# Teaching and Learning

Frank Oppenheimer, Exploratorium
Address to PTA, Pagosa Springs High School, 1957

*In 1957, Frank taught biology, chemistry, physics, and general science at Pagosa Springs High School in Colorado. In this address to the Pagosa Springs PTA, Frank describes his motivations and objectives as a high school science teacher, the same motivations and objectives that eventually resulted in the development of the Exploratorium.*

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Mrs. Richards asked me to help out with the PTA program this week. Since last week was occupied by tests it seemed impractical to organize any sort of a student demonstration. I therefore decided that it would he useful for me to try to formulate some of my objectives as a science teacher, and that my thoughts on this subject might possibly form the basis of some discussion at this meeting.

I believe that the major reason that I want to teach is to communicate my appreciation of and skill in science to the children. This motive is a simple motive, not very different from someone who exclaims to a companion while driving down the highway, "Look! There go three elk." I enjoy seeing elk and I thoroughly enjoy being able to understand natural phenomena, that is, being able to explain apparently complicated or new happenings in terms of simpler, more familiar, and perhaps more universal occurrences. I like knowing that the pressure on the walls of this building is due to the momentum of the countless molecules of air that bombard the walls and I dislike not knowing why the steer market was higher two weeks ago than it was a month ago. There are many who have no particular desire to communicate their pleasure in understanding except to a very few and who feel that teaching is a chore which interferes with research. I have at times felt that way, but for the most

part I like to tell what I know to anybody who will listen long enough. This rather obscure pleasure of communicating is, I suppose, not unlike the urge of a pianist who, having mastered a sonata, is anxious to play it over and over again to scores of audiences.

I suppose therefore that the first thing I try to do as a teacher is to get my student to understand so clearly some phenomena or device, such as the twinkling of a star or the ring of an electric bell, that they realize that understanding, like eating or making a basket during a ball game, is satisfying and fun. If I can succeed in making understanding seem like fun then I believe that the student will want to understand many things, that is, he will

become curious. If I can establish a pattern in a student of satisfying curiosity, by showing him that understanding is both possible and amusing, then perhaps the course I am teaching will have the effect of enriching his whole life. It may also make him a more useful and more sympathetic person.

I believe that another motive I have as a teacher is to prepare the students for further learning. Although I know that in reality many of the students may not learn one more thing about science than they find in my biology course, I find that I teach everyone as though they were going to continue learning the subject. The general science students may take a course in physics; the chemistry students may study chemistry in college; biology students might want to read a veterinary handbook. Thus, as I am teaching, I find that I have in the back of my mind what the content of the next course in the subject will be. I want this next course to be easy for them, but I do not want it to be entirely "old stuff." I find this distinction very hard to draw. Parts of subjects that I do not particularly enjoy, such as metallurgy in the study of chemistry I tend to under-teach, even though the students may need the knowledge. Parts of a subject that seem to me especially elegant, such as physical optics, I try to teach even to freshmen, though the subject could more profitably be introduced at a later date. But the line is hard to draw because a certain amount of fuzziness and puzzlement is probably good for the more advanced students.

Finally, I try in my reaching to give the students a sense of power to actually do something: to teach them, for example, to get numerical answers, bend a piece of glass, recognize a Spirogyra when they see one, or solve an unfamiliar problem. I think that I find this last objective hardest to fulfill.

Yet most people, and adolescents especially, are eager to become proficient in as many things as they can. In fact a frequent interpretation of education is limited solely to the belief that students should learn how to do things. One of the important aspects of sports is that they enable a substantial number of kids to become really good at something: catching a pass or pitching a bail or working with a group. I believe that a great many students enjoy and are helped by algebra because of the delightful opportunity for proficiency it affords in solving equations. Shop work, sewing, writing book reviews, typing, language courses, band and art are all important, not only because of the useful skills they teach, but because in each one a different group of students may find that they can do something well,

Therefore, as a science teacher, I know that I should allow the students to become proficient in as many ways as possible. There are many techniques in science. There is the manual dexterity of setting up and performing experiments, the mental dexterity of solving numerical problems, the technique of observing the results of an experiment and noticing, for instance, what a leaf or a nerve really looks like. And finally, there are the techniques of plausible reasoning, of putting together known facts and relationships to arrive at new conclusions. Now as I mentioned earlier, it looks as though I will succeed in making an alarmingly small number of my students proficient. Others in school may share my difficulty, but some of my problems are specific to science teaching and I would like, in concluding, to outline them.

One of the difficulties I encounter is the enormous variation in the initial ability of the students. If I give a test which covers the ground I have tried to teach, and it does not seem to matter which subject or class, the grades usually run from about 20 to 140 out of a possible 160. This range is greater than the intelligence range of the students and must reflect a cumulative effect of intelligence, motivation, and health. Since this spread exists very markedly in the mathematical ability of the students, I have difficulty in cultivating problem-solving proficiency in the students. It is as though one had to teach children both how to climb steps and how to pole-vault with just one set of instructions.

Secondly, teaching the many laboratory skills of science requires either money or time to devise, set up, and supervise the use of the laboratory equipment. I think it is harder to find money than time, but I can't find much of either.

And finally, I do not really know how to teach children work out problems for themselves. I can give them a problem to work out and say "think." But this procedure is about as effective as saying "wiggle your ears." I cannot tell them how to think, which nerves to use. Alternatively, I can have them follow me step by step as I reason something out, trying to let them get one step ahead of me. But usually the effect is about the same as if I had shown a small child how to saw a piece of wood by standing behind him and making his arms move the saw. The child would know what is required of him and what the motions are, but lie still could not do it himself. In short, how does one best teach the most satisfying of all proficiencies: the ability to fashion a new idea.

In discussing the aspects of my teaching - the kindling of curiosity by discovering the pleasure of understanding, the preparation and stimulation for further study, and the satisfaction of becoming adept in the processes of the hand and the brain - I have emphasized the enriching of the student's individual life. It would he easy to argue that these same aspects would make him a more useful scientist.