THE PACIFIC EXPERIENCE AND ITS IMPLICATIONS FOR SCIENCE EDUCATION IN THE 80s

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In the 1950s, the United States' scientific community took stock of science education in our elementary and secondary schools and concluded that if practices then prevalent continued, the US would shortly lose its competitive advantage in the arenas of science and technology. The deficiencies touched every aspect of scientific education. In brief, these were the problems: (1) the number of high school graduates opting for collegiate science and technological courses was dangerously small, (2) there was not enough curricular time devoted to science, (3) text materials were out of date and overemphasized technological applications to the near exclusion of theory, (4) teachers were ill prepared to teach modern science, and (5) the mode of teaching emphasized passive learning—text reading and lecture—and slighted laboratory work. A more complete castigation would be hard to imagine.

In response, the federal government, universities, and professional scientific organizations banded together to create new programs to overcome these failings. Their products are examplified by the acronym programs written under National Science Foundation (NSF) sponsorship, such as the Biological Science Curriculum Study, BSCS; the Chemical Education Material Study, CHEM, and Physical Science Study Curriculum, PSSC. Modern content, laboratory learning, and inquiry and problemsolving approaches characterize these programs. Technological application was all but eliminated. The designers reasoned that if students were helped to understand scientific theory thoroughly, they would also grasp its technological implications and applications. At the same time, the NSF launched an effort to upgrade the background of teachers through special collegiate-level training programs.

By the late 1960s the number of science and technological students was up, but the new curricula were themselves under fire. A vocal group came from the ranks of humanistic educators who mistrusted what, to them, was an excessive emphasis on scientific abstractions. They claimed that the new programs imposed inflexible instructional regimens created by academicians with little input from teachers and benefiting an alliance between an insensitive government and the military-industrial complex to the injury of citizens' interests. These critics did not create alternative curricula as had the academics a decade earlier; however, they did coin catch phrases such as "Environmental Education," "Science and Society," "Consumer Science," and "Relevancy," to accompany less-structured instructional motifs. Though many of these alternatives had some influence on curricula, they generally did not attract the material support that the earlier academic designs had achieved.

Now, in the 1980s the alarm has again been sounded, again to warn that our educational system is not producing the number of science graduates necessary to meet the demands of industry, the military, the schools, and academe itself. Further, there has been a constant erosion of quality of students entering the sciences since the late 1960s. Beyond all issues of decreasing scores on tests of factual information is the even more discomforting recognition of our failure to educate the lay person about the open nature of the scientific community and its ways of advancing knowledge. Emerging patterns of legislative restrictions on science curriculum content, federal restrictions on the flow of scientific knowledge, and restrictions on foreign graduate study all point to a failure of science curricula generally to develop an understanding of science in our lay citizenry. It seems we have come full circle and again face the problems of the Fifties.

The Question

The question addressed here is, "What do we now know about science education that can give direction to building a new—and this time enduring and successful—program for the late 80s and 90s?"

This is a challenging question, and one which is complicated by the fact that educators are not agreed on why previous programs have failed. It is accepted here that any new thrust in science education must deal with the elements of criticism accumulated over the past 30 years. However, from our Hawai'i experience in developing and disseminating science curricula, there are other very practical issues that must be attended to if the criterion of enduring curriculum is to be met.

Situated as we are in the mid-Pacific, we have been able to watch the progress of curricular ideas in three environments: the Mainland, Hawai'i, and the Trust Territory. In many respects the latter member of this trio is most informative. Micronesia, or the Trust Territory, has the youngest American educational system and, like a naive youth, demands answers to all the basic questions that are often lost in our more mature educational systems.

Micronesian schools have been subjected to the same school improvement strategies as those tried in Los Angeles, Kalamazoo, and rural Georgia. In many regards, the support of school change has been more massive than in the continental United States. Since the mid-1960s, Micronesian schools have been increasingly staffed by native Micronesians. Throughout this period, teaching staffs have been remarkably stable. Federal funding has been generous and uninterrupted. Educational upgrading has been a priority on the agenda of every commissioner. Yet today, the doctors, nurses, agricultural specialists, and other technicians essential to meet the needs of the Micronesian are in very short supply and general scientific literacy is in no better state than within the United States proper. These islands, too, reflect our national dilemma.

From Hawai'i's mid-Pacific vantage point, at least three curriculum problems shared by the three educational environments appear to influence the present shortfall in specialists and decline in scientific literacy. These are: (1) curriculum that is changed frequently; (2) programs in science that lack articulation among the component disciplines; and (3) program change with inadequate teacher training and follow-up inservice instruction.

Changing Curriculum

Some teacher educators and school administrators subscribe to the idea that the curriculum should be changed periodically to reduce boredom and to keep teachers continually challenged. In Micronesia, as well as the Mainland, regular program changes have been a fact of life. Many of these changes require rather drastic alteration of instructional behavior. But orientation to new materials is a brief economical affair, if given at all. As a result, teachers have learned to rely entirely on themselves and their creative resources to carry them through the exigencies of teaching new programs. Consequently, programs using new materials are typically short-lived. After each demise, teachers have happily moved on to the next program in a continuing quest for one that is "right."

This constant change in programs has lead to an erosion of the teacher's sense of competence. By not working with a program long enough to master its content and instructional methods and by not receiving field support or supervision, teachers are unable to gain a sense of personal success. Under these circumstances, teaching becomes an act of coping from crisis to crisis.

Nonarticulation

Program change produces another problem—the nonarticulated science curriculum. When the curriculum changes regularly, the science experience that a student has one year may have little or no relationship with the experience of the next. Learning science, a process of inquiry which builds on interconnected experiences, is effectively frustrated under these circumstances. A student in science needs an orderly sequence, a body of consistent definitions, and carefully interrelated skills.

Our experience demonstrates that science programs are not interchangeable—they differ in content, vocabulary, and in the skills they propose to develop. Once the continuity of a carefully selected curriculum regime is broken by change, it takes great effort to reestablish continuity. Because of these program differences, when curriculum change occurs it usually takes several years of teaching the new program for the teacher to master it. The period of change is often a period of diminished instructional quality. Finally, articulation within the subject matter of science is a problem that can seldom be solved by a school staff. It is a problem that usually requires external curricular design. If a new program does not naturally articulate with the rest of the science offering of a school, there is little likelihood that a school staff will have the time to remedy the problem.

Teacher Training and Growth

Where inservice training has languished on the continental US, it has flourished in Micronesia. If there has been any one common educational commitment in the Trust Territory of the Pacific, it has been the commitment to upgrade the educational competence of teachers.

Teachers' summers have been filled with courses in educational methods and foundations. The Territory has been remarkably successful in getting most of its teachers through its credential-granting program. It has been far less successful in obtaining training to support specific programs in its schools.

As elsewhere, it has been assumed that teachers can be trained to teach a subject matter by requiring them to attend general methods workshops and courses. As noted earlier, workshops to train teachers to use specific programs tend to be short (one or two days), descriptive orientations.

General methods courses, by definition, are no substitute for training in the discipline to be taught, and even with appropriate subject matter training, it is important to remember that one's knowledge matures gradually. Overlooked in almost all American education systems is the critical fact that teachers need additional training to teach the particulars of any *new* program. This is especially true where the function of the teacher

shifts away from the collegiate model of lecturer. Teachers *grow* into new roles as well as into subject matter, gaining increasing competence over time. Teachers need the reinforcement provided by a mentor's supervision during the first years of teaching a new program. Lacking inservice support during the first years of using a *new* program, teachers are likely to flounder and to reject the program as unusable. In the relatively few instances where such support has been given, programs tended to succeed well.

The experience of the Territory and the US generally in training teachers to use new programs suggests the need for (1) carefully constructed initial implementation workshops covering the complete content of the course, workshops that anticipate problems and explore the full range of program attributes; and (2) well-designed, follow-up inservice programs that will help teachers grow toward mastery of the new program and its content.

What have we learned? At the practical level of implementation, teachers need well-designed curriculum materials that are supported by an active program of inservice training and follow-up service. Further, teachers must be encouraged to stay with a program to mature professionally and provide program continuity.

Some Considerations

We have been thirty years in analysis and debate, in developing and testing different perspectives on science curricula. In some dimension, each curricular perspective that has captured the educational spotlight over the last 30 years is essential to the precollegiate science education of the future. To meet both the civic and technical needs of our nation, it appears that the next curriculum effort should attempt to honor each of these perspectives:

1. The technological tradition of the 1950s, the study of application of the principles of science to practical problems such as engineering, conservation, health, and so forth.
2. The academic tradition of the 1960s, the study of science as conceived of and practiced by scientists—how scientific knowledge is generated, both today and historically.
3. The humanistic tradition of the 1970s, the study of the way science and technology affect us personally as social and natural beings occupying a portion of the local and global environment.

But content is not enough. The ease with which one can generalize about appropriate perspectives on content belies the enormity of the job of design, development, testing, revision, dissemination, and follow-up that must be undertaken if we are to produce a durable and effective curriculum product for the next decade or so. This is evident when one reviews the still unanswered problems noted in the criticism of the 1950s and 1970s as they intertwine with foregoing problems of implementation. The critics called for (1) additional curriculum time for science; (2) more modern science content in materials; (3) greater use of inquiry learning; (4) more effective teacher training; and (5) greater teacher involvement in development. Filtered through our Hawaiian and *broad* Pacific experience these five demands suggest a number of considerations.

Consideration 1. If the demand to honor the three perspectives in the new science curriculum is taken seriously, the issue of curricular time becomes more critical than when it was first expressed in the 50s. Nowadays there is little chance of expanding the school day or preempting time from other school programs or activities. Instead, needed curricular time must be created by using existing time more economically. Science courses can be made more efficient by designing materials into articulated K-12 sequences. Such vertical articulation should attend to (1) a carefully defined and consistent use of vocabulary, thus eliminating the customary but time-consuming review of basic terms in each new science course; (2) sequential development of laboratory and other process skills; (3) logical and developmental ordering of concepts to avoid expecting students to solve problems beyond their conceptual reach; and (4) elimination of all but intentional redundancy. It is estimated that one-third of any given science course used today unintentionally duplicates content found in other courses used at different grade levels.

To gain additional curriculum time, articulation should be also sought between the school science curriculum and that of allied areas such as health, nutrition, agriculture, industrial arts, technology, mathematics, and social studies, particularly those social studies programs that deal with themes of science and technology in society.

A concerted effort should be made to increase the science offerings and requirements, particularly at the intermediate or middle school level. The literature of career motivation indicates that exposure to an intensive well-defined science experience at these ages may be pivotal in influencing many students toward further science and technological education and careers.

Consideration 2. The concern for the modernity of materials goes beyond the updating of science content. Materials should be designed in such a way that allows for ongoing revision to reflect new content in science. But, the experience of the

last 30 years shows that unless there is systematic provision for updating teachers about content changes, teachers will not incorporate these into the students' classroom experience and a program will become outdated rather quickly. For this reason there should be an active, continuing program of inservice training to support such a dynamic curriculum design.

Consideration 3. Laboratory and field work and inquiry learning are intrinsic parts of today's science. Therefore, inquiry is particularly characteristic of school programs that honor the academic tradition. Both the experience in the Territory and national studies have shown that few teachers use inquiry approaches although they were central to the programs of the 60s. Crucial to an understanding of the nature of science is an understanding of its methodology, its ways of making knowledge, which are rooted in inquiry. Thus any effective plan to support a new science curriculum must provide the means of maintaining inquiry in that program over the long term.

Without doubt, maintaining an inquiry environment either outside or inside the classroom, preparing for field trips, and defending increased noise levels to administrators and colleagues, creates additional work and problems. In Hawaii we have produced laboratory-field science programs that have had to face these problems. Developers and teachers agree that inquiry can be maintained when a program is backed strongly and continuously with appropriate inservice support that works with administration.

Consideration 4. When planning teacher training we pose three questions: Who is to be trained, how should training be carried out, and how are teachers to be encouraged and nurtured in their continuing professional maturation? One of the perennial problems of training teachers for particular programs is that teaching staffs are mobile. Studies show that after ten years only a small fraction of teachers, possibly 10 to 15 percent, are still teaching in the same school and teaching the same subject matter at the same grade levels, let alone using the same course materials. Many teachers leave the profession while others change their assignment. New teachers enter to fill these vacancies and need to be trained. For those changing assignment, the content and pedagogy are usually sufficiently unique at each grade level or in each new course offering that they require new and special training. Any effort to upgrade science education and to provide training must be prepared to deal with high mobility.

How should training be carried out? Experience suggests that teachers are most successful in implementing programs when they are given a program-specific training workshop—training that deals with the details of the intended year's instruction—followed by ongoing inservice support. The workshop part involves teachers in laboratory and field exercises, demonstrating ways to initiate and direct discussion, and teaching them the instructional and evaluational technique they will be using. The initial training for a new program depends heavily on post-workshop school visits, and on-the-spot training by program consultants. Teachers are not fully trained in a program until they have successfully taught it.

Teachers must have the opportunity to stay with a given program long enough to become good at teaching it. When teachers have mastered a new program, however, some get bored with it and feel less satisfaction in teaching it. This is a crucial moment in the dynamics of a program. Changing programs is not the solution. Our experience shows that several things can be done to overcome this sense of professional malaise. First, the school may arrange to allow the teacher to teach another grade level. Second, through continuing inservice training, the teacher may be encouraged to deepen his understanding of structure and pedagogy of the program and be helped to develop adaptations of the program in keeping with its intent and design.

Consideration 5. To satisfy the recommendation that teachers be directly involved in the development of curricula to insure that their activities and lessons are teachable, while at the same time satisfying the intellectual requirements of the academic and technological communities, we suggest the teaming of teachers and curriculum specialists grounded in the academic fields. These teacher-academic teams have generally worked well in developing our programs. All materials should be put through the rigors of academic evaluations and extensive field testing, before being released for general use.

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