Personal Views of the Beginnings of PSSC and My Film Experiences

by John G. King

Introduction

I can't find the reference, but somewhere in the collected letters of Evelyn Waugh he says in effect, apropos of a memoir, that he can remember things with perfect clarity, and he's sure that they're completely wrong. I can't remember what I write of here with perfect clarity, but I don't think it's absolutely wrong.

I spent three 1943 summer months at MIT as a freshman, and returned there from the Navy in fall 1946. I interacted most with Sanborn Brown and Jerrold Zacharias and attended weekly evening seminars run by Zach on all sorts of physics topics. I did a senior thesis in 1950 (suggested by Brown: detect hydrogen atoms in an atomic beam by attaching electrons to make H^-; it didn't work for me) and a doctoral thesis in 1953 (the hyperfine structure of the stable bromine isotopes), both supervised by Zach, except that he was rarely around. He had had important engineering and administrative roles during WWII, first at the MIT Radiation Lab where much radar development took place, and later at Los Alamos. Both places were manned by what he called the "first team". After the war he directed or participated in about 10 projects and summer studies, mostly dealing with aspects of national defense during the cold war.

Zach was often away from MIT and was not paying much attention to the lab he had set up to continue work with molecular and atomic beams, extensions of the beautiful work he had done in I. I. Rabi's group at Columbia before the war. I was the one who put in the 80 hour week he believed was necessary to get experiments going – experiments that were "like driving the chariot of Ben Hur". I taught unpopular Wednesday/Saturday morning sections of introductory physics, so that I could get back to the lab for most of the day. An incidental benefit was frequent Saturday lunch with Zach and people visiting him, the most memorable being Rabi and Edwin Land.

Zacharias' Ideas and Their Roots

MIT had started a program of faculty visits to high schools across the country to tell guidance counselors and students that MIT had (and has) 1) scholarships, 2) athletics, and 3) smart and energetic students but not necessarily extraordinary (as expressed at the time "you don't have to be Einstein"). In the fall of 1955 I was sent to New Jersey, stayed in 3 hotels over 5 nights, and talked to people at 20 schools. Meanwhile Zach went to Oklahoma on a similar mission and returned deeply upset. He had found that students were convinced that the earth was round but had no idea of the basis of their belief beyond having been told.

I remember some Saturday lunches with talk about Zach's Oklahoma experience, the weak preparation in physics of MIT freshmen, and Land's strong belief that short movies could eliminate the feel of a lecturer reading from dry and dusty notes while capturing the vital element of the presentation. Land's feelings about the importance of the visual in education were hardly surprising considering his photographic passions. I heard much talk about what might be done to improve high school science, eventually laid out in a

~1200 word memorandum: Date: March 15 1956; From: Dr. Jerrold R. Zacharias; To: Dr. James R. Killian, Jr. (then president of MIT); Subject: Movie Aids for Teaching Physics in High Schools. I will quote part of it (the entire memo is Appendix B in *A Different Sort of Time: The Life of Jerrold R Zacharias* by Jack S Goldstein. MIT Press, Cambridge, MA, 1992). This was all unknown to me until a couple of years later when I was given a copy of the memo.

> In an effort to improve the teaching of high school physics, I want to propose an experiment involving the preparation of a large number of moving picture shorts.
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> In order to present one subject, say physics, it is proposed that we make 90 films of 20-minute duration, complete with text books, problem books, question cards and answer cards. Each of these points requires some discussion but, before taking up the detailed mechanism, it is necessary first to look at the subject matter. Success or failure depends to a large extent on having the entire apparatus of the experiment really right. Like a high fidelity phonograph, one must have besides the machine a good piece by a good composer played by an artist. The room must be good, not too noisy, and the people have to want to listen, but that all depends upon the piece.
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> Physics is a new science, so new that it is hard to remember that this concept of atomic number was completely accepted only just before Moseley's death in World War I. The tidy notions of classical mechanics still predominate in the way we try to introduce the subject of physics and it usually happens that these notions are dull as presented because it is so difficult to present arresting experiments to liven them up. Because one needs to understand many of the basic ideas and mathematical methods before gaining a profound comprehension, it always seems logical to begin with the basic ideas of vectors, velocities, statics, hydrostatics, forces, mass, etc. Now I think that physics can be divided up into the following parts:
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> 1. The particles and the bodies.
> 2. Between these bodies we have laws of force.
> 3. Under the action of these forces the things that move with laws of motion (which we think we really know and for which Newton's laws of motion are respectable approximations for bodies which are not too big, not too small, not too slow and not too fast).
> 4. Mathematical methods which are used for comparing the theory with experiment.
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> So I propose, to be provocative, that we start with the particle. Some of these are heavenly, some are baseballs and some are molecular. Let's start with all three. But at this point, I want to discuss only the molecule ... for obvious reasons.

Here follows about 600 words detailing ideas, evidence, and experiments about molecules as examples of how it might be done. He goes on:

> The reason for giving the long list of experimental demonstrations about molecules is that one can then build up a structure of physics with at least one new interesting experiment for every lecture. These demonstrations can not be made with wax and string.
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> In any case, the material to be presented is going to require imaginative but painstaking work. A summer study is probably the best way to get the outline and the beginning of the text. Plans for the demonstrations could be laid out and perhaps arrangements could be made to have some things built and tested. Some sample films should be made to see whether we should alter the methods of the professional short subject shooters.
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> A word or two about texts and answer cards. One should try to foresee a great many simple-minded questions. They are after all the most important but they are sometimes hard to answer. In the first years of use of the films the edge in knowing the right answers should be given to the teachers. They have to appear wise and if they are asked questions by the students – and questions can be planted – they can give good answers if they have read over the lesson. It may be that there should be a special text to go with the student text which is prepared to lend an apparent dignity to the teachers.
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> The financial side of such an enterprise becomes obvious on considering the amount of film that will have to be thrown away before a first-rate reel is accomplished. Copies of the film are easy. But the efficiency of Flaubert was not high.

Here we have Zach's view of what a new introductory physics course should be like.

PSSC – The Movies

Characteristically he got going fast, sending a proposal to the NSF and starting meetings of a rapidly assembled first team to argue about content, style, technique and how to do it. They called themselves the Physical Sciences Study Committee – PSSC – and by December 1956 the first substantial conference defined much of what would be done. I had nothing to do with all this and only learned from Saturday lunches and more rarely from happening to be at meetings in Zach's MIT office

Zach had had an apparatus built to demonstrate the pressure of light and had decided to try out movie making with it, with a personable young engineer as presenter from whom he soon took over. *Pressure of Light*, filmed around MIT, became the first movie of the project.

Soon after, a movie theater in Watertown was converted into a studio with directors, cameramen, sound engineers, lighting and set people, gofers and script girls with widely varying backgrounds. Zach's brief reference to the "the financial side of such an enterprise" at the end of the memo didn't anticipate Sputnik a year and a half later which made funding flow wonderfully, in lumps of "Zachs" or $250,000. Zach had two rules for the films: There were to be no scientist/actors with lab coats or foreign accents, reinforcing the public stereotype from the movies, and the director was to "establish the man, establish the set, and get on with the film".

I can't remember how the notion that I should make a movie came up, but in late 1957 I was working on one of the early ones: *Time and Clocks.* After working up the script and demonstrations over a few weeks I would go to the studio from 8 to 5 for a week or ten days with all the business of film making: multiple takes, scene by scene, from which the final version could be assembled. Occasionally a whole sequence would work, uninterrupted by apparatus troubles, misstatements, buzzing flies, etc. Later I went on to make *Photons*, *Interference of Photons*, *Size of Atoms from an Atomic Beam Experiment*, *Velocity Distribution of Atoms in a Beam*, and I helped with shorter pieces: *Momentum of Electrons*, *Angular Momentum of Circularly Polarized Radiation* and a 30 second intro to *Straight Line Kinematics* featuring a 1928 Type 35B GP Bugatti. The last one, *Velocity of Atoms*, was made in 1964. They were all based on stuff that I had been or was involved with: lecture demos, teaching lab apparatus, senior theses, the early cesium atomic clock, and a vintage racing car.

My first films were directed by Hollywood types hired by Encyclopedia Britannica Films; they had little knowledge or interest in the science. Jack Churchill appeared as a consulting director and helped me get through *Time and Clocks* and the photon movies. He and John Friedman directed the rest while the studio became independent of EBF under the inspired guidance of Kevin Smith. I have heard that around 800 films were made by 1974, with perhaps 50 related to the PSSC program.

PSSC – The Book

Meanwhile others worked on the textbook, simply called *Physics*. Francis Friedman was in charge and wrote and rewrote most of it, coordinating contributions from colleagues and teachers with varied expertise. Now I have not studied this but I don't think the films ever had the central role originally envisioned, and Zach realized that this would happen. They were meant to convey excitement and passion for science, but there were at least four problems.

- It is amazing how quickly things look dated (mostly the teacher);
- How can one devote 20 class-time minutes to a film when there is so much to "cover"? (Of course films can now be shown anytime anywhere, but then one had to thread the 16mm projector …);
- Some teachers may not have liked being upstaged by the film;
- Movies are entertainment, not "serious" and somehow frivolous or boring. (I recall the military training films of my day).

I don't really know how much the PSSC movies were used in schools and what their effect was; but it was a valuable effect, even if only a small number were turned on by, say, *The Law of Gravitation* or *Time Dilation, an Experiment with Mu-Mesons.*

Edwin Land and the Idea of Teaching Physics with Movies

I think it was in 1958 that I got a copy of Zach's memo, but in May of 1957 I heard a inspiring lecture by Edwin Land: "Generation of Greatness: The Idea of a University in an Age of Science", later issued as a pamphlet. Taken together, lecture and memo make clear the roots of the PSSC program and some other educational developments at MIT.

Land was a scientist, engineer, and entrepreneur. He conceived the retinex theory of color vision, invented and developed the sheet light polarizer, instant photography, had more than 300 patents, and created the Polaroid Corporation with 4000 employees. He was a visiting professor at MIT in 1956 and spoke to faculty and students (the latter perhaps self-selected as bold enough to speak to him).

In his introduction in the pamphlet, Julius A Stratton, acting president of MIT, says that

> While there may be practical implications to the feasibility of some of Dr. Land's specific proposals, it behooves all of us, educators and laymen alike, to embrace his concern for the full development of the creative powers which are inherent in each and every individual.

The following quotes should make Land's ideas clear; I comment here and there:

> When our new, mature freshman comes in, then, to the new regenerated university of the 1960's, he will find a building which combines a series of movie theaters with a storehouse of great lectures. In these theaters, groups of students see many of the lectures that today must be given, in person, by their professors. Later, each student can see these lectures over again, whenever he wants to.

Land summarizes:

> In our reconstitution of the university of the future, we have made these proposals:
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> The university would accept the young men coming to it as men; and in the course of doing so, it would discard the present grading system in favor of one that would enable the student to check his accomplishment but would not encumber the relationship between the student and his professor.

This hasn't happened—except that we don't calculate the GPA to 3 decimals now; it's rounded off at 2. Also the gender views of the time come through. Despite having many woman assistants, Land refers to men, man, and boy nearly 50 times, but females not once.

> It would cherish and nurture the dreams of greatness that these young men bring with them when they come to the university, in particular by giving each of them, from the start, a research project of his own.

This really worked, initially through funds from Land to encourage profs to take on undergraduates, and is now well established at MIT as the Undergraduate Research Opportunities program (UROP).

> It would introduce them to the several fields of science through courses designed not to screen out non-specialists, but rather to give them the essential insights and ideas in these fields.

This hasn't happened.

> It would give them, in their introductory courses, and in all of their courses, the best teaching of the best lecturers, by preserving and multiplying these lectures into motion pictures.

Earlier in his talk Land had said:

> One proposal that interests me is to take the good lecturers at the moment when they are most excited about a new way of saying something, or at the moment when they have just found something new, and make moving pictures of them right in class. "Can the lecture with the vitamins in!"
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> I fall to the temptation of quoting Johnson: "People have now-a-days got a strange opinion that everything should be taught by lectures . . . I know nothing that can be best taught by lectures, except where experiments are to be shown." But the use of movies is not wide spread, but is or should be easier with current technologies.

Land then showed excerpts from three movies, including *Pressure of Light*.

> It would give them intimate association, from the first, with a mature colleague – the usher.

Slightly—I used to spend 10 minutes with my registration officer (advisor) at the start of the term and that was it. Now students are taken to dinner, and there are about 100 optional Freshman Seminars on a wide variety of subjects of interest both to leader and attendees.

The function of the usher (described in the talk, but not in print, as a combination of Weisskopf and Whitehead)

> … is to take these young men as they come to the university and see that they become, during the first two years, sophisticated in science generally, and sophisticated in the world of literature and the arts generally. They would see that these first two years are dedicated to a deliberate program of induction into mental maturity.

Land concludes:

> To treat young men like men; to use modern recording techniques to capture the moment of exciting teaching; to gather ninety great men out of our one hundred and seventy million – these, in retrospect, will seem like the small changes indeed if they succeed in building a generation of greatness.

I have done an awful lot of quoting (". . . I hate quotations, tell me what you know …" --Emerson), but I hope it gives some not uninteresting light on the beginnings of a program that deeply influenced science teaching in the following half century. Not as much as one might have expected or hoped, but as Zach used to say: "working on education is like peeing in the ocean", to which I add, while casting bread on the waters. In any case, I wish that Land's impassioned statement were better known, difficult as achieving his objectives might be.

