

The biggest obstacle is probably the education majors' lack of interest in science. They are not very excited to be in the class. To put it simply, they hate science. It is very difficult to teach anything to unmotivated students. Also, there exists a general math phobia among the students. They fear mathematical equations and are not very competent in basic algebra. For example, many students had a hard time solving the equation, speed = distance/time. They can calculate speed given distance and time, yet they get lost if they are asked to find time or even distance when given this equation.

Another problem with the students taking PHSC-350 is that they do not have the right problem solving skills. They do not look at problems in a systematic way or arrive at logical

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conclusions from their observations. They also lack data gathering and analysis skills. For example, they have difficulty constructing a table of data that presents the data in a clear manner, and they also have problems simply graphing the data from such tables.

Many of these problems could be traced back to the science courses the students had taken in the past. According to the students, those courses emphasized memorizing scientific facts rather than either understanding how things work or applying scientific methods. These courses introduced many abstract concepts and the students had a hard time applying those concepts to everyday phenomena. In addition, the students could have been weak in math to start with and that may have pushed them toward less math intensive sciences such as biology. In fact, many education majors take biology courses instead of physical science to fulfill their degree requirement for the stated reason that they were deliberately avoiding math. Only a few had taken chemistry and none had taken physics in our class.

All these factors add up to the students' negative attitudes towards science in general. In order to reverse this attitude, we at the Department of Chemistry and Physics at Radford University have been developing a hands-on, experience-based physical science course. Our foremost objective is to make science more fun to the elementary education majors. Unless they enjoy science, their future students--when they becomes teachers themselves--are also not going to enjoy science.

Secondly, the students need to "do" science. They need to perform laboratory experiments by themselves and observe outcomes with their own eyes. Along the way, they need to pick up qualitative observation skills, measuring skills (using metric units!), data gathering and analysis skills, and how to reach logical conclusions. The students need to go through the entire scientific method by themselves without the instructor dictating every step of the way.

The experiments should not require any fancy setup. The students could be intimidated by the sophisticated instrumentation alone. Rather, the experiments should be simple and easy so that the students could repeat them at home or in their classrooms using common household items. The students should find out that science does not need fancy equipment.

Finally, as many everyday applications as possible should be presented. By learning how

things work, the students would be able to see usefulness in and applications for science.

To achieve these objectives, we have set up the PHSC-350 in the following way. In each class students are asked to perform several experiments which require observation, data gathering, and data analysis. The instructor provides any necessary scientific background and explanation for the experiments as they go. Lecture time is typically no more than 15 minutes. The students either get bored or lost if the instructor keeps talking. Sometimes the lecture is given at the beginning of the class, sometimes during the middle, and sometimes at the end. It depends on what is appropriate for the lab. The students are required to keep journals of what they did in the class.

Because the students are not very excited about science, we try experiments with unexpected or dramatic outcomes, such as a change in color, something that makes noise, or something game-like. These experiments tend to be more "do it once and see" and less repetitive. However, we try to make the experiments more quantitative whenever possible and introduce many data analysis skills including the construction of tables of data, calculating average values, and plotting data. Also, we have them use simple instruments such as rulers, stopwatches, scales, and graduated cylinders.

The experiments are chosen so that the students could relate them to everyday phenomena. One of the most popular experiments is the measurement of average speeds of cars on a street. They go outside, pick two points on the sidewalk and measure the distance between them with a trundle wheel. Then, they time how long it takes for a car to travel between those points. In class they are asked to calculate the average speed of each car and find the average value for 10 cars. The students enjoy this experiment because they can see how the definition of the average speed is used and they are able to measure the average speeds by themselves. We have developed a lab manual containing nearly 40 similar experiments covering physics, chemistry, astronomy, meteorology, and biology.

To evaluate each student's performance in class, we emphasize exams less and put more weight on homework problems. We try to emphasize problem solving and analyzing natural phenomena more than memorizing facts. Also, the lab notebook occupies a substantial portion of the total grade. Grading lab notebooks encourages students to pay more attention

in class, to go over the notes and complete them after class, and to come to class and do the experiments. In the future, we will be evaluating the development of the experimental skills of the students.

After one semester, the reaction of the students has been very encouraging. The most common comment in the student evaluation forms is that they liked the class because they "did" many experiments. That's exactly what we were hoping to hear. In the future, we would like to put more inquiry based teaching methods and interdisciplinary projects that involve many different concepts in physical science. ■