A Different "Discovery" Approach

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With the introduction of new “discovery” type courses into many school curricula, I expected that many students who were previously bored by traditional classes would now be stimulated and excited by the new, more involving approaches to classroom work. However, when I began working with students in an Upward Bound program (and acting as counselor and confidante to others), I was surprised to learn that many of the students who had been exposed to these new, progressive science classes found them as dull and boring as the more traditional classes they were supposed to replace.

Last year, as I prepared for my first regular teaching position as a high school physics teacher, I began asking myself questions about my own educational experience. I hoped to find some clues to use in planning my physics classes that would make them more than just another dull school experience.

As I looked back on my high school and college science classes, I remembered how unexcited I was about the required lab experiments—now I laboriously would follow, step by step, the directions to an experiment; how relieved I was when it “came out right” so that I could then forget about it. Although some of the lab courses I took were supposedly “discovery” type courses, the procedures were so strictly laid out that there was no opportunity for real experimentation or innovation. As I was interested in learning about science (and physics in particular), and feeling frustrated by my regular class, I requested permission to use the lab after class hours to carry out some minor research projects in which I had a special interest.

Needless to say, I became very involved in these projects of my own initiation, and though I occasionally ended up with results similar to those required in class, the freedom to set up my own experiments in my own way, making mistakes and learning from them, progressing in any manner I wished, made all the difference to me. I was vitally involved and interested in what I was doing, for I was my own boss.

It was with these thoughts in mind that I began structuring classes for my students. For the moment, I would follow a more traditional approach in our lecture-discussion sections and use the Harvard Project Physics materials to generate discussions, demonstrations and provide a coherent flow of topics. It was in the lab periods (which constituted most of the class time) where I decided to try something more innovative. Rather than adhere to any text, in various ways I would try to encourage as much freedom and choice as possible.

We began with a unit on kinematics. At our first lab session I told the students we would be studying moving objects for the purpose of describing their motion. I then defined speed and showed the class how to use instruments that measure speed, demonstrating a stroboscope, a polaroid camera and a PSSC paper tape timer. Then I told the class they could pick any moving object they wished for study, and pointed out that they could choose unusual as well as usual subjects, such "How does the human body move?" "What are the different parts of the body doing when a person walks?" Or, "How does a fist about to hit something move?"

I divided the class into small groups and asked each group to choose a subject for study and then design an experiment to study it. One group of three high school seniors became interested in comparing the movements of a wind-up baby doll with the movements of a person.
Using the paper tape timer, they described their experiment as follows: (The account and illustration are taken directly from their lab report.)

"A Study in Motion-In this experiment a wind-up crawling baby was set into motion while having its speed and pattern of speed measured with a "clicking" apparatus. This apparatus is composed of a metal "clicker" which indented the paper tape being pulled through and under it every 1/60th of a second. By measuring the space between the indented dots on the tape, not only could the rate of speed be established, but also how constant and inconstant it was. A human crawl was also used, and each of the representative crawls were compared by a graph."

"...The doll seems to slow, jump, slow, and jump, etc. Again, as best we can determine, this rapid acceleration occurs when the weight of the object is transferred from the forward hand to forward the foot"

"...In taking this profile (a tape showing the speed of a person crawling) I attempted to follow the sequence of movement of the doll. Thus, the doll’s mechanism is designed to copy that of a person..."

Another 12th grade student wrote this description of herself skating while three classmates studied her motion in detail:

"...Perhaps I should give a physical picture of what is going on. The little block of wood on wheels is under one foot while the other foot is acting like a pusher or pumper. Starting at a time and distance zero, the 'pusher' takes a step and then distributes the weight to the cart foot. The wheels roll, then again, the weight goes back to the 'pusher,' and again back to the cart foot. The wheels go a little further and a little faster. This goes on frantically in scooter style for maybe two intervals since the cart and foot are rather awkward and the wheels are rather independent... ."

Other groups took for their subject of study various falling and rolling bodies, the acceleration of a rubber-band driven airplane, the speed of an oscilloscope trace, a spark from a Van de Graaff electric generator.

Better than two-thirds of the total class time was spent in the laboratory. At the beginning of each two- or three-day lab period, I spent five to ten minutes describing the equipment or instructions for laboratory
and being generally helpful where needed.

I think the essential difference between my approach and the more usual science classes stems from my belief that a student would learn more from attempting to structure a simple experiment on his own, than from an elaborate experiment that was set up for him. Let me explain.

The “discovery” method of many new physical science curricula is a method whereby the student is expected to “discover” some known scientific principle such as the existence of atoms or the relationship between force and acceleration. In designing the laboratory activity for the new curricula, those activities which could be influenced by variables other than the one being tested are often rejected as being simply confusing; and simpler lab activities are continuously being sought. The result may be a set of nearly “perfect” labs in which the major task for the student becomes understanding the directions. Furthermore, it seems that if students are expected to “discover” fundamental principles of science through experiments, they must be led very carefully and surely through the two or three centuries of research relevant to that topic. The very sureness of each step often destroys the sense of discovery. And, the “discovery” is really not the student’s at all, but the scientist’s whose work he is studying.

My goal is for students to truly discover how phenomena “work,” in their everyday environment, and while this may be a less ambitious goal than having a student “discover” conservation of momentum through a planned experiment believe a student actually learns more about how a scientist works by this method.

For, in allowing students the freedom of choice in the subjects they choose to study and, at times, freedom in structuring their course, this opens up a whole new realm of problems that the students must deal with. Not only do they have to figure out what the teacher wants, they must also decide what is important or simply interesting to themselves. Then, as they go about designing an experiment, say, to study the motion of a lame hamster or the physical properties of cornstarch mixed with water, they have very few instructions to tell them what to do. They must invent models, isolate variables, predict results and draw conclusions. In short, the students have to exercise the same mental processes that any scientist would, albeit the problems a scientist deals with are more complex.

I felt it would be a mistake to immediately make unlimited possibilities available to my students, for it is a rare student who knows where to begin. I decided to start with a structure that allowed for some measure of freedom and choice, and as time went on (and, I hoped as interest increased), leave more and more of the decisions on how to spend lab time up to the students themselves. For those few students who were unable to make free choices, I did allow them to use standard labs from the Harvard Project course. This textbook was always available if students chose to use it, and although many students followed the standard lab instructions for some of their projects, by the end of the year nearly every student had completed at least two or three original experiments.

Though the students who followed lab instructions had the opportunity to deal with some experimental difficulties, they gained a great deal more experience with the problems of research and experimental design when they worked on more original projects.

Near the end of the year one student, who previously had only rarely become involved in any class activity, mentioned that he had noticed that bright stars appear to move around in the sky, even though he knew that it was impossible. This led to an experiment which he and a another student designed to measure their classmates’ perception of the motion (or non-motion) of a tiny bright light in a blackened room. The students learned about recording data, how to use pilot studies to design an experimental procedure, as well as a lot of factual “by-products” such as the variation of dark adaptation time for different people and about the very low light levels that people need to “anchor” the light bulb visually in the room.

Another important learning experience in our labs came from my practice of assigning students to laboratory groups of from two to five people. I find this encourages tutorial-type relationships to occur within the lab groups. As students worked together in lab groups they would often divide the labor. A particularly gifted artist would draw diagrams for the lab report while the “engineer type” student planned the experiment or drew conclusions. Although this separation of functions might imply that some students avoided being involved or thinking through the problems, I in fact observed a great deal of discussion and peer teaching going on as the students set up and manipulated the lab equipment and prepared reports. Just seeing how different people think and solve problems in a small group setting was in itself an important learning experience.

Towards the end of the year, the class was spending most of its time in the lab. In addition, many functions which I had retained at the beginning of the year were now being decided by the class, such as what kinds of exams they wanted and when, what kind of reading schedules should be set up, etc. Some students indicated they had become involved in science labs for the very first time in their school experience, and general interest in the class had increased considerably. I do believe that by allowing students choice whenever possible, their motivation and interest were substantially increased.

Ed. Note. Mr. Sneider is interested in hearing from readers about other possible discovery approaches they have used.