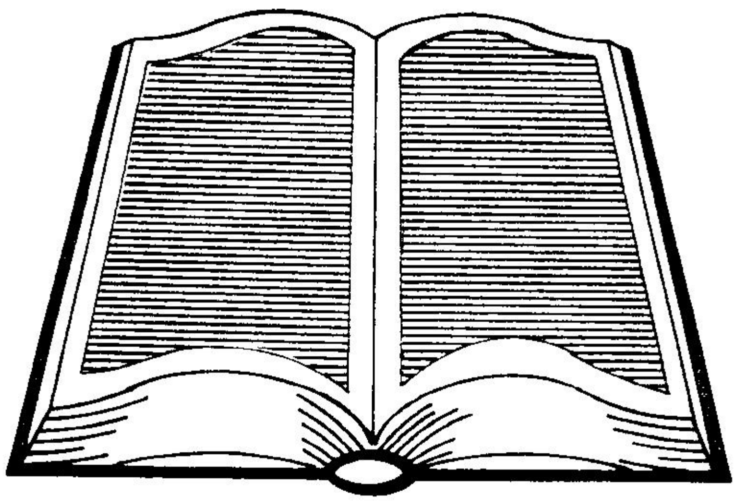
CEER-X-223

SCIENCE AND TECHNOLOGY EDUCATION CONFERENCE

PROCEEDINGS



"ENSEÑAD AL PUEBLO A PENSAR"

Eugenio María de Hostos

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH
UNIVERSITY OF PUERTO RICO • U.S. DEPARTMENT OF ENERGY
G.P.O. BOX 3682, SAN JUAN, PUERTO RICO 00936

SCIENCE & TECHNOLOGY

EDUCATION CONFERENCE

June 18 - 19, 1987

PROCEEDINGS

Caribbean Division (CD)

of the

American Association for the Advancement of Science (AAAS)

In Collaboration With

Asociación de Maestros de Puerto Rico

Ateneo Puertorriqueño

Center for Energy and Environment Research (CEER)

Editor:

Dr. Juan A. Bonnet, Jr.

President (1985-87), CD-AAAS

Director, CEER

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Science & Technology Education Conference
and
AAAS Caribbean Division - Annual Meeting
June 18 and 19, 1987
Condado Beach Hotel

PROGRAM

Thursday, June 18, 1987

Morning Session

Moderator: Dr. Emilio Colón

		Speaker
8:00 a.m.	Registration & Coffee	
8:30 a.m.	Welcome	Dr. Juan A. Bonnet, Jr. CD-AAAS-CEER Prof. Isabel Borin de Caine,* Pres., AMCPR Lic. Eduardo Morales Coll, President, Ateneo Puertorriqueño*
9:00 a.m.	Panel: Programs in Science Education	Dr. Manuel Gómez - EPSCoR & RCSE* Mr. Carlos Maysonet - SSSP Mr. Ronald Blackburn - CAUSA * Mr. José Berrios - MATHCOUNT
12:00 n	LUNCH Lunch Speaker Project 2061: Education for a Changing Future	Dr. Andrew Ahlgren - AAAS

Afternoon Session

Moderator: Dra. Lillian Haddock

		Panel
1:00 p.m.	Panel: Science Education and Technology	Eng. Hiram Puig - Member Educational Reform Commission Dr. Leandro Rodriguez, Dean of Engineering-RUM Dr. William Riefkohl, Chancellor, Regional Colleges Dr. Aníbal Nieves - EDP College Dr. Luis González Vale, Chancellor, PRJC
4:00 p.m.	AAAS Caribbean Division Annual Meeting	

*Oral presentation only.

Friday, June 19, 1987

Morning Session

Moderator: Mrs. Lucy Gaspar

SCIENCE EDUCATION AT DIFFERENT LEVELS

		Speaker
8:00 a.m.	Registration & Coffee	
8:30 a.m.	"Professional Partnerships: Scientists and Teachers Enriching Education	Dr. Al Wohlpart Oak Ridge Assoc. Universities
9:30 a.m.	"Science in the Middle Grades: A Time of Transition"	Dr. Steven J. Rakow University of Houston
10:30 a.m.	Science & Technology Education Private Universities	Dra. Maria de los Angeles Ortiz, Dean, Arecibo Regional College IAU - San Germán
11:30 a.m.	Science Education	Mrs. Awilda Aponte, Secretary-DE
12:30 p.m.	LUNCH Lunch Speaker Science & Technology Education Public University	Mr. Fernando E. Agrait, President, UPR

Afternoon Session

Moderator: Dr. Herminio Lugo Lugo

		Panel
1:30 p.m.	Panel: Science Education Reform: Teachers's Vision	Mrs. Lucy Gaspar - UHS Mrs. Carmen Pereles, Past Pres. Science Teachers Assoc. Mrs. Gloria E. Baquero Berwind School Dr. Eugene Frances - RUM Dr. Ariel Lugo
4:30 p.m.	COCKTAILS	

NOTES: Conference registration fee will be $25.00.
(Registration includes two (2) lunches and cocktails)
Student registration fee will be $10.00.

May 11, 1987

WELCOME TO THE SCIENCE AND TECHNOLOGY EDUCATION CONFERENCE

Dr. Juan A. Bonnet, Jr.
Director, CEER

On behalf of the Caribbean Division of the American Association for the Advancement of Science, I welcome all of you to the Science and Technology Education Conference. This conference is being held as part of the second annual meeting of the Caribbean Division. I extend a personal invitation to all of you who are not yet members of the Division to do so today, and also to attend our business meeting at 4:00 p.m.

I also would like to thank our co-sponsors: the Puerto Rican Science Teachers Association, El Ateneo Puertorriqueño, and the Center for Energy and Environment Research of the University of Puerto Rico.

The theme of this conference is very appropriate and relevant, since it addresses the crisis in Science and Technology Education. It is well recognized that we are living in a "Technological Era". This new era is based on the very fast development of new knowledge, especially in electronics and biogenetics; so it could be referred to as the "Information Revolution". Not only are developments occurring very fast, but the information or technical knowledge is disseminated very fast, and the adoption for commercial and world-wide use occurs very rapidly. Consequently, countries must maintain and develop their scientific and technological know-how at a very rapid pace, in order to be able to compete and develop their own economies.

Various studies relating to the problems of education in the United States have been produced in the last few years. The Education System has been blamed as one of the principal causes of why America is losing its ability to compete in the world market and the slow growth of productivity.

Among these reports are: "A Nation at Risk" by the National Commission on Excellence in Education in 1983; and "Educating Americans for the Twenty-First Century": a plan of action for improving Mathematics, Science, and Technology Education for all American Elementary and Secondary Students, so that their achievement is the best in the world by 1995. It was prepared by the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology in 1983. "What works: Research about Teaching and Learning" by the U.S. Department of Education in 1986; and "A Nation Prepared: Teachers for the 21st Century". The report of the "Task Force on Teaching as a Profession" by the Carnegie Forum on Education and the Economy, and others. Each one of these reports was prepared for a specific purpose or task, and has some recommendations on how to improve Science and Technology Education.

The American Association for the Advancement of Science is carrying out Project 2001---Educating for a Changing Future, since July 1985. This project looks at what is going on, and what others have recommended to improve it; but its minor goal is to take a fresh look at Science Education: what needs to be learned, how can that best be taught, and how to convert these findings into practical and functioning education programs. It is probably the most ambitious of all the projects mentioned.

Puerto Rico has recognized the importance of educating its people and is beginning to take some steps to develop its own scientific and technical infrastructure. A new industrial incentive tax was adopted in January. The governor appointed a Science and Technology Commission to advise him and the Commonwealth. The Educational Reform Commission has been working during the last two years. It is the main purpose of this Seminar to bring out the science teachers' vision and develop a set of recommendations related to Science and Technology Education to be submitted to the Commonwealth Educational Reform Commission.

As you can appreciate from the program, a very remarkable group of scholars from public and private educational systems has been invited to participate. Discussions on Science and Technology Education trends in the United States and Puerto Rico will be presented. In addition, three panels will also discuss different science and technology programs and views. Also ample participation from all attendees is expected.

We look forward to a very interesting and rewarding intellectual experience, and look forward to the conference recommendations.

Thank you.

THE SUMMER SCIENCE STUDENT PROGRAM: AN INNOVATIVE APPROACH IN SCIENCE EDUCATION

Mr. Carlos [illegible]
Director Summer Science Student Program

Introduction

The Puerto Rican economy has undergone important changes in the last forty years. Although industrialization and economic growth have improved the quality of life in general, they have produced at the same time many social and economic dislocations. The inability of the school system to provide the manpower needed by a dynamic modern economy is one of the most serious of these problems. The increasing demand for scientific and technical personnel is not fully met by the island's school system.

The Department of Education does not have enough resources to correct this situation. The design and development of innovative programs directed at the future scientist and technician may be a good way to overcome this problem.

This paper presents one such program. The Center for Energy and Environment Research has implemented for several years the Summer Science Student Program. The program is aimed directly at talented high school students who belong to low-income families and have demonstrated preferences for science and mathematics.

The Problem

Puerto Rico has undergone rapid economic and industrial development in the past forty years. The island's economy has shifted from one based on agricultural activities to a highly diversified industrial and services economy. As a result of this fast rate of development several social and economic dislocations have taken place.

Among the most pervasive of these dislocations is the educational system's inability to keep up with the ever increasing demand for technical and professional manpower. The gap between demand and availability becomes evident when positions go unfilled in spite of an endemic high rate of unemployment and when they often have to be filled by people brought in from off the island.

The situation is further complicated by the economic limitations confronted by the Department of Education which often force the public school system to operate under the least desirable conditions for learning. Some of these conditions are lack of educational materials, low academic training for teachers, inadequate physical facilities, and poorly designed curriculum.

According to Figure 1 the student, who is at the center of the learning activity, is heavily influenced by the teacher's performance. There are other factors such as the availability of

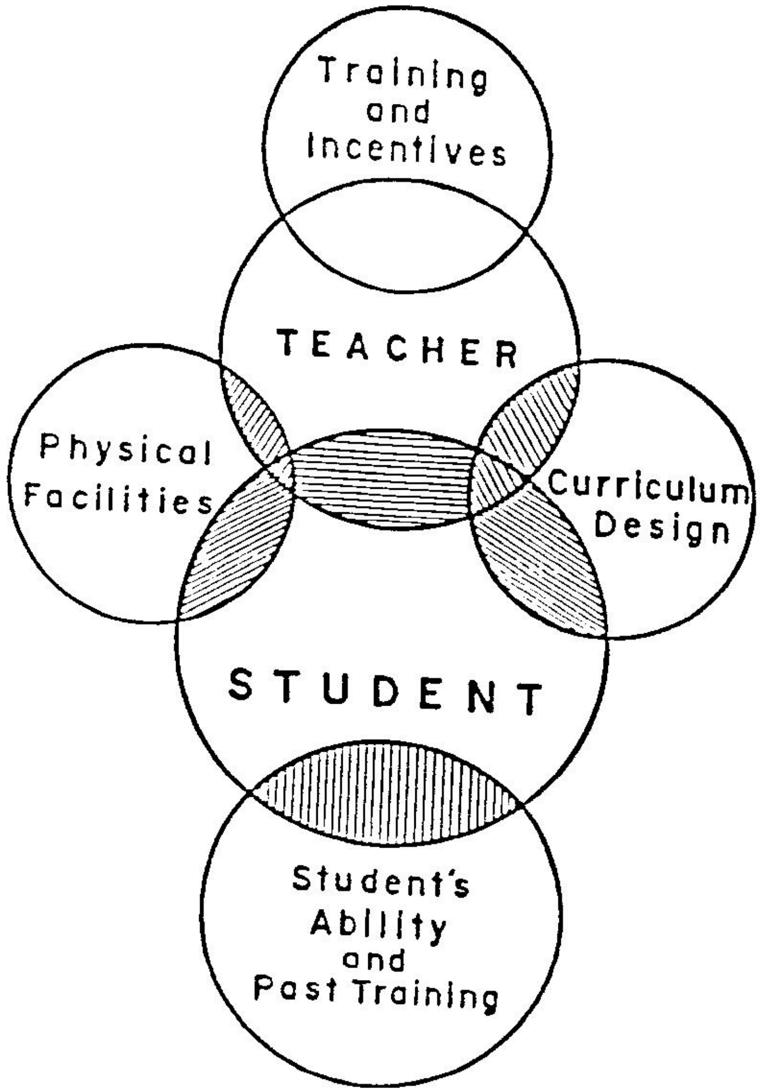

Training
and
Incentives
TEACHER
Physical
Facilities
Curriculum
Design
STUDENT
Student's
Ability
and
Past Training

Figure 1

physical facilities and curriculum design that also influence the student progress directly and indirectly by affecting the performance of the teacher. The student academic ability and past training are another set of variables that are important in influencing the learning process. When the influence of these factors is neglected in the planning of an educational process, the quality of education is low, and not only the students suffer the consequences, but also the society as a whole.

The Puerto Rican Department of Education has developed some programs in order to correct this situation. Unfortunately, the targeted groups have been the slow-learner student. The high-achiever student has too often been forgotten. As a result, there are only a few programs he can benefit from. Moreover, his own school is unable to provide this type of student with the resources he needs to develop his academic potential. The typical disadvantaged talented youngster in Puerto Rico will usually be placed in a homogeneous group and his needs and interests may not always be met. Under existing conditions the teacher will have little time to devote to the talented youngster.

The problem becomes more serious when the home situation contributes little to satisfying the educational needs of this type of student. Many times the parents fail to recognize the potential in the youngster and, even if they do, are unable to provide additional resources or the learning atmosphere where this child would develop. The economic status of the family will sometimes require that he work after school or during the summer, leaving him little time for enriching his school activities.

As a result of this combination of factors and circumstances, talented youngsters may become frustrated with school and lose their motivation. The lack of stimulating programs and of challenging interactions with peers will cause them to lose interest. Thus, a youngster who could have become a productive member of the society and a potential leader wastes his time and his talent.

To be able to develop our human resources to the maximum, it is imperative that we provide special programs that identify these students and rescue them in time to bring their academic potential to full realization.

The Summer Science Student Program

In 1979, as a response to the above problems, and confronted with the shortage of scientific and technical personnel on the island, the Center for Energy and Environmental Research (CEER) implemented the Summer Science Student Program (SSSP). The CEER which was established in 1976 is at present a research institution within the University of Puerto Rico.

The primary objectives of the SSSP are:

1. motivate participants to continue their education and pursue science careers, preferably energy related, upon completion of their high school;
2. enrich the educational opportunities of talented youngsters from disadvantaged backgrounds in the fields of science and technology;
3. make students aware of the importance of developing technical and professional skills;
4. train potential leaders in science and technology fields;
5. stimulate student interest in self-improvement through academic work;
6. supplement student training with such educational resources as library facilities, laboratory experiences, audiovisual materials, field work, seminars, lectures, and industrial-site visits;
7. provide students with an opportunity to interact with peers at the same level of competence so as to stimulate academic challenge;
8. provide students with counseling and orientation which will lead to self-development; and,
9. prepare science research projects suitable for science fair competition.

Participants in the program are selected among students who:

1. have shown aptitude and talent toward science and mathematics;
2. have a minimum average of 3.50 in science and mathematics in their high school junior year;
3. are recommended by their respective schools for outstanding academic performance;
4. satisfactorily pass the diagnostic tests in science and mathematics prepared in coordination with participating teachers and administered by the CEER; and
5. come from a low-income family.

The program is divided into a seven-week summer session and several follow-up meetings during the regular academic year. Throughout this process the student is exposed to an intensive academic instruction in science, mathematics, and research methods. A one-day seminar by an expert in technical writing and oral presentation of projects is added to the regular schedule. It is worth saying that the emphasis of this academic experience is toward the environmental sciences and energy related matters. As a part of the program each student has to develop a science research project suitable for the science fair competition. The students receive an elective academic credit for their participation in the program.

Finally, there are several cooperating entities that have contributed to the success of the program. Among them are the Education Department which provides the teachers and classroom facilities, the Department of Labor and Human Resources, and the municipality of San Juan, both of which pay the students. There are also many industrial and private foundations that support the program through their monetary contributions.

Achievements

1. The SSSP has evolved from a small and modest experimental program to a program that has benefited more than 400 students. In 1987 the program is covering 5 educational regions (Table 1) and includes students from more than 30 municipalities.

2. In 1986 the program received the President's Private Sector Initiatives Award. This award is sponsored by the White House Office for Private Sector Initiatives, the US Department of Labor, and the National Alliance of Business.

3. Many of the participating students have successfully completed or are currently pursuing university degrees in science, technology, and related fields.

4. Several students who began their science research project with the SSSP have won prizes in the science fairs sponsored annually by the Department of Education. In fact, some SSSP students were participating in the International and Engineering Fair held in Puerto Rico in May of 1987.

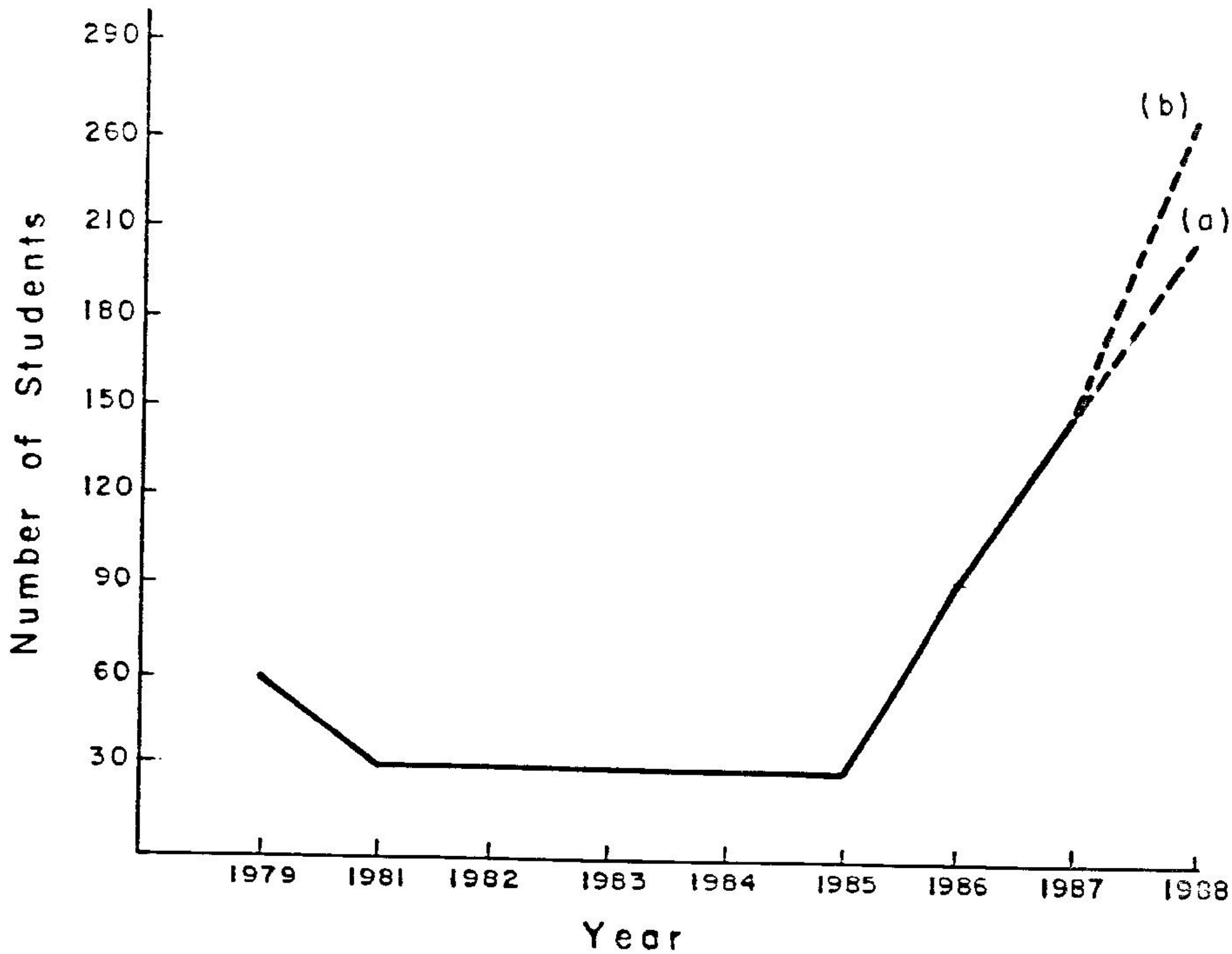
Future Objectives

It is expected that the 1988 version of the SSSP will cover at least 7 regions with about 210 participant students (Figure 2). If projection b is considered, then the number of students will reach 270. To these projections one has to add an average of three audit students for each region. The total number of students will be more than 230 in the first case and around 300 in the second case.

A more ambitious goal is to intervene with all the variables depicted in Figure 1 that influence student achievement. So far, the effort of the program has been directed to the improvement of the student's own ability in science and mathematics. It is expected that in the near future the program will intervene with

Table I

Year	Number of Students	Educational Region
1979	60	Mayagüez - San Juan
1981	30	San Juan
1982	30	San Juan
1983	30	San Juan
1984	30	San Juan
1985	30	San Juan
1986	90	Mayagüez, Ponce, San Juan
1987	150	Arecibo, Caguas, Mayagüez, Ponce, San Juan
1988	a) 210	Arecibo, Bayamón, Caguas, Humacao Mayagüez, Ponce, San Juan
	b) 270	Arecibo, Bayamón I, Bayamón II, Carolina, Caguas, Humacao, Mayagü. Ponce, San Juan



290
260
210
180
150
120
90
60
30
Number of Students
(b)
(a)
1979
1981
1982
1983
1984
1985
1986
1987
1988
Year

Figure 2

curriculum design, the availability of physical facilities, and teacher training and incentives.

Regarding the first item the CEER is seeking to implement a type of curriculum geared mainly to "hands-on" research. This will be totally opposed to the traditional approach in which the student is only a passive spectator. Indeed, a preliminary curriculam guide is now being tested by the teachers participating in this 1987 SSSP version. It is expected that a "hands-on up-to-date" curriculum will improve student ability on two fronts. First, by giving the students the tools needed to develop their potential, and, second, by enhancing the teacher's performance.

In the case of the availability of physical facilities, the CEER will seek the collaboration of other institutions to establish Centers for Scientific Investigations (CSI). The objectives of the CSIs are twofold. First, they will provide the research environment for the students entering the program during the summer, and, second, they will be the places where the students can continue their research projects during the regular academic year. The objective is to have one CSI in every educational region in which the program is carried out.

The CSI can be used also as a training facility for teachers. The establishment of one CSI in every educational region will allow the implementation of training programs for all science and mathematics teachers at a regional level. These training programs can be carried out by the participating teachers and academic directors within the SSSP, scientific and professional personnel from the CEER, the University of Puerto Rico, the Department of Education, and industry.

Conclusion

The SSSP is one of several programs directed at the improvement of student skills in science, mathematics, and research methods. The program, which began in 1979 with only 30 students, has evolved into one that includes 150 students and covers five educational regions. It is expected that by 1988 the program will have more than 250 students and cover the seven educational regions in which the Department of Education organizes the public school system.

The SSSP has been a response to the problems posed by a modern and demanding society to an underbudgeted school system. The results of the program have been positive in terms of the numbers of students pursuing university degrees in science and related fields.

The SSSP will enter a new dimension by developing a curriculum and by creating the Centers for Scientific Investigations. It is expected that these two innovations will enhance student learning abilities. The achievement of these goals will be a result of the efforts not only of the CEER but also of other public institutions and particularly the private industry which generously contributed to the program.

COMPREHENSIVE ACTIVITIES TO UPGRADE
SCIENCE ACADEMICS
PROJECT C.A.U.S.A.
Mr. Ronald Blackburn
Director C.A.U.S.A., FEAGM

BACKGROUND

In 1984, the Ana G. Méndez Educational Foundation and its university system, which includes the University of Turabo, Metropolitan University, and the Puerto Rico Junior College, signed a historic agreement with the Commonwealth of Puerto Rico Department of Education, to develop a long term, collaborative program to assist the public school system to upgrade science and math education in Puerto Rico. This agreement initiated a ten-year, three-component program in Teacher Training, Curriculum Enhancement, and Student Development at all pre-college levels, directed at increasing the capabilities of the island's 700,000-student public school system in science and math to better prepare our youth in these fields and to increase the number of good students entering science careers.

In these three short years, the AGMEF colleges have trained over 180 elementary and secondary school science and math teachers, and a comprehensive, joint curriculum revision and enrichment program is well under way. However, the most important undertaking within this collaborative program has been Project C.A.U.S.A., "Comprehensive Activities to Upgrade Science Academics", a major student development program directed at identifying, motivating, and preparing talented junior and senior high school students to successfully pursue college science majors and careers in math-based fields.

PROJECT C.A.U.S.A.

Recognizing the dire need to increase the number of Puerto Ricans in science fields and the fact that thousands of talented public school youth go unidentified and unserved, Project C.A.U.S.A. set out to design a reliable system to identify students with a high potential for a career in science and to offer them a year-round science and math enrichment program at the three AGMEF colleges.

In 1985, the Carnegie Corporation of New York awarded the AGMEF a $335,000 grant to design, develop, and implement the Academic Year component of Project C.A.U.S.A. During the initial year, the first systematic design to identify talented junior and senior high school youth in Puerto Rico was developed. Through this system, 180 9th, 10th, 11th, and 12th graders from 71 schools in 20 school districts were selected to participate in the program among over 2,300 applicants from 176 schools. An enriched curriculum and a host of curriculum materials in the sciences and math for the talented were developed, much of which is already being tested for use in schools island-wide.

The Academic Academy

The Academic Academy offers the 180 participants (60 at each AGMEF institution) an intensive 24 Saturdays, day-long enrichment program in the sciences and math in the college labs, supplemented by enriched coursework in English and intensive personal, academic, and career guidance counseling. To these are added seminars, lectures, exposure to researchers who serve as role models, field trips, visits to research facilities, student-originated research, and parental involvement activities, all in a college setting. In the program, students work with college science faculty, science teachers, and college student tutors to stimulate an interest in the sciences and to prepare them for college, with maximum individual attention.

The success of the first year alone is evidenced by an over 93% retention rate, admission of C.A.U.S.A. participants at major universities both in Puerto Rico and on the mainland, and a 100% college-going rate for the 45 participating high school seniors.

The Summer Institute and Summer Science and Math Camp

The Puerto Rico Community Foundation awarded the AGMEF $64,000 for the Summer component of Project C.A.U.S.A. Students participate in a six-(6)-week, half-day Summer Institute in which they are offered mini-courses in biology and chemistry and full college coursework in mathematics, to prepare them for college. Beginning with the Summer Institute, it is expected that every 9th grader entering C.A.U.S.A. will complete the equivalent of one year of college coursework in all science fields and math (including computer science) during their four-year participation.

Through a $105,000 grant from the Commonwealth Department of Education, supplemented by over $86,000 from the Puerto Rico Department of Labor and the Office of the Governor for student stipends, the project will offer 120 C.A.U.S.A. alternates a Summer Science and Math Camp, bringing the total number of students to 300. The six-(6)-week Summer Camp will offer a full day of enrichment activities in science, math, guidance counseling, and English to those talented students whom the Academic Academy is unable to serve.

THE MODEL

Through Project C.A.U.S.A. the AGMEF has developed a successful model for identifying talented youth and moving them into the science pipeline. The three keys to this success have been the strong support, leadership, and commitment of a higher education institution to work with the school system to improve science and math education, the strict collaboration achieved with this system, and the long term, comprehensive nature of this effort. It is a replicable model that could well prove equally successful for Hispanics on the mainland.

TIME FOR STUDENTS TO LEARN: PROJECT 2061

Andrew Ahlgren, AAAS

Address to AAAS Caribbean Division Annual Meeting and Science & Technology Education Conference, San Juan, Puerto Rico, June 19, 1987.

The roots of our present worries about science education are many: teacher training and salaries, college and state requirements, out-of-date curricula, lack of support in the student's home culture, and so on. I propose that even were all these problems to be cleared up, students would still not learn much science---because even good students of good teachers are not now learning much.

I would like to use this occasion to make four points:

(1) students are not learning science, even the science we think they are; (2) the only way to learn scientific concepts is to struggle with them; (3) so many topics are taught that there is no time for such struggle; and (4) The AAAS' Project 2061 intends to help reduce the overload of topics by specifying what is most important to learn.

1. First of all, research shows clearly that college students who have had a lot of science courses misunderstand even the basic ideas: inertia, natural selection, electric current, light, atoms, photosynthesis, and so on. Second, few educators really believe this research. Belief in such disturbing findings requires personal experience. I learned it myself when investigating what college students remembered six months after completing a course in introductory chemistry. When asked what percentage by weight iron was in iron oxide (FeO), most of them could find the atomic weights in a table and perform the appropriate addition and division. But when asked the analogous question about cream for a mixture of 150 g of coffee and 30 g of cream, most of them got wrong answers. The algorithm for chemical elements, which they had learned to apply without understanding, had no relevance for them to coffee and cream.

But stories about other teachers' students are not any more convincing than the research. Apparently the only way to learn the truth of it is to see it in one's own good students. I have therefore been given to practicing what I have come to see as a rather cruel exercise on my science-education graduate students, who are inservice teachers. I ask a teacher what she believes her students have learned best from her, and then direct her to sit and listen to her students talk about that topic---not test them in the usual way, but just to listen to them talk freely about it. Invariably these teachers have come back surprised and disappointed. If you are courageous, try it yourself.

2. Why do students get through courses with misunderstanding of the basic ideas? They don't learn the ideas because there is insufficient time to do so. There is insufficient time because so many topics must be covered. Textbooks, curriculum outlines, examinations---all put pressure on the shallow treatment of far too many ideas. Because of the need for speed, the only evident method of teaching is to TELL students everything. If they can form the same words back to us, we are willing to believe that they have understood and accepted the idea. Unfortunately, telling doesn't work. I don't make this as a statement of educational philosophy, that telling is by its nature bad. Most people get into teaching because they like to tell things. I like to tell things. (Here I am doing it). But it works only for filling in details for an audience that already understands the ideas. Students don't already understand the ideas. As Manuel Gómez said this morning, the waves go right over the students' heads.

3. Why doesn't telling work? The children do not come to us as blank pages. They already have ideas, explanations, and theories about how the world works. What we tell them is often inconsistent with what they already think and they cannot change without a struggle. Their options are (a) to reject what we tell them as nonsense; (b) to store the information as something to be used in answering questions in school, but not in the rest of the world; (c) to struggle for an accommodation between their old ideas and our new ideas---which often takes the form of expressing their own ideas with our new vocabulary: (d) to give up their old ideas and adopt our own. But this conversion will take place only if what we say is **intelligible** to them, is tenable, and explains their perceptions **more satisfactorily to them** than their previous ideas. This takes time, and it requires that the teacher listen to the students' ideas and assist in the struggle. Merely discounting their ideas and restating the correct ideas is not much help.

Why are teachers so reluctant to listen? The press of time is an important reason, of course, but there are others. There are external reasons, like examinations, which have been tailored over generations to allow students to answer correctly without understanding or believing a word of their answers. And students have learned the game. They know what helps them to pass examinations like that, and it is usually memorizing the words. They will be puzzled by and resist the teacher's probing and trying to change their own ideas. One of the requisites for open discussion of students' ideas is a classroom climate in which they feel it is safe to be wrong. (I noticed this morning that the measure on which students in the program described by Dr. Gómez showed the least improvement was on their participation in class discussion.)

But there is an important internal reason, too. The self-image of teachers, formed largely by the teachers they have had in their own schooling experience, does not include listening to students, nor letting them work on their own ideas (except perhaps in art or poetry). When I let my doctoral students discuss ideas in small groups, I pace up and down in the hallway outside the classroom, feeling guilty that I am not performing as a professor should---think of how much more they could learn if I were explaining things to them efficiently! And this happens every time I set up small group discussions, even though I know that the students will be likely to get better and more lasting meaning out of their own exchanges. (Exchanges carefully set up by me, of course, and critiqued by me afterwards.)

So any change will take courage as well as an interest in really changing the way students think. But change will surely be impossible without reducing the number of topics taught. As one of the teachers consulting to Project 2061 pleaded, "If you do nothing else in this project, please tell me what it is that I can stop teaching."

4. My fourth point, finally, is how Project 2061 will eventually be able to help. Project 2061 proposes to develop an intellectual framework necessary for a fundamental and continuing restructuring of science and technology education in our schools. It is the first large-scale attempt in many years to undertake a searching examination of what science is most worth learning and what knowledge of technology is most necessary for people to have in our society. Phase I, currently funded by the Carnegie Corporation of New York and the Andrew Mellon Foundation, is to answer the question, "What should everyone have learned about science, mathematics, and technology by the time he or she gets out of high school?" Phase II, still only in the planning stage, will ask, "Given the Phase I recommendations, what kind of learning experiences should students have?" And, eventually, Phase III will ask, "Given the Phase II recommendations, how can we get schools to provide those experiences?"

The substance under consideration in Phase I is broadly defined to cover understanding how the world works, including the world of nature and the world created by human beings, insights concerning the sciences as ways of knowing, skills that are useful in acquiring scientific knowledge, and knowledge of the limits and risks of science and technology, and of their impacts on society. Project 2061 is more concerned with ideas that cut across the disciplines than with the boundaries that separate the disciplines. It is not confined to drawing only on particular school science disciplines (namely, mathematics, physics, chemistry, biology, and the earth sciences), but instead cuts across all science and engineering fields. The eventual sorting of content into curriculum---the courses, topics, and grade levels---may turn out very different from the present configuration.

No distinction is being made---as far as the identification of basic content is concerned---between those students who expect to go to college and those who do not, or between those who may end up in science or engineering and those who will not. The first task of the project is to lay out specifications for learning that will serve all young people well regardless of their vocational aspirations. It expects to do this by recommending content that is significant for every student and also is suitable as a solid base for those interested in additional study. The intent is not to limit learning for anyone, but to ensure for everyone a foundation for growth.

The comprehensive analysis begun by Project 2061 will serve a double purpose: first, to stimulate new educational initiatives, and also to start a process of review and renewal that will continue beyond this project's completion. Project 2061 does not seek to impose a uniform national science education agenda. Its purpose is to develop guidelines that state and local districts can use for generating their own curriculum.

The recommendations of Project 2061 will reflect one or more of five criteria: (a) **Economic utility**---life is increasingly shaped by science and technology, and knowledge of them has become necessary for economic success of individuals and our society; (b) **Social responsibility**---to make informed decisions, citizens of a democracy must be capable of understanding the scientific issues that will inevitably affect all of our lives; (c) **The intrinsic value of knowledge**---some aspects of science and technology are so important in human history or so pervasive in our culture that a general education is incomplete without them; (d) **Philosophical context**---throughout history, people have pondered their place in the universe in space, in time, in the flow of life, and scientific discovery enlarges the context of philosophical thought; (e) **Enrichment of childhood**---childhood is a time of life that is important for its own sake, for the value of what happens then and not solely for what it may lead to later in life. The fascinating workings of nature inspire a child's imagination and sense of wonder. Science, quite simply, can be fun.

Project 2061 is a collaboration among five groups: 1) the **AAAS Board of Directors**, which has institutional responsibility for the conduct and quality of the project; 2) the **National Council on Science and Technology Education**, which has an advisory function through all phases of the project; 3) **Panels**, which are the creative working groups during each phase; 4) **Consultants** from every part of the scientific and educational community who will provide technical advice and a variety of perspectives to the staff, panels, and council; and 5) the **Project Director and Staff**. The panels are the key creative elements in Project 2061. The focus in Phase I is on the nature and use of science and technology and the knowledge and skills they involve. Accordingly, the Phase I panels are composed of scientists, engineers, and mathematicians. The focus in Phases II and III will be on the school curriculum, the improvement of teaching, and the learning characteristics of children. Teachers and other educators will have a primary role on these panels.

Each of the five panels in Phase I is composed of a chair and about eight other members. The membership of each panel is widely representative of its scientific domain, including scientists and engineers from private industry as well as academia, those who are relatively young as well as those who are senior, and women and minorities. The disciplines and professions have been loosely grouped into five categories, providing for panels on biological and health sciences; physical sciences and engineering; social and behavioral sciences; mathematics; and technology. Each panel has now filed its report and we are casting their ideas in a somewhat different format that emphasizes the themes that cut across the panel domains. Early next year, we hope to publish the Phase I report, which will also explain the reasoning behind the conclusions, and outline plans for Phase II.

But Project 2061 will begin to have an impact only years into the future. It is also important to pursue reform on a different scale today. What I heard this morning was both discouraging and encouraging. Discouraging, because of how difficult the problems appear to be. But encouraging, too, because of the enthusiasm and insight of such educators as Manuel Gómez and Ronald Blackburn, who seem to me to be very much on the right track.

THE WINDS OF EDUCATIONAL REFORM REACH PUERTO RICO

Hiram H. Puig
Member Secretariat of the Educational Reform Commission

Headlines in the Education section of the New York Times edition of July 6, 1986 read: BROAD CHANGE IS CENTRAL ISSUE. The article by Larry Rohter then goes on to say:

> In American education circles this year there has been much talk of reform, the more sweeping the better. The notion of broad changes in classrooms around the country has become the dominant topic of discussion among educators, particularly since the Carnegie Forum on Education and the Economy recommended in mid-May that the nation's education system be 'rebuilt'.

Both of the country's major teachers' unions, the National Education Association and the American Federation of Teachers, in separate annual meetings that year, strongly supported the Carnegie Forum's contention of the need for change. Both of them passed resolutions supportive of a nationwide educational reform.

Outside the United States, educational reform movements have been sweeping many countries. Within the American scenario, such is the case with Argentina, Brasil, Perú, Costa Rica, Colombia and Guatemala, among others. Experiences in those countries have been relayed to us by visitors and participants in congresses and conferences sponsored by some local institutions, outstanding among which is the InterAmerican University of Puerto Rico.

Not surprising to anyone, many of the issues for reform seem to be very similar everywhere, with topics such as:

* Structures and organization,
* Educational philosophy,
* Quality of teachers, and
* Teachers' salaries and benefits

at the top of the agenda.

In Puerto Rico, the drums calling for an educational reform of the public system have been sounding for decades. Local educational leaders have insistently addressed this subject in writings dated as far back as the 1920's.

Historical Background

The public school system was established here by law in 1903, under the Foraker Law of March 12 of that year. With the exception of university-level education, which underwent some changes in 1966, the public school system has undergone very little change structurally. For one, the Department of Public Education has continuously depended upon the centralized figure of authority of a single government official; formerly a Commissioner of Education and now the Secretary of Education. It is no wonder then, that, after 84 years of more or less the same thing, an issue foremost under scrutiny for reform in Puerto Rico is the question of centralization vs. decentralization in the public sector of education. This becomes particularly relevant when, vis-a-vis a decentralized private school system, the quality of education in the public sector is under continuous challenge.

When the present Commonwealth ("Estado Libre Asociado") political system was established back in 1952, a greater sense of urgency for an educational reform arose. The principles of public education, which the Constitution itself establishes, set the stage and provide a framework of public policy for education in Puerto Rico within which any reform must develop. Those principles are still valid today.

In writings published since the late nineteen fifties, concerned local educators heralded the need for a widespread reform of our educational system, both public and private. Dissatisfied with the state of affairs, the Governor of Puerto Rico, the Hon. Rafael Hernández Colón, requested in 1974 that the Legislature create a Commission on Educational Reform. The purpose of said Commission was to revamp the local educational system in its totality, from the elementary to secondary to post secondary and university levels of education. The Commission was comprised of top notch educators who dwelt upon the task for three years and presented a Final Report to the Governor in 1977.

Inherently a long-term continuing process, educational reform movements can be upset by transitions in government in any country. Puerto Rico is no exception. Regardless of the merits of the recommendations contained in the 1974 Report by the Commission on Educational Reform, a change in government in the 1976 general elections caused that no significant action, if any, was taken during the period from 1977 to 1985. No legislation to that effect was enacted.

Having undergone another transition in government in the 1984 general elections, in July 1985 the Legislature approved legislation to the effect of initiating the long awaited educational reform process. For this purpose, it created a Joint Commission of the House and the Senate, and a Secretariat.

The Joint Commission is comprised of the President of the House of Representatives and the President of the Senate as alternating presidents, and seven legislators for each chamber, with a guaranteed participation of every political party represented there.

On the other hand, the Secretariat is comprised of three ex-officio members: the Secretary of Education, the President of the Council on Higher Education, and the President of the University of Puerto Rico, and eight additional members, all of them experienced educators with a genuine interest in the field. The main function of the Secretariat is to advise and assist the Commission in drafting and proposing whatever legislation is needed for the reform.

The Joint Commission then appointed a full-time Executive Director to handle its administrative work and that of the Secretariat. At present, the Executive Director, the Secretariat, and the Joint Commission are eagerly at work. Thus far, the Joint Commission and the Secretariat have agreed by consensus in identifying the following priority areas for analysis and discussion:

1. Organizational structure of the system;
2. Improvement of faculty and learning environment of the students;
3. Relationship between public and private systems of education;
4. Vocational and technical education;
5. Interaction between the school and the community;
6. Financing of education and creative use of available resources; and
7. Goals and priorities of the educational system.

In the discussions of the above areas, it is expected that a clear public policy of consensus will emerge.

Methodology

Regardless of how valuable the information contained in the 1974 Commission on Educational Reform's Final Report may be, in thirteen years Puerto Rican society has undergone significant transformations. This warrants a renewed insight into the issues that the educational reform must now address. Because of this, the Joint Commission decided to:

1. Evaluate all previous studies for educational reform, including the 1977 Report of the Commission for Educational Reform.

2. Request updated reports from the Secretary of Education on initiatives that could be considered part of the reform, already achieved within the Department of Education.

3. Evaluate and take into consideration all articles published in newspapers and other local publications.

4. Assess all local legislation relevant to education and the Department of Education.

5. Conduct general public hearings to give every interested sector of opinion the opportunity of participation in the process of reform.

6. Conduct public hearings by specific themes assigned to sub-committees.

7. Conduct forums and round table discussions on specific subjects of interest.

The above list is not meant to be all inclusive, but an identification of topics to guide the initial discussions.

Meanwhile, on the other hand, the Secretariat has been delving into issues of a more specialized, technical, and philosophical nature that could establish a basis for future legislation. For this purpose, regular frequent meetings and brainstorming sessions are being held.

<u>Focusing on Science and Technology</u>

Physical sciences and technology are as much a part of modern culture as the humanities and social studies. Scientific and technological disciplines are necessary components in the integral formation of an individual, indeed an indispensable preparation for modern life, at the primary and secondary levels of education. Courses on science and technology at those levels should therefore be within the reach of the average student, and meaningful to all.

Notwithstanding the importance of science courses within the curricula, ubiquitous issues such as inadequate salaries, inadequate incentives, insufficient preparation, shortage of equipment and materials, inadequate facilities, and large student-to-teacher ratios, just to mention a few, seem to take a larger toll in the math and sciences departments at all levels, public or private. The effectiveness of teaching and the quality of the academic programs are at stake.

Experience indicates that science and technology courses at the secondary level enjoy but very little popularity among local youngsters in general. To master subjects in science and technology takes discipline and hard work, not very attractive ingredients to most students. There is an overall feeling that only a gifted minority undertake those subjects with amiability. Students must learn to relate science and technology to everyday experience at the elementary level, in order to appreciate the value of the high school courses and become interested in following post-secondary studies in those areas.

As any local first-year, college-level teacher in the math and sciences departments can attest, the average student from the local public system entering any college or university on the island, public or private, is likely to encounter difficulty in these subjects. It is not unusual at local institutions for freshmen to be required to undertake remedial work in math and sciences before they can join the mainstream of instruction. This creates a burden on the local university systems for having to maintain remediative programs without academic credit, often with a "revolving door" effect. Education in science and technology at both the primary and secondary levels must be strengthened to alleviate this situation at the post-secondary and graduate levels.

At the college level, the local public university maintains admission standards to programs in the sciences and technologies higher than the private sector. This produces the awkward situation that, at the post-secondary level, the public sector caters largely to outcomes from the private sector of secondary education. By default, private college-level institutions in Puerto Rico cater mainly to outcomes from the public system.

Within the public system, preparatory programs for college at the secondary and post-secondary levels have to be better articulated with entrance requirements for college-level programs, particularly in the science and technology disciplines.

From a macroscopic point of view, the overall public system of education must be evaluated to assess the mainstreams of student mobility and try to establish a quantitative balance. Students entering the public educational system at the primary and secondary levels have a right to expect to complete their universal education within the public system, all the way up to the college level and beyond. This should be particularly true in the sciences and technology curricula.

Education and Human Resources

The Puerto Rican community is striving for a higher standard of living and searching for ways to improve the quality of life on the island. The government has a mandate to provide the necessary educational opportunities for Puerto Ricans to achieve their individual goals while, at the same time, procure the collective goals.

Outcomes from the educational system should be prepared to enter the Puerto Rican work-force upon graduation, and become productive citizens. This collective goal must apply to education, in general, but more so to scientific and technological education in particular.

Those responsible for overseeing the educational system should be guided by the philosophy that those entering the system should be encouraged and be given the opportunity to study subjects which enrich their universal culture. At the same time, they must provide alternatives so that those students who reach their limits of mental ability or lack motivation for college work, [illegible] encouraged to enter the vocational and technical programs at the secondary and post-secondary levels.

Once in the vocational or technical mainstreams, the outcomes should be encouraged to seek jobs and enter the workforce upon graduation, rather than remain within the system.

On the other hand, students entering secondary levels should be encouraged to further their education with more advanced subjects in the social and physical sciences and mathematics. Those who demonstrate having the necessary mental capacity and motivation for college-level work should be encouraged to undertake it within their field of choice. But not, however, without adequate counselling and orientation. Special services for this purpose should be made available within the system, aside from teacher influence and encouragement.

Conclusion

The Puerto Rican community has proven to be capable of providing the needed human resources for supporting the commercial and industrial development of the island. The government has the responsibility of trying to match those resources with employment opportunities.

The availability on the island of adequate human resources both in quality and quantity at the profesional, technical, and skilled levels of work, both in the services and manufacturing sectors, is of paramount importance to the success of governmental efforts in promoting economic growth through commerce and industry, and fighting unemployment. Special efforts are being made to attract high-tech industries to the island and keep them here. The availability of personnel with educational backgrounds in the scientific and technological disciplines is essential to this end.

The underlying general educational philosophy should be that no one should leave our educational system at any level, without being prepared to do something useful in society. This will not simply happen; we have to do our best to make it happen. The educational reform is an important step in that direction.

SCIENCE AND TECHNOLOGY

Dr. Leandro Rodriguez
Dean School of Engineering, RUM

In the past, science and technology were the hobby of a few eccentric and bright men who worked hard for the development of new knowledge.

Nowadays, science and technology affect every minute of our lives. Scientific and technological developments surround us everywhere. These developments range from a simple watch to the complex field of robotics, which is starting to enter into our homes. Computers, especially the personal micro-computers, have become a common object in many houses in such a way that we already tend to undervalue them. Yet, if we compare these machines with the computers of just a few years ago, we can clearly see how powerful they have become. For example, a PC, which anyone can buy for less than a thousand dollars, has a memory of half a million bytes, while the computer on which many worked their Ph.D. thesis twenty years ago had only sixteen thousand bytes.

Not only the life at our homes has changed. Science and technology have caused a real revolution in every aspect. For example, in the field of medicine, we can see how science and technology have provided the medical profession with extraordinary tools which help doctors enormously in caring for our health. In industry we are now talking about computer integrated manufacture in which all activities are handled with the help of these incredibly useful machines.

It is almost impossible to think of any aspect of modern life which has not been influenced by the development of computers. General service offices are using word processors and symphony and data base are common in any of them. New developments in communications have systems totally operated by computers. Ships and airplanes are completely dependent of this marvel of the modern world which is already integrated even in the cars we drive everyday to and from our home or work. In banking you don't talk to a teller; now you talk to a computer.

<u>How this affects society:</u>

These changes affect society in many ways. Most of the time they simplify our lives. At other times they seem to make things more difficult.

Some cases where our lifes are simplified:

a) When you get to the airport and, instead of having to wait in a long line, you can board the plane directly by use of a preassigned seat system.

b) When you don't have to wait on long lines in the bank and can perform most of your banking operations outside of regular working hours.

c) When, after writing a paper for presentation that night, while proofreading it, you find out at 5:00 P.M. that the secretary left out a paragraph on page four out of twenty-five pages. Then you can be more than thankful for word processors.

d) When you need a document right away and it is sent to you immediately by telephone from computer to computer.

We can keep bringing up new examples of how computers have made our lives easier.

But, as mentioned before, sometimes you think computers are making your life miserable. This is so when:

A) You try to renovate your driver's license and they tell you that you have to pay a ticket issued for speeding when you know you didn't get it or that you have to pay a ticket which you already paid and for which you have a receipt, but the information has not been entered in the computer.

B) When you want to pay a bill but are told that you can't do it because the electricity is out and the computer is not working.

C) When traffic lights controlled by computers specify a cruise velocity of 90 mph to guarantee the correct traffic flow.

D) When your computerized refrigerator starts to signal that its door is open even though you can see it is well closed.

E) When employees of the Puerto Rico Telephone Company tell you that a direct dialed telephone call was done from your phone at a time you were out on vacation. Yet, they insist that they are correct because the computer says so.

F) When you need to repair your car but cannot find a mechanic who understands its complex electronics.

<u>University of Puerto Rico-Mayagüez Campus</u>

There are three very important problems which arise from this extraordinary situation. First, it is very difficult to keep up to date with the development of knowledge. Second, it is also very difficult to keep up laboratory facilities; and third, it is almost impossible to fit in a four-or five-year program all the knowledge that an engineer will need in this very complex technological world.

It is my personal opinion that up to now we have been doing a very good job at the College of Engineering of the University of Puerto Rico at Mayagüez in keeping up with these developments. I base this judgment on the fact that our graduates are in great demand both here and abroad and that when they go to do graduate studies they perform very well at the very best and prestigious universities.

<u>The question is: What we are doing to keep up with this rapid development?</u>

Many measures have been taken in recent years to keep up with this rapid development. Among these we can mention the following:

1. Managing our budget in an efficient way so that we can continue to improve laboratory facilities with available financing because, in general, we do not have money assigned for laboratory improvement.

2. Recruiting talented graduates and sending them to study for a doctoral degree at prestigious schools in the United States.

3. Giving more emphasis to our graduate school and to research work since this is the only way to keep our faculty up to date.

4. Getting more federal funds for research and development.

5. Helping our government in the solution of the complex problems that affect our society and through the involvement in the solution of these problems our professors improve professionally.

6. Trying to obtain more monetary support from private industry.

7. Requesting the use of computers in all of our programs.

<u>What we will be doing in the near future:</u>

No matter what we are doing, there is always more to be done. We have made plans for the near future which we know will help to keep our College of Engineering in a very good position among others, so that we may be able to provide the excellent professionals needed by our modern world. Among these measures we can mention:

1. The start of a Ph.D. program in Civil Engineering by January 1988.

2. The start of a Ph.D. program in Chemical Engineering by August 1988.

3. The creation of Ph.D. programs in all fields of engineering offered at our institution by the year 1992.

4. The start, by next August, of a Computer Aided Manufacturing Program in Mechanical Engineering.

5. The continuous revision of our graduate and undergraduate curricula in moving towards a more professional school in which the first two years could be studied elsewhere, while one could come to our Campus for the last three years, which will correspond to the engineering courses, and also in providing tools in business administration.

6. The creation of programs in bio-technology.

7. The creation of options in the field of Computer Aided Manufacture, both in the Electrical and Industrial Engineering program.

8. Keeping more active in the continuous education program.

These are our goals, both short-and long-term. With this in mind we will continue working to provide Puerto Rico and the world with the professionals in science and technology who are needed for the progress of humanity.

DELIVERING TECHNOLOGICAL EDUCATION: THE ROLE OF THE REGIONAL COLLEGES

Prof. William Riefkohl
Chancellor
Regional Colleges Administration
University of Puerto Rico

The Regional Colleges Administration of the University of Puerto Rico plays a special role in the delivery of technological education to the youth of Puerto Rico. The University Law of 1966 states that the Regional Colleges:

> shall have the duty of offering academic education at the university level, and complementary programs for training in short parauniversity and higher technical careers in relation to the needs and aspirations of the communities where they may be established.

This subsystem of the state-level university has units in six centers: Aguadilla, Arecibo, Bayamón, Carolina, Ponce, and Utuado---where need is particularly great or where it has turned out to be uneconomical for private institutions to be established.

The public university thus meets an important part of its service obligations through the Regional Colleges system. This subsystem provides opportunities in four-year programs, as well as transfer programs to the larger units of the University of Puerto Rico System, making it possible for many students to undertake advanced undergraduate and graduate training in the principal centers of scientific and technological research in Puerto Rico.

The regional colleges offer technical programs which are in many cases unique within the U.P.R.

Some examples:

* Ponce offers physical and occupational therapy an architectural drawing.

* Arecibo offers microbiological technology, industrial chemical processes technology, and applied animal health sciences.

* Bayamón is specialized in civil construction technology, industrial engineering technology, instrumentation technology, production engineering technology, electronics, and computer science.

* Aguadilla offers degrees in computer programming for business, quality control technology, and environmental quality technology.

- Carolina has programs in banking, finance and insurance, graphic arts, commercial advertising, industrial maintenance, automobile technology, and the highly successful hotel administration program.

- Utuado offers agricultural management and administration, agricultural disease control, horticultural technology, food processing technology and animal husbandry.

At present the enrollment of the entire regional colleges system is around 13,850 students. This makes the Regional Colleges Administration the second largest unit of the University of Puerto Rico System, after Río Piedras. The numerical size, geographical distribution, and special character of our educational services imply special needs as to physical facilities, which are slowly being met: the first phase of the agricultural sciences laboratory in Utuado is nearing completion; the Carolina Regional College will move into new academic and administrative buildings on its new campus in late 1988; and a mayor construction program will begin at the B.T.U.C.

The commitment of the Regional Colleges Administration to the community it serves---to the people it trains, their future employers, and the society as a whole---requires us to be willing to break away from the traditional forms of administering academic institutions: our efforts must not be limited to semester-length or quarter-length courses. Short courses are a real alternative in meeting the needs of business and industry in the communities where the colleges are located. The Continuing and Special Programs Division is the mechanism used to meet this need, but much more can be done in this regard. For example, courses are offered for industry in the plants themselves, and we can devise Saturday or weekend technological training programs.

To remain current in meeting the needs of business, agriculture, and industry, constant curricular revision is essential. This requires funding which is scarce in the public education system, since 85.3% of our 1986 monies from the General Fund and legislative allocations were committed to personnel-related expenditures. That means that only some 14.7% was available for the rest of the colleges' needs for extracurricular activities, equipment, materials, supplies, maintenance, and so forth. The personnel-related expenses are virtually all fixed expenses and they put limits on our ability to create or renew programs. For this, which is essential to achieving excellence, external funding must be sought regularly.

In training students for an applied technological role in our rapidly modernizing society, the Regional Colleges must have access to the equipment that will make our students valuable to industry when they graduate. This implies a constant review of equipment needs and a plan for renewal. Some private colleges have already made arrangements with industry and place their students in their laboratories. Apart from the obvious value of the on-site experience, this substantially reduces equipment costs and saves many in-house training costs for the institution in those areas in which there is a good fit between industry's needs and the institution's educational priorities. The Regional Colleges Administration anticipates expanding such arrangements.

The acquisition of equipment is not the only cost in curricular revision. Faculty must be given opportunities for in-service training and further professional development, and there must be a plan to meet both the needs of the system as a whole and to meet the changing need of the society for technological education. Computer sciences must be given considerable priority: developments in this field are extremely rapid and have on-going implications for technological education.

Ernest Boyer, in his article, "Toward the Year 2000 and Beyond: A Community College Agenda," says that

> by combining the best of the campus, the corporate classroom and technology, community colleges can help shape lifelong learning for the nation. Community colleges must be leaders in building bridges between traditional and non-traditional education. (AACJC Journal August/September 1986)

The Regional Colleges are attending to this need within the community. As an example, we have employees of the pharmaceutical industry near Arecibo attending courses on microbiology as part of the industry's professional development program for its staff. More can be done and will be done as we develop a course of action to this effect.

We are also contemplating the idea of developing courses for our alumni population, adults, and elderly groups within the areas the Regional Colleges serve. There are many adults who would like to change careers or specialize in related fields and we want to be in a position to give them the opportunity to do this.

Recently the Secretary of Labor emphasized the need for educational systems to respond to unexpected needs of the community for training or retraining at their place of work or by contracting educational institutions. The Secretary also remarked on the issue of educational institutions preparing students according to the needs of the labor market, including education to create managers who are self-employed. Job market analysis seems to indicate that educational institutions are not preparing their students for the jobs available and the unemployment rate is high among higher education graduates, many of whom are working in areas not related to their academic preparation.

An important thing to mention here is that for educational institutions to be up to date in the latest technology is a very difficult task, for academic structures do not allow quick curricular changes. Given this inherent limitation in institutions, it is essential in training students for technological careers and for lifelong learning to provide them with the basic skills which will permit them to be flexible in finding their place in the working world. This involves mathematical training and the fundamental skills of reading, writing, clear expression, and critical thinking.

In _A Nation at Risk: The Imperative for Educational Reform_, colleges and universities were advised to

> adopt more rigorous and measurable standards, and higher expectations for academic performance and student conduct; and that 4-year colleges and universities raise their requirements for admission. This will help students do their best educationally with challenging materials in an environment that supports learning and authentic accomplishment.

The Regional Colleges Administration of the University of Puerto Rico, in attention to these issues, has begun to foster faculty development that can lead to greater curricular flexibility by

* encouraging faculty research, especially in areas of their expertise;

* supporting the inclusion of research experience in the courses and programs of the colleges; and

* favoring interdisciplinary and cooperative faculty research projects.

The Regional Colleges, as must be clear from the foregoing, are essentially instruments of outreach and articulation. The University of Puerto Rico as a whole has begun to realize its potential for providing technological education even beyond the confines of Puerto Rico. The part the Regional Colleges can play in this is to participate in technological and educational exchange with comparable institutions, governments, and industry of the nations of the Caribbean.

In summary, at the Regional Colleges Administration, we are committed to

* specializing the colleges in programs that serve particular regional as well as technological and educational interests;

* strengthening and supporting the associate degree programs;

* carrying out an institutional policy on academic and applied research;

* promoting an institutional policy that is open to the Caribbean through the exchange of faculty, lecturers, and students;

* reducing enrollment in transfer programs and increasing enrollment in 2-and 4-year technological programs;

* establishing strategic planning and curricular revision as an on-going process; and

* developing and strengthening relations with industry and business in order to achieve greater cooperation with these sectors.

It is our understanding that these policies will have the effect of fine-tuning this instrument of technological education so that it will serve Puerto Rico increasingly well in the coming years.

TECHNOLOGICAL EDUCATION:

ITS CHALLENGE AND FUTURE

Aníbal Nieves Nieves, Ph.D.
President EDP College

The quality of any educational system must be judged by the results it renders on the life of its individuals and on the society which it serves. This means that the quality of life of the individuals and of society is highly influenced by the quality of the educational system which serves them.

Through education, knowledge is acquired, skills developed, and attitudes changed. We can say, without fear, that education is the most significant factor that influences the quality of people's life. In this sense, technological education has, at present, the highest potential to impact the quality of life.

Through education, society's most precious resource, its people, is developed. This is particularly so in a society where its basic system is founded on an economic basis.

Technical or technological education plays a significant role in the development of this resource.

The "Diccionario de la Real Academia Española" in its 20th Edition, defines the word "technical" as: "conjunto de conocimientos propios de un oficio mecánico o arte industrial", and "tratado de los términos técnicos" or "lenguaje propio, exclusivo, técnico de una ciencia o arte".[1] Similar definitions are found in other sources:

"<u>Technical</u>---belonging to a particular art, science, profession, etc."[2]

"<u>Technology</u>---the branch of knowledge dealing with scientific and industrial methods and their practical use in industry; <u>practical science</u>"[2]

"<u>Technical</u>---connected with a particular art, craft, science, etc."[3]

"<u>Technology</u>---the science of the mechanical and industrial arts; applied science; engineering"[4]

"<u>Technical</u>---of or having to do with an art, science, discipline, or profession"[4]

"<u>Technology Education</u>---a comprehensive curriculum area which has an action-based instructional program concerned with technology; its evaluation, utilization, and significance; with industry; its organization, personnel, systems, techniques, resources, and products; and their combined social and cultural impact"[5]

Under the last definition are the certificate programs, associate degrees, baccalaureates, and post-graduate programs in areas such as: computers, electronics, instrumentation, secretarial, quality control, industrial technology, civil technology, mechanical technology, health related areas, etc.

From these definitions of the term <u>technical</u> and <u>technology</u> we find that it deals with concepts which stem from the arts and sciences, but with an applied approach. This is why educational technology (this is the term we will use henceforth) is a "bona fide" activity, authentic and essential within the conglomerate of professional activities, belonging to the fields of sciences, arts, and technology.

Technology has enthroned itself in our lives, and it seems it will continue determining our destiny inexorably.

The most significant product of technology in this century is the electronic computer. This instrument, capable of processing data and producing information at speeds never dreamed of by our predecessors, has impacted our lives in all its aspects: education, health, communications, production of goods and services, research, space navigation, etc.

The advancement of technology in the field of electronic computers is unprecedented. Computers can process data and solve problems thousands of times faster than was possible in the 1940's and 50's, at a fraction of the cost.[6]

In just four decades computer technology has developed from vacuum tube electromechanical machines to electronic computers with miniaturized components capable of operating at billionths of a second speed. These technological advances walked hand in hand with price and processing time reductions in the order of magnitude of 99%.

Due to time considerations we cannot explain other technology or products whose impact in our lives have been considerable.

Considering modern technology's ultra dynamic nature, we can expect products whose impact on society will be greater than the electronic computers.

This unprecedented development presents a challenge to technological education: "to survive, technological education has to grow, develop and keep up with technological advances".

To fulfill this challenge, technological education must be as dynamic as technology itself; updating its resources (physical facilities, faculty, curricula, etc.), as often as growth in technology dictates.

If educational technology meets its challenge, it can be the appropriate trustee for the preservation and advancement of the wealth of knowledge and skills derived from technology.

In order to comply with this, technological education must satisfy the following requisites:

We must raise the level of technological education strengthening its base and structures. At its base it must be more formal, endowing it with socio-humanistic fundamentals, since it must be at the service of humanity. Its structure must reflect the advancement of technology, following technology's rate of growth.

We should labor strenuously to change the attitude of society towards technological education.

If technology's influence in our lives and future is so prominent, and considering that it's the appropriate vehicle to obtain the preservation and advancement of knowledge, then we wonder why technological education is not given the importance it deserves.

Technological education is fighting to receive the recognition it has long deserved but not obtained.

The refusal of our traditional society to change its attitudes towards technological education is an important factor in the lack of recognition in this respect.

Our society considers technology as a second-class education. For example, we could probably hear a parent expressing himself in this manner:

"Well, I would like my son to be a professional, for example, a doctor, lawyer, engineer, etc., but if he can't, then let him take a technical course and go to work."

From this expression, which is common in our society, we can deduce that there is prejudice against considering technological studies as a first-class education.

We must make our society conscious that technological education is not and should not be considered second-class.

The International Technology Education Association (ITEA) has been working at an international level to obtain this deserved recognition.[5]

Working hand in hand with the Technology Education Advisory Council (TEAC), the ITEA coordinates and articulates efforts towards this objective. TEAC was founded with the objective of providing the necessary inputs to technological education---about

In the area of the future of educational technology, ITEA has developed a 1990-96 plan. Its essential elements are:

- -Develop and improve model technology education program.
- -Expand support for people to develop technological literacy.
- -Upgrade teacher education.
- -Research and develop new/improved instructional delivery system.
- -Expand curriculum resources.
- -Enhance the expertise of personnel.
- -Improve public awareness and support.
- -Involve business and industry.
- -Increase personal commitment to the profession.
- -Strengthen the Foundation for Technology Education.

From the preceeding we can infer that ITEA's (ten) essential elements are directed to the improvement of technological education.

Now that Puerto Rico has become conscious of an education reform we believe it is time to place the technological education in its proper perspective, which, for merely traditional reasons, has not been acknowledged.

<u>With regard to this, we recommend:</u>

- -Establishing a defined public policy regarding technological education.
- -Creating social consciousness of the importance that technology and technological education have for our future.
- -Developing a model program for technological education, including intense application of educational technology.
- -Supporting the public and private entities in their effort towards the improvement of technological education.
- -Encouraging the professional development and improvement of the human resources of the public and private entities dedicated to technological education, including the corresponding improvement in the remuneration for professional services.
- -Helping the continuous development and improvement of the physical resources necessary for a technological education of excellence.
- -Requesting the support and involvement of industry, commerce, and other private sectors of our community in an effort to develop technological education.
- -Intensifying the orientation of guidance counselors, professors, school and university directors of the island, so that they understand the potential of the technological careers, and be in a better position to adequately orient the students.

[illegible] place [illegible] processes [illegible] of our country.

I leave this challenge to the Commission of Educational Reform, the Education Department, and the Council on Higher Education of Puerto Rico.

Thank you.

ROLE OF PLANNING IN THE DEVELOPMENT OF ACADEMIC PROGRAMS IN SCIENCE AND TECHNOLOGY

Dr. Luis E. González Vales
Chancellor
Puerto Rico Junior College

The theme of this panel is particularly relevant to the Puerto Rico Junior College. I would like to share with you some of our experiences in the process of developing new programs in the areas of Science and Technology.

Our institution has been considered traditionally as a Junior College or transfer institution. This was the charter given by our founders and has guided the development of the college during the first three decades of its existence. Three years ago the need to redefine the mission of Puerto Rico Junior College became a priority item on our agenda. This need was urged by the fact that, with the proliferation of two-year transfer institutions, competition was keener, and also by the conviction that a redefinition of mission and goals was appropriate. The result of this process, which involved not only the college but also the Central Administration of the Ana G. Méndez Educational Foundation and the Board of Directors, was a statement of the college's mission and its conversion into a community college.

Under the new mission it was envisioned that the college programs and services have to be more in tune with the needs of the community we serve. The community was understood to mean the socio-economic groups and the industrial sectors within our geographic area of services.

Once the decision was made to transform the institution into a community college we were faced with the problem of how to go about it in order to achieve an orderly transition from what we were to what we wanted to be. Answers had to be provided for such questions as what kind of programs should be established, what would be their duration, and what cognitive objectives should be pursued, among others.

To answer those and other questions so as to develop our service, academic programs, and research efforts, a strategic planning model was adopted.

Before going into specifics, it may be worthwhile to share with you some of the achievements in the area of science and technology programs. During the past three years enrollment in these programs has grown 400%. This represents, based on the data provided by the Office of the Vice-President for Planning and Research of the Foundation, the highest percentage growth of any higher education institution on the island during that period. This development has been due, in no small part, to the planning system put into effect.

Using the concept of strategic planning, special emphasis was placed on studying the external factors that had direct bearing on the institution's growth and development. By so doing we were better able to adapt ourselves to the changing conditions prevalent in our times. At the same time an organized and rational process was introduced in the planning process that insured all relevant factors were considered before coming to a decision concerning a program. The process stimulated creative thinking on the part of our faculty and academic administrators.

Strategic planning was particularly suitable to our conditions and its use was also dictated by a series of external factors that affected the college, such as:

* Scarcity of resources due to changes in the economy and new and more stringent federal fiscal policies.
* Accelerated technological development.
* Growing complexity of current social problems and lack of adequate institutions to confront them.
* The growing importance of information and information systems as an element in the process of change, both economic and social.
* The globalization of economic, financial, and technological processes.
* Changes in the composition of population age groups and the gradual aging of the population.
* Proliferation of post-secondary institutions.

All these elements, external to our institution, had to be and were considered when revising existing offerings or when developing new ones.

A methodology was developed by the Academic Dean, Dr. René L. Labarca, and his two principal assistants in the area of Science and Technology, Professor Roberto Delgado, Assistant Dean for Science and Technology, and Professor Johnny Villamil, Head of the Science and Technology Institute (department).

As a part of the process of evaluating existing or new offerings they devised a series of questions that needed to be answered so as to give proper consideration to the external and internal factors.

When evaluating the external environment the following were considered:

* Is there a need for such a program based on the existing or projected conditions of the work market?
* What are the skills expected by prospective employers?
* What laws or regulations do exist that affect the career or project?

* Do the economic indicators warrant the development of the program?
* What is the expected demand for this type of professional?
* What is the potential enrollment?
* Is there any experience with programs of this nature in other post-secondary institutions?
* Is the program presently being offered by other institutions?

In terms of the internal factors to be evaluated a close look was given to the following:

* Do we have the qualified academic personnel to offer the program?

* Do we have the necessary facilities and equipment to support the program or can these be procured by means of a consortium or other means?

* Is the program economically viable?

* Is the program pertinent to the mission and philosophy of the institution?

* Are there any courses already existing that meet the needs of the program?

* What new courses need to be developed?

Once answers were provided to these and other questions, then we proceeded to match the external conditions and opportunities with the strengths and weaknesses of the institution. The final determination resulted in a strategic plan which will charter the course to be followed.

If after the above-mentioned analysis a decision is made to start the program, then we proceed to elaborate an Operational Plan. Such a plan is the blueprint followed by the Academic Dean and Head of the Institute in the implementation of the project.

In developing the curriculum close attention is paid to the skills required by the prospective market so as to insure that the graduates of the program are competitive. In developing new programs we have used an incremental approach. A basic curriculum has been established, which allows for the sharing of some basic or modular courses by several programs in allied or close fields, reducing costs and the requirements for qualified personnel. This core curriculum then becomes the basis upon which specialized or concentration courses are mounted to complete the program.

The process described above entails an interdisciplinary approach to the design and development by faculty and administration, as well as the use of external consultants.

All new programs developed require the appointment of an Advisory Panel. This panel provides a liaison with the external environment. It is part of their responsibility to review the curriculum and provide input concerning the needs of the market and the new tendencies in the practice of the discipline.

Reference was made before to educational consortia. This concept involves a contractual relationship mutually beneficial between the institution and outside resources which allows for the shared use of physical facilities, equipment, and human resources in the pursuit of common aims in academic programs, services or research.

To illustrate this point further our institution has programs in radiology and ultrasound. Both programs use, thanks to the consortium, the facilities of the Oncological Hospital at the Río Piedras Medical Center. The possibility of using such facilities is crucial to them.

The methodology described can be adapted to research programs. It promotes research geared to the solution of concrete problems faced by the community we serve. This will make more relevant the results of research projects and will promote the development of closer ties between the institution and the community.

So far our experience has been very positive. It has allowed us to introduce new perspectives in our institution and has greatly assisted in the orderly transition of our college into a Community College.

INSTITUTIONAL PARTNERSHIPS: SCIENTISTS AND TEACHERS ENRICHING EDUCATION

Presented by Dr. Alfred Wohlpart, Chairman
University Programs Division of Oak Ridge Associated Universities

The world we live in is in a constant flux. Most of us are unaware of the directions in which we are moving because the changes are gradual and we focus most of our activities on our families and jobs. There are, however, constellations of events which jolt us and make us aware that it cannot be "business as usual." These events, once recognized, call for an explanation of the cause and a plan for a cure.

Events that are now coming together and clamoring for our attention: the U.S. trade deficit; the loss of U.S. technical prominence; the decrease of U.S. competitiveness in world markets; the finding, training, and retention of good teachers; the changing composition of our population with minorities becoming majorities in several states; the decline in the quality of mathematics and science education as documented in over 20 national studies; the failure of American students to achieve parity in science and mathematics with students of other national education systems; the relatively low numbers of high school students entering science and engineering undergraduate programs; and the low numbers of such students pursuing graduate study.

To some, these issues are interrelated, and the underlying cause---either directly or indirectly---is education at all levels. The schools and, by inference, the teachers are made responsible for these societal ills. I personally believe that, as with so many national issues, there is no single cause, but instead a number of causes acting together. Without question, education is an important ingredient in the mix of causes.

One of the methods of handling an identified issue is to label it a "crisis," elevate the rhetoric to a fever pitch, and throw some money at it, hoping and waiting for it to go away. I don't think we can deal with education in this manner. There is the tendency to forget that we have made significant progress and that what we are doing today is good. But---we are in a position to make it better, more responsive to our present-day needs and expectations! Perhaps we in education have been slow in adapting to social changes and expectations. However, in the rush to cure the patient, let us not forget that the educational system is heterogeneous, that problems must be tackled at the state and local levels, that it will be a long-term process, and, finally, that we must have the will to stay with an innovation and reform long enough so it can bear fruit.

For better or for worse, we have linked our future as a nation to science and technology---the economic well-being of the U.S. depends in a large measure on the state of science and technology. Since our economic well-being is at stake, and since education is at the heart of science and technology, science and mathematics education play a central role in our society.

Why should we improve the quality of science and mathematics education? There are many good reasons. First of all, we owe our best efforts to education, because of its intrinsic value. If we focus solely on other reasons for improving education---such as technical preeminence or competitiveness---our chances of success may be limited. We must make "learning" an effort which is worthwhile for the enrichment it brings to the student's life, rather than because of a competition between our country and others. We must nurture the joy and excitement of learning.

Additionally, to sustain our economic well-being---our way of life---we need highly trained scientists and engineers. Our workforce must feel comfortable with science and technology as more and more jobs involve science and technology. And, finally, we need a scientifically literate citizenry to vote and make decisions on matters relating to energy, science, technology, health, and the environment---the alternative is a national scenario where these decisions are made by an increasingly smaller number of more and more highly trained technocrats. To be a literate and cultured person in the twentieth century requires an understanding and appreciation of science.

To gain a better understanding of the status of mathematics and science education, we sponsored a conference two years ago entitled: "The Mathematics and Science Education Crisis---Symptoms, Causes, and Possible Cures." The conference brought together teachers, scientists, personnel from State Offices of Education, and College of Education personnel.

The conference participants decided that we are facing a long-standing problem which will require long-range solutions, that the situation may deteriorate in the near term, that a range of solutions will be required because of the nature of the problem, that this in itself will add additional challenges, that a solution will require the involvement of a large and diverse number of actors, and that it is unlikely that a lasting solution can be found without involvement of the political process.

Let me briefly tell you about the organization for which I work. I work for Oak Ridge Associated Universities, which is a consortium of 49 major universities in the southeastern U.S., including the University of Puerto Rico. We are also a contractor to the U.S. Department of Energy. The Center for Energy and Environment Research, which is headed by Dr. Bonnet, has close ties with the Department. So we at Oak Ridge Associated Universities have linkages with the U.S. Department of

Energy, the University of Puerto Rico, and the Center for Energy and Environment Research.

The Department of Energy is a mission-oriented agency with a number of national laboratories which conduct research. The Department employs 60-65,000 people at these national laboratories; many of them are scientists and engineers. The Department spends some $8 billion dollars annually on scientific research and development at these national laboratories, in private industry, and at universities. The Department of Energy cannot carry out its mission of research and development without properly trained scientists, engineers, and technicians at all degree levels. Manpower supply and demand are thus of considerable interest to the Department. The Department has traditionally worked closely with university and college faculty and students. However, individual national laboratories have always interacted closely with local and regional elementary and secondary schools. The challenge for the Department is how to involve the national laboratory scientists and engineers most effectively in programs to enhance elementary and secondary school teaching. A number of different programs have been developed and are now ongoing. Let me briefly describe some of these to give an idea about the breadth and variety.

* Summer Research Participation. High School teachers, selected locally and nationally, are appointed to work in a professional scientific and engineering environment during the summer. Designed to increase the teacher's awareness and understanding of current science and technology and to promote the transfer of this knowledge to the classroom.

* Science Bowl. Teams of students compete in tournament style, answering questions on a broad range of science, mathematics, and computer science topics. Designed to recognize local students with special interests and aptitudes in science and mathematics.

* Summer Freshman Chemistry Course. High school juniors and seniors attend a six-week course on a state college campus taught by a high school teacher. Participants receive a modest stipend and academic credit for the course.

* Introduction to Particle Physics. Junior high school teachers work with staff scientists at a national laboratory to develop a five-part science unit of classroom activities; area teachers attend summer workshops to become familiar with the kit and then introduce the materials into the classroom.

* Summer Honors Workshops at National Laboratories. Outstanding high school juniors and seniors are chosen by governors from each state and two territories to participate in an intense, two-week workshop in a specific technical area. Activities include classroom instruction, hands-on research

experience, tours, and seminars. Annually, each of five DOE laboratories hosts 32 students.

* Science Education Center/Travelling Science Show. A four-pronged outreach to both students and teachers, this set of programs includes classroom instruction and demonstrations by laboratory staff instructors to science classes, in-service training to science teachers, student computer laboratories, and personalized computer instruction to teachers.

* Ecological Study Center. Designed to introduce students in grades K through 12 to ecology, this program centers on a 13,000-acre Environmental Research Park at a national laboratory. Background is laid in the classroom for the half-day field activity period which emphasizes a hands-on approach to topics such as forest succession, pre-predator relationships, stream ecology, and small mammals.

* Contests, career days, equipment loans, etc. Many varied activities are ongoing at national laboratories to encourage and promote the interactions of precollege educators with professional researchers, as well as to share the resources of state-of-the-art equipment and facilities with both students and teachers.

I want to shift focus, now, and tell you about an exciting new program we have recently begun. Several years ago, we became interested in linking the scientific and engineering resources in the Oak Ridge/Knoxville area to the local and regional elementary and high schools. The specific question we asked was: How can university, industry, and national laboratory scientists and engineers collaborate with elementary and high school teachers to enhance science and mathematics education? We developed a model, which was based in large part on our experience with university and college faculty and presented this model to a group of teachers and school administrators. We asked them to identify needs that they thought could be met by the local science and engineering establishments. They then determined that the proposed model would meet the needs they had identified. The National Science Foundation provided funding for three years, and we are confident that the Department of Energy will support the program in subsequent years.

We call the program STRIVE, which stands for Science Teachers Research Involvement in Vital Education. One of this program's most exciting aspects is that it is a collaborative effort and involves the following organizations:

National Science Foundation
Department of Energy
Oak Ridge National Laboratory
Oak Ridge Associated Universities
State of Tennessee
Regional High Schools
The University of Tennessee
Local industries
American Women in Science
Sigma Xi, Oak Ridge Chapter

The primary objective of STRIVE is to enhance science and mathematics education through subject matter enrichment of teachers and linking teachers with scientists and engineers for consultation and collaboration.

STRIVE operates year-round, with a summer and an academic-year session. The summer session has three components: research participation, subject matter enhancement, and development of teaching modules. The academic-year session is composed of the following elements: Saturday Science Forum, Scientist Lecture Program, and what we call "networking."

Research participation: Teachers participate as collaborators in ongoing research. A senior scientist acts as a mentor to the teacher and guides the teacher in the research. The teacher becomes an equal and contributing member on a research team. Research positions are available at a Department of Energy laboratory---the Oak Ridge National Laboratory, the University of Tennessee at Knoxville, and several industrial laboratories. One of the enlightening discoveries for us was the fear that teachers have of not being able to perform the research or of not being accepted by the scientists as a peer. As it turned out, this was not a problem. But this perception did prevent some teachers from applying to the program.

Subject Matter Enhancement: Advanced lectures for teachers in their teaching areas. Teachers are brought up to date and exposed to state-of-the-art science.

Development of Teaching Modules: A series of workshops to explore innovative teaching methods, to design laboratory experiments and demonstrations, and to investigate ways of incorporating new ideas into the curriculum.

The summer program lasts eight weeks. Teachers receive graduate credit in their discipline and continuing education credit. They receive a stipend of $200 per week, and travel and housing allowances. We also provide funds to develop teaching materials.

In order to sustain and nurture the linkages teachers established with laboratory scientists during the summer and to expose a large number of teachers and students to modern science, we developed an academic-year program with the following elements: a Saturday Science Forum, a Scientist Lecture Program, and we encourage Networking.

Saturday Science Forum: A series of multi-media lectures held on Saturday mornings covering broad pedagogic, science, technology, and policy issues. Each forum is presented by a distinguished educator or scientist and is targeted for both teachers and their students. Topics from the 1986-87 series included:

Orders of Magnitude: Introduction to Instruments
Outer Limits: The Nature of the Universe (Orbital Telescopes)
Inner Limits: The Nature of Matter (High-Energy Machines)
The Planetary System: Discoveries and Origins (Planetary Probes)
Earth: Geology, Geography, Environment (Satellite Survey)
Man: Brain, Mind, Computer (Cat-Scan, NMR)
Molecular and Atomic Range: Beyond Baryons and Mesons, Toward the Infinitesimal
Review and Forecasts: Things to Come (New Instruments and Methods)

Scientist Lecture Program: Scientists from government, university, and private research facilities visit schools to present lectures and laboratory demonstrations, or to meet with students and teachers to assist with research projects. A brochure listing available speakers and topics is published annually for distribution to regional school systems; lecture costs are fully funded.

Networking: Science and mathematics teachers develop ongoing linkages to the participating research facility and to the scientists and technicians on staff. These ties provide long-term resources for former participants, developing a professional partnership.

By the end of this summer, 45 teachers will have participated in the summer program. They in turn will provide some of the knowledge they gained to other teachers. Over 400 teachers and students attended last year's Saturday Science Forum. Two of the participating teachers have been hired as consultants by the Oak Ridge National Laboratory; a third has submitted a proposal to the State of Tennessee to solicit support for mathematics and science presentations at professional conferences and meetings. This year, we expect to support over 150 scientist lectures at high schools.

Several audio-visual teaching aids and resource materials were produced from the academic-year workshops during STRIVE's first year. To give you an idea of the range of products, let me describe a few of the projects:

Super Ideas Notebook. Descriptions of ideas for classroom activities, including field trips, experiments, thinking exercises, etc.

Slide Shows. Two slide shows produced by the teachers, one on "How to Prepare a Science Fair Project," and one on the "Study of Rocks and Minerals."

Photos from the Electron Microscope. Set of color prints taken of a variety of subjects as seen under the electron microscope.

Teacher's Resource Booklet. A pamphlet listing resources available to area teachers.

Videotape. "A Research Technician at Work," a narrated, color videotape depicting real-life duties of an actual researcher at the national lab.

Has it been a successful program? We believe so, and the feedback we get from teachers and the laboratory mentors supports this. Have we had an impact? I believe the teachers who have participated will return to the classroom enriched and with their batteries recharged. Ultimately, their students will benefit from their teachers' vigor and enthusiasm.

And where do we go from here? I think there is general agreement that we cannot continue business as usual. Yes, we need high-level assistance from Washington in the form of policy and dollar support. But equally requisite to solving the current dilemma is the local/regional area. At this level, we can generate concrete action to enhance science and mathematics education where it begins---in the precollege classroom. One of the ways of encouraging the creation of such initiatives is to form a group of interested and dedicated citizens, including teachers, who can identify needs and local resources and then assist in matching the two. We have formed such a group---called PRISM, which stands for Partners for Resources and Initiatives in Science and Mathematics---to assist us in identifying needs, opportunities, and resources. Together, we will explore ways of meeting needs through local and regional resources.

You here in the Caribbean have taken similar steps with the formation of groups such as the Puerto Rico Resource Center for Science and Engineering. Local programs such as this will give rise to the professional partnerships we at ORAU have found to be the driving force behind progress in education. Together, we can improve the system and make a difference!

SCIENCE IN THE MIDDLE YEARS: A TIME OF TRANSITION

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Psychologists who study the impact of birth order on a child's personality suggest that being a middle child is a very difficult role. The oldest child gets many of the privileges and is often very spoiled, being the first child in the family. The youngest child is also often pampered and protected as the baby of the family. The middle child can get lost in the difficulty of raising a family. I knew of one middle child who was convinced that he must have been adopted because there were no baby pictures of him in the family album.

Schools can be like the family with older children getting many of the privileges earned by their age, and very young children just being considered cute. But what happens to the child in the middle---those children of approximately ages ten to fourteen? They too often get lost in the bureaucratic difficulties of running a school. Yet this time is a critical transition point in the development of the child.

In the short time that we have together, I would like to examine the nature of children in the middle years (that is, ages ten to fourteen), considering some of the transitions that are going on in their lives and how these transitions affect their schooling. I would like to specifically focus on the science education of middle students and offer some suggestions as to directions that I feel might be appropriate for teaching this age.

There is a danger, when one is invited to address an audience as distinguished as this, to elevate oneself, in one's own mind, to the level of "expert." Of course, we all know that an expert is "anyone from out of town." A stricter definition suggests "an expert is anyone from out of town who tells you what to do, then leaves." I hope that you will take my comments, not in the sense of telling you what to do, but rather in offering strictly personal views of the future of science education for students in the middle years.

Let me also share with you one other point that might help to avoid the perception that I am totally locked in the academic ivory tower. As part of a pull-out program through our local school district, I teach a course for fourth-grade students entitled "Science Skills." Children are bussed to the University once each week for 15 weeks to study science for 4 straight hours. During this time we do an intensive series of hands-on activities to acquaint the students with the skills that scientists use to investigate the world. Many of my perceptions about science education have been formed by my exposure to these bright and enthusiastic ten-year-olds.

THE NATURE OF THE EARLY ADOLESCENT STUDENT

Children in the age range of ten to fourteen (often called "early adolescents") are going through a period of rapid change. Physically, they are developing at a rate faster than at any other time in their lives with the exception of the first three years of life. Often their rate of physical development does not match their rate of emotional and social development leading to tremendous concerns about how they are perceived by others.

This physical development is marked by increases in height, body breadth and depth, lung capacity, heart size, and muscular strength. Because body growth is often faster than muscular development, poor coordination can result. Individual growth patterns, however, are not simultaneous according to age level. Hence, some thirteen-year-olds may be very tall and well developed while other classmates still retain much more child-like characteristics. This concern over "will I ever grow up" becomes a major preoccupation for many children of this age.

As adolescents develop, they identify less with the authority of their parents and teachers and more strongly with the pressures of their peer group. This is the root of the term "adolescent rebellion." It is truly an indication that the child is developing a level of moral maturity allowing the child to recognize that in life there are a variety of alternatives. Hence, decision-making becomes difficult. They are less likely to accept teacher or parental directives without question. Though they have difficulty making up their minds, they do not want others to do it for them. Thus, they see their peers as an important and non-authoritarian aid in making decisions, and their dependence increasingly shifts from that of their parents to that of their friends.

Much of what we know about the cognitive and reasoning skills of adolescents comes from the work of Jean Piaget. According to Piaget, individuals progress through four stages of cognitive development. Each stage is characterized by specific patterns of reasoning that individuals at that stage are able to apply to problem-solving situations.

Adolescents span two of these developmental stages, the concrete operational stage and the formal operational stage. In the concrete operational stage, one's thinking is related to concrete objects. Students at this age need the opportunity to see and feel real objects (manipulatives). Math and science are both especially appropriate subject fields for providing adolescent children with the opportunity to learn by means of real objects.

Some adolescents may be in the formal operational stage. These students are able to think in terms of abstract ideas and concepts. They have the ability to apply probabilistic and proportional reasoning to their problem solving, to consider all possible combinations of two or more objects or events, and to apply theoretical reasoning to the identification and control of multiple variables.

Recently, psychologists have recognized that children in the early adolescent years may exhibit characteristics of both the concrete operational stage and formal operational stage. These children, termed by Eichhorn (1966) "transescents" may demonstrate formal operational skills when faced with tasks for which they have some previous experiences, but demonstrate concrete operational skills when faced with novel situations. The key for teachers of early adolescents is to recognize that the typical classroom will contain children who exhibit concrete operational abilities, those who exhibit formal operational abilities, as well as some who exhibit characteristics of both stages.

THE NATURE OF THE EARLY ADOLESCENT CHILD AND SCIENCE TEACHING

Given this knowledge of the nature of the early adolescent student, how should science be taught to these students?

First, it is imperative that students be given extensive hands-on experiences. The laboratory should be the center of teaching for early adolescent students (I would argue that it should be the center of focus for ALL students, but I can convincingly justify this contention as it applies to early adolescents). Traditionally the laboratory has been used for confirmation. The teacher (or the textbook) presented a concept to the students. The students then did a laboratory experiment to confirm what the authority had told them. This violates our understanding of the mentality of early adolescents in two ways. First, to present a concept to children verbally (either by means of lecture or text reading) without previous experiences with the objects or events being discussed does not give them the concrete referents necessary to form a clear understanding of the concept. Secondly, this approach continues to present the teacher as the authority. At a time when students are questioning adult authority and seeking to develop a reliance upon their own decision-making skills, the lecture-lab approach reinforces their sense of dependency upon adults.

An instructional technique which has been effective in providing students with initial concrete experiences is the Learning Cycle Approach (Atkin and Karplus, 1962; Rakow, 1986). This technique was first introduced in an elementary science program called Science Curriculum Improvement Study or SCIS.

In the Learning Cycle, students are first given materials to be investigated and manipulated and told to find out everything that they can about the materials. This is referred to as the EXPLORATION PHASE. During the Exploration Phase students gain a first-hand knowledge of the materials, and hopefully generate interesting questions which they may wish to investigate. Also, given the opportunity to allow the students to "follow their own agenda" first, they are more likely to follow the teacher's wishes. Anyone who has tried to teach a class of first or second graders using magnifying glasses knows that they initially want to explore everything around them, including themselves, before using the magnifying glasses as the teacher wishes them to. This Exploration Phase truly exemplifies the creative, investigative nature of scientific inquiry.

The second step of the Learning Cycle is the CONCEPT INTRODUCTION. This might involve a lecture, a film or video presentation, discussion, textbook readings, or an investigation. The key feature of this stage is that the teacher introduces the vocabulary relevant to the concept by using the strategy of "concept invention." Concept invention is the process of defining a concept in terms of the hands-on experiences students have had during the exploration stage. For example, if students discover that adding certain chemicals to a "mystery" blue liquid (bromthymol blue indicator) turned the liquid yellow, the teacher might invent the following concept: "Any substance that turns mystery blue liquid to yellow is an acid."

The final, and perhaps most important step, is CONCEPT APPLICATION. During this phase of the Learning Cycle, the teacher applies the concept to new situations, especially situations that are relevant to students' lives. Increasingly science educators have been concerned that students see the practical applications of science and technology in their lives. The Concept Application stage allows students to transfer their knowledge to new learning experiences. For example, the teacher studying acids might discuss all of the places that students come into contact with acids or the teacher might relate the idea of acid to the environmental problem of acid rain.

How else might teachers make use of their knowledge of the nature of the early adolescent in teaching science? Given the students' developing social awareness and skills, teachers might make use of grouping techniques to encourage students to develop those social skills. Work by Roger and David Johnson (1982) from the University of Minnesota has shown that the use of structured cooperative groups is a much more effective instructional strategy than competition or individual work. Specifically there is a higher level of content acquisition and retention when lessons are taught using cooperative groups, students are more positive about themselves, other students, teachers and school, and there is a greater level of acceptance of minority and handicapped students by the mainstream students in cooperative classrooms.

What makes a cooperatively structured class? Most fundamentally, it doesn't just happen. Students must be taught the skills of cooperation, but once taught these skills, the time savings in reduced discipline problems can more than compensate for the extra effort in teaching the social skills. More importantly, the greatest reason that people are fired from their jobs is not due to incompetence, but rather because of an inability to get along with others. The teaching of cooperative skills is really the teaching of life-long socialization skills.

Once students have developed the skills to work cooperatively, they must be given a task in which they sense the importance of cooperation to successfully complete the task. This is referred to as "structuring positive goal interdependence." The teacher must help the students sense that they "sink or swim together." One technique that is often used is to base the student's individual grade to some extent on the outcome of the group's efforts. Another technique, referred to as jigsawing, is when a task (for example, a report on energy sources) is divided into discrete units, each student being assigned one unit. For the group to complete the report, each student must complete his or her individual assignment, and these individual assignments must be collected together to make the group report.

Finally, assigning the students specific jobs in the group will help to minimize the tendency for one student to do all of the work and the other students to sit back and watch. In my fourth grade science skills class, I work with groups of three students. One student has the job of Principal Investigator. That student is responsible for seeing that the group successfully completes the assigned investigation. This student leads the group discussion, helps the group to assign tasks, and asks the teacher for assistance when no one in the group is able to answer the question. The second role is that of Materials Manager. This individual is responsible for collecting the materials and returning the materials to the storage area at the end of the investigation. The Materials Manager is also responsible for coordinating the group's clean-up activities. The final role is that of the Recorder. The Recorder is responsible for collecting information from all of the group members and recording that on the group data sheet. The Recorder is also responsible for seeing that the group results are turned in to the teacher.

These are just two of the instructional techniques that can be applied to the science classroom which recognize the unique learning and classroom climate needs of the early adolescent student and put these needs to good educational use. Unfortunately, all too often teachers who work with children of this age either have inadequate preparation in science or little or no formal education in adolescent psychology. In most U.S. Schools of Education, university students training to be teachers of early adolescents are either educated with the elementary teachers or are educated with the high school teachers. A study by Paul DeHart Hurd and others (1981) characterized the science teacher of an early adolescent as follows:

The typical science teacher in a middle or junior high school is a male who majored in biology in college and has some advanced science study beyond the AB degree. His career commitment in teaching was not at the middle and junior high school level, and he has had no educational preparation for teaching early adolescents. (p.11)

The National Science Teachers Association has clearly recognized this problem in the Recommended Standards for Middle/Junior High Science Teachers when they state:

> The methods course designed for middle/junior high school teachers should emphasize science curriculum development, appropriate instructional strategies and materials, techniques for evaluation of pupils and programs, and the application of recent research in the psychology and sociology of the early adolescent as it relates to science instruction. (National Science Teachers Association, 1983, p.66)

Clearly, successful science programs for students in the early years recognize the personal transitions through which these students are passing between the ages of ten and fourteen. Teachers who work with students at this age not only have a broad based science background which helps students to see the interrelatedness of science, technology, and society, but these teachers are also aware of the unique social and psychological burdens which early adolescent children carry, and they are able to design their instruction is such a way as to help these children develop into responsible adults.

THE FUTURE OF SCIENCE EDUCATION FOR EARLY ADOLESCENTS

Given the theme of this conference as well as my own concerns, I would be remiss in not taking a few moments to consider what might be an appropriate future for the science education of early adolescents. While astrology and crystal-ball gazing run counter to my empirical training, I believe that I can offer some extrapolations which might best be perceived as hopes rather than predictions.

The year is 1987. A twelve-year-old early adolescent student was born in 1975. That student will be 25 at the beginning of the 21st century. Essentially ALL of that student's productive working life will be spent in the next century, and, if present trends continue, that student will retire somewhere around the year 2040. It would be ludicrous to believe that we could possibly know what information that student will need to possess to be a productive citizen of the year 2040. A story that I heard recently graphically illustrates this point.

A professor of medicine at the University of Southern California had taken his students through all of the texts he knew in medicine during their four-year course. At graduation he called them together and said: "Now that you have finished your course I want to tell you one thing more. Half of all I have taught you is wrong. But the trouble is, I don't know which half."

We are living in a time of information explosion. Once society was based on the gathering of food. The Industrial Revolution brought about another change in society. Agriculture was no longer the dominant force in society. Rather industry and the production of goods was primary. Only two centuries after the Industrial Revolution, the production of goods is no longer the dominant force in society. That force is information. What will it mean for students to be literate in an information society?

Daniel Boorstin (1980) writes:

> It is a cliché of our time that what this nation needs is an "informed citizenry." ...I suggest, rather, that what we need---what any free country needs---is a KNOWLEDGEABLE citizenry. Information, like entertainment, is something someone else provides us. It really is a service! We expect to be entertained, and also to be informed. BUT WE CANNOT BE KNOWLEDGED! Each of us must acquire knowledge for ourself.

If we think of a continuum, we can better understand Dr. Boorstin's concerns. At one end of the continuum are DATA. Data are unprocessed---they merely exist. These are the sensory inputs bombarding us. Data which are processed are INFORMATION. For example, the words that I form (data) are being interpreted by you as hopefully intelligible thoughts (information). However, as information increases, it becomes increasingly important for people to be able to filter meaningful information from irrelevant information. The ability to make use of meaningful data results in KNOWLEDGE. Knowledge is much more useful than either raw data or information. It is broader in meaning. But knowledge can also be evaluated in terms of values and attitudes to form WISDOM. Hence, our continuum contains at one end DATA, next INFORMATION, followed by KNOWLEDGE, and, at the far end, WISDOM.

At one time in history, "to know" meant to have information in one's memory. At that time, the culture was passed from the elders to the youngsters by means of oral history. Now there is far too much information for anyone to know by memory. In fact, libraries have difficulty maintaining even a small fraction of the world's information. Hence, "to know" has changed meaning. In today's society, "to know" means to have access to the informational process. Thus, schools of the future will focus less on the transmittance of information and more on the development of information access skills.

What does this mean for the science teacher of the future? Perhaps more so than any other field, the information of science is multiplying at a dizzying rate of speed. I would suggest that our medical professor may have underestimated the proportion of lies that he told to his class. We are constantly recognizing that notions that we held as inviolate are now considered foolishly erroneous. Superconductivity may be one of the most striking and contemporary examples of the tentative nature of our scientific tenets. I think that it is increasingly obvious that science teaching must focus less on the transmittance of temporal facts and principles and more heavily on the development of critical thinking skills. We must provide students with the ability to use scientific reasoning and some basic scientific information to make reasoned decisions. After all, if trends continue, only 3% of your students will go into careers in science, but 100% of your students will be citizens. If we are to have an informed society, then we must help students to develop the skills to filter through the noise of information and seek that information which allows them to make the best possible decisions.

Finally, to bring this back to our early adolescents---that age is critical in forming long-term attitudes toward science. Students in the early adolescent age are beginning to form ideas about their future careers. More to the point, they are beginning to select into and out of certain courses. These choices will have life-long implications. While not every student can or should be a scientist, all students need a chance to develop positive attitudes about and toward science. The years of the early adolescent are often the last time that we, as teachers, have to affect these attitudes. That puts a tremendous responsibility on teachers to help students to see the relevance of science for their daily lives. For that reason, a problem-centered approach to science teaching which relates the scientific concept to real-world problems will more effectively help students to develop these attitudes and skills. It is promising to see that some work is being done in this direction. At the high school level, the American Chemical Society has developed a chemistry program called CHEM-COM which helps students to see the role of chemistry in their community.

Through science teaching, we have the ability to help our students become literate citizens in this age of information. I can't help but take a broader view of science teaching than the simple transmission of the information of science. By providing students with the skills to be life-long learners we have done something for them that will extend our influence upon them long after they have left our classrooms. After all, isn't that what teaching is all about?

SCIENCE EDUCATION IN THE ELEMENTARY AND SECONDARY PUBLIC SCHOOLS

by
Awilda Aponte Roque
Secretary of Education

June 19, 1987

The Department of Education has as one of its main purposes the improvement of science education at the elementary, junior, and senior high school levels. The understanding of key science concepts, the acquisition of process skills, and the attitudes and values inherent to this field of knowledge are definitely its most significant goals. To attain these important objectives of education it is recognized that the main task and challenge of this Department consist in creating an academic environment which enables the learners to understand natural phenomena and to live as informed citizens in a technological society.

Science, within the context of a general education, is considered as a basic subject for every student, from kindergarten through the twelfth grade. The acquisition of "basic skills," as defined by several educational programs, should not be viewed as similar to the development of language and computation skills, or as an equivalent to the well-known three R'S (Reading, 'Riting, and 'Rithmetic). A broader concept of what a basic skill is has emerged to recognize a fourth R, which stands for Reasoning and, of course, this stands for science.

The Department of Education endorses science education for all learners, because all students should be exposed to it and benefit from this instruction. The development of a literate citizen in science does not result from the teaching in a single course or grade. It can only be achieved through a carefully planned K-12 program. The Department of Education is fully committed to ensuring the educational system and the community in general a well articulated and coordinated science curriculum that develops the student's power of critical thinking and reinforces other fundamental skills. The Department is also committed to providing a competent teacher who facilitates learning and achievement in the field of science, and to making available the necessary facilities and resources to implement a K-12 laboratory-oriented program. In addition, we have developed special projects for underachievers and for talented average students.

The Science Program of the Department of Education, one of the basic education programs, is organized around a group of broad comprehensive conceptual schemes, namely, diversity, change, interaction, organization, limitation, and continuity. The development of these concepts is integrated with the development of processes such as observation, classification, formulation of inferences and predictions, measurement, communication, use of space-time relations, use of models, interpretation of data, formulation of operational definitions and hypotheses, and experimentation. Similarly, the development of values and attitudes, such as the need to know and to understand, to inquire, to search for data and their meaning, to demand verification, to feel respect for logic, and to consider the premises, assumptions, and consequences in the solution of a problem, is essential to the attainment of the objectives of science education in the elementary and secondary schools.

The task, as you may all agree, is a real challenge in itself. It requires talent, disposition, determination, and resources of all kinds to ensure the effective achievement of these objectives. It is also understood that the Department of Education, as a governmental agency, needs the support and assistance of other agencies, of industry, of institutions of higher education, both public and private, and of the community itself. Without this support and assistance, every effort could result in a fruitless venture.

In our interest to achieve a better education and especially a more effective way of teaching science, we are engaging in a comprehensive curriculum revision of the science program.

At this time I would like to share with you some of the more significant aspects of the revision of the Natural Sciences Program that we are embarking upon. I hope this will give you more insight and a clearer view of our objectives in terms of science education in Puerto Rico.

The Department of Education, promotes a different program for talented students in which 1,400 high school biology, chemistry, and physics students participate, at a cost of one hundred sixty-five thousand dollars ($165,000). This program will continue during the next school year.

The rich experiences provided in this program are being enjoyed by students, teachers, and parents.

The success and culmination of all these efforts were evidenced by the 37 awards obtained by our delegation at the Thirty-Eighth International Science and Engineering Fair held in San Juan from May 10 through May 16, 1987.

During this fair Puerto Rico became a magnificent international scientific scenario where more than 2,000 participants had the opportunity to share their culture and scientific knowledge. We are certain that every participating student will remember this outstanding international event.

I would like to take this opportunity to thank our many sponsors among which I must recognize the University of Puerto Rico, the Puerto Rico Tourism Company, the Puerto Rico Community

Foundation, the Angel Ramos Foundation, the Department of Health, the Police Department, and private industries.

To continue this effort in updating the science curriculum, the Department of Education will initiate, during the 1987-88 school year, the use of a new curriculum in chemistry for high school students. The selection of new curricula for physics is planned for the coming school year (1988-89).

This important revision could not have been implemented effectively without taking care of the professional training of the science teachers. The Department of Education designed a special inservice training program, at a cost of nine hundred fifty-eight thousand dollars ($958,000). During this training program 2,255 public school teachers participated in study courses, workshops, and seminars at different universities. Also, 707 private and public school teachers received the benefit of a program with paid registration to complete their certification requirements and to improve their knowledge and competency in the subjects they teach, at a cost of one hundred thirty-five thousand dollars ($135,000).

This effort would not have been completed except for direct technical assistance to the classroom teachers from 100 science coordinators who were appointed to the school districts to facilitate the implementation of the curriculum revision.

Special attention has been given to talented students in the natural sciences. New and challenging programs have been designed for them. In the revised program, the student adopts a more active role in experimentation, and the teacher, as a facilitator, leads the students to a better understanding of the world. Today, we can say that, thanks to the dedicated effort and work of many teachers, coordinators, and supervisors, part of this revision has been completed, and we shall continue from here.

The evaluation of new curriculum materials for students in the first, second, and third grades has been completed. These new materials will be in use in every school during the next school year. For the fourth, fifth, and sixth grades, the Department of Education has acquired new books and teacher's guides at a cost of one million eight hundred thousand dollars ($1,800,000) during the 1986-87 school year. Likewise, at the secondary level a new curriculum has been implemented for students and teachers in the seventh, eighth, and ninth grades at a cost of two million six hundred thousand dollars ($2,600,000). Similarly, a new biology book was purchased for high school students at a cost of one million seventy-two thousand dollars ($1,072,000). A guide for the teaching of high school biology is in the process of being produced.

This curriculum revision not only covers the traditional topics commonly included in regular courses, but new topics of great interest to our students, such as cancer, and the effects of drugs in the human body. Thematically, both subjects are developed from a preventative point of view.

These efforts represent only the initial steps towards the revitalization and revision of science education in our public schools. There are future plans which represent both short and long term changes. I would like to mention a few in order to provide you with a more precise idea of the future of science education from the Department of Education's perspective. These plans are as follows:

1. The implementation of special new programs to fulfill the needs of those who are not particularly interested in this field of knowledge or in scientific and engineering careers.

2. The organization of one high school of science and mathematics in each of the seven educational regions.

3. The certification of every science teacher, both at the elementary and secondary school levels.

4. The implementation of an experimental plan to require three units in science for high school graduation: one in biology, one in chemistry, and one in physics.

We must continue to help our students to achieve a better education, an education of excellence. We believe that our teachers' talents and experiences, together with our efforts, will build a new school for today and for the future of Puerto Rico. Thank you.

SOME IDEAS FOR SCIENCE & TECHNOLOGY EDUCATION IN PUERTO RICO

Fernando E. Agrait, President
University of Puerto Rico

I would like to thank the Caribbean Division of the American Association for the Advancement of Science (AAAS) for inviting me to participate in its third annual meeting dedicated to Science and Technology Education. The theme of this conference is quite timely, given the challenge of competitiveness faced by our universities today and Puerto Rico's initiatives, at this point in our history, to become better at innovation and developing a primary role for science and technology. It is also significant because the Caribbean Division, founded in 1983, it the newest of the four geographic divisions of the Association, and the first one outside the U.S. The Division brings Puerto Rico into an important network. Founded in 1848, with more than 136,000 members, it represents the oldest society in the world for the advancement of science.

At this time I also would like to congratulate Dr. Herminio Lugo Lugo, for having been elected as new President of the Division, and to thank Dr. Juan A. Bonnet, Jr., your past president of the Division, for having the vision and leadership to establish this Caribbean Division of the Association with headquarters on our island. The Division includes all the islands in the Caribbean Region, Central America, and Southern Mexico.

We have to recognize that Puerto Rico has entered the high technology era in a very rapid manner. Today we find ourselves using all the electronic technology of the times---from cable TV and video, to portable telephones and computers, as well as sophisticated instrumentation for biomedical and engineering research. We have more pharmaceutical manufacturing companies on our island than in any of the states in the USA. Many high-tech companies have opened manufacturing operations in Puerto Rico, joining the pharmaceutical and apparel companies which have had similar operations here for two decades. Industries are beginning to diversify their operations in Puerto Rico from manufacturing to developing new products and processes. In the high-technology era in which we are living now, which is "knowledge-based" and relies on "information", we have to reconsider our educational priorities.

The Puerto Rico workforce has changed dramatically over the last twenty years. The employed workforce totaled about 758,000 people in [illegible]. White-collar and service-sector jobs have increased to over [illegible] of the total in [illegible], up from 50% in [illegible].

The levels of education have also increased significantly. From 1975 to 1985 those with one or more years of college increased notably from 15.9% to 31.9%. Some 160,000 students are presently enrolled in Puerto Rican universities. The college enrollment is about 50 students per 1,000 population, which is a much higher ratio than the average ratio in the USA of about 35 students per 1,000 population.

There has been a tremendous upsurge of interest in this decade to attract high technology companies to create more jobs. The competition from foreign countries, such as Taiwan, Japan, South Korea, Singapore, and some states, such as Texas, California, Georgia, and Massachussetts, is very keen. A 1982 study by the Joint Economic Committee of the US Congress of factors that influence the regional location choices of high technology companies found that the availability and skills of a labor force ranked first among a firm's location considerations, followed closely by labor costs. Proximity to academic institutions ranked fourth among the twelve factors considered.

Here in Puerto Rico, our Governor, the Honorable Rafael Hernández-Colón, recently appointed an Advisory Committee on Science and Technology. This group will play an important role in policy development for a coordinated scientific and technological research effort, compatible with Puerto Rico's industrialization program. I am honored to preside this Committee. Also the new Industrial Incentives Act, approved in January 1987, provides for a special industrial fund to help develop new processes and products, and to foster science education on our island. It has been estimated that $15 to $25 million will be available yearly for this effort.

Now it is also time to consider how to reorient our educational systems to respond to the new global economy, where technology-based products and services are essential to participate in world markets. As an example, Ireland has made a major effort to expand engineering, electronic, and computer science courses in its established universities, and the government has set up nine technical colleges to increase the flow of technically trained personnel needed by newly-arriving foreign electronic and computer firms.

It is important to point out that we want to produce a broad-based education. Besides their solid training in mathematics and science, important literacy skills, languages, and the use of other communications media are a priority. More general skills, such as critical thinking, planning, the humanities, and the ability to live in our society, are also indispensable. There is also a broad-based agreement that citizens in today's society need to have a greater understanding of science in order to make informed collective and personal judgments. "Scientific Literacy" as well as "Computer Literacy" is becoming essential in our era. Life in our "information society" will be more intelligible and rewarding to those with a sound academic preparation.

Let me now review what we are doing at the University of Puerto Rico to respond to these societal requirements. As soon as I was appointed President of the University System, I established a Scientific Research Advisory Committee to advise me personally. The Committee recommended, and I adopted for the first time in the University's history, a scientific research policy for our academic system. The policy is designed to promote research throughout the University through sound planning and management, as well as special individual and institutional incentives.

The two oldest Research Centers at the University, the Agricultural Experiment Station, founded in 1915, and the Center for Energy and Environment Research (CEER), established in 1957, have been strengthened, and both are working in close cooperation with appropriate Commonwealth agencies. CEER is successfully completing its transition from a totally dependent federal agency contractor to a University of Puerto Rico-based institution responding to our island's problems and needs.

We have established a very successful Small Business Development Center at three of our units. This Center provides training, and business plan development, among other things, to Puerto Rican entrepreneurs.

Also a new Research and Development Center has recently been established at the Mayaguez Campus of UPR. We foresee that this new Center will be the base for the possible establishment of a Research Park on University property at Mayaguez. In January we established a University/Industry Research Center with the pharmaceutical and chemical industries. The Center is headed by a Board of Directors representing industries, foundations, and university representatives which I preside. At the School of Medicine we have established an active center to develop protocols related to AIDS research.

In addition, we have strengthened our relations with federal agencies, such as the National Science Foundation, the National Aeronautical and Space Administration, National Institutes of Health, the Department of Energy, the Department of Education, and others. These linkages are resulting in new programs, such as the Experimental Program to Stimulate Competitive Research, widely known as EPSCOR.

The EPSCOR program is aimed at the development of competitive research in Puerto Rico, and is supported with partial funding from the National Science Foundation. It represents an integral part of the local commitment to develop the intellectual resources which are needed to stay ahead in today's fast-changing technological marketplace. Eleven primary research areas have been carefully selected for development under EPSCoR which are relevant in several ways: they may relate to the industrial and economic development of the island or exploit the uniqueness of Puerto Rico, while leading to new scientific discoveries and fundamental advances, and some research projects are aimed at helping to solve the region's ecological problems.

When we consider that almost 65 percent of the total federal research and development funds in the U.S. are allocated among ten top states, EPSCoR becomes even more important to help in developing and maintaining the institutional infrastructure needed to conduct competitive research. Along with EPSCoR, other programs such as the Research Centers in Minority Institutions, in which two UPR campuses participate, and the Minority Biomedical Research Support Program (which provides benefits to five of our units), are important in assisting us to develop research potential in various fields of science. It is widely recognized throughout the nation's higher education community that the most serious hindrances to the pursuit of new scientific and technical knowledge are based mainly on the lack of adequate research facilities, state-of-the-art equipment, and strong but flexible management support. The programs I have mentioned are thus extremely important to the University System because they provide resources to strengthen these areas.

Another area which we are expanding is the university-sponsored science programs for high school students. As an example, the Summer Science Student Program (SSSP) of the Center for Energy and Environment Research has expanded this summer, serving 150 students in five educational regions: San Juan, Ponce, Mayagüez, Caguas, and Arecibo. The University's Research Center for Science and Engineering also has approximately 150 students enrolled in pre-college science programs.

To pave the way for your deliberations, and realizing that this Seminar will result in some recommendations related to Science and Technology Education that will be submitted to the Commonwealth Educational Reform Commission, I would like to mention that as a member of the Commission I will be anxious to receive your ideas and suggestions, and will give them careful consideration.

In closing, let me mention some areas that I believe should receive high priority at the secondary school level. These areas are: First, mathematical and computer literacy. Science and technology students should be taught precalculus and computer basics before reaching university. We are ready at the University to help the Commonwealth high schools to achieve this. Second, critical reasoning, based on the scientific method, should be taught as early as possible. Third, science and mathematics courses at the high school level should only be taught by teachers with at least a university minor or preferably a B.S. in their field. Of course, the necessary basic education courses should also be compulsory. Fourth, the assistance that our University provides to the Commonwealth and the Department of Education, to help in science and technology curriculum development, honor student programs, and special summer science and mathematic courses, should be broadened.

I hope that you will consider these ideas in your deliberations, and wish you a successful conference. The University community will be looking forward to your advice in this important endeavor of improving our Science and Technology Education for the well being of our young generation.

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RECOMENDACIONES SOBRE LA REFORMA EDUCATIVA EN EL CAMPO DE LAS CIENCIAS

Por el Panel de Educación en Puerto Rico
de la División del Caribe de la
Asociación Americana para el Avance de la Ciencia

I. INTRODUCCION

Por varias décadas se ha estado ventilando en la opinión pública del país la necesidad imperiosa de que haya una verdadera reforma educativa que mejore el clima académico en los salones de clases de manera que el aprendizaje sea de excelencia y que los egresados del sistema de instrucción pública obtengan una educación esmerada, posean los conocimientos suficientes para enfrentar los problemas de la sociedad moderna y reciban un cúmulo de actitudes que los cualifiquen para ser ciudadanos útiles y de gran productividad.

Es de conocimiento público el hecho de que nuestro sistema educativo no está consiguiendo los objetivos fundamentales que por lo menos las clases de más alto nivel instruccional anhelan. Las personas entendidas en la materia están conscientes que mientras el país se desgarre políticamente, el sistema educativo de nuestro pueblo seguirá su escala descendente y no habrá logros positivos que ayuden a resolver los problemas sociales agudos que estrangulan nuestra sociedad, tales como el de las drogas, el alcoholismo, la falta de salud mental, la criminalidad y la desintegración de la unidad familiar.

Consciente de su responsabilidad para con el sistema educativo del país, la División del Caribe de la Asociación Americana para el Avance de las Ciencias (AAAS) dedicó su Asamblea Anual de 1987 a celebrar una conferencia sobre el tema de la Ciencia y la Tecnología. Durante los días 18 y 19 de junio se reunieron en el Hotel Condado Beach distinguidos educadores en ciencias con científicos y expertos en tecnología con el propósito de unir esfuerzos y someter a la Comisión de Reforma Educativa sus opiniones y recomendaciones sobre la reforma educativa en la enseñanza de las ciencias y las matemáticas.

Este documento recoge las recomendaciones sobresalientes presentadas durante los dos días de discusiones sobre el tema. Se entiende que la lista bajo ningún concepto incluye todas las recomendaciones. Entendemos también que se hace difícil el poner en marcha todas las recomendaciones expuestas por los diferentes panelistas. Las mismas reflejan el estado de deterioro en que se encuentra la enseñanza de las ciencias y las matemáticas en Puerto Rico, a pesar de los grandes esfuerzos que hacen el Departamento de Instrucción Pública, la Asociación de Maestros de Ciencias de Puerto Rico y los recintos universitarios públicos y privados del país, entre otros.

El documento representa la aportación oficial de la AAAS del Caribe y, como se explicó en los párrafos anteriores, surge de las aportaciones presentadas sobre el tema Ciencia y Tecnología

Educativa en nuestro país: Antillas Anual. Esperamos que esta aportación sirva para sentar las bases para una verdadera reforma en la enseñanza de las ciencias y las matemáticas en Puerto Rico.

II. CONCEPTOS GENERALES SOBRE EDUCACIÓN.

Mucho se ha hablado y se ha escrito durante las últimas décadas sobre la crisis en la educación en las ciencias en nuestras escuelas y universidades. La enseñanza de ciencias ha sido objeto de duras críticas en los procesos educativos. Esta crisis que percibimos en la enseñanza de las ciencias es el resultado de una sociedad que ha avanzado a pasos agigantados económica y tecnológicamente, mientras que el sistema educativo no ha podido proveer los mecanismos necesarios para que sus miembros puedan sobrevivir adecuadamente en una sociedad cambiante.

El momento que viven nuestra sociedad y sus instituciones demanda un esfuerzo bien creativo de todos los ciudadanos hacia el logro de una reestructuración total del proceso educativo en nuestra isla. Los cambios que ocurren en el mundo actual y en nuestra sociedad puertorriqueña exigen que nuestro sistema educativo sea uno dinámico y alerta, que responda a dichos cambios. Es necesario que como educadores en las áreas de ciencias y matemáticas seamos serios, honrados y responsables y que nos preguntemos si la educación en ciencia necesita llevar a cabo cambios substanciales.

Debemos también preguntarnos si hay que modificar nuestras prácticas de currículo y de instrucción. ¿Qué repercusiones tienen en el proceso educativo el desarrollo actual de la ciencia, la tecnología y la sociedad en que vivimos? ¿Es necesario reexaminar toda nuestra estructura educativa? ¿Tendremos que hacer cambios que mejoren grandemente nuestra habilidad para promover el entendimiento de las ciencias entre nuestros estudiantes y la ciudadanía en general?

La situación actual nos sugiere que urge tener una reforma educativa que reestructure la educación actual, envolviendo una convergencia de nuevas actitudes hacia el tiempo con nuevos enfoques hacia la acción. Según el Prof. Fernando E. Agrait, hay que considerar una reforma educativa como "un proceso dirigido a fortalecer las instituciones educativas para que puedan responsablemente proveer una educación de calidad que tenga como objetivo fundamental la formación integral de un hombre enmarcado en la realidad y los valores de nuestra sociedad puertorriqueña". Una verdadera reforma educativa es, sobre todo, un esfuerzo de investigación, de reflexión crítica y de pensamiento creativo que va descubriendo e inventando una forma más adecuada de educar las nuevas generaciones puertorriqueñas.

Para lograr esa reforma en la educación en las ciencias y las matemáticas ya se están haciendo grandes esfuerzos en Puerto Rico. Se entiende que debe ser un esfuerzo de conjunto y tiene que tener coordinación, promoviendo un cambio en la actitud de muchos, especialmente los educadores, del público y de todas las actividades relacionadas con la enseñanza de las ciencias y las matemáticas. Todos tenemos que estar dispuestos a echar a un lado las actitudes que han estado al servicio de muchos durante los últimos años, y cambiarlas por unas que propendan hacia una educación en la cual el estudiante logre aprender por sí mismo, perdiendo en esta forma el miedo que el sistema ha impuesto sobre las ciencias y las matemáticas.

Los pedagogos reconocen cuatro elementos fundamentales para los procesos del aprendizaje.

1. Contenido---este es el más utilizado en nuestras escuelas.

2. Contexto---la relación de lo discutido a la vida diaria del estudiante. Los profesores en muchas ocasiones esperan que el alumno descubra esta relación por su cuenta.

3. Motivación---un maestro motivado comunica entusiasmo para la ciencia a sus estudiantes. Una vez que el estudiante esté motivado, su aprendizaje será más rápido.

4. Procesos cognoscitivos---el desarrollo de destrezas que serán utilizadas en la solución de problemas.

Según la opinión del Dr. Andrew Ahlgres, de la AAAS, ni aun los estudiantes de nivel universitario están aprendiendo ciencia. No hay tiempo. Demasiados temas que cubrir y el profesor se dedica a hablar y los estudiantes a escuchar. El currículo de ciencias está obsoleto. Se hace necesario que se enseñen solo los temas esenciales.

¿Cómo vamos a cambiar la enseñanza de las ciencias en nuestro sistema? Nuestro sistema educativo mata la creatividad. Socialmente es limitante. Tiene que enfrentarse al problema de una educación para las masas. Luego, si verdaderamente se desea una reforma educativa esta no puede comenzar con el Departamento de Instrucción. <u>Los cambios tienen que surgir de abajo hacia arriba por lo cual tienen que empezar con el maestro del salón de clases</u>. Hay que cambiar la metodología de la enseñanza de la ciencia. Los profesores al nivel universitario también tienen que cambiar su forma de enseñar. Los padres tienen que participar en el proceso especialmente apagando los televisores de sus hijos. En la escuela pública hace falta el liderazgo de los padres. La calidad del profesorado tiene que mejorarse y los profesores universitarios tienen que venir al salón de clases y participar en el programa de ciencias de nuestras escuelas públicas.

Se reconocen cinco criterios para determinar la importancia que tiene la educación en ciencias en nuestra sociedad.

1. Económico---la enseñanza de las ciencias es esencial para aumentar la productividad en nuestra sociedad.

2. Conocimiento---en una sociedad donde la tecnología cada día cobra mayor importancia, el conocimiento científico es necesario para el disfrute de los adelantos.

3. Cultural---la ciencia es parte importante de nuestra cultura; por lo cual un egresado educado y culto debe tener conocimientos científicos.

4. Valor personal---el conocimiento científico es esencial para darle significado a la vida de los ciudadanos en esta sociedad altamente tecnológica.

5. Recreativo---ya que la tecnología es algo de consumo diario, el hombre ha de sentir placer en la recreación proveniente de la tecnología. Para compartir este placer los conceptos científicos son necesarios.

Se dice que nadie quiere cargar con la culpa. Como hemos apuntado en la primera parte de este documento, la enseñanza de las ciencias y matemáticas en Puerto Rico está en crisis. Las universidades culpan al Departamento de Instrucción Pública como responsable del descalabro. Este replica que son las instituciones universitarias las que preparan los maestros y como estos no están adecuadamente preparados, la enseñanza es floja. Los maestros de escuela secundaria culpan a los de la elemental como los responsables. La realidad es que todos somos responsables. Todos hemos fallado en cumplir con nuestro deber. Si hubiéramos cambiado nuestras actitudes anteriormente, la situación no sería tan grave como ahora aparece. Como todos hemos fallado, el resto del documento se dedica a formular algunas de las recomendaciones principales presentadas en las diferentes actividades de nuestra Asamblea Anual de 1987. Todas las secciones del documento tienen suma importancia para esclarecer la maraña académica y administrativa en la cual estamos inmersos.

III. RECOMENDACIONES DE REFORMA EDUCATIVA AL NIVEL UNIVERSITARIO

Se presentan a continuación recomendaciones de reforma educativa para ser transmitidas a los Departamentos de Ciencias, Matemáticas y Educacion de los diferentes recintos universitarios del país.

A. ESTUDIANTES DE CIENCIAS Y MATEMATICAS.

1. Proveer a los estudiantes la oportunidad de participar en actividades de investigación,

experimentación y destrezas en la solución de problemas.

2. Proveer facilidades para que los estudiantes participen en campamentos de verano de manera que amplíen sus horizontes e interés en los campos del conocimiento científico.

3. Mejorar los métodos de reclutamiento de manera que los departamentos universitarios de ciencias y educación acepten los estudiantes más talentosos.

4. Estimular la integración del estudiantado a los campos de las ciencias y matemáticas a través de organizaciones estudiantiles que cooperen con los programas departamentales.

5. Auspiciar concursos a nivel local para ofrecer la oportunidad a presentar sus trabajos científicos o a tratar de superarse en la solución de problemas de índole científica.

B. PROFESORES DE NIVEL UNIVERSITARIO.

1. Proveer recursos para que los profesores puedan asistir a congresos y seminarios nacionales que son una fuente principal de nuevas ideas y de renovación personal.

2. Organizar actividades en las que ocurra un intercambio de ideas entre profesores de ciencia, científicos y educadores.

3. Que anualmente se les exija a los profesores creditaje en Educación Continuada---esta podría formar parte importante para las evaluaciones que anualmente se hacen para ascensos y permanencias.

4. Proveer seminarios para los científicos y los maestros de ciencia y matemáticas sobre metodología de la enseñanza de estas materias. Estos deben presentar sugerencias de creatividad para mejorar la instrucción de la ciencia en el salón de clases con énfasis en la integración de materias.

5. Incorporar como parte integral de los materiales los procesos de la ciencia, tales como observación, medición, predicción, inferencia, registro y análisis de datos, formulación y examen de hipótesis, desarrollo y conducción de experimentos, metodología de laboratorio y conducción de viajes de estudio, entre otros.

6. Debido a la preparación de los laboratorios y a la velocidad con que cambia el conocimiento en ciencias, a los profesores universitarios deben asignarseles no mas de dos preparaciones por día.

7. Proveer facilidades físicas bien equipadas para los programas orientados hacia los laboratorios.

8. Asignar no más de 30 estudiantes por sección en el laboratorio para asegurar la atención individual y la seguridad.

9. Crear un sistema de evaluación que permita reconocer los mejores profesores y retenerlos en servicio. Identificar los maestros entusiastas que proyectan una imagen de credibilidad y que tomen ventajas de la influencia ambiental y social, que identifiquen las necesidades del estudiante estando alertas a las actividades de este. Que usen los temas controversiales para enseñar ciencia y que envuelvan al estudiante en la ciencia en vez de hablar de ella.

10. Crear una red de profesores que puedan intercambiar programas de computadoras desarrollados localmente.

C. PROGRAMA ACADEMICO DE NIVEL UNIVERSITARIO.

1. Diseñar seminarios, talleres, institutos y cursos para el readiestramiento de maestros de ciencia de los niveles elemental y secundario, así como para los candidatos a maestros de ciencia de los Departamentos de Educación.

2. Que se establezcan programas de Bachillerato en Educación en Ciencias y Matemáticas.

3. Crear un instituto de investigación pedagógica y desarrollo teórico que pueda ser en cooperación con la industria y con otras instituciones de nivel universitario.

4. Desarrollar programas de investigación científica para estudiantes de escuela superior y universitaria.

5. Desarrollar talleres y seminarios que ayuden a los profesores universitarios a conocer el desarrollo físico y emocional del estudiante para ayudarle a entenderse a sí mismo para que este pueda lograr sus expectativas físicas, emocionales e intelectuales.

D. REFORMA CURRICULAR RECOMENDADA.

1. Que se [illegible] interuniversitarios de profesores que [illegible] ideas sobre los cursos de ciencias y matemáticas y las asignaturas que deben tomar los futuros maestros de estas.

2. Los materiales escritos deben ser consecuentes con las metas y objetivos que establece la institución y orientados hacia los intereses y el mundo de los estudiantes.

3. Diseñar cursos integrados con equipo multidisciplinario incluyendo los mejores profesores de las diferentes materias.

4. Utilizacion y desarrollo de actividades de laboratorio sencillas para suplementar ejercicios y que estén correlacionados con actividades de la vida diaria.

5. Revitalizar y diversificar el currículo para atender diferentes ritmos de aprendizaje (rezagados y talentosos) como para atender diferentes intereses y situaciones sociales. La revitalización debe incluir por lo menos:

   a. conceptos básicos de las ciencias naturales y las matemáticas;

   b. conceptos básicos de las ciencias sociales;

   c. aprendizaje en acción y experiencias en servicio;

   d. actividades de contexto para que el estudiante pueda comprender la aplicación de estos conceptos a su vida diaria.

6. Las universidades deben reexaminar los programas de preparación de maestros de ciencias y matemáticas; el tipo de educación técnica que ofrece y la relación de esta con la educación general y con las destrezas de aprendizaje que faciliten el readiestramiento del estudiante para enfrentarse a cambios tecnológicos que afectan el mercado de empleos.

E. RECOMENDACIONES GENERALES PARA LAS UNIVERSIDADES.

   1. Diseñar un plan de colaboración en el que las universidades deben compartir entre sí sus recursos y facilidades.

2. Ofrecer salarios competitivos con los que se devengan en otras carreras relacionadas con las ciencias y las matemáticas.

3. Ofrecer oportunidades y apoyo financiero y administrativo para que los profesores puedan participar en organizaciones profesionales.

4. Apoyo, reconocimiento y compensacion apropiada por supervisar actividades científicas extracurriculares, como ferias científicas, competencias u olimpiadas científicas.

5. Brindar licencias de duración variada que permitan que los profesores puedan asistir a conferencias y participar en cursos cortos o completar créditos académicos hacia un grado superior.

6. Proveer un presupuesto adecuado para la compra y mantenimiento de equipo y materiales para los laboratorios y otras actividades que requieren instrumentación.

IV. VISION DEL MAESTRO EN LA REFORMA EDUCATIVA---NIVEL SUBGRADUADO.

A. IMPORTANCIA DEL MAESTRO EN LA REFORMA EDUCATIVA.

Al considerar el concepto de educación de excelencia nos encontramos con que hay confusión sobre el particular. Nos preguntamos si el ideal de la escuela pública es hacer lo mismo que hacen las privadas. Esto nos lleva al convencimiento de que tenemos que investigar sobre el particular, pues no hay precisión en el diagnóstico que se hace. Por lo tanto, tiene que establecerse una consulta entre los afectados: los estudiantes, los maestros, los padres, los administradores y la gente de la empresa y la industria.

Los resultados de la encuesta deben ser articulados para poder derivar conclusiones. En un estudio sobre la escuela, Goodlard nos habla de la lucha educacional del día de hoy. Indudablemente que cada grupo tendrá una idea diferente sobre lo que es educación de excelencia y allí mismo comienza la lucha que nos envuelve a todos cuando a excelencia educativa se refiere. Urga la aclaración de este concepto, pero que se ajuste a la realidad puertorriqueña.

El factor fundamental en cualquier reforma educativa lo es el maestro y en el campo de las ciencias y las matemáticas, por lo complicado de la materia, este factor cobra mayor importancia. Dentro de este marco de referencia, buscamos maestros capaces de:

1. formar hombres para el futuro con autorealización en una sociedad más compleja y menos estructurada.

2. ser responsable de sus propias responsabilidades donde la educación continuada sea una meta. Que sea capaz de reaprender lo aprendido.

3. depender más de su habilidad racional y tener capacidad para el pensamiento crítico.

4. tener destrezas de comunicación no importa lo que estudie.

Este maestro tiene una responsabilidad con él mismo, con la profesión y con sus estudiantes. Si todos los maestros vivieran esta filosofía, el salón de clases sería un sitio saludable para el desarrollo de los estudiantes. Este concepto nos lleva a concluir que para lograr la excelencia en la educación y poner en ejecución la reforma educativa, el sistema tiene que contar con el maestro como el factor determinante.

A continuación se trazan las características de este maestro:

1. es un maestro motivado que provee dirección y seguridad a sus estudiantes, especialmente en el nivel intermedio;

2. se comunica efectivamente con sus estudiantes, padres iguales y administradores;

3. planifica, experimenta y estimula a sus estudiantes a pensar, a evaluar información y a verificar conclusiones;

4. trabaja con sus iguales y administradores;

5. amplía sus conocimientos;

6. es responsable y leal a su profesión y se autoevalúa periódicamente;

7. participa en organizaciones profesionales;

8. asume responsabilidades en comités de padres y maestros;

9. tiene habilidades intelectuales superiores y es emocionalmente estable;

10. es amante de la lectura, la música y el arte;

11. es capaz de evaluar lo que se le envía como guía y toma decisiones sobre estos; responsablemente hace un diagnóstico, lo discute con sus superiores y procede a hacer cambios.

B. ALGUNAS NORMAS ADMINISTRATIVAS QUE DEBEN MODIFICARSE.

1. Los salarios, ascensos y retención de los profesores deben basarse en un sistema de evaluación efectiva que incluya a los iguales. Esto genera recompensas para los mejores maestros, estímulo para los del promedio y los flojos se mejoran o deciden irse.

2. Los maestros consultores (Master Teachers) deben envolverse en el diseño de los programas de maestros y en la supervisión de los maestros que estén en periodos probatorios.

3. Se recomienda que se establezca una escala de salarios que considere los siguientes factores:

   a. preparación académica: B.S., B.Ed., M.S., Ph.D.

   b. años de servicio---experiencia en el salón de clases

   c. maestros consultores (Master teachers)

   d. maestros principiantes---sueldo debe aumentar por competencia profesional y ejecución

4. Debe establecerse un programa de adiestramiento en servicio continuo:

   a. para mejorar los maestros con adiestramiento adecuado pero que no tienen los conocimientos del nuevo contenido, uso de nueva tecnología y en metodología en los currículos de ciencias y matemáticas;

   b. para los que tienen poca o ninguna preparación en la enseñanza de las ciencias y matemáticas;

   c. estos adiestramientos deben ser compulsorios para la renovación de contratos o para ascensos.

5. Debe delinearse un programa de orientación efectiva de estudiantes de las escuelas secundarias de manera que se estimulen a los mejores a seleccionar la educación en ciencias como su profesión.

6. Debe hacerse una revisión total de los currículos de ciencias y matemáticas para que estos estén de acuerdo con nuestra sociedad cambiante.

7. Estimular un esfuerzo de conjunto entre los colegios que preparan maestros y los que ofrecen especialidades en ciencias y matemáticas para que juntos ofrezcan programas de educación continuada.

8. Promover la investigación pedagógica en la enseñanza de las ciencias y matemáticas y diseminar a través de todo el sistema los hallazgos para su incorporación en el salón de clases.

9. La enseñanza de la ciencia debe ser interdisciplinaria enfatizando los conceptos básicos y enseñándolos partiendo del fenómeno natural seleccionado.

10. Se debe aumentar el número de días de clase ya que el proceso de aprendizaje se afecta por las interrupciones continuas. Los días que el maestro esté ausente los repone al final del año y termina su trabajo más tarde.

B. RECOMENDACIONES GENERALES.

1. Revisar los estudios sobre reforma educativa hechos anteriormente para incorporar aquellas recomendaciones que aún estén vigentes.

2. Reducir al mínimo las intromisiones políticas en las decisiones educativas.

3. Preparar un perfil del egresado que esperamos producir cuando el estudiante abandone las aulas escolares.

4. Preparar un perfil del maestro que deseamos sea responsable de la enseñanza de las ciencias y las matemáticas en nuestras escuelas elementales y secundarias públicas y privadas.

5. Que se planifique para aumentar el número de profesores con maestría que enseñen ciencias y matemáticas en las escuelas del sistema público.

6. Regionalizar la enseñanza de las ciencias para facilitar la iniciativa del maestro local.

7. Desarrollar materiales de enseñanza en español y pertinentes a Puerto Rico.

8. Mejorar la enseñanza del inglés y del español para mejorar la comunicación oral y escrita. Se recomienda, además, fortalecer la enseñanza de las matemáticas, que es el lenguaje de la ciencia.

V. EL PAPEL DEL ADMINISTRADOR EN LA REFORMA EDUCATIVA.

En la ejecución de los diferentes programas educativos los administradores, especialmente el Director de la Escuela, pasan desapercibidos para las autoridades escolares. La función fundamental de este oficial administrativo es de vital importancia para el desarrollo del currículo escolar. El Director puede ser un facilitador o una piedra de tropiezo para el programa académico. El Director tiene que aglutinar los esfuerzos de sus maestros, padres y la comunidad para llenar las necesidades de sus estudiantes.

El Director puede ser factor de importancia para:

1. que los temas de las ciencias sean material de estudio en otras asignaturas;

2. participar, en unión al maestro, en la evaluación de las actividades académicas de la escuela;

3. estimular al maestro para continuar estudios, a que participe en la educación continuada, en talleres y institutos en ciencias y matemáticas, ferias científicas y otras actividades relacionadas;

4. crear en su escuela un clima favorable para el desarrollo de las ciencias y matemáticas o cualquier otra asignatura que le interese estimular.

Dada la importancia del Director de la escuela se someten las recomendaciones para fortalecer este puesto:

1. Redefinir el papel del Director como líder académico.

2. Estimular su colaboración con grupos de investigación pedagógica.

3. Revisar los programas universitarios para la preparación de los Directores de escuelas.

4. Creación de centros de mejoramiento profesional para Directores.

5. Crear en las escuelas cursos nuevos que interesen a los estudiantes que no van a estudiar ciencia.

VI. IMPORTANCIA DE LA INVESTIGACION CIENTIFICA EN LA REFORMA EDUCATIVA.

Hay una relación estrecha entre la enseñanza de las ciencias y la investigación científica. Sin el laboratorio, la ciencia no es ciencia. El laboratorio fundamenta su importancia en el método científico. Los grandes descubrimientos científicos que diariamente se informan surgen de la utilización de este método en la investigación científica que se lleva a cabo en los laboratorios de las universidades y firmas industriales. La investigación científica provee entonces el continuo fluir de nuevos conceptos científicos que enriquecen los currículos de todos los centros educativos del país. Luego, la investigación científica es de vital importancia en el fortalecimiento de los currículos de ciencias. Una reforma educativa en los campos de las ciencias debe por obligación incluir la investigación científica como uno de los puntos principales para poder mejorar la enseñanza dentro del salón de clases.

Se enumeran a continuación algunas recomendaciones para estimular la investigación científica en las escuelas públicas y privadas de Puerto Rico, así como en los diferentes recintos universitarios del país:

1. Fortalecer la enseñanza de las ciencias en los niveles elemental, intermedio, secundario y universitario desde una perspectiva de investigación y descubrimiento.

2. Ofrecer para los maestros en servicio y para los candidatos a maestros en ciencia cursos universitarios sobre investigación científica. Estos cursos deben ser requeridos para ambos grupos. Debe continuarse el entrenamiento de maestros a largo plazo sobre la estimulación de la investigación científica en todos los niveles dándoles seguimiento periódico a aquellos que son entrenados.

3. Fomentar el establecimiento de bibliotecas de ciencias en todos los niveles y estimular el uso de estas por aquellos que desarrollan proyectos de investigación científica.

4. La enseñanza de las ciencias debe cambiar de tal manera que se enfatice el hacer en vez del observar.

5. Fomentar campos de enseñanza pertinentes a nuestra isla de manera que la investigación científica sea más efectiva en el desarrollo científico de Puerto Rico. Algunos que se sugieren son:

   a. Ciencias terrestres
   b. Ecología tropical
   c. Ciencias atmosféricas
   d. Ciencias marinas
   e. Parasitología tropical

6. Liberalizar los mecanismos utilizados para la compra de materiales y equipos para uso en los laboratorios de ciencias.

7. Mejorar la disponibilidad de equipos a los maestros de ciencias usando almacenes regionales donde los profesores de ciencia puedan conseguir lo necesario para estimular sus estudiantes en los laboratorios y, por ende, en la investigación científica.

8. Se recomienda una computadora personal para cada salón de ciencias entendiéndose que los profesores recibirán entrenamiento sobre el uso de estas. La computadora debe incorporarse a las experiencias del salón de clases

orden se puede usar para la recopilación de datos y el análisis estadístico de éstos, formulación de gráficas y para la ejecución de programas de ciencias adaptados al nivel de enseñanza específico.

9. Incorporar los congresos y las ferias científicas como parte integral del currículo de ciencias en los niveles elemental, intermedio y secundario.

10. A los estudiantes que se destaquen en la investigación científica en los niveles intermedio o secundario se les debe ofrecer la oportunidad de trabajar en los laboratorios de investigación de las universidades o de la industria privada.

VII. PROBLEMAS DE LA CIENCIA EN PUERTO RICO Y SUS REPERCUSIONES.

La ciencia en Puerto Rico tiene tres problemas principales.

1. La fuga de cerebros a los Estados Unidos. En décadas pasadas Puerto Rico exportaba ciudadanos sin experiencia educativa. Al presente hay una sangría de personas que emigran tras recibir una educación universitaria de primer orden: ingenieros, médicos, enfermeras, etc.

2. La localización de las ciencias básicas en la metrópolis---los pueblos de la isla carecen de facilidades científicas.

3. La obligada educación instrumentalista de la ciencia.

Enumeramos a continuación las repercusiones directas o indirectas que para la enseñanza de las ciencias tienen estos problemas.

1. la formación de un científico comienza en la escuela;

2. el currículo escolar parcela el conocimiento científico en asignaturas diferentes; esto plantea el problema del contenido frente a las destrezas;

3. la escuela es una institución de valor social;

4. la cultura es la expresión de la sociedad.

Recomendaciones para la reforma educativa en ciencias y matemáticas:

1. Salir de los textos para entrar en los contextos

2. Utilizar las relaciones interdisciplinarias buscando todas las interrelaciones posibles

3. Establecer una política explícita de ciencia y tecnología:

   a. utilizar el entorno natural del país

   b. estimular la formación de recursos humanos especializados

   c. establecer sistemas de apoyo a los programas de ciencias

   d. diseñar una política científica y tecnológica concordante con el desarrollo del país

   e. asignar recursos financieros adecuados para nuestro desarrollo científico

   f. promover las actividades de los investigadores

   g. solicitar de la industria que sostenga la investigación científica

   h. promover esfuerzos comunes entre los sistemas universitarios, el Departamento de Instrucción Pública, las escuelas privadas y la industria

   i. propiciar el intercambio de información científica

   j. respetar la libertad académica y el conocimiento científico

   k. fortalecer la enseñanza de las ciencias y las matemáticas

   l. usar instrumentación moderna en los salones de clases

VIII. CONCLUSION.

La División del Caribe de la Asociación Americana para el Avance de las Ciencias desea aportar estas ideas a la Comisión de Reforma Educativa con la esperanza de que las mismas sean consideradas al hacer las recomendaciones finales a las autoridades pertinentes. Recalcamos que la verdadera reforma tiene que efectuarse en el salón de clases, prescindiendo de la asignatura que se enseñe. El maestro es el instrumento fundamental que hará que la reforma sea airosa o un fracaso estrepitoso. Es responsabilidad del gobierno y de las autoridades escolares el crear un clima propicio para que la reforma educativa se efectúe en el salón de clases y no en las esferas administrativas o en los círculos políticos del país.

Puerto Rico espera una reforma educativa que produzca en [illegible] egresado un ciudadano útil para nuestra sociedad. La responsabilidad de producir egresados de excelencia descansa en el maestro. Las autoridades escolares tienen la responsabilidad de ser facilitadores para que producto de primera calidad sea producido en todos los salones de clase del país. La sociedad tendrá que hacer un frente unido para respaldar esta reforma educativa en todas sus repercusiones. Si esto se consigue, Puerto Rico podrá sentirse orgulloso del cambio que habrá de efectuarse en nuestra sociedad.

1987 ANNUAL MEETING
CARIBBEAN DIVISION
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
Dr. Juan A. Bonnet, Jr., President
MESSAGE
Condado Beach Hotel
June 18, 1987

Good afternoon. I would like to start my last annual summation to the Division members by thanking you for having given me the opportunity of serving you as your first President. It was a very rewarding intellectual experience and, deep in my heart, I feel very gratified to have led you through the formation of the Division and to leave today a well organized and dynamic Division.

First I will briefly review some of the most important activities that were carried out by the Division since our last annual meeting.

Our last annual meeting was held on June 8 to 11, 1986, at La Parguera, Puerto Rico. The theme of the meeting was "Marine Industries: Promising Future to Old and New Ventures".

Two seminars for high school science teachers on water resources and their use were sponsored by the Division in cooperation with the Department of Education and the Science Teachers Association. Each seminar was attended by about 45 teachers. In addition, a seminar on water resources management was held in cooperation with the Puerto Rico Chemist Association. Two hundred chemists attended this activity.

The Division sponsored the participation of our secretary/treasurer, Mrs. Lucy Gaspar, to attend a conference, "Forum-86---Science Curriculum---AAAS", at Arlington, Virginia.

The Division organized and hosted a panel on potable water quality during the 11th Scientific Research Congress held in San Juan, Puerto Rico, sponsored by Inter American University.

At the AAAS annual meeting in February in Chicago, Illinois, the Division, in cooperation with the AAAS Office of Opportunities in Science and the Association of Puerto Ricans in Science and Engineering (APRSE), sponsored a workshop, "Hispanics in Science and Engineering: Past, Present, and Future."

In publications the Division co-sponsored a pamphlet on "Small Business and Toxic Wastes Regulations." It is also in the process of initiating a series of publications in cooperation with the University Editorial Board. The first publication will be on Advancement in Energy and Environment Sciences by Dr. Juan A. Bonnet, Jr. Dr. Juan G. González is also preparing the proceedings of last year's seminar on "Marine Industries", and also the proceedings of this year's Seminar on Science and Technology Education will be published.

It is very important to mention that the Division relations with AAAS are excellent. As you know, Dr. William D. Carey retired after twelve years as Executive Officer and Dr. Alvin Trivelpiece already substituted him in that position. Dr. Trivelpiece already expressed his deep interest in visiting us and accepted our invitation to hold the next AAAS Board of Directors meeting in San Juan, Puerto Rico, on December 5 to 7, 1987. On that occasion they will also consider the possibility of celebrating the 1992 AAAS Annual Meeting at the San Juan Convention Center. We already contacted the Commission for the Fifth Centennial Celebration of Columbus's Discovery of the New World, the Puerto Rico Convention Bureau, and the Commonwealth Tourist Department to endorse the Division invitation to AAAS.

The next major activity of the Division planned is a Caribbean Regional Conference on "The Role of Scientific and Engineering Societies in Development". This Conference will be held December 8 to 11, 1987, at La Concha Hotel. The Division will also host the annual meeting of the Interciencia Association and the Continuing Committee on the Role of Scientific and Engineering Societies in Development on December 6 and 7, 1987, prior to the Caribbean Region Seminar. The organization of this seminar is foreseen as a very important step to promote regional cooperation, to strengthen the Scientific and Engineering Societies in the Caribbean Basin, and to establish our Division as an umbrella to stimulate and foster cooperation in the Region.

The Division has joined the Office of Opportunities in Science of the AAAS and the Association of the Puerto Rican Scientists and Engineers in preparing to hold a workshop on "Hispanics and Education" at the 1988 AAAS annual meeting to be held on February 11-16, 1988, in Boston, Massachusetts. Also, conversations are under way with the UPR Editorial Board to initiate a series of joint science publications.

Before ending our period we also started a new membership drive with a Division brochure. This is already producing results and even today we have some new applicants.

From the deliberations of the educational and technical seminar, that we are celebrating as part of this annual meeting, a set of conclusions and recommendations will be sent to the Commonwealth Educational Reform Commission. This is one of the ways the Division promotes that science be given proper consideration in the forthcoming education reform on our island. I encourage the new Board of Directors to present these conclusions at public hearings and at a Press Conference.

Before finishing, I would also like to recommend that the new Board of Directors consider ways to establish a mechanism to get more participation from our Division members from the [illegible] Regional Director at-large in the Board, including one-year minimum outside of Puerto Rico, etc. Another by-law change that should be considered is the election of a permanent Executive Secretary or Executive Director to run Division affairs and maintain continuity with the AAAS headquarters. The other three AAAS-Divisions have successfully used this approach.

I would like to thank our co-sponsors in this seminar, the Puerto Rican Association of Science Teachers, the Ateneo Puertorriqueño, and the Center for Energy and Environment Research of the University of Puerto Rico, for all their cooperation and also to wish the new Division President, Dr. Herminio Lugo Lugo, and the new Board of Directors best wishes, and I assure them it will be a very rewarding experience. I am at their disposal to advise and help as deemed necessary.

THANKS TO ALL OF YOU for having provided me the necessary support during my years as President of the Division.

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