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ABSTRACT

Presented is a case study intended to describe one of the projects, developed by the Curriculum Research and Development Group (CRDG) of the University of Hawaii, through several stages of its evolution. Some 80% of the intermediate schools in Hawaii use part or all of this science curriculum program. Described is a multidisciplinary environmental science program which emphasizes fundamental concepts of the biological, earth, and physical sciences and relates these to practical issues of man's use of the environment. It is designed for use in grades 6-10. There are three sequential levels to the program, each contributing one year of science instruction. The conceptualization of the project, a brief outline of the program as it exists today (1976) and a description of the crafting process followed by a sketch of dissemination activity are presented. A few comments are given on lessons learned and conjectures made about state or regionally developed curricula. (Author/EB)

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From Theory to Design and Development: Foundational Approaches in Science Teaching, A Case Study

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This case study is intended to describe one of the projects developed by the Curriculum Research and Development Group (CRDG) of the University of Hawaii through the several stages of its evolution. The project is the Foundational Approaches in Science Teaching, or FAST project. FAST has been chosen for discussion because it is one of the early projects of CRDG. It possesses many characteristics in common with other projects and now enjoys a high level of acceptance by the public and private schools of the State. Some 80 percent of the intermediate schools in Hawaii use part or all of the FAST program of instruction.

FAST is a multidisciplinary environmental science program which emphasizes foundational concepts of the biological, earth, and physical sciences and relates these to practical issues of man's use of the environment. It is designed for use in grades 6-10. There are three sequential levels to the program--FAST 1, 2, and 3. Each constitutes one year of science instruction.

In Part I this paper will trace the beginning conceptualization of the project, then in Part II give a brief outline of the program as it exists today. In Part III it will undertake a description of the crafting process followed by a sketch of dissemination activity. Finally, in Part IV a few comments will be offered on lessons learned and conjectures made about state or regionally developed curricula.

PART 1: GENESIS OF FAST

Curriculum projects are products of a special mix of opportunity and people. A project's origins and later dynamics cannot be fully understood unless one has a sense of the mix and the context in which the project developed. So it was in the development of FAST. In June of 1966, a major conference was held in Hawaii to review the status of the full curriculum of State schools, to assess the direction of the then flourishing national curriculum movement, and to set goals for a state sponsored curriculum development effort. Motivating the conference were two factors, the cornucopia of Title III monies then just beginning to flow to the states and the ambitions of Hawaii to produce a state-wide curriculum without peer through its newly constituted curriculum design agency, the Hawaii Curriculum Center (HCC). It is important to remember throughout this presentation that Hawaii has a single state-side system of primary and secondary education.

Initially, the HCC was a combined enterprise of the Department of Education (DOE) and the University of Hawaii College of Education Laboratory School. Within three years of their union, there was a separation of the responsibilities of the two agencies. Two separate organizations were formed. The Department of Education kept the name Hawaii Curriculum Center, and the University division took the name Curriculum Research and Development Group. Even with the separation of the agencies, an unusually high degree of cooperation remains with both groups committed to the achievement of the original visionary goal.

The science section of the June 1966 conference had representation of a broad spectrum of the State's educational interests, including the University of Hawaii's College of Arts and Sciences and College of Education, the Department of Education, the private sector of education, and industry. The section report of science was a bold statement calling for a sequential K-12 science curriculum to be instituted in response to a state-wide needs assessment study. It further called for a standing science education council to be established to monitor the process.

In the fall of 1966, the Hawaii Science Curriculum Council was formed as an advisory group to HCC. In accordance with the recommendation of the conference, the Council immediately undertook a needs assessment study and presented its findings in November of that same year.

Analysis of needs proceeded out of two sets of assumptions. The first was addressed to the import of science education in the general education curriculum. It asserted that effective citizen participation in the social transactions of a scientifically and technologically based democracy demands a scientifically literate citizenry. Schools, therefore, are called upon to provide studies of as many dimensions of science as can be authentically experienced within the resource and time constraints of the educational system.

The second set of assumptions was addressed to the structure of the science curriculum. This set had matured in the mid-1960's, particularly in the works of Phenix[1], Schwab[2], and King and Brownell[3]. In essence the assumptions constitute three propositions and a conclusion. (1) Science as we know it has been generated out of the discourse of disciplinary communities. (2) The structure of the scientific disciplines has been reasonably well identified in the works of the historians and philosophers of science. (3) The very existence of the scientific disciplines is founded on their instructive character, or capacity to transmit their operational structure from one generation of disciplinarians to the next. (4) Therefore, a science curriculum modeled after the structure of the scientific disciplines should give students an authentic view of science and have a high probability of instructional success.

The Council found the national work in the area of the elementary school promising, but untested, and the programs developed for the high school (BSCS, CHEMS, PSSC, etc.) already implemented and functioning. However, the curriculum of the intermediate school had yet to be shaped to articulate with the new programs.

The intermediate science curriculum in Hawaii's schools was, in 1966-67, basically textbook-centered with little place for laboratory work. The sequence of courses ran biology, grade 7; physical science, grade 8; and earth science, grade 9. One science course was required in grades 7 or 8. Others were elective. The major blemish on the total science curriculum (K-12) was an almost complete absence of material for the study of Hawaii's unique environment. In both biology and earth science, ecological examples were drawn from mainland environments where there are snakes, coyotes, birches and silicon sands--all foreign to Hawaii.

The committee recommended the following: 1) Curriculum work should be started on a three-year program for the intermediate school to bridge the gap between process-oriented programs of the elementary school and the disciplinary programs of the high school. 2) The program should be rooted in field and laboratory inquiry. 3) The program should accommodate the subject matter of the then current curricular sequence. 4) The program should give perspective to the role of science in society. 5) The program should reflect with as high a degree of fidelity as possible the operations of the disciplines of science. 6) The program should be as inexpensive as possible. 7) The program should be addressed to the full range of students found in normal classes in the intermediate school. 8) The program should provide for teacher training and inservice support.

PART II: STRUCTURE OF FAST

Let us now leap over the intervening years and describe the program as it exists today so that it is possible to see how the recommendations of the Council have been carried out. The content of the program is organized into three strands (see Figure 1). Ecology and Physical Science provide two formal science strands, while a third strand called the Relational Study provides

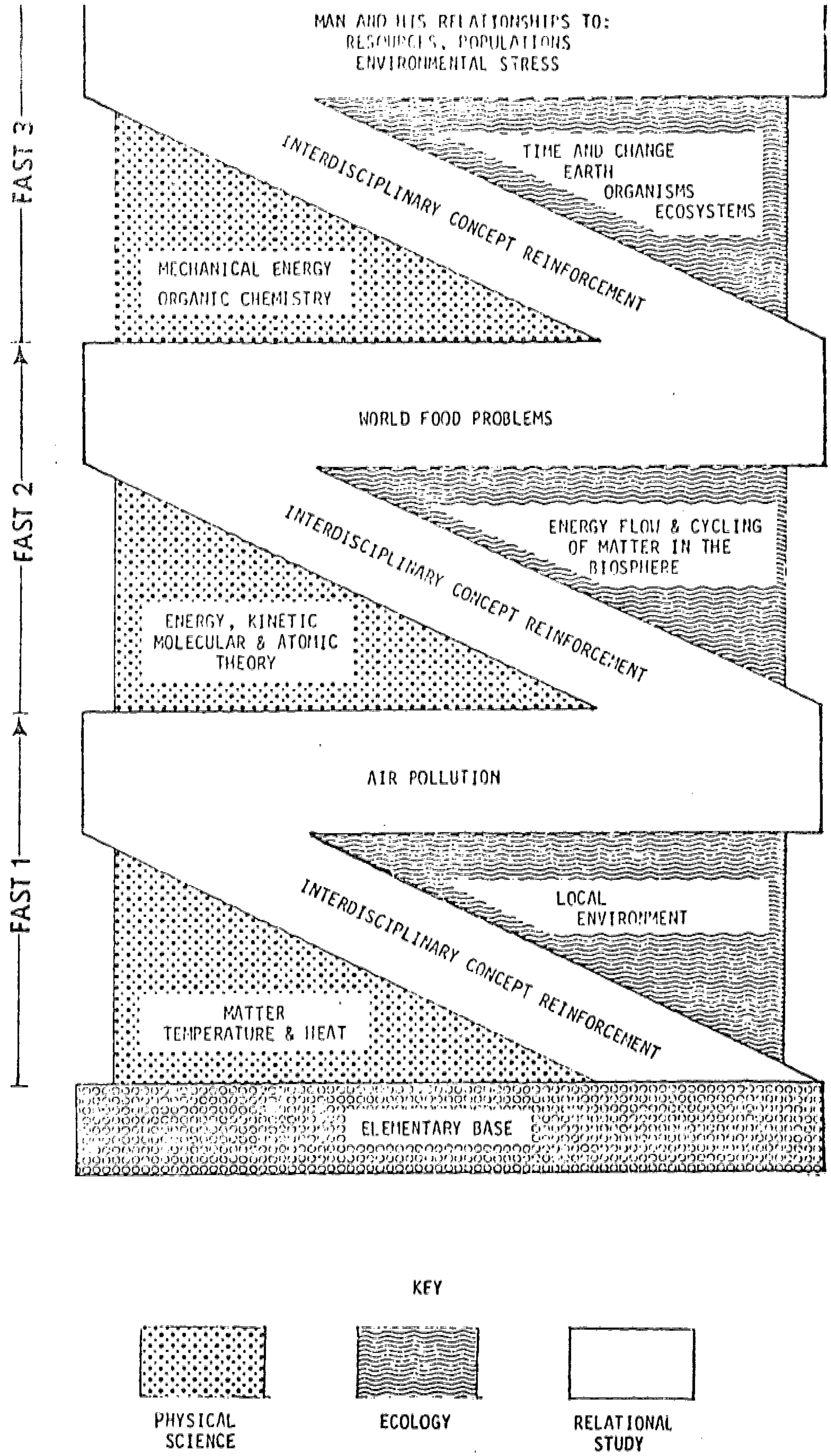


Figure 1. Structure of FAST Program.

integrating material to develop an understanding of the relationships among the sciences and between the sciences and technology in satisfying societal needs. Figure 1 shows the major scientific topics and socio-technological issues that are studied at each level of the program. For example, in the first level the Physical Science strand concentrates on the development of an understanding of the physical properties of matter and the role of heat in state change. Concurrently, the Ecology strand concentrates on investigation of the students' local school and home environment. Regular inserts of Relational Study content tie these two studies together by causing students to reflect on the similarities and differences of the styles of inquiry of physical science and ecology. Finally, a terminal Relational Study unit involves the students in study of a major social issue, air pollution, thereby demonstrating the social relevance of knowledge developed by the physical and ecological sciences. The same general structure is developed in each of the three levels of FAST.

A closer look at the first level of the program will better clarify the design. Figure 2 lays out the unit structure in detail. The unit topics of the Ecology strand are shown on the right, the topics of the Physical Science on the left. In FAST 1 students begin work with a study of buoyancy and density phenomena, taking into consideration different media and the effects of temperature. Introduction of basic laboratory skills, measurement, graphing, and equipment manipulation are an integral part of the inquiry and are not taught as separate topics. Concurrently, students investigate plants and animals, considering their natural growth cycles and conditions for optimum maintenance. Relational connections between the two strands are at this point found in the use of common tools.

In the Physical Science strand, students next pursue studies of gases, emphasizing pressure and buoyancy, then proceed to studies of state change and heat. Concurrently, in the Ecology strand they study some area of the school

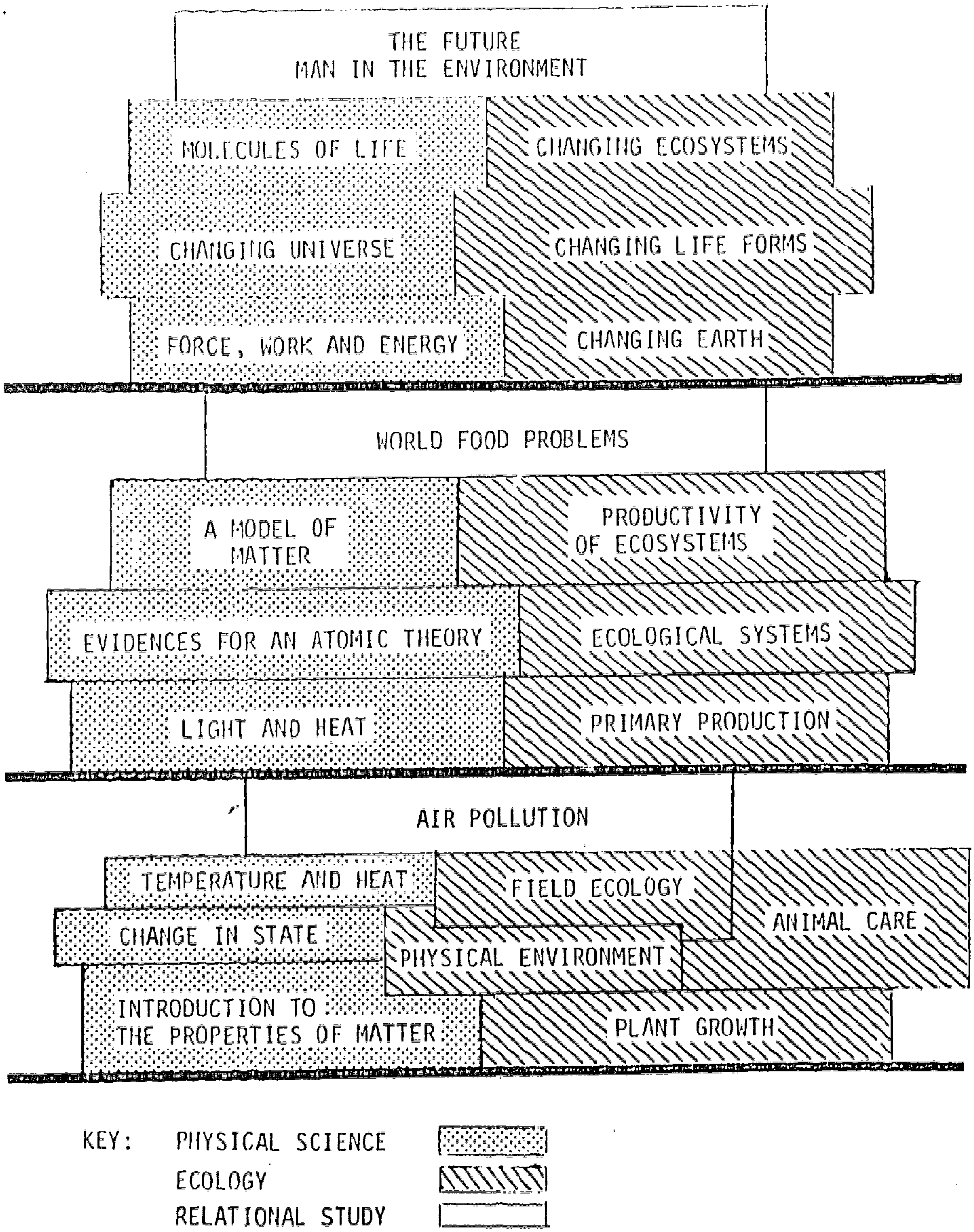


Figure 2. Unit content of FAST 1, 2, and 3.

yard, its soil, plant cover, animal populations, and the effect of weather on that area. Here the connections between the strands become very strong. The physical science has provided the analytical knowledge necessary to explain winds and the water cycle while the ecological strand describes the holistic import of the weather elements on the environment.

As a capstone to the first level, the content of the Relational Study is directed to the study of air pollution. This causes students to focus on the knowledge they have gained in the other two strands and to relate this knowledge to the practical world of social decision. Here the student is confronted with the reality of often conflicting values when scientifically based environmental impact projections are viewed in the light of economics, aesthetics, and legal factors.

To understand the operations of the ongoing program, the mechanism for introduction of topics needs explanation. Figure 3 shows the same units of FAST 1 outlined according to their temporal appearance over the course of the school year. Both Physical Science and Ecology units are broken into smaller blocks of one to two weeks of work which are taught alternately, for example, a Physical Science block, an Ecology block, a Physical Science block, etc. This arrangement has a double advantage. First, it gives an opportunity for natural processes studied in the Ecology strand to go to completion while students are engaged in a collateral Physical Science activity. It is in this sense of simultaneous ongoing ecological investigation that we speak of the concurrency of studies. Second, this rhythm of investigation gives a psychological break in the inquiry, which greatly leavens learning. A year of single-discipline coverage can become patterned and flavorless, especially for the beginner who has wide-ranging interests.

In the day-to-day classroom activity, students work through the many tasks that occupy disciplinarians. Between 60 and 70 percent of class time is taken up in laboratory or field work observing, describing, experimenting, and generally

SUGGESTED TIME SCHEDULE

Month	PHYSICAL SCIENCE	ECOLOGY Unit 1 Plant Growth	ECOLOGY Unit 2 Physical Environment	ECOLOGY Unit 3 Animal Care	ECOLOGY Unit 4 Field Ecology	RELATIONAL STUDY
Sept.	Unit 1 Introduction to the Properties of Matter	Seed Germination			Field Survey	
Oct.			Soil and Water			
Nov.		Plant Propagation			Field Sampling	
Dec.			Water in the Air			
Jan.	Unit 2 Changes of State in Matter		Weather Station			
Feb.						
Mar.	Unit 3 Temperature and Heat		Rain	Animal Care		Air Pollution
Apr.			Water Out of Plants		Field Ecology	
May						
June						

Figure 3. Suggested Time Schedule, FAST 1.

doing those things necessary to develop a logical and consistent explanation of selected phenomena. The remainder of the time is used in preparing reports, defending hypotheses, general discussion, demonstration by both students and teachers, preparational activities for new work, and individual grappling with challenge problems.

The roles taken by students and teachers become important in replicating the disciplinary experiences. As a neophyte in the sciences, students spend much time as research colleagues, working at the tasks of hypothesis formation and testing. Roles of writer, speaker, critic, and discussant flow from the group analysis mode of laboratory and field work. Finally, students are encouraged to act as peer teachers in mastering concepts and techniques and as evaluators of their own and group work.

The basic teacher role shifts from lecturer to organizer and research director-facilitator. Though mini-lectures and demonstrations are employed the principal method of knowledge generation is student investigation. Discussion becomes very important to the dynamics of class progress, and the teacher is often cast in the role of discussion leader. Ideally, the basic evaluation responsibility is placed on students with the teacher acting as validator.

As part of the experience of being a scientist, students write their own text. Information for their text comes out of their own investigations, which are guided by a set of written problem statements and procedural notes. These worksheets are supplemented with a reference library which describes laboratory techniques and presents information that goes beyond the scope of student investigation.

There are other characteristics of the program which can be considered special features. Though a wide range of techniques are employed in quantifying data, graphing is used as the basic technique. Use of graphing has made possible the involvement in quantification of many students who otherwise would have been unable to cope with the mathematics of such a program.

The perennial problem of reading deficiency is handled by a series of mechanisms. To supplement written instructions, the teacher's guide includes procedural flow diagrams for non-readers. These can be used as thermofax masters for producing classroom sets. The reading level of FAST 1 using the modified Flesch scale gives a readability ranging from 5.2 for the student worksheets to 8.0 for the more sophisticated reference library works. Considerable time is spent during teacher training in preparing teachers to familiarize students with the special structure of science writing, so that the materials may be read with greater understanding. Most important, the written and pictorial record of the student-made text appears to stimulate reading.

Cost problems have been reduced, if not solved, by relying on standard catalog materials--beakers, flasks, thermometers, etc. All supplementary materials are made by students during experimentation or by teachers in their training institutes.

It has been our experience that the change from the conventional to FAST style of teaching takes, at minimum, a full year to gain fluency. A new teacher first must be trained in the use of the materials. For many teachers, this means learning new ways of coping with class control and organization. Because of the major change in classroom operation, the project has its own field liaison who is responsible for regular classroom visitations, teacher counseling, and the orchestration of deeper teacher involvement.

In this brief description is seen the reification of the directives of the Council. The subject matter required by the State has been covered while reflecting with a high degree of fidelity the disciplinary and applied nature of the modern scientific enterprise. The program has dealt with the range of students who normally populate the intermediate schools through slight modification of material and by special instructions of teachers during training, and the costs have been pared to the bone.

PART III: DEVELOPMENT OF FAST

Having described the product, we can now return to the cycle of development that has produced FAST. Three things must be emphasized. First, FAST was developed in a laboratory school setting. Here there was a constant interplay of theory, practical school experience, and the clear, cold light of the reality of classroom trial. Second, even with this empirical base, the program had to be further modified in the even more penetrating light of pilot testing. Third, the field success of the program has rested on highly structured teacher training and intensive follow-up field support.

With the official establishment of the FAST project for exploration in the fall of 1967, three steering committees were established, one for each of the strands. These committees generally met separately, but joined their efforts when interfacing problems needed exploration. Their first function was to work out with the staff outlines of potential content. These outlines were then crafted into a set of exploratory units which were tested with University Laboratory School students. Feedback was direct and specific. Basically, the first year was just what its name implies--exploratory. At its conclusion, the staff had produced a sufficiency of materials and outlines to make external review advisable. Reviewers included some of the principals who contributed to such programs as CHEMS, BSCS, and CBA. The ideas of the three-stranded structure of the program and the general approach to inquiry were received with enthusiasm, and with this validation, development officially began in the fall of 1968.

Over the next two years, the content of the program was shaped and tested and reshaped in a continuous succession of Laboratory School trials. The ordering of experiments, the language, and the mathematics employed were all molded in this empirical process. By the summer of 1970, FAST 1 was ready for piloting testing. Using a teacher-training grant from the National Science Foundation, 30 teachers, mostly from the Island of Oahu, were brought to the University of Hawaii and given six weeks of intensive training. This training included a complete hands-on trial of all experiments and TV monitored micro-teaching of the early experiments in the program, using summer school students brought into the Laboratory School. An extensive background lecture series was given in the areas of physics and ecology. During the course of the following year, biweekly feedback sessions were held to collect information for use in revision work. In addition, one staff member was assigned the task of acting as field liaison with the teachers, visiting classes on a weekly basis to detect program deficiencies and successes.

The same procedure of crafting and testing was used in the development of FAST 2 materials which were ready for piloting in the summer of 1971. Again, a National Science Foundation Grant was used for teacher training in the previous summer. After the 1972 cycle was complete, our National Science Foundation money ran out, and we were forced to develop new dissemination techniques.

Austerity forced a trimming of our massive teacher-training model. Over the next two summers, we successively pared the training from the original six weeks to four, then to two weeks. Time economies were made by reducing the number of hands-on trials of experiments, eliminating all microteaching in favor of role playing and dropping the content background lectures. Much to our surprise, we found that we had been overtraining our teachers, overtraining in the sense that we had been providing them with more information than they could effectively assimilate in the course of a single summer. This revelation reinforced a basic hypothesis that curricular change that needs development of new teaching skills is a long-term process, requiring continued teacher involvement with people knowledgeable in a program.

PART IV: GENERALIZATIONS

With this background, a series of generalizations and hypotheses can be made about program development and dissemination. The FAST project contrasts in many ways with the massive first generation science curriculum projects of the 1950's and 1960's. Most obviously, its production costs were much less in total dollars. A major factor in the high cost of the first generation program was the scope of initial piloting. This was essential since earlier projects relied principally on field trial information for revision. FAST, in contrast, was able to employ a laboratory school environment for feedback for a full three years before piloting.

For FAST, a major economy came in anonymity. From their inception, the early curriculum projects were engaged in a massive public relations effort forced by the educational concern of the time and the style of testing and dissemination. This activity is exceedingly draining of time and talent. FAST, being developed in the mid-Pacific, was out of the spotlight and could concentrate most of its energies on production. This is not to say that there were no demands for accountability, but such demands were relatively easy to handle in the close community of the DOE, University and legislature.

Developmental rate and permanency of staff is very important in cost reduction. Rapid development requires many hands and minds all working simultaneously. This is necessarily redundant, and information flow is increasingly complex, requiring a large administrative hierarchy of monitors and coordinators. Quick turnover in personnel was a common feature of many of the early projects, where writers produced a product and then left after a summer to teach or do research. By accepting a slower developmental rate and placing the function of writing in the hands of a permanent career staff, FAST has been able to greatly reduce expenditures. Most staff members have worked together on the project for five or more years and know the full history of problems and solutions. At its peak, FAST had but six developers.

Possibly, the greatest inducement to cost cutting is knowledge that the project is under budgetary restrictions. Painful and oppressive as a tight budget may be, it does force all concerned to continually ask the question "is this purchase necessary?"

Initial Dissemination

We have learned much from the dissemination efforts of the first generation projects and have built upon that experience. Dissemination of earlier projects was based on several assumptions. First, it was assumed that teacher training is necessary to the initial implementation of projects. Our experience validates this.

Second, it was assumed that a cadre of trained teachers would have the capacity to act as models and constultants to their colleagues and thereby maintain the vitality of established programs. History has proven disappointing. Overlooked was the extreme mobility of science teachers of the 1960's and a reluctance to establish professional dialogue. A survey of 40 secondary teachers in one district who were National Science Foundation trained between 1960 and 1970 revealed that of the 40, 10 percent went into administration, 15 percent into higher education, 25 percent retired, 30 percent left teaching, and only 20 percent remained in the classroom at the end of the period.

Third, it was assumed that colleges and universities would automatically take up the training of new teachers in their pre-service courses. However, many, if not most, collegiate science educators held to the philosophy that they were teaching for professional careers that would span the lifetime of many programs. Therefore, discussion of first generation courses most often became a part of a general survey of curriculum. As a result, fledgling science teachers floundered in their first encounter with the first generation programs and more often than not abandoned them, heaping contumely upon the entire curriculum development movement.

Fourth, it was assumed that the product of the projects was better than anything in the field and, therefore, could in final analysis compete on the open market through normal publishing channels. The reputation of the projects gave a false early success pattern. However, sales figures were a poor measure of the havoc spread among the untrained.

With this history, we had some clues as to how to proceed in dissemination. First, only those teachers who have been trained in the use of the materials are certified to teach FAST. Sale and distribution of materials are controlled by the University of Hawaii, assuring compliance with certification requirements.

Second, we have specially trained a group of field teachers who do the vast majority of in-service training. This capitalizes on the cadre concept, but assures that time and financial support are provided for the activity. Learning to use a new program cannot be left to chance encounters in the lunchroom or after school.

Third, we have temporarily accepted as a reality the philosophy that pre-service training should continue to be general. As a result, all recent graduates are treated as any other teacher and go through the entire training program.

Fourth, though missing the gloss of commercial work--they are typewritten--the materials have been well received by students and teachers and do successfully compete in the market without any state mandate.

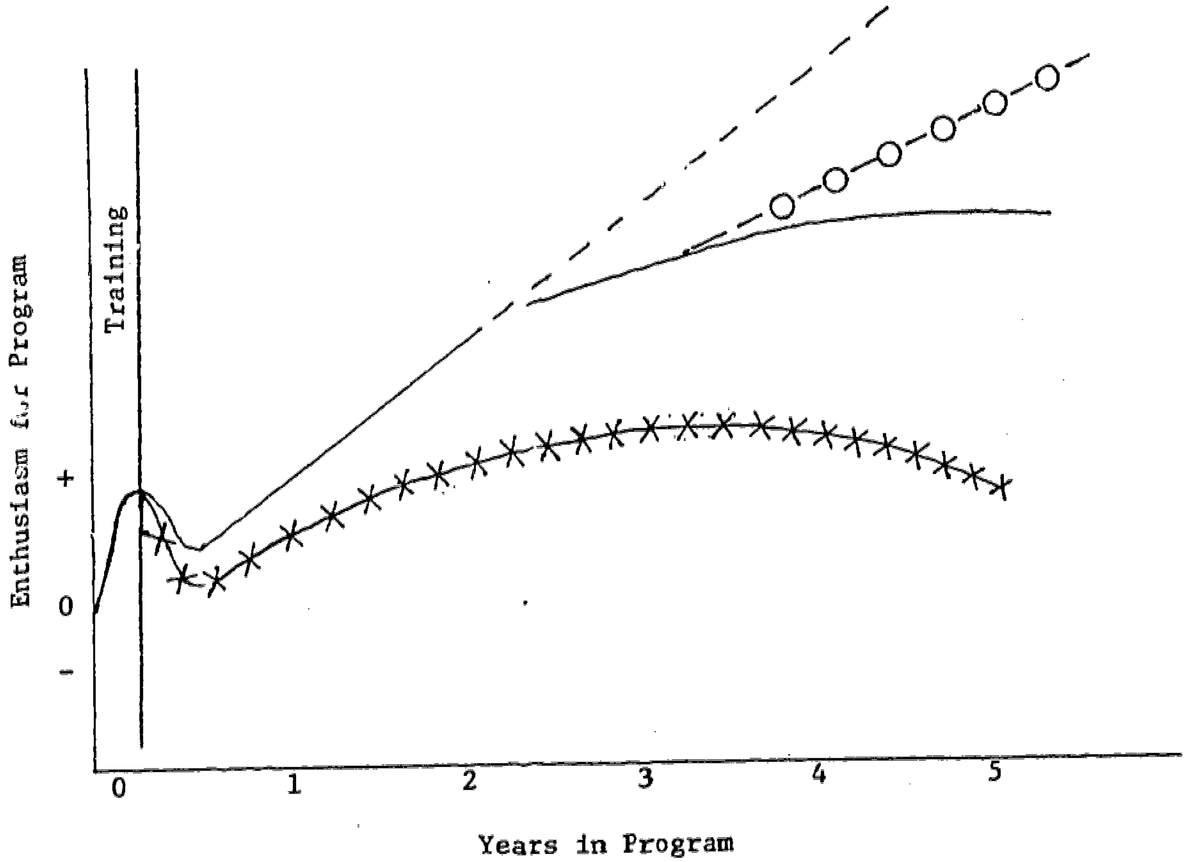
Beyond Dissemination

There is another body of dissemination knowledge which goes deeper than the lessons found in studying the first generation programs. We have found that there is a teacher enthusiasm curve that must be taken into account in considering the projection of usefulness of any program. As previously noted, we have a full-time field liaison person assigned to visitation and attending to the needs of teachers. Because of geographical isolation of some neighbor island teachers, in earlier stages of the project, we were unable to completely service all field teachers. When this occurred, we found that there was an early drop-off in enthusiasm for the program, compared to that of teachers regularly contacted by our field representatives.

Closer examination of enthusiasm has revealed an interesting cycle. After summer training, our teachers reach a peak of initial enthusiasm. Then, in the first month of school, the harsh reality of inflated expectation comes home. This is a phenomenon that is common even when teachers are forewarned. With the aura of panacea gone, teachers readjust to more realistic expectations and reestablish a growth of enthusiasm (see Figure 4).

A plateauing trend shows up in enthusiasm about the fourth year for the supported group, earlier for the unsupported group. Then, a tapering off occurs in following years. The plateau however, does not appear in the involved teacher trainer cadre group. Armed with this generalization, we hypothesize that in addition to differential stroking, we are dealing with a learning phenomenon. After three to four years, teachers appear to have learned all they care to of the subject matter of a program and are looking for new information to master.

The contrast between cadre groups and non-cadre groups was informative since the cadre group generally was equal or superior to non-cadre in subject matter mastery. We hypothesize that by involving cadre teachers in training we have supplied a new content to be mastered. As training cadre they must give attention to the detail of student learning deficiencies, classroom organization, evaluation, the structure of the disciplines, etc. In effect, by being involved as trainers, teachers have gained new insight and set new goals.



Trained Teachers With Field Support

Trained Teachers With Field Support Who Became Part Of The Training Cadre

-o-o-o-o-o- Trained Teachers With Field Support With Further Collateral Training

-x-x-x-x-x- Trained Teachers With No Field Support

Figure 4 Scale of Enthusiasm of Teachers with Different Program Involvement Level.

Out of this experience, we are now undertaking to develop further FAST program-specific institutes for all teachers to study in depth the same topics that have triggered the continuing positive enthusiasm slope of the training cadre. This program is in its infancy, but seems to reestablish the desired positive enthusiasm curve among teachers generally. From the standpoint of developing true master teachers, this insight appears an essential next step. Equally important, it may prove a means to greatly prolong the functioning life of a program.

In summation, we feel we have demonstrated that substantial curricular efforts of consequence can be mounted and supported out of local or regional resources. However, we question whether the hold-over mechanisms of the 1960's for curriculum dissemination can be successfully employed to support such programs. Where support resources for training and follow-up services are available, programs such as FAST have a high prognosis for successful long-term operation.

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