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ABSTRACT

The impact of cultural background on science learning is explored in this compilation of papers and reports from an inter-American Seminar on science education. For the purposes of enriching science program planning, teacher education, research, and practice in the schools, varying ideas are offered on the effects of cultural background on science learning. Papers and other materials are presented under the chapter headings of: (1) introduction (specifying the purposes and organization of the seminar); (2) culture, cognition, and science learning (addressing such aspects as bilingual children's cognition, ethno-science, and curricular pluralism); (3) theory, goals, and strategies of science teaching (including an exploration of instructional strategies, a meta-analysis of the effects of teaching problem solving, and ideas on teaching science); (4) program development (explaining projects in primary school science, ecology, ocean fisheries, and science education in the Caribbean); (5) educating teachers for culturally diverse students (focusing on science teacher training projects); (6) working group projects (providing summaries of each of the four working group's topic areas); and (7) summary and projections (citing the seminar's recommendations for future actions). Four appendices contain a list of seminar planners and participants, a schedule of activities, a list of educators making up the inter-American science education network, and data sources and science education journals. (ML)

SCIENCE EDUCATION & CULTURAL ENVIRONMENTS IN THE AMERICAS

INTER-AMERICAN SEMINAR ON SCIENCE EDUCATION

PANAMA CITY, PANAMA
DECEMBER 10-14, 1984

JAMES J. GALLAGHER & GEORGE DAWSON
EDITORS

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NSTA, NSF, OAS

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In preparing this report, we have had the invaluable aid of Armando Contreras, Alejandro Gallard, Nora Sabater, and Lucila Góngora who served as translators, editoral assistants, rewrite specialists, and many other roles for which they were inadequatley paid. We thank the four of you for your kind and expert help.

Finally, this work is available in both Spanish and English Editions as an aid to science educators throughout the Americas.

J. Gallagher
G. Dawson,
December 1985

Preface

For most readers of this book, the natural sciences transcend cultural and national boundaries. We appreciate the universal character of science and we value the free flow of scientific information among scientists and educators of the world. The objectivity of science and its logical-empirical basis appeal to us because it frees us from constraints of dogma. We prize the view that the correctness of assertions can be tested against reality by empirical means.

But many other people in our world feel quite differently. Natural sciences call into question beliefs and practices that are part of popular culture and daily existence. Science can be seen as an enemy of religion and authority. Its rational stance and its skeptical approach have been viewed as threatening to political and religious leaders. Moreover, we all know that the beliefs and values which people hold can influence their willingness and ability to learn and use scientific knowledge in daily life.

It was this issue, the impact of cultural background on science learning, that the Inter-American Seminar on Science Education addressed. The Seminar planners inferred that across the Americas, hundreds of cultural groups were approaching science learning with varied beliefs about nature and people and these beliefs influenced learning of science in different ways. We also felt that examining research and practices concerning the effects of cultural background on science learning would illuminate our understanding of this complex issue in ways that could strengthen the education of youth in science by enriching program planning, teacher education, research, and practice in our schools. The seven chapters and four appendices which follow contain a description of the Seminar and its results. We hope you find it enriching!

CHAPTER 1 INTRODUCTION

Background of the Seminar

The Americas comprise more than 30 nations with over 600 million people, about 60 percent of whom speak Spanish or Portuguese. Most American nations, including those in the Caribbean, are classed as developing nations. As such, they are investing a larger share of their national resources in education than developed nations. Yet, even with this proportionately larger investment, educational resources sometimes are meager. As many as 50 percent of youth receive only one or two years of schooling. Many teachers have no college training; some have not finished high school. In many nations, only a small portion of youth, usually from the more developed areas, receive a high school education. This is in sharp contrast to mass education, through high school, found in other nations such as the U.S. and Canada.

In all countries, one of the major educational issues centers on education of youth in science. This is due to the increasing importance of science and technology in personal and national development. In many countries, education in science is an important feature of long-range policies of economic development. But most national leaders recognize that educating youth in science is not a simple matter. It is complicated by shortages of qualified teachers, by lack of appropriate facilities, equipment, and curricula, and by difficulties in teaching science to many youth, especially those from social and cultural groups whose belief systems are at odds with the belief systems underlying science.

In all countries, the values of youth are influenced by the cultural system in which they are raised. This can be counter-scientific for a variety of reasons including the myths, superstitions, religious beliefs, or "world views" held by a particular group of people. These values and belief systems, with which young people grow up, strongly influence attitudes, thought, and behavior. Consequently, they influence their desire to learn science, their understanding of it, and ability to apply it both within and outside school. It is, therefore, incumbent on science educators to learn more about the relationships that exist between the cultural backgrounds of young people and their interest in and ability to learn and use science. This issue served as the genesis of this Inter-American Seminar on Science Education.

Therefore, a major purpose of this seminar was to call attention to, and encourage serious consideration of, influences of cultural background of youth on cognition and learning in science. The seminar organizers firmly believed that examination of this topic would benefit both participants and others in the science education community regardless of national origin, because all educational activities are affected by the cultures in which they occur, and curriculum designers attend to learners' preconceptions, attitudes, and belief systems.

Purpose

This was the first Inter-American Seminar on Science Education in which participants from all American nations presented papers and deliberated issues regarding teaching and learning science. The theme of the seminar was "Science Education and Cultural Environments in the Americas." This theme was explored through four sub-themes:

1. Children's cultures, cognition, and science learning--through which we examined the current state of knowledge regarding the relationship among these three entities.

2. Theories, goals, and strategies for teaching science--through which we explored alternative approaches to science teaching which have been designed to address the cultural diversity of learners.

3. Developing effective science programs--through which we deliberated on curricular and instructional designs that promise to aid a larger segment of American youth in developing an understanding of science and technology and their role in contemporary society.

4. Educating teachers to teach culturally diverse youth--through which we investigated strategies for helping teachers utilize data about students' cultural background in providing more effective instruction in science.

It is in this framework that the participants in the seminar met and discussed a series of 25 papers and addresses by scholars, practitioners, researchers, and governmental officials dealing with the overall theme and the four sub-themes. The specific purposes of this conference were:

1. To assemble approximately 40 scholars from North, Central, and South America and the Caribbean to respond to presentations of experts. The presentations focused on the general theme, "Science Education and the Cultural Environments in the Americas" and the four sub-themes identified above.

2. To engender serious scholarly work on these subjects through an open competition among teachers, scientists, science educators, and scholars from relevant fields. This competition was the basis of selection of presenters of 20 papers which served as the core of this conference. These papers related to the sub-themes, and they were selected by a small panel created from the steering committee and conference co-chairs.

3. To establish a communication network among teachers, scientists, science educators, and other interested scholars in North, Central, and South America and the Caribbean. Communication among such persons in the Americas is limited. This conference served as a basis for exchange of information, philosophies, and research, especially regarding the relationship among, culture, cognition and science learning.

4. To produce and disseminate a set of Conference Proceedings which includes (a) condensations of the papers delivered at the Seminar, (b) a synopsis of the deliberations of four discussion groups which were formed as part of the seminar, (c) a list of participants, including institutional addresses (d) a list of other leaders, researchers, and scholars who are concerned about science education who were not able to attend but who should be part of the network of communications, and (e) a list of pertinent information sources available to scholars and practitioners in the Americas.

Organization of the Seminar

The Seminar was organized and sponsored jointly by the Organization of American States (OAS) and the National Science Teachers Association (NSTA) with additional financial support form the National Science Foundation (NSF). OAS has a significant mission to improve education in its 31 member nations in North Central, and South America and the Caribbean. Pedro Turina, Educational Specialist OAS, was a member of the Seminar Steering Committee and was instrumental in planning the seminar and in providing important contacts in Latin America. Ubiratan D'Ambrosio, Director of Brazil's Interdisciplinary Center for the Improvement of Science Education was also a member of the Steering Committee and provided significant help in conceptualizing and planning the seminar.

OAS incorporated this seminar as part of its 1984 program of activities and played a key role in publicizing the seminar in Latin America and Carribean nations. NSTA was the key agent of publicity in the U.S.A. and Canada and provided the major coordinating responsibility. NSF and OAS provided major funding for the seminar with NSTA providing initial funding for planning. Clearly, each of the three agencies provided resources and expertise which were essential to the formulation of the conceptual structure of the seminar and its successful implementation.

The theme of this seminar was first conceptualized at a planning meeting held at the NSTA Convention in Dallas, Texas on April 7, 1983. This meeting was called by James Gallagher, Pedro Turina, and George Dawson. Others in attendance were Ubiratan D'Ambrosio, Sarah Klein (Past President of NSTA), Willard Jacobson (International Council of Associations for Science Education), and Evan Uzwyshyn (Canadian Association for Science Education). Following this meeting, early December 1984 was established as the target date for the seminar and Panama City was selected as the site. In addition, proposals were prepared for OAS, NSTA, and NSF to secure advice of appropriate individuals within these organizations and necessary funds.

Announcements of the Seminar and the Open Competition for Participation were made in September 1983. These were publicized in all 31 American nations through the OAS offices, through professional education organizations including NSTA, and through the network of personal contacts of key individuals comprising the NSTA International Committee, the Seminar Planning Committee, and leaders of OAS science education projects in the Caribbean and Latin America.

The deadline for receipt of drafts of papers was May 31, 1984. In all, over 75 papers were received. Screening of these papers and final selection of participants was made by George Dawson, James Gallagher, and Pedro Turina. Twenty papers were selected by this process using the criteria outlined by the steering committee. Five additional papers were invited to provide a balanced program of presentations. Selections were made in early June and all who entered into the competition and all prospective participants were to have been notified by July 1. Names and addresses of participants are listed in Appendix 1.

Due to unforeseen problems with communication, some participants were not notified until much later than our July 1 target date. This caused serious inconvenience to some individuals for which we are extremely sorry. In at least one case, this precluded attendance at the seminar and we regret the loss of the benefit to our deliberations.

Logistics of communication; arranging conference facilities, lodging, meals, and transportation; delivery of tickets; duplication of papers; and other activities essential to the smooth operation of the Seminar were more difficult and time consuming than the seminar organizers had anticipated. We say this not as complaint, or alibi, but to alert future planners of multi-national conferences to the difficulties of organizing such efforts. The acknowledgement in the preface highlights some of the individuals whose persistence and thoughtfulness were essential to organization of the seminar.

The seminar was held at the ATLAPA Conference Center in Panama City, Panama, December 10-14, 1984. Participants were housed at the Marriott Cesar Park Hotel which is adjacent. Local arrangements were facilitated by the University of Panama and the Central American Institute for Supervision and Administration of Education (ICASE). The schedule of activities is replicated in Appendix 2.

Participants were welcomed at the opening session which began at 7:00 p.m., December 10, by William Aldridge, NSTA Executive Director and Ramon Tello, OAS Deputy Director. Opening addresses were given by Pedro Turina who spoke on "Problems of Science Education in the Americas" and James Gallagher who described change needed for "Educating Youth for a World of Advancing Technology."

During the remainder of the conference, December 11-14, sessions altered between paper presentations and working group meetings. Twenty-five papers were presented by participants to the assembled group. All paper sessions and question periods which followed were simultaneously translated so that they were available to the audience in both Spanish and English. Chapters 2-5 of this report include condensations of the papers organized according to the four sub-themes of the Seminar.

Four working groups were established based on participants' interest in the four sub-themes. Each working group was headed by a bilingual group leader and two rapporteurs, one who was Spanish speaking and one who was English speaking. Working groups were effective because of the large percentage of bilingual participants who willingly served as interpreters for those less fluent in the two languages of deliberation.

Each working group was given the task of applying the concepts and information presented in the papers to their respective sub-theme by examining the following questions:

1. What are the key <u>problems</u> and <u>issues</u> relating to the group's sub-theme that suggest needed changes in order to improve education of youth?

2. What <u>activities</u> are in progress related to the group's sub-theme in the areas (a) research and (b) development and practice.

3. What are the obstacles to research, development, and effective practice related to this group's sub-theme?

4. What human and material resources are available to resolve problems and issues and bring about desired changes regionally nationally, and internationally?

Working groups met for approximately six hours in at least three different sessions during the conference. On Friday, near the closing of the seminar, leaders of working groups presented a summary of the deliberations and recommendations of each of the four working groups. Summary reports of the working groups are included in Chapter 6.

The Seminar schedule allowed ample time for small group interaction. Participants were encouraged to talk with people from other nations and to cross the "language barrier" as much as possible rather than spending most of the time with people who spoke the same language. Participants responded well to this request. Many diverse small groups had informal conversations between sessions and at mealtimes. The openness and willingness of participants to work at communication in informal groupings attest to the interest and enthusiasm of those who attended.

Midway in the seminar, on Wednesday afternoon, participants were provided with a tour of Panama City and the Miraflores Lock of the Panamanian Canal. This gave opportunities to observe some aspects of Panamian culture and society as well as to see some important historic sites. It also gave a needed break from the intense deliberation and "information overload" which meetings like this demand of participants. On Thursday evening, the participants were entertained by a student dance group from the University of Panama, "The National Folklore Ballet." This also enriched participants' knowledge of the historical and cultural features of Panama. These afternoon and evening activities were interesting, informative, and essential changes of pace for the esprit de corps.

The closing session of the conference was held on Friday, December 14. Pedro Turina and Frederick Erickson each provided a summary of the deliberations from somewhat different perspectives. Summaries of their reports, as well as actions and recommendations growing out of the seminar, are included in Chapter 7.

This report also includes two additional Appendices that should be of value. Appendix 3 lists a network of science educators in the Western Hemisphere whose expertise and interests constitute valuable resources. Appendix 4 is a list of periodicals, published throughout the Western Hemisphere, that are pertinent to science education.

CHAPTER 2 CULTURE, COGNITION AND SCIENCE LEARNING

Seven papers are presented in Chapter 2 which examine the relationships among children's cultural background, their cognitions, and learning of school science. The chapter begins with Erickson's presentation of a conceptual framework for understanding ways in which cultural differences between students and their teachers can influence learning of school subjects. Champagne contrasts ethno-science and formal science and examines the influences which children's preconceptions, beliefs, and values can have on learning science in school settings. Villavicencio describes her work in teaching mathematics to children from Quechua and Aimara communities in rural Peru. This work, based on these native groups' own mathematical formulations, gives us an example of ethno-mathematics being used in teaching. Smith provides an example of how the ethno-science of Indian children in Canada can be used in teaching science and he also describes some of the impediments to this approach. Quinn and Kessler describe their work in teaching science to bilingual children in Texas in which they found that bilingualism enhances students' learning of some components of science. Maddock brings an even wider perspective as he analyzes multiple problems encountered in bringing Western science into cultures which hold very different values and belief systems. This chapter concludes with an analysis by McDiarmid of persistent curricular problems which influence education of all youth but which have special significance to youth from minority groups whose values and beliefs often differ from those who determine educational policies.

These seven papers provide a rich exposure to the multiple issues which must be understood if educational policy makers, and those who implement policies in classrooms and elsewhere, are to make sensible decisions about what and how to teach youth whose experiences and beliefs differ from those of science teachers and what is represented in science text books.

CULTURE DIFFERENCE AND SCIENCE EDUCATION

Frederick Erickson
Michigan State University
East Lansing, MI 48824
U.S.A.

Editorial Note: Frederick Erickson is an educational ethnographer, one who uses techniques and methods from anthropology to understand processes and organization of schooling. In this paper, he reviews conceptions of culture and language, which derive from his background as an educational ethnographer, to provide a conceptual framework for understanding the ways in which cultural differences between students and science teachers can influence learning of the subject. The paper is, at the same time, both theoretical and practical.

* *

Culture, as a social scientific term, refers to learned and shared standards for ways of thinking, feeling, and acting. It follows then that teaching can be viewed as cross-cultural communication, since by definition the teacher has learned ways of thinking and acting that have not yet been learned by the students.

The subject matter of science involves culturally learned presuppositions of ontology and epistemology that developed in Western Europe over the past three hundred years. These presuppositons may or may not be shared by the teacher and the students. The pedagogy of teaching science also involves presuppositons about what is proper in social relations between leaders and followers, experts and novices. These presuppositions also may not be shared by the teacher and the students.

In the discussion that follows, we will consider the implications of cultural differences between students and teachers in both kinds of presupposítons--those involved in what we can call, in the spirit of Aristotle, the metaphysics or science as a belief system, and the politics (or praxis) of pedagogy in science instruction. Both sets of presuppositions go largely unexamined by both teachers and students alike. Such presuppositons about the taken-for-granted nature of things are implicit. They are learned for the most part outside conscious awareness. They are available as resources for us to shape our actions in accordance with them without our needing to be consciously aware of their existence as a resource, just as our culturally learned knowlege of a language--its sound system and grammar--enables us to act according to very specific patterns we are enacting. It is this implicit nature of much of our cultural knowledge--the transparency and the invisibility of standards we make use of in acting in the world--that is the most important attribute of culture in the discussion which follows.

We have used here the term "standards" in discussing the notion of culture and cultural patterns. Culture has been defined formally as sets of shared and learned standard for perceiving, believing, acting, and evaluating the actions of others (Goodenough, 1963: 259. See also Goodenough 1981: 61-95). The term so defined refers not to the perceptions or actions themselves, but to the standards of judgment that stand, so to speak, behind the perceptions and actions (or that inhere in them but are analytically separable from them). The definition makes a fundamental distinction between behavior and the underlying standards according to which behavior is shaped and evaluated as it is enacted. The standards can be thought of as thresholds or boundary ranges for judgments of appropriateness. For example, we can measure the loudness of speech in decibels, but whether a given decibel level is perceived and evaluated as "too loud" and "aggressive" or "too soft" and "timid" is a matter of the application of culturally learned standards of judgment to the mechanically measureable phenomenon of speech sound.

Particular standards of judgment differ between differing networks of persons. The judgment standards employed are "local" in that they are network-specific at the level of a group of persons who interact regularly, such as a family or a school classroom. The judgment standards also usually involve "nonlocal" features--some aspects of judgment that derive from indirectly linked networks by which individuals come in contact with cultural traditions shared broadly across time and space.

We can see through examples from language the inter-relations between "local" and "nonlocal" aspects of learned cultural traditions. Let us consider differences in kinds of spoken Spanish. Colombian Spanish is spoken a bit differently from Mexican Spanish. There are regional and social class differences in speech within the two countries. The speech of any given family differs slightly from any other family of the same region and class, if only in special vocabulary words or sayings that are considered humorous or are considered an invitation to argument. The speech of each individual within the family differs slightly in pronunciation as well as in vocabulary. Consistency in speech style from day to day can be thought of as tradition at the group level. It can also be thought of as tradition at the individual level--stylistic consistency that is handed down from the self to the self from one day to the next. (N.B. The term <u>tradition</u> is used here in it literal sense from the Latin <u>traditio:</u> that which is handed down). The sets of speech traditions that differ among individuals are called <u>idiolects</u>, in contrast to the sets of speech traditions called <u>dialects</u> that are shared among members of networks, and that differ across networks.

It is thus apparent that the notion of a <u>language</u>, considered as a system of culturally learned rules, or standards of judgment, is an abstraction. The concrete "Spanish" that is spoken by a particular speaker is both unique to that speaker--different in some small features from the speech of any other speaker of Spanish--and it is also similar in many features to the "Spanish" that is spoken by others currently and in the past. Some of the other speakers who influence the individual are present in that individual's immediate network of face-to-face relations. Other speakers influence the individual through indirect connections across networks that extend very broadly across time, into the past lives of countless speakers of Spanish who have lived in previous generations.

The closer we get to individual performance and to performance variation among individuals, the more "local" in space and time are the origins of the particular features of cultural patterning according to which performance is differentiated. These differences are often slight in behavioral form but they can be very significant in meaning. One kind of significance is that subtle features of style in performance can be a resource in bonding and attachment. Recent research with birds, for example, has shown that the newly hatched chick is able after hearing only a few sounds from its mother to distinguish the mother's vocalization from that of other birds of the same species. Birds, like humans, appear to have idiolects. Like humans as well, infant birds bond with the distinctive vocal performance style of their primary caregiver.

The farther we get from individual variation in performance the more "nonlocal" in origin are the differentiating features of style--from idiolect to family dialect, from family dialect to regional, class, or ethnic dialect, from dialect to language, from one language to another. At each of these levels we find that within a given network of association among persons certain features of style in performance tend to be similar. When one crosses a network boundary, cultural style features tend to differ. This is true across many different kinds of network boundaries--across those of kinship, of division of labor in a work group, of social class, religious affiliation, ethnicity and race, geography, and even of gender, as attested to by a growing cross-cultural literature on differences between the speech styles of men and women. Whatever the type of network, as one crosses the boundary from one sub-network to the next, one usually finds a slightly differing set of culturally learned standards of appropriateness. To recall our earlier example of loudness of voice in speaking, in one network of speakers talk at a given decibel level may be too loud while among members of another network talk at exactly the same decibel level may be judged too soft.

Another way to consider the organization of variation in cultural knowledge within a population is to see culture differences as demarcating lines of political division within a society. Networks of people differ in their access to power and prestige. One can trace boundaries of networks of members who share cultural knowledge of various sorts, not only of language, but of social ideology and values, religious beliefs, technical knowledge, preferences in food and nutrition, practical knowledge of how social institutions work, and aesthetic tastes--in recreation and sport, in personal display in dress and popular music, and in "cultivated" tastes in the fine arts, cuisine, and literature. These lines of culture differences trace differences in strategic social position across differing segments of society just as the lines on a weather map trace differences in temperature and air pressure across differing geographical regions. Thus boundaries of culture differences can be thought of as isobars of power and rank in society.

When the political interest of various culture-sharing networks differs such that conflict between those social groups is occuring, culture sharing can be a resource for in-group solidarity and culture difference can be a resource for inter-group hostility. Rather, the culture difference may not <u>cause</u> conflict between various interest groups. The differing interests themselves may be grounds for conflict. This is the opposite of the situation in which cultural similarity is associated with bonding and attachment. In situations of intergroup conflict culture difference may be made use of in intensifying the conflict that already exists, or culture difference can be used as an excuse to make overt some conflict that was already present covertly. In such situation at which latent conflict becomes manifest around an issue of culture difference we can say that cultural boundaries have become cultural <u>borders</u> (McDermott & Gospodinoff, 1979). The metaphor of a border is apt, since on either side of a border there is a differential allocation of rewards and penalties for certain kinds of cultural knowledge. Think for example, of the border bewteen the United States and Mexico, which is also a line across which knowledge of Spanish and English is differentially rewarded.

Making use of cultural knowledge as grounds for conflict at a political border is a very old phenomenon among humans. An example comes from the ancient Hebrews, as described in chapter twelve of the biblical Book of Judges. At the time, approximately 800 B.C., the Hebrews were not yet fully unified politically under a monarch and they had not yet completely occupied the territory of Canaan. They were still a loose federation of tribes, identified as kinship groups or clans, who periodically came together in an unstable and tense alliances against common enemies. A dispute broke out between soldiers of two of the clans, the men ot Ephraim and the men of Gilead. After defeat in a battle with the Ammonites, who were the common enemy, the men of Ephraim were trying to escape across fords in the Jordan River. The fords were guarded on the Hewrew-occupied side of the river by Gileadites. The men of Gilead checked the clan identity of the retreating soldiers by testing their cultural knowledge: "When any of the fugitives of Ephraim said, "Let me go over," the men of Gilead said to him, "Are you an Ephraimite?" When he said "No," they said to him, "Then say Shibboleth." He said, "Sibboleth," for he could not pronounce it right; they they seized him and slew him at the fords of the Jordan." (Judges 12: 5b-6a) The two clans of Hebrews differed in their pronunciation of the initial sibilant in the word "Shibboleth." The Gileadiates used the /sh/ phoneme for that consonant, while the Ephraimites used the /s/ phoneme. The Ephraimite soldiers were aware of this cultural difference and made use of it to construct a sociolinguistic test at a geographic and political border which, because of the test that was imposed, became a cultural border as well.

The preceding example illustrates the politics of culture difference. If the example seems archaic and irrelevant, think of the social distribution of knowledge and the use of the /z/ phoneme in contemporary Spanish in Latin America. In Castillian Spanish, one pronunces /z/ as if it were /th/, hence "cabe/tha" for "cabe/z/a." The Castilian pronunciation is the preferred upper class pronunciation, thus to say "cabe/z/a" marks one as of lower class rank. One can imagine a political border scene analogous to that at the Jordan ford occuring in interaction between a lower class prospective patron and a maitre d'hotel at an expensive restaurant in Mexico City, Santiago, or Lima. One can also imagine analogous encounters between lower class prospective students and college admissions interviewers at an expensive private university or high school.

Before beginning to consider the educational significance of this general discussion of culture patterns, one final general point on culture difference needs to be made. Some evidence suggests that culture difference between groups increases under conditions of conflict between the groups. We have seen how culture difference can be a badge of social identity. When members of a group want to distance themselves symbolically from members of another group one way to do this is by becoming progressively more culturally different from the other group. We are not sure why separate culture patterns come about, nor are we sure why some groups come to be progressively more dissimilar across time. Intergroup conflict could be one explanation. It would follow that in situations of intergroup conflict members of differing networks would tend to display, more and more saliently, the cultural differences that existed at the outset of the sequence of conflict.

We can now turn to the significance of these general notions of culture difference for education, and in particular for pedagogy in science education. There are three main areas in which culture difference between teachers and students can influence the teaching and learning of science: cultural differences in cognition, cultural differences in speaking and listening, and the role of culture difference in conflict at inter-cultural borders. (Because of limits of space the discussion here is necessarily brief. For more extensive discussion of these issues see Erickson, in 1986, Mehan, 1979, and McDermott & Gospodinoff, 1979, and Gumperz, 1982).

Cultural differences in cognition could affect the way the learner approaches the subject matter of science education because of presuppositions about the nature of the world that the learner brings to the learning situation. Group-specific assumptions for ontology and epistemology could have some influence here, but it is important not to overestimate the possible influence, because that could lead to stereotyping and lowered expectations for performance. Not a great deal of research has been done on this topic, but major recent studies (e.g., Gladwin, 1970, and Scribner and Cole, 1981) suggest that nonliterate people are capable of rigorous, abstract thinking. These findings run contrary to earlier assumptions that nonliterate or semiliterate rural and urban poor people are deficient in basic cognitive skills. Thus the fundamental capacity of students to reason is not likely to be affected by cultural difference.

Some folk beliefs may influence students in science classes at the outset of their instruction. Examples of this are belief in spiritual as well as physical causes, belief in a theory of bodily humours through which the hotness or coldness of food affects disease, and culture-specific conceptions of space and quantity that can affect mathematical thinking, such as the folk topography of the Aymara, in which there are not straight lines. This might present an Aymara student with initial difficulty with Euclidean geometry. A possibility also exists that there are culture-specific differences in cognitive style, with some groups more facile at spatial reasoning and other groups more facile at linear, logical reasoning. Evidence for the existence of these culture-specific differences in cognitive style has been inconclusive, however.

Considerable evidence exists that in general there are differences in reasoning between lay and scientific thinking on certain basic principles in science. In physics, for example, it is found that students often approach the study of velocity and momentum with implicit conceptions that are Aristotelian, e.g., the belief that a projectile loses force as it travels through space. Especially if a teacher aims to teach students to reason scientifically--to engage in higher order thinking--it is important to be aware of their implicit conceptions, which can be thought of as a subcultural system of lay scientific thinking. Participant observational fieldwork research methods--so called "enthographic" methods--which have been used by anthropologists to study ethnic cultural groups can be employed usefully in studying students' lay scientific thinking, regardless of the special cultural groups form which the students come.

Cultural differences in communication style--in speaking and listening--

may have more influence than cultural differences in cognition on the teaching and learning process. Even among those who speak the same language there are cultural differences in standards of appropriateness across sets of members of what can be called speech networks, or speech communities. There are cultural differences not only in pronunciation and vocabulary, but in fundamental assumptions about the social nature of talk; assumptions of what can be said, what should be left unsaid, how to show verbally and nonverbally that one is paying attention, how to show emphasis at crucial points in a discourse, whether it is polite or impolite to ask direct questions of others, whether it is appropriate or inappropriate to compete openly through talk, e.g., showing that one knows the answer to a question when one's classmates don't know the answer. These cultural assumptions about the social pruposes and uses of speech have been shown to differ markedly across major social divisions in society; along lines of class, ethnicity and race, and rural or urban residence, as well as along lines of gender. In some circumstances these cultural differences could influence teaching and learning in science to a considerable extent. To discover these influences it is necessary to study them specifically, from one speech network to the next among the speakers of a given language.

Even these cultural differences in ways of speaking and listening, however, may or may not have strong influence on teaching and learning. It is important to remember here the notion of cultural borders that was presented in the earlier general discussion. Under conditions of intergroup conflict even small cultural differences can make a big difference as an excuse for hostility. As the conflict escalates, the big cultural difference can increase. For example, in one study from the United States, Piestrup (1973) found that when elementary teachers reacted negatively to the culturally nonstandard speech of black children the children came to speak more and more nonstandard form of speech across the school year. In a situation of conflict over cultural difference the cultural difference increased progressively over time. This is one kind of example in which the reaction of teachers to students appears to trigger student hostility in what can be interpreted as a form of covert political resistance. Resistance can take other forms, the most notable of which is the covert refusal of students to master relatively simple kinds of knowledge and skill that the teacher is trying to impart. Thus culture conflict over issues that on the face of it may seem to have nothing to do with subject matter content, such as that of science, can actually influence teaching and learning of that subject matter. It may be that these indirect relationship between cultural communication style and science learning are more significant than what might seem to be the more likely and direct relationships between science learning and students' cultural styles of cognition and folk beliefs about ontology and epistemology. To shed light on these issues further research is necessary.

It is apparent from this discussion that classroom teachers play an important role as managers and brokers of the micropolitics of conflict in the classroom. A teacher can point to small cultural differences among students and use this as grounds for intercultural border work. Alternatively a teacher can overlook the form of students' expression and concentrate on the content being expressed. In the latter case, small cultural differences are not being used as intergroup borders in the classroom. This may make for important differences in student learning.

To conclude, all teaching can be seen as involving inter cultural communication of one sort or another. The teacher can be seen as a translator and as an inter-cultural broker. It is the teacher's responsibility to operate in such a bridging role on behalf of all students, regardless of the range of cultural diversity among students in a given classroom. That role of bridging, of inter-cultural mediation, is a complex one. It is currently only beginning to be understood. In that complexity appears to lie the roots of equity in pedagogy. This seems true for the teaching of science as it does for teaching in other subject fields.

The responsibility of the teacher for inter cultural equity in pedagogy is one of the reasons that teaching as a profession is a noble vocation. It is also one of the reasons why the conscientious practice of teaching on daily basis is such hard work.

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CHILDREN'S ETHNO-SCIENCE: AN INSTRUCTIONAL PERSPECTIVE

Audrey B. Champagne
American Association for the Advancement of Science
Washington, D.C. 20036
U.S.A.

Editorial Note: Audrey Champagne is a science educator with a diverse array of talents. She is well known for her work in policy analysis. In this paper, she examines the influences of instruction in science on learners' informal scientific knowledge by reporting on her own research and studies of others. She concludes her paper with some important advice for teachers, researchers, and educational policy makers.

* *

When children begin their formal study of science, they already possess knowledge which they use to explain and make predictions about their physical world. This body of knowledge has significant characteristics in common with formal science that children are expected to learn in school, and it is the base in which understanding of formal science is built. This paper examines the form and function of children's formal science, its relationship to a culture's ethno-science, and its influence on the process of learning formal science.

The word science carries many connotations including the notion that it is the province of a select elite who pursue new knowledge. Similarly, the term theory is not well understood. Despite popular prejudice, people engage in science and develop theories all the time whether part of a primitive or developed culture. Granted, these are significant differences between the scientist's, the citizen's, the layman's, and the child's observations and experiments. However, children at play and scientists at work in laboratories conduct experiments and construct new knowledge in much the same manner.

Humans have well-developed theories about the natural world whether or not they are exposed to formal science. The term ethnoscience applies to behavior and theories that have evolved informally within cultures to explain and predict natural phenomena. The term ethno-science used here refers to a culture's procedures for learning about the physical world and the culturally accepted theories that explain it.

Ethno-science and formal science are quite similar in form and function. Both consist of a body of knowledge and processes to analyze experiences with nature. Both are subject to verification through application of agreed upon standards and procedures. There are differences, however, in the verification process for formal science and ethno-science. In formal science, the scientific community evaluates new theories. In ethno-science, theories obtain acceptance because they are functional and permit satisfactory explanations and predictions in the realm of daily experience.

Theories of ethno-science and formal science share another characteristic: Both are difficult to modify or replace. Max Planck is reputed to have said that scientists are not converted to new theories --

old scientists just die and their theories die with them. A developing body of data suggests that learners of science share this reluctance to alter or abandon their theories. Research data show that naive theories of motion held by both adolescents and adults are not changed by formal instruction in science. Even after a formal course in high school or college physics even good students used naive theories of motion to explain observations of motion (Champagne 1980).

Naive theories also seem to transcend cultures. Studies conducted in many scientifically sophisticated cultures show that there is remarkable consistency among lay person's naive theories of the physical world (Green, 1980, 1981; Hewson, 1983; Leboutet-Barrell, 1976; McDermott, 1984; Selman, 1982; Tiberghien, 1980; Wiser, 1983). Even more remarkable is the fact that the naive theories differ as strongly from Newtonian mechanics that is widely taught in schools and colleges as a model of motion for macroscopic objects and hold such similarity to the Aristotelian model which requires an unbalances force to retain motion.

Our present state of knowledge about children's ethno-science is quite limited. Much is based on studies of adolescents and adults in formal educational settings on a narrow range of physical phenomena. To understand children's ethno-science, we must understand the ethno-science of the culture in which they are reared which, in turn, requires description of the theories, principles, concepts, facts, and procedures for processing and manipulating information in that culture.

Research by Jean Piaget and more recent work by cognitive psychologists provide information about the principles, concepts, and information processing strategies that comprise the ethno-science of the cultures studied and the ways in which these elements are organized in memory (Erickson, 1980). The results of this work demonstrate that ethno-science differs from formal science in two dimensions: (1) the extent and quality of information and (2) its structural organization (Champagne, 1980b; Chi 1981).

Theories of ethno-science often lack the unity of formal science and may even be contradictory. Newtonian mechanics can explain free-fall and movement on an incline by a single set of rules whereas ethno-science generally requires two different sets of rules. Moreover, the principles for free-fall and motion on an incline in ethno science may have contradictory principles (e.g. weight does not influence free fall, but heavier objects roll faster down an incline).

The meaning of terms is another case where formal science and ethno-science differ. Students often can give scientifically correct definitions for terms but their usage of the term in an explanation belies quite a different understanding. Velocity and acceleration have different meanings but students who can state correct definitions often use these terms interchangeably in explaining observations and events.

Cognitive research on the nature of students' naive theories demonstrates that difficulty of altering them and suggests some reasons why this is the case. These reasons include (1) naive theories have cultural validity and have withstood the test of time, (2) they have enabled people to survive the world of daily experience, (3) it is psychologically uneconomical to give up a well-understood and useful theory, (4) new experiences in formal science are interpreted through the body of knowledge which students currently apply to that phenomenon, and (5) students remember that part of the text of formal instruction in science which coincides with their current beliefs and forget the part that is in conflict (Champagne 1980B). Moreover, when students do experiments to prove a point of view where there is disagreement, they show concern for the details of experimental conditions only when the results of experiments contradict their apriori ideas (Cauzinille-Marmeche, 1984; Champagne, 1980; Anderson, 1986).

This brief overview is meant to give readers a sense of current knowledge about children's ethno-science and its influence on learning of formal science. We now turn our attention to the implications of these findings for the design of science instruction. Instruction is a plan for bringing about changes in knowledge states (Simon, 1981). The developing cognitive perspective on learning argues that instructional design requires detailed specification of both entering and preferred states of the child's knowledge (Champagne, 1982). However, the present state of our knowledge about children's ethno-science is inadequate to meet this criterion for instructional design, yet serious efforts to improve the quality of science instruction require better descriptions of the knowledge children bring to science. But, children need to be taught so we are faced with the question of how the information we have now can help us to improve science instruction.

The operational aspects of answers offered to this question are not new but they may be more meaningful given the emerging empirical and theoretical base that explains their potential effectiveness. The recommendations all have a common thread--social interaction and cognitive change. The work of Perret-Clermont (1981) suggests that involvement of children in social interactions around shared experiences with physical phenomena can produce a socio-cognitive conflict that is an important step in inducement of deep cognitive change required for children to adjust their thinking about the physical world to a more canonical form. If this strategy were to be incorporated into science classrooms, considerable reconceptualization and restructuring of science teaching would be required. The strategy re-emphasizes the need for observation. Manipulation not for developing skills of experimented design but to give children and their teacher a bounded, shared physical event on which to base their discussions -- to give discussions concreteness.

The strategy proposed has two phases: An introductory phase which provides the teacher with opportunity to learn about students' ethno-science and in which the teacher takes an active role in initiating and facilitating discussion about the children's predictions, and the beliefs, principles, and assumptions on which predictions were based. In this introductory phase the teacher also may need to play the role of coach by providing information that is pertinent for use by children in further discussions.

The second phase includes demonstration of the principles discussed in phase one, discussion to develop consensus on what was observed, and reexamination of the arguments proposed in the introductory phase in light of the actual observation. The desired outcome of this phase is resolution of conflicting theories and development of understanding of conical theories at a level appropriate to the age of the children. If elements of conical theories are not proposed by children, the teacher will introduce them and help students compare conical theories and their own to establish differences between them and to establish criteria for making judgments about why the conical theory is better than those proposed by children. Therefore, the function of this phase is to help children reformulate naive, ethno-science theories into a new theory that approaches conical, formal science. It emphasizes direct confrontation of alternative views to generate cognitive conflict among peers, mediated by an adult. Having the confrontation among peers facilitates verbalization and forestalls acquiescence to the theory presented by an authority figure. However, any strategy to induce change in students' theories must recognize that students do not, readily perceive inconsistency in their own theories or between their theories and those of others (Derver, 1983). Engaging children in social interaction seems a plausible mechanism for creating dissatisfaction with their naive theories through socio-cognitive conflict.

Conceptualizing science teaching as modification of existing ethno-science provides a new perspective for design of instruction. As argued above, neither learning theories nor our knowledge of children's ethno-science is adequate at this time for a truly scientific basis for design. However, current knowledge provides the basis for both practical modifications in the form of science instruction and a research agenda.

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IMPLEMENTATION OF A METHODOLOGICAL ALTERNATIVE FOR THE TEACHING OF MATHEMATICS TO CHILDREN FROM RURAL COMMUNITIES OF PUNO, PERU USING THEIR LANGUAGE AND CULTURE AS A BASE

Martha Villavicencio
Lima, Perú

Editorial Note: Martha Villavicencio is a Peruvian researcher who works with bilingual children in the rural zones of her country. From her working experiences she describes a bilingual project, which has as a fundamental objective to evaluate existing culture and to use elements from it to introduce desired changes in the mathematical instruction process, which blends students' native culture and the western culture.

* *

Background

Peru is a country of many languages and many of its people are plurilingual. About one-third of the Peruvian population, over five years of age, speaks one of the 60 native languages used in this country. One third of these spoken native languages are used in the cities and the other two-thirds in the rural zones. For the most part, the native tongue is Quechua, and approximately one fourth of the national population speaks it. The second largest group in Peru are the Aimara and their language is also widely used.

The project described in this paper was actually developed in Puno. In this rural zone there are three prinicipal languages spoken: Quechua, Aimara and Spanish. Approximately fifty percent of the Punian population speaks Quechua, 41 percent speaks Aimara and the rest are monolingual Spanish speaking. Puno is one of the least developed rural areas in Peru, both economically and educationally. Thus, for example, Puno has been shown to have one of the highest rates of illiteracy in the country. Of the total population 15 years of age and over, 49 percent are illiterate. In what is known as primary formal education, 80 percent of the children are monolingual native language speakers when they first enter school.

The Bilingual Educational Experimental Project of Puno

In the past, the absence of an alternative educational system which considered the linguistic-cultural particularities of the students' spoken native language generated the Bilingual Educational Experimental Project which since 1977 has been financed by the Ministry of Education of Peru with assistance from Germany.

The project is integrated in a framework which recognizes the value of an education which is bilingual and respects the native language and the social-cultural elements which are an internal part of it. The project also takes into consideration, the language and the external sociocultural components of the particular cultures of the native populations. This focus implies the postulates of an education which is bilingual and bicultural -- an education within two cultures also spanning two languages.

The general objectives initially established in this project are:

1. To design, elaborate upon, and experiment with a technology which efficiently helps attain the objectives of a bilingual educational system.

2. To propose the needed technical-pedagogical frameworks for the implementation of a bilingual educational system which is in accord with the sociolinguistic-culture of the rural communities of the Peruvian highplains and other zones with similar characteristics.

Implementation of the Alternative Methodology

The alternative methodology incorporated in this project was conceptualized as the set of activities for bilingual mathematical education to facilitate students' attainment of the mathematical objectives in the primary grades. Implementation of the mathematics alternative has been achieved across five different themes.

1. Diagnostic research.

2. Defining the methodological alternatives and educational materials.

3. Application of the methodological alternative and educational materials.

4. Research and evaluation.

5. Validation of methodological alternatives and materials.

Diagnostic Research

The diagnostic research was accomplished within three levels: the adult, the child and the teacher. At the adult level, the research was accomplished in 17 rural communities (10 from the area of Quechua and seven from the Aimara area). The information was collected via structured interviews. The studies of adults' understanding and use of mathematics revealed that:

1. The counting system used by native language speakers is addition by tens.

2. The recording of numbers and certain numerical operations are done by using the fingers, earthworms, little rocks, bones, dry dung, etc. In very few instances they use elements which are graphic and symbolic.

3. Addition is done by means of altering numbers to be added and using bare ten groups starting with those units of highest order.

4. Multiplication is done by repeated addition for which they rearrange the multiplicand in thousands, hundreds, tens, and ones, accordingly. They multiply these numbers by the multiplier and finally add all the resulting numbers.

5. During the day, they distinguish periods of time in relation to work, food, and rest, for which exists native language expressions. They orientate themselves to time by observing the movement of the sun, the moon, and stars or using as a reference the cock's crow.

6. To measure distances, as well as using the metric system of tens, they use arms, feet, and other parts of the human body. The liter and the bottle are the units most used when measuring volume.

7. In the places where they make clothes for the villages, they use basic geometric figures like: triangles, parallelograms, and hexagons. They also use simple curves and irregular dodecagons.

The study of school age children's mathematics showed some parallels with five and six year olds from the same community who had not yet entered the system of primary education. The information was collected using structured interviews. The most revealing conclusions with respect to children were:

1. Children classify objects most easily when the criterion used are property values associated with "size": large or small. They also classify less frequently using properties like color and form.

2. "The circle" is the geometric figure which the children identify with the greatest frequency. Less frequently, they identify the "square," "rectangle" and "triangle," respectively. Similarly, the color "red" is the easiest for children to recognize. Then comes "yellow" and "blue" which is the least frequently recognized.

3. Less than 50 percent of the children handle well the ordering of objects from small to large and vice versa.

4. Less than 50 percent of the children are capable of discriminating between "the first," "the last," "the second " "the third" in a group objects.

5. Less than one third of the children can solve problems of addition in which the sum is less than ten.

The diagnostic study also was accomplished with 17 first grade teachers who were interviewed in their own educational centers. It was found, among other things that:

1. During mathematics classes, teachers use both Spanish and Aimara or Quechua languages to describe concepts and procedures.

2. The planning of activities is done through 'learning units' that last 10, 15, 20 and 30 days with no reference to how much teaching should be done in Spanish or in the indigenous language.

3. Procedural learning of mathematics is emphasized, as opposed to conceptual learning.

4. For didactic materials, teachers use resources such as: grains of corn, bottle caps, little rocks, matches, clay balls, little leaves, sticks of barley, threads, balls of cloth, etc.

Definition of the Methodological Alternative

The methodological alternative in conjunction with the instructional materials developed were defined by using the following base:

1. The results of the diagnostic study.

2. The national curriculum of mathematics for the first grade.

3. Jean Piaget's theory concerning the evolution of intelligence.

4. The principles of Zolton P. Dienes concerning the learning of mathematics.

Using the aforementioned four points as guidelines, two versions of instructional materials were designed: Aimara-Spanish and Quechua-Spanish. Materials were prepared for both teachers and students. In the teacher's guide attention is given to the processes of teaching and learning in which two phases are distinguished:

1. A concrete-intuitive stage which consists of independent and guided games.

2. A conceptual stage which consists of activities that imply the representation and application of concepts including the use of graphs, signs, and/or symbols.

Regarding the use of languages, the following strategies were implemented:

1. Use of the student's native language in that work which students do in order to make different technical discoveries.

2. Employ the Spanish language in the development of activities which have as their objective the supporting of skills and acquisition of abilities.

In addition to the supporting instructional materials for the teacher, we designed packages of reinforcing materials in two versions: Quechua-Spanish; and, Aimara-Spanish. Also, we implemented the use of the "Yupana"* Abacus which was used by the clerks of the imperial Incas. One makes this instrument using as a base, paper, cardboard, wood or clay and little rocks or grain. The "Yupana" has a rectangular shape and is divided in four rows and five columns. Each column represents a place value in a counting system of tens. At the end of each row there are four rectangles with one, two, three, and five little holes, respectively. The instrument is used in operations such as: addition, subtraction and

*Yupana: Quechua word that eticlogically derived from 'yupay' which means to count.

multiplication.

Application and Evaluation of the Alternative Methodology

The application of the alternative methodology and the proposed educational materials has been conducted in 33 experimental educational centers as initially planned. In 1982, the instructional materials were utilized in the first grade, and in 1983 in both the first and second grade. Currently they are being used in all three grades.

Two types of designs were used to evaluate the methodological alternative placed into practice. One design was descriptive and the other quasiexperimental. The first was used to obtain information relative to the utility and adequacy of the materials regarding pedagogy, graphics, and linguistics. The quasiexperimental design was used to obtain a better control of the attainment of the learning objectives.

Analysis of the evaluation results confirmed the following hypotheses:

1. The mathematical materials for primary education, facilitate a better understanding of mathematics in the Aimara and Quechua children when compared with traditional materials.

2. The pedagogical and linguistic elements which were used to structure the new instructional mathematical materials are functional and adequate regarding the socio-cultural reality of the Quechua and Aimara children of the rural areas of Puno, Peru.

3. The instructional materials are easily handled by both the teachers and children, making possible an adequate fitting of the process of teaching and learning mathematics for children whose native language is either Quechua or Aimara.

Methodological Alternative and Validation of Materials

The results of the analysis of the evaluation were used to make an adjustment of the instructional materials use in the first two grades of primary bilingual education. In this way, it has been possible to obtain a valid final product adequate to the socio-linguistic-cultural reality of the rural highplains communities of Puno.

Prospects

In the experimental project of Bilingual Education in Puno, it has been determined to implement the alternative methodology in the first six grades of primary education starting in 1986. These studies permit the extraction of important conclusions and the formulation of new hypothesis about the process of learning mathematics by children from rural areas of Peru.

A MODEL FOR TEACHING NATURE ORIENTED SCIENCE

Murry Smith
Frontier School Division
Dauphin, Manitoba, Canada

Editorial Note: Smith provides an analysis of work being done with Indian children in Manitoba, Canada to help them learn about the connections between the myths and beliefs of their own culture and the science taught in school. He provides both a theoretical perspective and practical examples of how this integration can occur.

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Overview of the Problem

Teaching Science to Native American children is a challenge, for to teach science, one must recognize cultural differences and how they affect concept development. Not only is this a challenge in Native American classrooms, but it is a concern in any cross cultural situation. Certainly, the percepts that a child comes to school with will affect his learning. However, before exploring this area called Ethno-science, one must define science, and then develop a curriculum that would be culturally compatible.

This applies as much to Native American children as to any crosscultural situation. People desire to understand technology because they view it as a way of raising their standard of living. However, with this technology, there is a cultural frame of reference. The problem is to find ways of passing on the technology within the context of the culture and without disturbing its frame of reference or cultural milieu.

The American Indian student enters the school system with a cultural heritage and set of values appreciably different from that of the education system itself. It should be the aim of the system to adapt to the needs of the Indian student, not to try to change the students to fit into the system (LeBrasseur, Margot, M. and Freark, Ellen S., 1982, p. 11).

Focus of the Problem

It is assumed that children of native heritage learn and process information much the same as other children. However, they view the world through a framework of cultural bias. Therefore, they can benefit from modern teaching methods and develop the same concepts providing this framework of cultural bias is taken into account. In order to do this in science education, the concepts must be defined, a plan of action decided, and both must be inundated with cultural traditions, precepts, and examples.

Science education, as it is defined in Manitoba, adheres to the Piaget model and a process approach to learning.

The main keys to the child's mental growth, as Piaget brings them out, are:

1. The importance of the student's own actions in learning.

2. The way this turns into a process of inward building; that is, of forming within his/her mind a continually expanding structure corresponding to the world outside (Isaacs, 1061, p. 18).

During the period of concrete operations children need more carefully structured activities involving more complex relationships than do infants and, in subjects such as science, they profit from a well organized "experimental" work which enables them to make their own measurements, and observations, and discoveries.

Thinking Processes Development

As the children do hands-on activities, they develop the learning processes which are inherent in thinking. These processes are as follows: observing, classifying, comparing, communicating, measuring, inferring, predicting, and using space/time relationships. Some of these processes are culturally biased. That is, the processes are developed within the context of the child's environment.

One of the basic processes is described as using the senses to denote objects and events. It is these observations that result in qualitative and quantitative statements according to the Manitoba Science Curriculum. Native students seem to have well-developed observation skills. "Colliers' use of photography in evaluating Navajos suggests that they excel at tasks requiring fine visual discrimination" (Cattley, 1980, p. 26). However, due to language and past experiences, they may state their observations differently.

Classification is another thinking process inherent in all children. Given a number of objects in order to study their characteristics classification systems can be developed on the basis of one or more properties, directly or indirectly observed (K-6 Science Curriculum, 1976, p. 14-15). All classification systems are arbitrary, and their usefulness depends on the function they serve: i.e., the science course in the school classifies plants and animals according to similar structure, whereas Cree and Objibway people traditionally classified plants and animals according to their function and use. Both classification systems are valid.

Once some data have been collected, there is a need to communicate or store the information. Usually, this is done in a written form. Keeping in mind that a number of native children are using their second language, this becomes a difficult task. Models, diagrams, maps, graphs, as well as oral communication should be considered as alternatives. For example, ". . .the Navajo excells in visual and spatial configuration; and that his verbalizations tend to be more indirect, metaphoric, mythological in nature as a means of communicating information" (Cattley, 1980, p. 29).

Observations can also be quantified by measurement. Traditional native people have measured distance, size, time, and proportion. Cree and Objibway children excel in this process as proved by divisional mathematics surveys recorded from 1981 - 1984. Such measurements are usually reinforced with concrete examples and precise oral descriptions.

Objects also may have shape, symmetry, direction, spatial arrangements, motion, speed, and rate of change (K-6 Science Curriculum, 1976, pp. 12-15 -- Using Space/Time Relationships). As mentioned previously, native children have well-developed visual skills. Seemingly, they should do well in studies requiring this process. Traditionally, native people have used the process of prediction. This requires forecasting future events used on the observable data. For example:

> At the end of the trapping season, trappers can predict an increase or decrease in muskrat population by examining the female's reproductive organs. Eight small dots (about the size of rose hip seeds) on each side of the tubes indicate that an increase in number of young can be expected. Fewer than four dots means a decrease in number (Scribe, 1980).

Another example of how native people used the skills of predicting is:

> Muskrat activity before freeze-up in late September or early October helps trappers to predict winter snowfall levels. The muskrat needs a thick snow cover to keep the interior passage of its lodge from freezing. Therefore, if the muskrat builds an unusually big lodge out of the bullrushes and cattails that line the marshy river banks trappers "know" the snow will be light - the muskrat's lodge msut be large to trap as much snow as possible. On the other hand, trappers anticipate a heavy snowfall, if muskrats delay their lodge building until after freeze-up. Then most of the muskrats' efforts are carried by the dropping water level and build a small shelter which is not easily visible once the snow falls (Scribe, 1980).

The next process which is important to learning is inference. Inferring is defined as suggesting more about a set of conditions than is observed (K-6 Science Curriculum, 1976, pp. 14-15). This particular process is culturally biased as it depends on how the child see the world and his understanding of how it operates. Since this requires extrapolation, one must be aware of the child's frame of reference (Smith, 1982, p. 15).

Traditionally, this skill was used for tracking game. It also helped correlate weather, and animal behavior. In many Cree communities, it is believed that a person can call the Northern Lights (Aurora Borealis) down by whistling. This belief would have a great deal of bearing on any further inferences the child may make regarding this phenomena (Smith, 1982, p. 15).

Cultural Bias

Without understanding the cultural background which students bring with them, the science teacher is placed at a disadvantage. After teaching a concept, he/she may ask if the student understands. Even though the answer is positive, teacher and students may have understood from opposing frames of reference which sets up discrepancies between the content that the teacher is teaching and the knowledge that is important to the child. It is these discrepancies that can lead to emotional turmoil and loss of self-respect. An example of this is the hunting of the snow bunting in some Cree communities.

> Both in the spring and autumn, boys of seven to twelve years of age hunt snow buntings. They are encouraged to do so by their fathers. Slingshots are used in order to develop good eye-hand coordination for the rifle that is to follow. At one time even these small birds were used as food for the family. In school these boys are taught conservation and told to stop this practice. Hence a double standard exists that challenges the students' values (Smith, 1980, p. 16).

Similarly, in primary grades, students are asked to place pictures of animals into various groups. At times, native students classify rabbits as food rather than the anticipated group of pets. Here, both answers are correct, depending on the frame of reference of the respondent.

"Teacher attitude is all important in any ethno-related course and the teacher must be extremely sensitive to the feelings of the student and community in all topics of study" (Snow, 1972, p. 89). Unawareness of insensitivity to students' cultural beliefs and values on the part of teachers can inhibit effective communication between teachers and students. In Native American cultures and the Third World Countries the problem is the same. People desire scientific knowledge because they see it as a means of raising their standard of living. However, scientific knowledge and western thought may be contrary to cultural views and attitudes. The dilemma is to accept the idea or to destroy the cultural view, and that is too great a price to pay. One must search for ways of transferring ideas and practices while leaving the culture intact. Education is communication, and what really needs to be communicated to Indians are not the facts of the white culture but the idea that Indians can learn from whites without committing psychological or ethnic suicide (Reyhner, 1981, p. 21).

While this may appear logically sound, it is difficult from a practical perspective because there is not one, but many unique native North American cultures. ". . ., there are over 400 Native American tribes, each with to some degree a different culture (see, for example, Keshena, 1980). Since culturally based materials developed for one tribe may not be appropriate for use by students from other tribes, curriculum developers in this area may need to look primarily at those universally (or widely) accepted activities that are culturally appropriate for numerous tribes (Cheek, 1984, p. 5). Once these activities have been chosen they must also be modified to fit the culture and the environment in which they are being taught.

One topic that is culturally bound and appears on Elementary Science Curricula is plants. In all of North America, north of Mexico, native people are known to have utilized 1,112 species of plants as food. Of these at least 19 were cultivated. The Indians of the Great Lakes region utilized an estimated 275 species of plants for medicine, 130 for food and 27 for smoking (Mueller, and Walker, unpublished).

If such facts are not discussed in the classroom, native students could get the impression that their forefathers had nothing to offer the discipline of Botany. It is by incorporating such facts into the class that the division between the school, community, and child is reduced. Astronomy also can serve to integrate culture and science.

Astronomy in a Ethno-Science Context

Astronomy is so often poorly handled in the school curriculum because many teachers lack a background in it. This is somewhat disturbing, as Astronomy is now collecting more data than any other scientific endeavor. However, to read textbooks today, one would surmise that only the Greeks had legends and had organized the heavenly bodies into constellations. Now in the 1980's a newly formed discipline called Astro-Archaeology is turning up a great deal of evidence that, as far back as 12,000 years ago, North Americans had an astounding understanding of the skies.

One example of this is found in Skidi Pawnee mythology. "The Milky Way was said to be the ghost pathway of the departed spirits - divided in two, one for those who died natural causes and the other for those who died prematurely, as in battle" (Chamberlain, 1981, p. 5). The stars of the east were male stars, and the greatest among them was a red star, know as Morning Star. It was his duty to drive the other stars westward. . ." (Ibid., p. 32).

The Pawnee astronomers had divided the heavens according to star clusters. Similarly the Greeks classified star clusters and personified them. By teaching astronomy this way, cultural similarities are stressed and cultural differences are emphasized less. It gives native children a sensitivity for their culture and forces children of other cultures to examine their frame of reference and values.

Astronomy also develops space/time relationships. In Manitoba this is stressed in the Junior High School science program. The objective of the Astronomy unit is to describe the motion of objects in the day and night sky. Children studying this unit should be aware that native people also observed these phenomena. "The Indians correctly described the apparent motion of Venus, how it comes evening farther up the Western sky until it is half-way from the sun to the zenith, then to go slowly back past the sun and to appear west of the sun in the morning" (Ibid., p. 54). Not only did they observe these phenomena but they devised simple and ingenious ways of recording and tracking them. By doing so they came to the understanding of the summer solstice. It is now believed that they could predict the re-occurring solar phenomena. This was done by using circular rock observations called Medicine Wheels. "Medicine Wheels consist of in general of a central circle of rock pile (the hub), from which rocks radiate like spokes. Often associated with the wheels are other piles of rocks (or cairns) and occasionally one of concentric circles" (Eddy, 1982, p. 15). "The largest number of known Medicine Wheels are found in the prairie provinces of Canada; at least thirty are known in Alberta and ten in Saskatchewan? (Ibid., p. 52).

As did the Greeks, the Pawnee saw messages in the stars. They took direction from them and tried to analyze their meaning. An excellent activity is to give children a sketch or photograph of the heavens and let them organize the stars into "constellations." Native students should realize that their forefathers also did this. "Also near the Star-Which-Does-Not-Move (North Star) were two stretchers, illustrating how the people should transport their sick and dead. These are the Dippers (Ursa Major, Ursa Minor)" (Chamberlain, 1981, p. 55).

Astronomy is one discipline that can be enriched using examples from other cultures. It can also serve to help children realize that a different frame of reference develops from a different cultural milieu. The following is an example of how this can be accomplished for an ethno-astronomy unit of study.

PROBLEM: How does the Big Dipper (Stretcher) change position throughout the year?

HYPOTHESIS: Once the Stretcher has been identified, the children are asked what they think the position of this constellation will be in three months.

DATA COLLECTION: A diagram of the North Star (Star That Does Not Move) and the Stretcher is drawn in the classroom on paper. The first clear night a stake is driven into the ground corresponding to the North Star and rocks are placed on the ground corresponding to the Stretcher Stars.

ANALYSIS: In three months the exercise is repeated. By this time, the Stretcher has moved. This distance is measured and another set of rocks is placed on the ground. The rotation of this constellation is then extrapolated.

STATEMENT OF CONCLUSIONS: This statement is designed to compare with the hypothesis and give a defendable fact.

Such an activity will help students conceptualize the revolution of the earth and verify the earth's rotation on its axis.

Summary:

This lesson and the overall model suggest several defendable positions. A theoretical model is established. This model ensures that scientific concepts are taught in an ethno-scientific context. The model incorporates the latest learning theories and ensures thinking skills development. However, the most important aspect of the model is that it develops attitudes that build cultural pride and encourages cross cultural tolerance.

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BILINGUAL CHILDREN'S COGNITION AND LANGUAGE IN SCIENCE LEARNING

Mary Ellen Quinn
Alamo Heights School District
San Antonio, Texas, U.S.A.

Carolyn Kessler
University of Texas
San Antonio, Texas, U.S.A.

Editoral Note: The empirical study reported here was an effort to measure and compare the ability of monolinguals and bilinguals to formulate scientific hypotheses, and write syntactically more complex language and to generate multiple metaphors. The investigators concluded that bilingualism appears to have a positive effect on the cognitive ability of students to formulate scientific hypotheses and to use language of increasing complexity, both syntactically and semantically. The issue is raised as to why bilingualism might have such an effect.

* *

Introduction

Bilingual children are amazingly creative, both cognitively and linguistically. They seem to be capable of generating a vast array of divergent solutions to science problems and use a rich set of metaphors to express these solutions. DiPietro (1976) suggest that linguistic creativity provides for the production of infinitely varied sentences. If this is so, then those educational situations and experiences which encourage students to produce many solutions to problems should be a means for teaching creativity. For example, the presentation of a science problem together with the direction to generate as many solutions as possible to that problem provides an ideal situation for such teaching. Thus, this study examines the interaction of language and cognition as seen in the science classrooms of monolingual English speaking children in a large, urban eastern city and Spanish-English bilingual children in a large urban, southwestern city in the United States.

The purpose of this study was to investigate the effects of bilingualism on science learning and language development. There are two main arguments which will be made:

1. The ability to use the science processes is a manifestation of cognition and that bilingualism enhances that ability in at least one of its aspects;

2. While an aspect of cognitive ability is improving, language development, and, specifically, the metaphorizing process is more apparent for bilinguals than for monolinguals engaged in the process of formulating solutions to scientific problems. (hypotheses is synonymous with solutions and it is defined as a testable explanation of an empirical relationship between at least two variables).

Science and Cognition

The science curriculum projects of the 1960's, were a strong effort to make the link between the cognitive processes involved in thinking and the essentials of a sound science program clear. Two projects, Science Curriculum Improvement Study (SCIS) and Science, A Process Approach (SAPA) exemplify this effort by stressing the cognitive processes of observing, inferring, predicting, hypothesizing and experimenting. These have been determined to be some of the basic cognitive processes by Guilford (1965), Bloom (1956), Gagné (1965) and Bruner (1960).

Table 1 summarizes relationships between inquiry skills and the decision-making processes of science using the classifications of Data Collection, Data Organization and Data Use.

Table 1. Inquiry skills aid the child in the decision-making process.

INQUIRY SKILLS PERMIT:

Data Collection	Data Organization	Data Use
Observing	Classifying	Inferring
sights sound	Mapping	Interpreting
smell feel	Graphing	Hypothesizing
taste	line bar cloud	Predicting
Experimenting Recording		
Measuring	Charting	Modeling
Diagramming	flow level	
Drawing	Separating variables	
Investigating	Controlling variables	
Contrasting		

We would like to give special attention to hypothesizing in this study because the ability to engage in if/then reasoning is considered a form of synthesizing which means that observations and previous knowledge are united in a simple solution to a problem. Bloom (1956) places synthesis at the highest level of his cognitive taxonomy. Thus, the ability to formulate scientific hypotheses, or to relate two or more variables in a cause and effect situation, can be considered one aspect of cognition.

Science and Bilingualism

The subjects for this study were sixth grade monolingual (English) students which were part of an upper middle-class socioeconomic group in the Philadelphia area and bilinguals (Spanish/English) which were from the lowest socioeconomic group in San Antonio, Texas. Both the monolinguals and bilinguals used English (the second language for the bilinguals), for the science lessons in this study and exactly the same set of lessons were given to them.

The criterion variable scores were assessed for hypothesis quality, syntactic complexity of the language used in writing hypotheses, and semantic creativity in terms of the use of metaphor in expressing scientific hypotheses. Results showed that the bilinguals achieved higher scores on all measures: hypothesis quality, syntactic complexity and metaphor index.

Background Work for the Study

The framework for investigating the ability of children to form hypotheses is set forth by Quinn and George (1975) and subsequently by Kessler and Quinn (1971) in studies conducted on sixth grade, monolingual students of two different socio-economic settings. These studies led to the conclusion that the socio-economic level is a non significant variable in ability to generate increasingly complex hypotheses.

Kessler and Quinn (1977) conducted a pilot study comparing the effects of nonbalanced bilingualism and monolingualism on the ability to formulate scientific hypotheses and to write increasingly more complex expressions of those hypotheses. Holding the socioeconomic status of the students, the science teacher and the experimental treatment as constants, results obtained from 28 sixth graders (14 English-speaking monolinguals and 14 Italian-English bilinguals which were in the process of replacing Italian with English) matched for IQ, grade-point average and reading ability indicated that the ability to generate hypotheses favors bilinguals, even when bilingualism is subtractive.

The results of the pilot study led these researchers to further hypothesize that fully proficient bilinguals taught how to approach the discrepant situations presented in science problems would experience greater gains in their hypothesis quality and linguistic complexity scores than their monoligual peers. Proficient bilinguals who added English as a second language to their first language, Spanish, during the schooling process are considered bilinguals. Additive bilingualism is operationally defined as the ability to use two languages successfully in school experiences. All scores for additive bilinguals are reported for English, the second language for all subjects in the study. Results of that investigation confirmed both hypotheses. For a complete report of the study, see Kessler and Quinn (1977).

Subjects

Subjects for the present investigation reported in this paper were sixth-grade students in two intact classrooms, one monolingual English-speaking and one Spanish-English bilingual with 26 students in each group. They were from the same population as that for the above study with the monolingual children from an upper middle class area of Philadelphia and the additive bilinguals from a Mexican-American neighborhood in the lowest socio-economic area of San Antonio, Texas. In the San Antonio neighborhood, Spanish functions both as the language of the home and of the community. The bilingual subjects had all participated in a bilingual education program for grades K - 3. By grade 6 all instruction was in English, but Spanish continued to function in peer interactions, in the home, and in the community. Because of the bilingual program in which they had participated, the bilingual children were literate in both Spanish and English.

Treatment

The treatment given the experimental monolingual and bilingual groups consisted of 12 science inquiry film sessions and 6 discussion sessions, each session 40 minutes in length. All lessons were taught by the same teacher in English. Each film session, based on a 3-minute film loop depicting a single physical science problem, ended with the students writing as many hypotheses as possible in a rigorously controlled 12-minute period. The individual papers were then scored on three criteria: Quinn's Hypothesis Quality Scale, the Syntactic Complexity Formula developed by Botel, Dawkins and Granowsky, and the Metaphor Index developed for the purposes of this study.

At the end of the 18 sessions comprising the treatment, three additional film sessions were presented to elicit hypotheses that were scored for hypothesis quality, syntactic complexity, and metaphor index. These scores constituted the criterion variables for this study.

Metaphor Index

Since both hypothesis quality and syntactic complexity are addressed in previous publications, attention is given here to the Metaphor Index and the reasons for its inclusion in a study on culture, cognition, and science learning.

Nietzsche (1971) claims that the impulse toward the formulation of metaphors is one of the fundamental impulses of man and that every metaphor of perception is individual and without its equal. Quoting frequently from the work of Nietzche, Kaput (1979) states that the nature of human thinking is essentially metaphoric and that the metaphorizing process is our primary means for creating and, especially, transferring meaning from one universe of knowledge to another. In linguistic terms, Brown (1958) speaks of metaphors as expanding the semantic range of some word or words. It appears that he sees metaphors in single words as well as phrases, clauses, complete sentences and extended discourse over larger language units. He claims that the metaphor lives when the word brings to mind more than a single reference and the several references are seen to have something in common and that there is a click of comprehension as the similarity is recognized.

It is this well-stated ability of a metaphor to point up a surprising similarity between apparently unlike things that we used in selecting the definition of metaphor for this study. For the purposes of this investigation, metaphor is defined as "the relating of disparate objects and ideas to find a commonality among them."

To obtain the Metaphor Index utilized in this study we counted the number of hypotheses generated on each of the criterion variable papers, then counted the metaphors expressed in the written statements of scientific hypotheses, and divided the total number of metaphors by the total number of hypotheses generated. The Metaphor Index for each group, monolinguals and bilinguals, is then expressed as a percent.

Results

The results presented in Tables 3 and 4, which show mean scores by monolingual and bilingual groups for hypothesis quality and syntactic complexity, were obtained by multivariate analysis of covariance. Table 3 gives the means for the quality of hypotheses generated by both groups.

Table 3. Means for Hypothesis Quality

Variable	Monolinguals (N=32)	Binlinguals (N=30)
Hypothesis Quality	53.3	176.0
Reading Level	7.0	3.8

Difference is significant at $p<.01$.

Table 4 gives the means for the syntactic complexity of the written language used in expressing the hypotheses.

Table 4. Means for Syntactic Complexity

Variable	Monolinguals (N=32)	Bilinguals (N=30)
Syntactic Complexity	130.0	181.8
Reading Level	7.0	3.8

Difference is significant at $p<.01$.

On a standardized test of reading, the monolinguals were superior to the bilinguals. However, in the generation of high quality scientific hypotheses and syntactically complex language, the bilinguals significantly outperformed the monolinguals.

The results for the Metaphor Index comparison are presented in Table 5 for the population in this study.

Table 5. Means for Metaphor Index (in percent)

Variable	Monolinguals (N=26)	Bilinguals (N=26)
Metaphor Index	19.3	26.1

The actual quantity of hypotheses generated by the students were 579 for monolinguals and 1945 for bilinguals. The quantity of metaphors they produced in expressing the solutions to science problems were 112 for monolinguals and 273 for bilinguals.

The bilingual children generated more hypotheses and more metaphors than their monolingual peers. Metaphors are taken here as indicators of the semantic creativity of language use and hypotheses as indicators of the cognitively creative ability to utilize data in making generalizations and manipulating variables. In both aspects of creativity, language and cognition, the bilinguals appear to excel.

Conclusions and Discussion

Studies from this research on the interaction of language and cognition with a science inquiry program suggest that children proficient in two languages are capable of entering into the creative processes of divergent and convergent thinking more fully than their monolingual peers. The generation of multiple solutions to science problems, and hypothesis formation, is an expression of divergent thinking and a form of creativity. Bilingual children in a science inquiry program of the type described here generate many more solutions to problems than the monolinguals. Utilizing metaphors to express science solutions is a type of convergent thinking, a form of creativity relating disparate objects and ideas to find a commonality. A metaphor points up a surprising similarity between apparently unlike things in the process of creating and transferring meaning from one universe of knowledge to another. Bilingual children participating in the science program studied here generate more metaphors then the monolingual children.

The metaphorizing process of creating and transferring meaning from one experiential base to another appears to point to cultural dimensions of the environment in which the bilingual child's language and cognitive creativity function. The written hypotheses of the monolingual children evidence much greater concern about the precision in their expressions of solutions to science problems than do those of the bilingual children. Hypotheses generated by monolinguals utilize more exact, analytical references such as 'to the right,' 'about two meters,' 'the one on the left,' 'the one filled with water,' or 'the pressure of the air.' Conversely, the hypotheses generated by the bilinguals are rich in metaphors pointing up surprising similarities in finding ways to make generalizations and manipulate variables. Metaphors such as 'the same thing would happen if I used beer,' 'of the two kinds of water - clean and dirty - dirty would work the same way,' 'the same thing would happen if I used drano or cough medicine,' 'just like when they make drinks with alcohol...when they put alcohol in and don't put coke or seven-up, the ice stays down because of the alcohol's strongness,' 'I could use a tennis shoe, a patrol boat or a barrel' illustrate these surprising similarities in making relationships for convergent thinking. Expressions for conducting further tests to verify hypotheses exemplify the metaphorizing process as seen in 'I would try it in my house with malt' and 'a test for this is when you get poisoned, you rub alcohol on your body and it makes you warm.' If human thinking is essentially metaphoric and the metaphorizing process primary means for transferring meaning from one universe to another, then the metaphors generated by bilingual children in this study may be taken as reflections of not only their thinking but also their universe, the culture of which they see a part and which they bring to the universe of the science classroom and the types of problems presented there. An understanding of these dimensions of the child's universe becomes critical in evaluating language and cognitive abilities. Recognition of these expressions of creativity as insights into the bilingual child's culture and into the creative use of language and cognitive abilities becomes an essential part of the science curriculum.

This investigation on the interaction of language and cognition with a science inquiry program suggests that children with a high degree of bilingual language proficiency are capable of entering into creative processes in divergent and convergent thinking more fully than their monolingual peers. This enrichment that appears to accompany bilingualism is intimately related to the cultural universe or experimental domains of the learners. The cultural background of the Mexican American children in this study appears to effect the way they formulate scientific hypotheses in the creative, metaphoric use of language. A science education program which would require more precise, analytical language prematurely would fail for these children to take into account cultural diversity and its contributions to creativity in language cognitive functioning.

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DEVELOPING BETTER SCIENCE EDUCATION PROGRAMS: CULTURE, ALIENATION, AND ATTITUDES

Maxwell Maddock
University of Newcastle
New South Wales, Australia

Editorial Note: Max Maddock has a rich background of experience in science education research and development in Australia and in many developing nations. In this report, he analyzes several critical problems in bringing the traditions of science into a culture which has very different beliefs and values. He describes alienation that can occur between youth and adults as a result of science instruction and makes recommendations for minimizing this alienation through community education which springs from the community's knowledge and beliefs regarding topics of desired social-technological change. In this paper, Maddock analyzes relevant research and development activities to enrich our understanding of the issues and possible solutions to them.

* *

Although I cannot speak authoritatively about science programs in Latin America and the Caribbean, my work in Australia, the Pacific, Asia, and Africa has provided insights which may help discussion on developing better science education programs in the Americas, particularly in developing nations.

Much of the effort in improving school science programs has been based on the viewpoints of scientists. The viewpoints I will present are much broader than this and will include the following:

1. The concepts of value and relevance of school science in varied cultural settings;
2. The alienating effect of formal schooling; and
3. The importance of attitude development as an integral objective of school science.

Value and Relevance of School Science

It is important to recognize that science is a cultural enterprise with its own particular ideology and its, fundamentally, social knowledge (Mendelsohn, 1977). It has taken on the mantle of a religion, with its high priests (university academics) laying down dogma (scientific methods and the "sacred cows" of content), its rituals for gaining acceptance into the "fold," its missionaries (science education agents in developing countries), and its lay workers (the science teachers). Science teachers act as "gate keepers" (Bullivant, 1975) who control access to a specific store of scientific knowledge and attempt to socialize students into the culture by coercing them to develop attitudes which predispose acceptance of a particular world view.

It was pressure from the "high priests" of science in the 1960's which engendered the curriculum reform projects in U.S.A. and U.K. The "missionaries" seized on these projects as the "gospel" for promotion of science education in developing countries. Implementation of these courses created many difficulties as indicated in my review of science curriculum centers in Asia (Maddock, 1982). Further, Maybury (1975) showed that these new programs have resulted in disillusionment as one after another failed to produce desired effects among students in developing nations.

There is a need to develop more critical techniques for defining the purposes of science education in developing nations, for producing effective programs aimed at such purposes, and for evaluating their effectiveness. Partly because of disenchantment with introduced courses, and partly due to increasing capacity in developing nations to produce their own curricula, there has been a shift towards development of indigenous school science programs. For example, there is a growing unanimity in Asia that education in science and technology should not alienate learners from cultural heritages and values, that curricular must be adapted to cultural conditions and practices, integrated closely with real life, and result in a better quality of life (Chin Pin Seng, 1979).

A key question that must be addressed concerns the relative role of providing scientific and technological literacy for the general population through programs that lead to a healthier life-style for the wider population and for training of future scientists and engineers who constitute a small segment of school age youth. At the Waigani Seminar held recently in Papua New Guinea to develop guidelines for national science policy, this issue was hotly debated. One view was that school science should emphasize training of scientific manpower and the poor quality of graduates was lamented by scientists. Palmer (1984) advocated further specialization and pointed out that the goals of quality and equality in education was in opposition to one another, while Bunker (1984) lamented the "impoverished content" compared with African countries.

However, when one examines school science syllabi, visits science classes, and looks at the impact of science instruction on the vast majority of the population, one begins to wonder about the real purposes of science instruction. The content is so often irrelevant to the social context in which most students live, and few attempts are made to bridge the gap.

The Waigani Seminar recognized the need for broader based scientific and technological literacy and drew up policy recommendations to the government that education of future scientists must not be at the expense of relevance for the general school population. Moreover, there was a strong body of opinion that more specialized courses for future scientists should start in the senior school years and that tertiary level training may take longer. Science for the general school population is needed to help them make socially relevant decisions having to do with disease, diet, hygiene, environmental quality, and appropriate use of technology. The concept that science is objective, and universality is somewhat utopian, because no activity can be isolated from the culture of those who use it, and decisions on application of science are, by nature, culture bound.

Alienation and Schooling

There is a growing concern in many developing nations that formal schooling has an alienating effect on youth. A report from Kenya lamented the tendency of schools to engender alienation instead of social integration (Republic of Kenya, 1976). Calls have been made in Asia for reshaping the curriculum so that education will not divide students and their families (Ahmed, 1977) and Papua New Guinea has set up its Secondary Schools Community Extension Project (Stanton, 1977; Vulliamy, 1981). However, much science instruction is aimed at shifting students away from "superstitious beliefs" by trying to develop "scientific attitudes." A significant literature exists regarding lack of success of such efforts (e.g., Lord, 1958; Jahoda, 1970 and Za'Rour 1972).

In a series of studies in Papua, New Guinea, a disturbing level of alienation has been demonstrated with strong evidence that science teaching is one of the contributing facts (Maddock, 1983b, 1984). My studies showed that more educated Papua New Guineans had a more positive "scientific attitude" as measured by the Environmental Phenomenon Attitude Scale (EPAS) than less educated village people, and also differed from their attitude to traditional religion as measured by the Traditional Religion Attitude Scale (TRAS) (Randall, 1977). Data also showed that people holding higher scientific attitudes perceived village people as ignorant, backward, and tradition bound. My studies in 1974 and 1980 showed that males, highlanders, and people educated predominantly in church schools were more alienated than females, coastal dwellers, and people educated in government schools. Higher performers on national examinations in science, mathematics and English were more highly alienated while least alienated students were the lowest performers.

If an important objective of school science is to prepare personnel to put science-bound agricultural and health projects into practice in villages, one wonders how they can communicate at a meaningful level with people they perceive as negative, ignorant, and backward. Thus alienation, engendered by schooling creates tension detrimental to development projects as pointed out by Hartman and Boyce (1977) regarding the "gulf of arrogance" between family planning experts and villagers in Bangladesh.

<u>The Relevance Dilemma</u>

It is well known that the 1960 science programs developed in the U.S.A. and U.K. were aimed at the top 20% of youth. My observations in New South Wales has convinced me that much science taught in high schools there is irrelevant to most youth. If relevance is lacking in developed nations, are not these same courses even less relevant in developing nations. As Ahmed said of science education:

> It is confined to the book...cut off from the real concerns of society...Education is generally formal, aloof, and passive (1977, p. 183).

Hoppers (1980) points out that most school leavers cannot use their schooling because it has remained separated from reality, with development of few skills for acting innovatively in their environments. Knamiller (1984) pointed out that paradox of schooling in third world nations. National leaders want education to help alleviate problems of unemployment, nutrition, health care, sanitation and housing, but parents see schools as the institution that can aid in escape to the world outside. Moreover, science, more than any other school subject is seen as the key to economic and social advancement.

Knamiller (1984) recommends that relevance for school science can be attained by linking science and technology especially when related to contribution in health, nutrition, agriculture, and personnel training. He suggests that school science should focus on three major complementary thrusts: technology education, environmental education, and issue-based studies. However, one of the problems with these approaches is how to convince parents and students that they are superior to traditional academic science, which provides a small group of students access to prestigious courses.

The Real World of Children

Children's world view develops at an early age through daily experiences including contact with members of their family and community. Science programs rarely acknowledge the world views of children but instead, impose the scientific world view with a strong connotation of its efficacy (Bullivant, 1975; Ingle and Turner, 1979; Fensham, 1980). Many "sacred cows" such as the kinetic theory of matter are quite irrelevant to young people both in developed and developing nations, yet these theoretical constructs are taught to most children quite early even though this knowledge is both impractical and incomprehensible for most young people.

Science courses must take children's prior knowledge or world views into account "to make room for the co-existence of the old and the new" (Ingle and Turner, 1979). Maybury (1975) calls for research and development utilizing the combined talents of anthropologists, rural sociologists, linguists, and specialists in child development for successful curriculum development. Bulmer (1971) suggested designing courses which take off from the indigenous culture and Andrews (1970) reported on a Papua New Guinea symposium which recommended taking full knowledge into account when developing new science courses. These issues were raised again by Wendt (1979) and recent revisions of the Papua New Guinea syllabi draw on the ethnoscience of that region. More research is needed regarding children's views of the world and the influence of culture, language, and values along the lines of recent work at Waikato University in New Zealand (Osborne, 1980).

Attitudinal Science and Society Objectives

Objectives for science education in both developing and developed countries are often stated in terms of attitudinal outcomes beneficial to society. An underlying assumption is that teaching science content according to a particular pedagogy will result in the achievement of the attitudinal objectives. For example education in the Philippines is seen as having the power to impart "desirable attitudes" which will in turn benefit health, nutrition and the "quality of life" of the poor (Manuel, 1979). In the N.S.W., Australia secondary science syllabus (Secondary Schools Board, 1980), clear environmental and health education objectives are stated. Unfortunately most evaluative research is focussed on cognitive, rather than affective outcomes.

The results of studies carried out since 1977 indicate virtually no success in developing more positive attitudes to environmental conservation (Maddock and McDonald, 1982) or community and personal health (Maddock, 1983A, Maddock, Moore and Warren, 1984), and show very weak or zero-order relationships between attitude and results on science-content tests, and between attitude and awareness of issues related to the object of the attitude.

The case of the community and personal health objective provides a graphic example. Even though the syllabus aims at developing appropriate knowledge and understanding of bodily functions and the effects of nutrition and drugs, a study with over 600 high school students found that attitude to community and personal health shifted markedly in a negative direction with increasing grade level from 7 to 11 while awareness of health issues increased dramatically (Maddock, 1983A). Another study showed that primary pupils were significantly more positive in attitude than high school students (Maddock, Moore and Warren, 1984). A further study with college of advanced education students carried out in 1984 revealed a very weak correlation between attitude and awareness.

There is some evidence to suggest that other factors related to the culture of the subjects may influence the information-knowledge - attitude interaction. For example, an Australian study by Eyres (1978) showed that the greatest impact concerning environmental issues came from sources outside the school: Cultural-personal factors affected health attitude and awareness. (Maddock, Moore and Warren, 1984). In an attempt to pursue this issue further, a large scale follow-up study to investigate relationships between awareness, health-related behavior, and personal and cultural background variables has been undertaken, the results of which are still being analyzed.

If attitudinal outcomes are as important as they appear to be world-wide, then much more research needs to be focussed on the nature of attitudes, the kind of information base needed to develop them, and the relationship with cultural factors. This challenge has recently been taken up in Asia by the Regional Centre for Science and Mathematics Education (RECSAM) in Malaysia as one of its priority areas for its 1984-89 program.

Towards More Effective Programs

The strategies I recommend for developing more effective programs place high priority on:

1. research using a wide range of strategies to identify themes related to community needs which lend themselves to a science education approach;
2. research into folk-science and children's views of the world, to identify a base for starting the identified themes;
3. community and adult education in a non-formal setting;
4. developing school and community integrated programs on real-life which educate children and the adults in the community in the same general direction, rather than developing a "generation gap";
5. carrying out evaluative research which places considerable emphasis on the achievement of attitudinal aims;
6. using an integrated research strategy which takes anthropological, sociological, and linguistic factors into account;

7. developing new specialized "scientist-oriented" science courses for senior high school and tertiary level which take account of the changed junior courses.

Two exemplary approaches to reducing the amount of alienation between youth and adult community members are in progress in the Philippines. A program of indigenous science education has been developed which takes into account needs identified by the community and existing knowledge and beliefs of its members. Instructional modules have been developed in both English (the language of instruction) and Filipino (the national language) for use in schools. Simple, comic-book format materials written in Filipino also have been made available for use with adults so that the same message about social and technological change can be presented to both adults and youth (Hernandez, 1980). The San Salvador "Survival of the Family" project and a forest community project addressed the needs of people living in their specific environments with emphasis on sanitation, disease, nutrition, and appropriate technology (Da Silva, 1979; Villavicencio, 1979, 1980). Both of these projects have demonstrated success and have the potential to make a greater impact on rural communities than formal school programs which concentrate on "sacred cows" of science aimed at preparing a few trained scientists.

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CURRICULAR PLURALISM REQUIRES CULTURAL PLURALISM: AN APPLICATION OF A SOCIO-PSYCHOLOGICAL THEORY

Garnett L. McDiarmid
Ontario Institute for Studies in Education
Toronto, Ontario, Canada

Editorial Note: In this paper, which is a condensed version of a much longer paper, McDiarmid identifies some persistent curricular problems of crucial importance, outlines a theory which is broad enough to help us comprehend these problems, and shows how the theory is useful in analyzing specific problems related to education of North American Indians living in Ontario, Canada. He shows that broader based curricula enhance learning rather than restrict it but that societal forces generally work to narrow the curriculum of schools. Thus, he closes his paper with a strong plea for political persuasion as a prerequisite to innovative curriculum policies and practices thereby enriching the opportunities of youth as well as of society as a whole.

* *

Those of us who are concerned about the broad field of curriculum development (as distinguished from the specialized fields of course development) are reminded periodically that there are several persistent, fundamental problems. Empirical research shows that they appear in both Canada and the United States, and it is reasonable to assume that they appear in other countries also. If we add to this list of general problems, certain specific issues in Amerindian education, and examine them as a totality, it becomes very clear why our traditional remedies of hortatory and superficial course development are inadequate to meet the needs of native students.

In this paper, we shall see that the perennial recalcitrance to solutions of these problems signifies that we are confronted by profound cultural forces which are moulding the schools into an increasingly utilitarian instrument of socialization. In the process they also function as discriminatory agents against the children of the poor. To understand these forces and to begin to understand how to deal with them, it is necessary to consider a theory which is sufficiently widely based that it can predict or hypothesize some determinants of curriculum manifestations. This is a prerequisite step to the derivation of supportable ideas for change.

This paper is divided into three, parts of unequal length. I shall itemize and only briefly comment on a series of empirically researched, persistent curriculum problems; develop a socio-psychological theory broad enough to comprehend these problems; and finally, I will introduce the topic of Amerindian education, as studied in Ontario, Canada, using both general curriculum and specialized implications for teaching science, as research evidence and theory permit.

Persistent Curriculum Problems

Reports of research on schooling practices written by Hodgetts (1968), Silberman (1970), Sarason (1983), Goodlad (1983), and Joyce and Clift (1984) provide a picture of schooling that is:

1. dominated by a textbook-chalkboard method of didactic teaching which is described as mindless and uninteresting;
2. characterized by a narrow repertoire of pedagogical alternatives leading to a sameness in design of substance of all subject areas;
3. based on a view of knowledge as something to be acquired rather than explored, reckoned with, and converted into personal meaning and development.

Paradoxically, there have been exceedingly well publicized demands that education "return to the basics" amid charges that standards have fallen. Often these charges are ill-founded and are based on misrepresentations of data to assert a favored opinion of those making the assertions (Neatby, 1953; Farr, Tuinman, and Rowis, 1974; McDiarmid, 1977). In view of the homogeneous research results that have identified the recitation approach to teaching, how can we relate to theory the fact that periodic charges of rampant permissiveness continue to make headlines?

If we add to this litany of frequently encountered problems the knowledge that (a) when a wide range of elective subjects was permitted in Ontario High Schools, Indian dropouts decreased significantly but (b) when the introduction of elective subjects was strongly resisted and finally terminated by powerful forces in society, the dropout rate increased (McDiarmid, 1977), then we have a list of problems pertinent to our concerns. Each of these problems requires an explanation and appropriate counter action if we are to avoid the repetition of superficial "do-good" curriculum modifications with which we are so familiar.

Daily Occurences in Theoretical Perspective

The importance and power of theory is described concisely in the following quotation from Toulmin:

> The true measure of the insight which any serious theory provides lies, above all, in the richness and variety of the novel questions it forces on our attention, and in its power to reveal significant connections between elements, or fields of inquiry, that had previously appeared entirely independent. This means not just the power of the theory to generate additional questions for investigation, but also its capacity to discredit questions left over from earlier accounts and to replace them by other, more operative questions (Toulmin, 1972, p.504).

This conception of theory can enrich our conception of curriculum. As a starting point, we can consider that every curriculum is built upon a set of intentions and comprises a set of activities by which the intentions are realized. The theoretical and practical implications of this formulation are profound.

Alternative intentions of the curriculum for public schooling of youth constitute a major point of contention among varied groups in our pluralistic society. One such contention arises between people who view the intention of the curriculum as normative socialization of youth and those who prefer that schooling develop children's autonomy, creativity and uniqueness. Another conflict, pertinent to this Inter-American Seminar on Science Education, relates to the degree to which school curricula build upon or replace the values and beliefs which young people bring from home, community, and church.1

Since it is eminently clear that our society is pluralistic, with different groups holding a continuum of beliefs about the education of youth, that range from strict normative socialization to child-centered individualism, we should expect to see that continuum reflected in the school curricula which are designed for young people. Moreover, it should not be surprising that those persons in the society who exert the greatest influence over other matters will also have a strong influence on the curriculum of schools. Neither should it be surprising that groups with conflicting interests will also be in conflict regarding schooling.

<u>Activities Categorized According to Intentions</u>

Figures 1 and 2 represent three intersecting dimensions of intention: Teachers' role, students' role, and the role of instructional activities. There are several advantages of the graphic form. We can demonstrate the operational distinctions among curriculum practices that teachers and the public can identify, by their disagreements, as being of critical importance. We also can illustrate the incongruity between child rearing practices and teaching activities in particular sub-cultures. For example, my assessment of teaching practices in Indian reserve schools places them directly in quadrant 4 (Figure 2) while, at the same time, the parental expectations fit in quadrant 7, near the position of Summerhill.

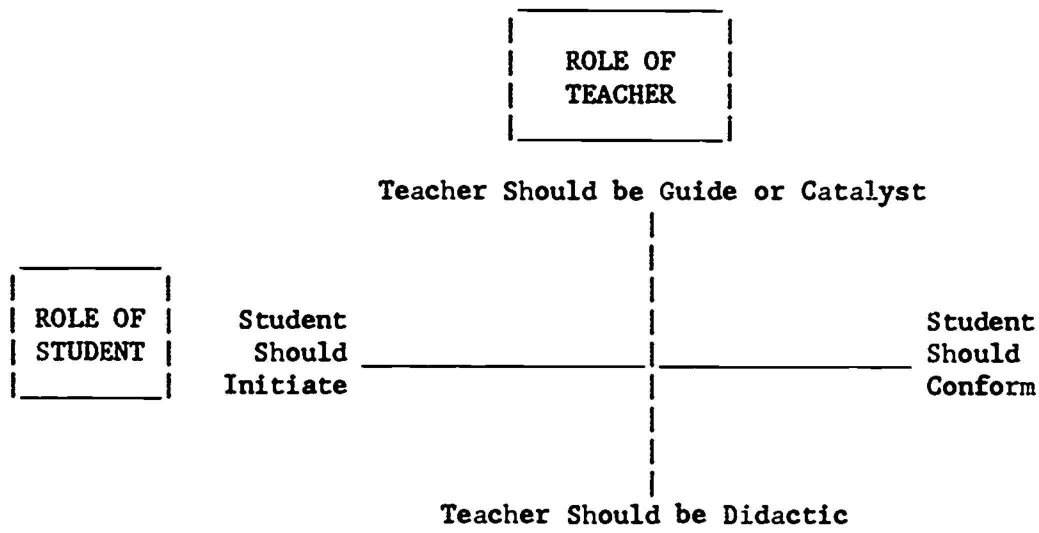

Figure 1 - A Circumplex With Two Scales Only

The labels on this diagram should be read in conjunction with the polar positions of Figure 2 (structure of the curriculum).

1 A more thorough analysis can be found in a longer version of this report which is available through the ERIC and REDUC systems (McDiarmid, 1984).

Also, we may say that the graphic form of this taxonomy illustrates that we cannot teach process and product in isolation. We can see that what we once categorized as a teacher's methodology of a lesson also significantly becomes a teaching activity in interpersonal relationships for children. Further, it is my contention that the three dimensions are necessary and significant to perform three tasks:

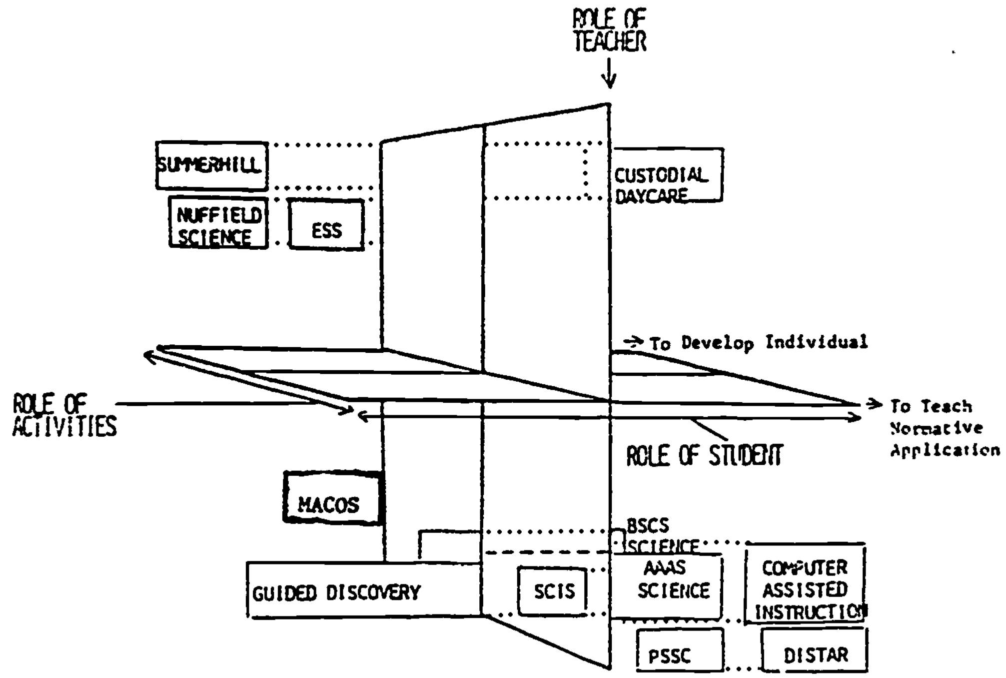

Figure 2 - A Three-Dimensional Representation of Curriculum Structure Showing Relative Positions of Selected Curriculum Activities

The text refers to the rear and front sections of this multiplex, in the upper right corner as quadrants 1 and 2; in the lower right corner as quadrants 3 and 4, and so on, going clockwise. Thus all odd numbered quadrants indicate the placement for activities that can be judged to be intended for individual, personal development. The even numbered quadrants indicate the placement of instrumental or normative activities.

(1) to categorize and thus compare and contrast all curriculum activities;

(2) to represent the fundamental distinctions of intention as expressed in practice, perception, and rhetoric among the contending subgroups in society; and,

(3) to form an intermediate theoretical position between (a) the definition of <u>curriculum</u> as the relationship between intentions and activities of schooling and (b) the identification of socio-cultural determinants of the curriculum.

Turning to the role of parents regarding the socialization of children, the work of Becker (1964) and Schaeffer (1959) can be used to highlight pertinent issues. Becker points out that family expectations and treatment of children can be understood in terms of two continua: (1) permissiveness-restrictiveness and (2) warmth-hostility (See Figure 3, middle level). This perspective is enriched by the model of social attitudes outlined by Eysenk (1953) in which the continua are (1) radicalism-conservatism and (2) tenderness-toughmindness (See Figure 3 top level). Studies of teachers and teaching (Hook and Rosenshine, 1979; Chall and Feldman, 1966; Kulik and McKeachie, 1975; Edwards and Morris, 1980; Ehrman, 1969; and Apple, 1979) all point to substantial reinforcment in schools, of conforming world views.

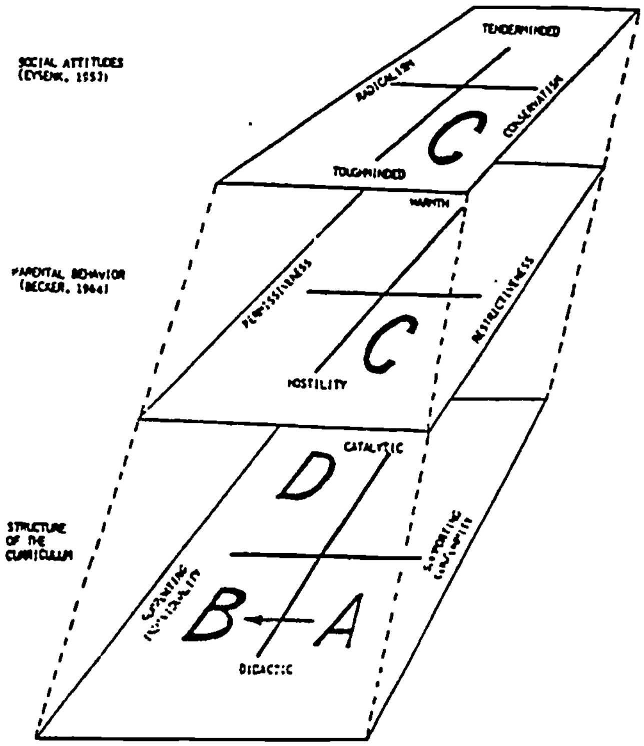

Figure 3. An Exploded Diagram Depicting an Overlay of Three Analytic Models.

The aim of this essay may now be restated: To show that the school curriculum is a cultural device that carries society's intentions regarding the socialization of children into effect--a social instrument whose manifestations and consequences disclose operationally the essential values of its governing society.

An Application of the Theory

The foregoing argument has been developed as a preamble to demonstrate the derivation of the theory from empirical data rather than from a strictly rational conceptualization. The application of the theory, in which I will restrict my references to Amerindians, must similarly be developed in stages: if it is to apply to real life situations, superficial derivations would be misleading. The implications of the theory relate to interpersonal relationships generally, to classroom or teacher - student relationships more particularly and also to a new way of looking at the politics of education. I shall refer briefly to the substance of science teaching in the concluding section of this paper.

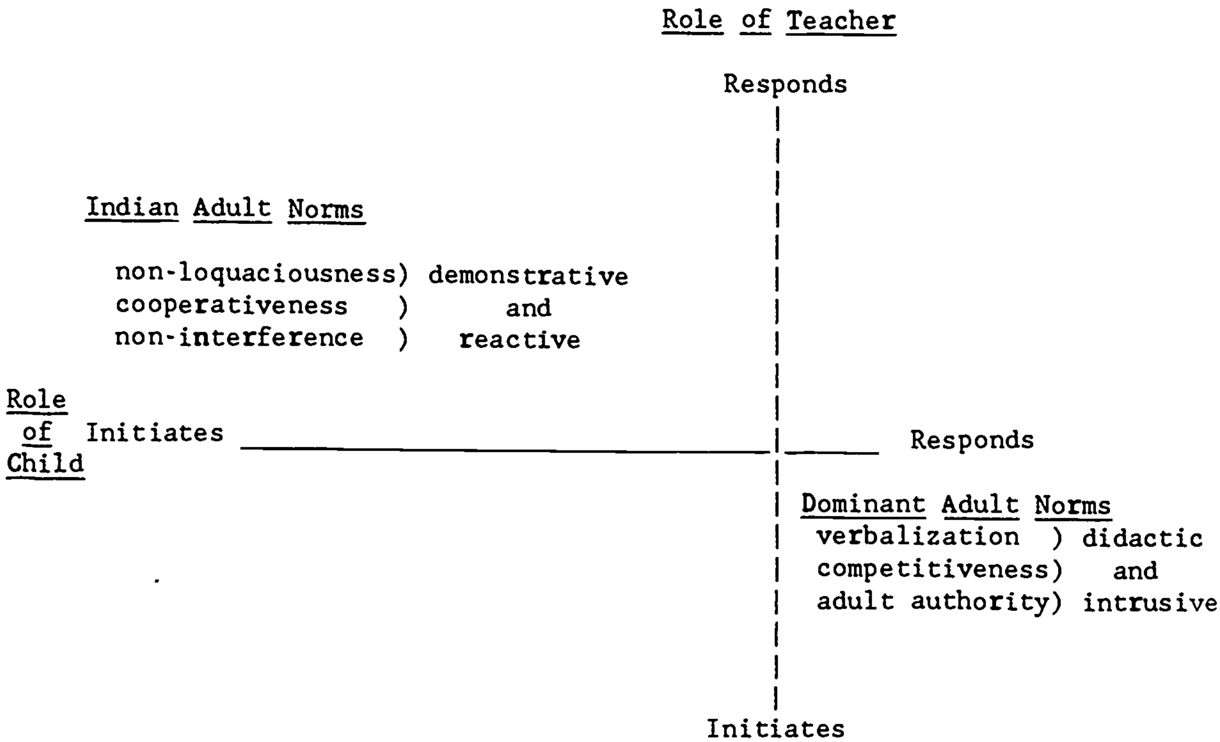

Figure 4. Diagrammatic Location of Socialization Norms in the Dominant and Indian Cultures.

Figure 4 is an adaptation of Figure 1 (the graphic portrayal of a factor analysis of parental behaviors). In this case I have located several predominant socializing characteristics of the Indian and dominant cultures. Variability within these cultures will be discussed later but as a first approximation, these are the types of behaviors that are perceived by teachers who are relatively unacquainted with Indian cultures.

New teachers who have some intraceptive facility begin to compare their own behaviors with those of native people with whom they are involved. Eventually they attempt to come to terms with a non-loquacious, non-intrusive society. They become aware of their own socialized behaviors of verbosity, competitiveness, and intrusiveness and attempt to become facilitative. Typically, they start to consider that the concrete materials they should be using in their lessons would best be those that appear in their students' immediate environment. From that insight it is a small step for them to begin to seek assistance in interpersonal and cognitive domains. It is arguable that the former is the paramount situation most particularly when one gradually realizes that some Indian parents want some recognizable form of traditional interpersonal relationships for their children in school, while, at the same time, a significant number in the same communities ask teachers for dominant culture demands upon children (e.g., punishments and homework).

The latter action of parents is one example from a second-order set of perceptions of which intraceptive teachers become aware because it is a fact that neither the Indian nor other sub-cultures can be considered as homogeneous. We live not only in a multiethnic society; we live in an increasingly differentiating multiethnic society. Although these differences cut in a number of directions, e.g., religion and the "New Values" described by Yankelovich (1981), it is more central to this discussion that we understand that middle class values are increasingly being adopted among the generally deprived peoples. This effect holds for a number of subcultures (Banks, 1983) including, by my own research--and in a very complex manner--North American Indians.

Part of the complexity of the matter comes from the denial process of the Indians themselves. Indeed, I have the personal impression that they are stronger in their declarations of traditional homogeneity than all other groups with which I am acquainted. The reality of the differentiation, however, is apparent in demands that Indian children be accorded equal grade scores and equal graduation numbers in training programs for the prestigious occupations. Associated with these demands is an abandonment of the pervasive Indian cultural expectation of non-interference in the exercise of school authority. For teachers and curriculum planners, the dilemmas of working in relatively self-contained communities whose members exhibit these contradictory expectations are real and profound. They are all the more serious to negotiate because the contenders, in obvious attempts to preserve the appearances of cohesion, will not acknowledge their own roles in the basic problem. The problems are confounded when Indian children are immersed in an urban situation.

What can we do? The path of innovation is not an easy one. If we recall that on several occasions since the end of World War II there have been several attempts to upgrade science programs and to stimulate discovery-type activities among students--and at the same time, if we recall the research evidence that was cited at the beginning of this paper that reports overwhelming didacticism in the schools--then we have a potent measure of the difficulties that confront those of us who seek ways to bring the curriculum into congruence with the daily lives of Indian children. We need, in the first instance to understand the social dynamics that have kept the school on their heavily conformist, adult-centered course. If we want to have a differentiated curriculum (in this case adaptations that are designed for culturally heterogeneous students), we must seek ways to create a public climate that will tolerate pluralism and self-definition. I must note deliberately, once again, that "public" in this context includes teachers--and professors.

In order to link the implications of this conclusion to the theoretical position I developed earlier, I have assembled the previous model and descriptions of curricula, parental behaviors and social attitudes in a portrayal of three overlay transparencies in Figure 3. If we keep in mind the fact that the predominant curriculum characteristic in our western culture is authority oriented didacticism; that this entails interpersonal relationships (student-teacher) that are reinforced by parental and more general cultural sanctions (position "A" on the diagram), then we can readily see that any clock-wise movement, let us say to position "B" (guided discovery) will excite the endemic, authoritarian anxieties of the parents and general population who occupy Eysenck's conservative/tough minded quadrant, position "C." This will be more emphatically the case if those who are advocating the movement from "A" to "B" employ the rhetoric of position "D." It is obvious from the periodic demands to "return to the 3 R's" (I have lived through three such cycles in my career), that the conformists are always with us, waiting for the opportunity to drive back into the fold those brave individuals who temporarily stray onto the paths of pluralism and self-definition. Given the widespread nature of the sample populations that went into the original studies for these factor analyses, we must acknowledge that it is not just a set of local cranks with whom we must contend. Here are social attitudes, expectations, beliefs, and myths that affect the school culture as profoundly as Max Weber's Protestant work-ethic influences the general culture. (I presume that these affects are related.)

<u>Plans to diversify science programs to meet the supra-normative needs of Indian children must be embedded in strategies to legitimate the very nature of pluralism.</u> The clear implication of this derivation from theory--and practice--is that power groups must be persuaded by responsible authorities to accept a wider degree of latitude both in teacher practices and in curriculum design than they typically allow. They must be presented with evidence that shows that a broader based curriculum <u>enhances</u> learning rather than <u>restricts</u> it because more children will be educated. This policy does not lower standards, which is the common allegation of the traditionalists, because in every system the elite two percent, or ten percent, still graduate; but in addition, many children who would otherwise be dropouts are enticed to stay in schools that will offer courses that interest them and are perceived as useful. The experience of the USA and Canada in offering special benefits to veterans following World War 2 shows the potential benefit to national governments who are interested in increasing their school retention rate.

<u>A Test of the Theory</u>

The Province of Ontario offered a naturalistic laboratory to test this hypothesis in the last decade. As often occurs in times of a prosperous economy, our province permitted seconda' school students to take courses that were optional to the traditional versity preparation courses. The total percentage of students retai. d in high school gradually increased but the Indian children increased their proportion of the stay-ins to a much greater degree. The following table tells the story.

TABLE 1

COMPARATIVE ENROLLMENT RATIOS

	Indians on Reserves			Ontario as a Whole			
Year	GR 7-13(a)	Total Pop'n(b)	S/Tip	GR 7-13(c)	Total Pop'n (Thousands)	S/Top	S/TOP S/Tip
1968-69	3695	52,981	6.97	805,409	7,306	11.01	1.58
1969-70	4171	54,072	7.77	842,259	7,452	11.30	1.45
1970-71	4381	55,342	7.92	877,076	7,637	11.48	1.45
1971-72	4687	56,553	8.29	905,030	7,703.1	11.75	1.42
1972-73	4995	57,768	8.65	917,419	7,833.9	11.71	1.35
1973-74	5037	59,405	8.48	924,457	7,938.9	11.64	1.37
1974-75	5110	60,576	8.44	940,732	8,093	11.62	1.38
1975-76	5069	61,621	8.23	948,420	8,255.8	11.49	1.40

Sources: (a) 'Enrollment of Registered Indian Students in Federal and non-Federal Schools, By Grade.' Document 5120-10-3022. Department of Indian Affairs.
(b) 'Registered Indian Population,' Document 5000-20-1700. Department of Indian Affairs
(c) Education Statistics, Ontario Ministry of Education, 1975. Indian enrollments grades 7 and 8 are added to original data.

Table 1 shows comparative data from federal Indian schools and from all Ontario schools, the base line of which is the year the Minister of Education made his "equality of educational opportunity" speech in the legislature. Changes in population growth are controlled by the derivation of ratios of the number of students to the total Indian population (S/TIP) and to the total Ontario population (S/TOP).

It will be noted that in the base line year, 6.97 percent of all Indians on reserves were enrolled in grades 7-13. That ratio increased for four successive years. The data for Ontario as a whole indicate that 11.02% of the general population was enrolled in grades 7-13 and the ratio increased for three successive years to 11.75%. The rate of increase for Indians given an extra year, was almost two and one-half times of that general school population, since their enrollment increased by 1.68% as against .73% for the general population.

The disparity between Indian and non Indian enrollment, however, is discouraging. The last column of Table 1 indicates that the S/TOP ratio was 1.58 times larger than that of S/TIP in 1968-69. It decreased to 1.35 in 1972-73 but has increased steadily since then.

Although the basic data are not shown here, the discrepancy in retention rates for grades 12 and 13 combined are much more revealing. Except for mature student status, grades 12 and 13 are the completion years prior to admission to community colleges and universities, respectively. From 1968-69 to 1975-76, the general Ontario enrollment in the senior grades are 3.6, 3.2, 3.2, 3.3, 3.5, 2.7, 3.2, 2.8 times higher than the corresponding Indian enrollment. The ratios are more variable because of the small numbers of Indian students involved. The discrepancy decreases across the eight years but is still very large.

The rise in the enrollment ratios of both Indian and non-Indian students in Ontario coincides with the official provision for a more varied secondary school population. The falling ratios coincide with the period of criticism that the schools have endured and to which they have responded, long before the recent official announcement of a more structured curriculum.

Conclusion

This paper has been devoted to the topic of identification and emphasis of societal determinants of the curriculum. We are now able to see why the problems which I labelled in the Introduction to this essay as "persistent" are in fact very difficult to eradicate. Consequently, I have not attempted to address the equally important topics of cognition and teaching strategies which are also components of school learning. In the final analysis, it is my conclusion that the strategies that must be employed in order to develop both curriculum policy and curriculum practices must account for the fact that there are powerful forces in society that attempt to preserve the status quo by means of their control of the schooling process. These forces can frustrate even the most profound schemes that are designed to enhance the cognitive processes of a majority of any country's children.

If a country is sufficiently far-sighted to want to broaden the educational base of its citizens it must be concomitantly prudent to establish safeguards to permit variation to occur. Standardization entails restriction; pluralism offers freedom and growth.

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CHAPTER 3 GOALS, AND STRATEGIES OF SCIENCE TEACHING

Six papers in Chapter 3 explore both theoretical and practical matters relating to science teaching in multi-cultural contexts. The chapter opens with a report by Ortleb of work in St. Louis (Missouri) schools in teaching science to students with diverse cultural backgrounds. Next, Luna, González, and Yunen report on a national study of achievement in science and mathematics among students in grade 8 in the Dominican Republic. Curbello provides a summary of his meta-analysis of research on the teaching of problem solving in science and mathematics. The chapter concludes with three essays by Góngora, Rodas, and D'Ambrosio each of which explores more philosophical perspectives of science teaching. D'Ambrosio provides a useful rationale for ethno-science by contrasting it with what he calls "real science" instruction with which most people are familiar.

Therefore, the first three papers in the chapter are descriptions of the state-of-the-art in three different contexts, whereas the last three are more philosophical about needed directions in science teaching.

INSTRUCTIONAL STRATEGIES FOR TEACHING SCIENCE TO STUDENTS WITH DIVERSE CULTURAL BACKGROUNDS

Edward P. Ortleb
St. Louis Public Schools
St. Louis, Missouri, U.S.A.

Editorial Note: There is ample research to indicate that the diverse cultural endowments of students influence the way they learn. However, teachers generally have been prepared to deal with psychological characteristics rather than cultural characteristics. Six ethnic variables are presented, described, and related as to how they influence students' learning styles. These six variables form the framework for suggestions on structuring the learning environment and on teaching techniques for science education. Science is a suitable discipline for dealing with diverse cultures because it affords an opportunity to work with a variety of materials and activities.

* *

A major conclusion of the work of the anthropologist Cole and his associates was that "cultural differences in cognition reside more in the situations to which particular cognitive processes are applied than in the existence of a process in one cultural group and its absence in another" (Cole et al., 1971, p. 233). This statement forms the basis for this paper. Implied in this philosphical viewpoint is the notion that a teacher can structure the classroom environment in such a way that the cultural variables can be utilized to advantage. Students can be assist ' in adapting to the demands of the instuctional program.

Most educators have been thoroughly indoctrinated to structure their instruction to meet individual differences. However, although teachers are rather comfortable in dealing with psychological differences in student learning, they are less comfortable in dealing with cultural differences. Brembech and Hill (1973) indicate that, as educators, we are unclear about the role of cultural endowments and that instead of treating cultural characteristics as we do psychological differences, "we tend to assign 'good' and 'bad' designations, and we let our expectations of students be influenced by them" (Brembech and Hill, 1973, p.3). Decker (1983) asserts that teachers are finding themselves attempting "to teach youngsters whose values and beliefs are quite different from our own" and using methodology that is ineffective (Decker, 1983 p. 44). This has caused frustration and discouragement, and yet teachers continue to use the same methodology as though more of the same will eventually be successful. In his outline of stategies for intercultural communication, Seelye (1984) notes that most problems of interaction between an educator of one culture and a pupil of another "stem from the implicit, culturally conditioned assumptions each makes about the other" (Seelye, 1984, p.195).

Of the many elements that shape our generally negative responses to cultural diversity, Brembech and Hill (1973) have identified three: (a) research has focused on the individual within the school setting rather than as a member of a culture; (b) psychological variables are more easily studied than cultural; and (c) psychological differences can be dealt with more objectively than cultural differences (Brembech and Hill, 1973 p.3). Although, it is incumbent upon educators who work with different cultural groups to consider ethnic and cultural variables in structuring the learning environment and developing teaching techniques, there is not a great deal of research in this area.

Teachers who try to structure the learning environment and use teaching techniques in isolation from the learning styles of their students will experience what Hilliard (1984) has labeled as a "distortion of the natural teaching-learning process" because it can separate teaching from learning and/or submerge the reciprocal nature of the process (Hilliard, 1984, p.121).

Hunter (1984) has identified three categories of decisions that teachers must make in reference to the learner: (a) content decisions - "based on what the students know now, what they are ready to do next, as well as the probable degree of intellectual complexity of the new task"; (b) learner behavior decisions - "A second category of decisions the teacher makes focused on what the student will do to learn." and (c) teaching behaviors, made after the other two, which utilize learning principles to affect motivation, the rate and degree of learning, and the retention and transfer needed in a new situation (Hosford, p.171).

It is clear that an understanding of cultural endowments is crucial for each of the teaching decision categories presented above. A teacher has to consider the student's cultural traits and values in determining the appropriate content. Similarly, the teacher must make decisions regarding the sort of activity in which the students should engage to best meet their needs. Teaching behaviors have to be selected to elicit response from both the class as a whole and from individual students. It is important to see ethnic characteristics as powerful resources for learning since they spring from the students' primary culture. Burger (1973) outlines six ethnic variables that influence the way students learn in classrooms. These will form the basis for some suggested instructional strategies and learning environment structures that follow.

1) Cognition versus Affect versus Psychomotor

Bloom (1976) has noted that most of our schools are biased in favor of cognitive learning and biased against affective and psychomotor learning. This is because we teach in a style that favors the cognitive learner. Many social scientists believe that, compared to other cultures, Anglo culture emphasizes cognition and deemphasizes affect and psychomotor. Some specific research (Bruner, et al, 1966, Goodnow, 1969) has centered on identifying the methods by which certain cultures introduce cognitive development activities. This work indicates that Western style schools emphasize cognition skills at an earlier age than others, making children more adept at problem solving skills.

If cognitive-based activities are not appropriate for certain students, then it would be appropriate to structure activities in the affective and psychomotor domain. For example, certain AmerIndians are reported not to do well with excessively cognitive-oriented instruction, since their culture favors the affective and psychomotor domain. In her review of Afro-American cognitive style, Shade (1982) refers to research that indicates Afro-American children require a great deal of stimulus variety in contrast to Euro-American children when processing information. This has direct bearing on problem-solving performance. Researchers have also noted that many Black and Mexican-American children do not learn efficiently through a cognitive learning style; they learn faster through instructional modes that allow group interactions and include things to see, feel, hear and touch (Decker, 1983). In primary grades, certain problem-solving skills can be taught using manipulatives and pictures. Students requiring varied stimuli to successfully process information for solving problems can be supplied with instructional materials having high variability.

2) Communication

In his essay on multiethnic and global education, Cortes (1983) states that intercultural communication is not merely learning other languages, but it also "involves the skills of observing and interpreting nonverbal communication and knowledge of the different meaning that the same or similar words (albeit in different languages) have for members of other cultures" (Ovando, 1983, p. 647). Teachers must consider the whole range of communication elements - body language, gestures, personal space, conversational distance and social customs - to more accurately assess how to work with students of diverse cultural backgrounds.

Often we are unaware of the effect that voice volume, gestures, and nuances of speech have on a listener of a different culture, i.e. Americans generally look directly at the eyes of the person to whom they are speaking; in another culture such as that of the American Indian or the Mexican-American, this is a sign of disrespect or discourtesy. Teachers are generally aware that the nuance of a spoken word, a gesture or body movement may communicate much more than a declaratory statement, but these communicative strategies may not be understood by a student of a different culture, or they may even be antithetical.

The essence of communication is sharing. The receivers of the communicative signal can only respond within the level of their comprehension. To insure safety and to insure that the student has a meaningful experience, extra effort must be made by the science teacher to be sure that every student understands the full implications of what the teacher is attempting to communicate. The teacher must also recognize the ethnic variables associated with student's oral and written communications. For example, some cultures severely limit the social dialogue of young females, and consequently, they have little experience in communicating in classroom-size groups. This becomes awkward when they are asked to present an oral report or to share the findings of their experiment. Burger cites the example of Puerto Rican students who consider a school examination so formal that it deserves an ornate and allusive style of answer. Without an understanding of this ethnicity, the teacher might summarily judge this as an effort to conceal ignorance. (Burger, 1973, p.12)

3) Time

Cultural differences exist in regard to attitudes toward time. Some groups observe schedules and appointments with an almost military precision while others treat them with some indifference. Western-style civilizations are often preoccupied with a "fast is better" syndrome, and the pace of their educational systems is considerably more accelerated. Agrarian or pastoral societies have a more relaxed attitude toward time and schedules. In dealing with students of cultures where time schedules are less precise, the science teacher may have to structure timelines for reports that allow periodic self-checks by the students to enable them to assess their progress in a series of intermediate steps.

The temporal differences that pervade a culture also pervade the maturing of its constituents. The pace in schools of Western-style cultures may be inimical to students from a culture where education does not usually involve a time pressure (Burger, 1973 p.13). The teacher needs to assess the student's strengths based on that student's culture rather than on the culture of the teacher. Often a lack of familiarity with terms or activities by students from a differently oriented culture is interpreted as a lack of ability. However, the students' prior education may have been slower paced, and they simply have not been exposed to the same curriculum materials.

4) Social Organization

The social organization in which the individual functions (family, tribe, kinship, community) has a direct relationship to how the individual performs within the classroom. Students from a culture that fosters a close kinship (e.g. Hispanic) may find themselves in an alien world when they enter the American classroom. They may feel lonely because of the cultural break (Burger, 1973 p.15). Rather than assign them to a laboratory station arbitrarily, the science teacher should consider an assignment to a station either near a student from the same culture or a student who has empathy for the newcomer. Landes (1965) describes the situation between a teacher and the student of a Korean family. Due to its patriarchial hierarchy, repeated efforts to contact the family through the mother were disregarded. However, when the father was invited to the school with the wife, and they were consulted privately before a general conference, all went well. Teachers are cautioned not to try to impose their ethnicities upon other cultures so that the learning process is not impaired.

5) The Goodness of Human Nature

The differences in attitudes toward human nature can vary from a strictly moralistic society that views human nature as basically amoral to a more progressive society that views human nature as basically good. The first culture would supervise the child closely and strictly; the latter would allow more individual freedom. A student, who is a product of the former philosophy, when confronted with a classroom situation in the latter culture, will experience confusion and loss of direction. The teacher will need to structure the learning activities to aid the student in gaining a sense of purpose and direction. Science investigations offer an excellent opportunity to establish a comfortable compromise between the two divergent attitudes; because there are both structured and open-ended components to investigations, a student can begin to experience a feeling of individuality as an organized science investigation unravels and reveals other avenues to explore.

In the situation where there is variance in regards to acquisition for personal gain versus sharing, students can be encouraged to share their knowledge with their peers by tutoring them (Burger, 1973 p.16). In this way bright students can eliminate some of their guilt feelings generated from the fact that they are gaining something at the expense of others.

6) The Sense of Environmental Control

Parsons (1964) coined the term "instrumental activism" to denote that aspect of American society by which the individual seeks to control the environment to "contribute to the common good." This attitude has engendered a strong commitment to improve nature. Instead, some other cultures have a strong commitment toward reconciliation with nature. These cultures have distinctive attitudes regarding the controllability of the universe. Some cultures believe that events are caused. There is, then, a further division whether caused events can be influenced by the individual. Attitudes toward causation affect the ways in which people learn (Burger, 1973 p.17). It determines how students view their role in controlling their destiny. The teacher must try to bridge the gap from a fatalistic to deterministic attitude. The teacher should demonstrate to the student how each activity is a step toward a goal. Unless this is done, the student will see little relevance in learning about the Kreb's cycle or an organic chemical formula to attaining a high school diploma. If the students are expected to attend class daily, then they also should be given some assurance that each day's class will impart some practical knowledge.

III. Conclusion

In this paper a brief review was presented of the effect of cultural and ethnic diversity on learning styles. There is ample research to indicate that the diverse cultural endowments of students influence the way students learn. However, teachers are less prepared to deal with cultural characteristics than with psychological characteristics. Six ethnic variables were presented, described and related to how they influence students' learning styles. These same variables formed the categories for suggestions on structuring the learning environment and on teaching techniques for science instruction. If our goal is to provide an effective education for every student, then our task must be to determine the conditions under which various processes are manifested and to develop techniques for seeing that these conditions occur in the appropriate educational setting (Cole, et al. 1971, p.233).

Teachers who acknowledge that children learn in different ways and learn at vastly different rates will have different materials of instruction available and a variety of reference materials at hand (Brandwein, 1962, p.24). Science is a suitable discipline for dealing with diverse cultures. Science instruction affords an opportunity to work with a variety of materials and activities. The science teacher who wants to be an effective director of learning activities will need to seek the appropriate materials to work with, select the appropriate teaching style and recognize the learning styles of each student.

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BRIEF DESCRIPTION OF THE STUDY "THE TEACHING AND LEARNING OF MATHEMATICS IN THE DOMINICAN REPUBLIC"

Eduardo Luna, Sarah González, Rafael Yunen
Universidad Católica Madre Y Maestra
Santiago, Dominican Republic

Editorial Note: This is a description of a national study regarding the teaching and learning of mathematics in grade 8 in public and private schools in the Dominican Republic. Over 50,000 students in approximately 1,000 schools in both urban and rural areas were tested. In addition, curricular materials and classroom practices were analyzed.

* *

1. <u>Background of the Study "The Teaching and Learning of Mathematics in the Dominican Republic."</u>*

Very little real and effective research has been done on the roots of the Dominican educational problem. The vast majority of research done in this field is mostly in the way of descriptive reports prepared by foreign technicians (or by Dominicans who work for them); undergraduate theses, which are limited to very specialized areas of a problem, or very generalized essays which lack an empirical basis and focus on education disconnected from its global function and interaction with the rest of Dominican society.

In 1980 a group of the Universidad Catolica Madre y Maestra (UCMM) scholars decided to pool their knowledge in different areas to focus on an important aspect of the educational situation - - the evaluation of classroom teaching and learning. The following fundamental questions were identified by the Dominican scholars as being central to the issue of evaluation:

a. How much knowledge has a student acquired after X number of years in school; i.e., "How much" does a student <u>really know</u> when he finishes school?

b. What <u>does the student</u> know and how can he use that knowledge?

c. Is there a difference between (1) "what we want him to know," (2) "what we actually teach," and (3) "what he has learned?"

d. What proportion of this learning is derived from his non-school environment?

e. What weight do the different factors (social, pedagogical, individual, etc.) carry in the learning process?

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f. Which elements cause a difference in learning among the students at different schools in different regions of the country?

g. Is it possible that the school contributes in increasing social differences when the same performance is not achieved by all schools despite geographic location or the socioeconomic level of its students?

The UCMM scholars decided on a selection of objectives, together with a delimitation of subjects and levels to be evaluated. It was felt that the teaching of mathematics in eighth grade was an appropriate topic to obtain answers to some of the questions outlined.

2. Dominican Education System

The following is a description of some general qualities of the Dominican Educational system which may result in a better understanding of the characteristics of the students which participated in this study:

1. The National Council of Education and the Secretary of Education are in charge of directing the educational program.

2. The Secretaria de Educación, Bellas Artes y Cultos (Department of Education, Fine Arts and Culture) supervises and evaluates all schools as well as finances a great many of them.

3. There are three different types of schools in the Dominican Republic which are located in urban or rural settings:

    a. public schools (totally financed by the government);

    b. semi-official schools (partially financed by the government);

    c. private schools, which receive no financial aid from the government.

4. There are two kinds of educational programs (Traditional and Reformed) which are used throughout all the schools and were established by the National Council of Education which also approves the texts used for teaching.

The contents of the mathematics curriculum in the Traditional Program (developed in 1950) correspond to the mathematics generally taught in the United States during the period 1950-1960. While the major emphases' are on arithmetic and measurement; topics from geometry, sets, and statistics are also included. The topics from sets and statistics were added at the beginning of the 70's. The contents of the mathematics curriculum of the Reformed Program correspond mainly to the curriculum materials developed by the Second Mathematics Study Group (SMSG). The emphasis is not only on algorithums, but also on their justification. In addition, the structure of number systems is included.

3. Generalities of "The Teaching and Learning of Mathematics in the Dominican Republic (TLMDR)

A. Justification

This study is based on the following points:

- In the Dominican Republic very little importance has been given to the teaching of the basic sciences.

- Mathematics, like any other subject is under the influence of many non-school factors. However, mathematics has the advantage of being a universal language, which, given certain precautions, permits a comparison of our students' achievement and our classroom processes with those in other countries. These comparisons would help in the development of Dominican education when compared to other countries with similar and/or different conditions as the Dominican Republic.

- This kind of study will provide needed empirical data that can be used to design new strategies which adjust to the Dominican educational situation, and improve the teaching and learning of mathematics. Thus, the strategies to be recommended would be based on knowledge of both the students' and the teachers' needs and deficiencies.

- The opportunity to conduct for the first time a major mathematics study which would lead to the creation of a group of Dominican researchers developing analytical skills necessary for the assessment of classroom activities and student learning in basic school subjects.

- One of the major limitations to the development of Third World countries is the lack of indigenous scientific knowledge which is appropriate to their situation. A proper improvement in the teaching of the basic sciences would noticeably help in the cultural development in such countries.

B. Objectives and Frame of Reference

The Dominican study had a three-fold purpose:

- Investigate the nature and scope of the mathematics curriculum.

- Investigate how much mathematics is taught and in what ways.

- Study how that teaching affects both students' learning and their attitude towards mathematics.

For the purpose of this study, the mathematics curriculum was seen to consist of three dimensions: the intended curriculum, the implemented curriculum, and the attained curriculum. This theoretical framework was adopted from the Second International Mathematics Study (SIMS) conducted by the International Association for the Evaluation of Educational

Achievement (IEA).

The intended curriculum is the mathematics curriculum as defined by official agencies such as the Ministry of Education and as codified in curriculum guides. The implemented curriculum is the curriculum as taught by teachers in their classrooms. The attained curriculum is the curriculum assimilated by the students as evidenced by their knowledge of the subject and their attitudes towards it.

Also, the TLMDR wants to analyze the influence of other factors on achievement in mathematics such as socio-economic status, geographic location, type of school, and gender.

The student population selected for investigation was defined as follows: "All students registered in the eighth grade of the Traditional Program or in the second year of the Reformed Program attending classes either in the morning or afternoon sessions."

C. <u>The Sample</u>

A) Population: According to the statistics prepared by the Ministry of Education of the Dominican Republic, during the 1980-81 academic year, there were about 60,500 students distributed as follows:

a) 33,500 in 272 public schools in urban areas

b) 4,800 in 126 semi-official schools in urban areas

c) 4,000 in 138 private schools in urban areas

d) 18,200 in 563 public schools in rural areas

It is interesting to note that 55 percent of the semi-official schools and 80 percent of the private schools are located in Santo Domingo and Santiago, which are the two largest urban areas in the Dominican Republic.

B) Urban Sample

In the urban areas, the schools were classified according to pedagogical and demographic-political-administrative characteristics. The pedagogical classifications were as follows:

1. Public primary and intermediate schools;

2. Public traditional high schools;

3. Public reformed high schools;

4. Private and semi-official schools which are authorized by the Ministry of Education to give examinations;

5. Private and semi-official schools which are not authorized to give examinations.

The cities in which the schools were located were categorized by using the size of the population as a criterion:

a. Population greater than 1,000,000;

b. Population between 100,000 and 1,000,000;

c. Population between 49,000 and 100,000;

d. Population between 15,000 and 49,000;

e. Population of less than 15,000;

C) Rural Sample

The twenty-seven political provinces of the country were classified in three groups:

1. Large rural population with political contacts.

2. Large rural population with no political contacts.

3. Small rural population.

From each of these groups two (2) provinces were selected at random. As a result we obtained a 2x3 matrix from which the schools were chosen. This resulted in selecting in the rural areas a total of 40 schools, 43 classrooms with approximately 1,300 students and 40 teachers.

4. Components of the Study

A. Curriculum Analysis

In this phase of the study curriculum objectives and content were analyzed. The basic instrument used to carry out the analysis was the Table of Specifications prepared by the IEA International Mathematics Committee (based on the chapter "Evaluation of Learning in Secondary School Mathematics," written by J.W. Wilson in the Handbook on Formative and Summative Evaluation of Student Learning (Bloom, B. S.; Hasting, J.T.; Madaus, G.F.; McGraw-Hill, 1971).

B. The Classroom Processes

This phase of the Study examined the instructional methods and classroom practices. The information was obtained through questionnaires answered by principals and teachers.

In order to motivate the teachers to complete the Classroom Questionnaires, we organized a personal visit to each one of the teachers participating in the study. During these visits we explained the purpose of the questionnaires and the importance of the information that they could give us. We also assured them that such information would be considered confidential, and that no school would be identified in our reports. We used all the questionnaires, but one, prepared by the IEA.

C. The Attained Curriculum

This third component of the study measured students' achievement and attitudes toward mathematics. The measurement of achievement was conducted by means of multiple-choice tests covering significant aspects of the mathematics curriculum. The mathematics concepts which were examined included those related to arithmetic, geometry, elementary statistics, algebra and measurement. Student mathematical skills to be assessed included computation, comprehension, application and analysis. (Weinzweig, A. I., Wilson, J. W., "Second IEA Mathematics Study: Suggested Tables of Specifications for the IEA Mathematics Test," Working Paper I, Wellington: IEA, January 1977)

The final selection of cognitive items was made from a set of items which included the final collection used in the Second IEA Mathematics Study. These items were pilot tested three times, ending up with a collection of 180 items including 116 from the international pool. This last group of items will allow us to eventually make some comparisons with other countries.

In addition to those items, we also prepared a questionnaire for the students in order to obtain information about the actual occupations of their parents, their nutritional level, their possible occupations, and other environmental characteristics. Our interest in doing so was based on the results of our pilot project, which revealed that private school students have pre-test scores that surpass post-test scores of students in the same grade in public and semi-official schools.

Also, the growth during the academic year was greater for students in private schools than for students in public and semi-official schools. This finding may reflect the inability of our school system to reduce social inequalities. In fact, it seems that the educational system enhances, and deepens, social inequalities. This last statement is of great importance if we take into account that for every 1,000 students that enter the first grade of the Primary School, only 160 enter the last year of this cycle in six years. Of these 160, only 120 continue at the intermediate level. Of these 120, only 30 complete high school.*

Finally, we were also interested in measuring two other variables: mathematics anxiety and sex stereotyping. In the pilot studies, we have observed that males' achievement in mathematics exceeded that of female groups. This result may be due to socio-cultural factors that predispose and determine the type of professional activity corresponding to each gender.

Since the cognitive component of the study was longitudinal, two measurements were made:

a) A pre-test, at the beginning of the school year, and

b) a post test, at the end of the school year.

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*Secretaria de Estado de Educación, Bellas Artes y Cultos: Diagnóstico del Sector Educativo en República Dominicana, 1979, p. 36. (This data corresponds to 1970).

With these two measurements we determined growth during the academic year and achievement in mathematics for the students in the target population.

The measurement of the socio-economic status of the students was made through a questionnaire administered to the students in the pre-test. To measure the attitudes and other environmental characteristics, another questionnaire was given to the students at the end of the school year.

5. Application Procedures

The study team had to define an appropriate strategy to reach the schools in the sample, in order to have complete control in gathering the data. This strategy included four personal visits to each one of the schools in the sample. In this way, we had direct contact with the principals and teachers who were going to give us the information we needed throughout the study.

On the first visit, we verified the selected sample, the location of these schools, and identified the principals and teachers who were to collaborate with the study. Also, on this visit we confirmed the date when classes would begin in order to insure that the pre-test was administered in the first six weeks of classes. Then we decided with the principal the date for the pre-test. This visit was extremely important to establish a socio-affective relationship with the principals and teachers which would be favorable to the Study. All important and specific data for each school were recorded, as well as any environmental characteristics that needed to be pointed out.

With all this information in mind, we prepared the procedures for the application of the questionnaires in each classroom. The designed procedures guaranteed a complete supervision of the administration of the questionnaires by the research team, and, therefore, minimized the difficulties that could arise while they were being administered. They are as follows:

1. The training of a team of senior students who, under the supervision of the research team, would administer the pre-test and the post-test. This procedure is radically different from the one used in other countries where the materials were sent by mail to the schools. In those countries, the teachers themselves were then in charge of administering the pre-test and the post-test and of mailing those materials to the national centers.

2. The preparation of 13" x 10" envelope in which the students would write personal information (name, age, sex) and information about their school (name of the school, name of the mathematics teacher). Inside this envelope, the students would find the questionnaires for the pre-test. (We prepared another envelope at the end of the school year, with the questionnaires for the post-test). On the envelope we also recorded the following information:

a) the school code,
b) the classroom code,
c) the code of each questionnaire inside the envelope.

This data would facilitate the assignment of the questionnaires for the post-test.

3. For each classroom in the sample a package of envelopes was prepared. Outside of each package the following data was recorded: name of the school, its address, classroom identification, name of the principal and name of the mathematics teacher.

4. For the administration of the questionnaires, in the pre-test and the post-test, we classified the schools in the sample in two big groups: northern region and southern region. Each group could be evaluated in one week. For the assignment of the classrooms to the teams of evaluators each group of schools was subdivided by regions to facilitate the access to those schools in the assigned time.

Until now, we have described the application procedures for the schools that follow the "regular school-year calendar" (from September to June). Similar procedures were used to evaluate the schools that follow a special" calendar for areas rich in the production of coffee (January to September); this calendar has been created to allow students to participate in the coffee harvest.

On the second visit to the schools in the sample the objectives were:

a) the administration of the pre-test to the students

b) the administration of School General Questionnaire and the Teachers General Questionnaire.

To assure the success of the implementation of the pre-test, we sent a telegram to each school in the sample, 15 days in advance of the assigned date, reminding the principal and the mathematics teacher(s) of the date of the pre-test assigned to their school. Also, in the telegram we indicated the name(s) of the evaluator(s) who would visit their school.

A third visit took place one month before the administration of the post-test to insure the following:

1) Hand delivery of the Classroom Processes Questionnaires (Fractions, Ratio, Proportion, and Percent, Measurement, Geometry) to the teachers involved.

2) To set the dates for the post-test.

The fourth and last visit took place during the last two weeks of class which accomplished the following:

1) The administration of the post-test to the students.

2) The administration of the Teacher Opportunity-to-Learn

Questionnaires.

3) To pick up the Classroom Processes Questionnaires.

4) To obtain additional data about the classes such as the number of days in which the students had mathematics classes during the school year and number of students who were present in the pre-test and absent in the post-test and number of students present in the post-test.

6. List of Publications of the TLMDR

A. Publications Until August 1984

1. The Adventures of an Educational Research Project in the Dominican Republic: "Student Achievements in Mathematics."

2. Selección de Items Cognoscitivos Utilizados en el Estudio "La Enseñanza y el Aprendizaje de la Matemática en la República Dominicana."

3. Resultados Sobre Género y Matemática del Estudio "La Enseñanza y el Aprendizaje de la Matemática en la República Dominicana."

4. Informe sobre el Muestreo Utilizado en el Estudio "La Enseñanza y el Aprendizaje de la Matemática en la República Dominicana."

5. Sociología del Rendimiento en Matemática: Apuntes sobre la Metodología Empleada y Hallazgos Principales.

6. Descripción de un Plan para la Aplicación Personalizada de Cuestionarios en los Estudios Longitudinales Sobre Rendimiento Educativo.

7. Análisis del Curriculum Propuesto en Matemática para la Educación Intermedia y para los Dos Primeros Cursos de la Reforma de la Educación Secundaria en la República Dominicana.

8. La Enseñanza de las Fracciones Comúnes y Decimales en el Octavo Grado (Programa Traditional) y en el Segundo Año (Programa de Reforma) en la República Dominicana)

9. El Aprendizaje de las Fracciones Comúnes en la Escuela Intermedia y en los Dos Primeros Años de la Reforma de la Educación Secundaria en la República Dominicana.

10. El Aprendizaje de las Fracciones Decimales en la Escuela Intermedia y en los Dos Primeros Años de la Reforma de la Educación Secundaria en la República Dominicana.

11. Manuales de Codificación:

   a. De las Preguntas Relativas a Ocupación de los Padres.

b. De la Pregunta Relativa a Niveles de Nutrición.

c. De los Cuestionarios de Procedimientos de Clase.

d. Del Cuestionario General del Profesor.

e. Del Cuestionario General de la Escuela.

B. Publications Being Prepared

1. El Aprendizaje de las Razones, Proporciones y Porcientos en la Escuela Intermedia y en los Dos Primeros Años de la Reforma de la Educación Secundaria en la República Dominicana.

2. La Enseñanza de las Razones, Proporciones y Porcientos en el Octavo Grado (Programa Tradicional) y en el Segundo Año (Program de Reforma) en la República Dominicana.

3. El Aprendizaje de la Geometría en la Escuela Intermedia y en los Dos Primeros Años de la Reforma de la Educación Secundaria en la República Dominicana.

4. La Enseñanza de la Geometría en el Octavo Grado (Programa Tradicional) y en el Segundo Año (Programa de Reforma) en la República Dominicana.

5. El Aprendizaje de las Mediciones en la Escuela Intermedia y en los dos Primeros Años de la Reforma de la Educación Secundaria en la República Dominicana.

6. La Enseñanza de las Mediciones en el Octavo Grado (Programa Traditional) y en el Segundo Año (Programa de Reforma) en la República Dominicana.

7. El Aprendizaje de Probabilidades y Estadística en el Octavo Grado (Programa Traditional) y en el Segundo Año (Programa Reforma) en la República Dominicana.

8. El Aprendizaje de Otros Temas de Aritmética en la Escuela Intermedia y en los Dos Primeros Años de la Reforma de la Educación Secundaria en la República Dominicana.

9. El Aprendizaje de Álgebra en la Escuela Intermedia y en los Dos Primeros Años de la Reforma de la Educación Secundaria en la República Dominicana.

10. El Aprendizaje de la Matemática en el Octavo Grado (Plan Tradicional) y en el Segundo Año (Plan de Reforma) en la República Dominicana.

11. Actitudes de los Estudiantes del Octavo Grado y Segundo Año de la Reforma Frente a la Matemática en la República Dominicana.

12. Características Generales de los Profesores de Matemática del Octavo Curso y Segundo Año de la Reforma en la República Dominicana.

THE EFFECTS OF TEACHING PROBLEM-SOLVING ON STUDENTS'ACHIEVEMENT IN SCIENCE AND MATHEMATICS: A META-ANALYSIS OF FINDINGS

José Curbello
University of Puerto Rico
San Juan, Puerto Rico

Editorial Note: This is a brief summary of a longer report by the author. This summary and the longer report are based on the author's doctoral dissertation completed at Florida State University. Those interested in detailed information about this study should contact the author, at the address above, or his dissertation director, George Dawson, Professor of Science Education, Florida State University.

* *

In the last two decades, the school curriculum has undergone significant changes. Curricular programs have been implemented in the area of science and mathematics with one of the stated purposes being the development of students' problem-solving abilities.

This study is a report of a meta-analysis of research on the effects of these curricular approaches on students' problem-solving abilities. In a meta-analysis different research studies are treated as though they were a sample of a single population. The studies analyzed in the meta-analysis were found in the research literature on science education, both published and unpublished, related to the teaching of problem-solving in science and mathematics.

Many researchers and theorists, among them Bruner and Gagné, have studied problem-solving from different perspectives and have established guidelines regarding the conditions under which learning of problem-solving strategies are best learned by dis^overy, while Gagné argues for guided, sequential learning. Gagné stressed the importance of establishing basic associations and facts in acquiring the basic skills and principles of problem-solving.

This meta-analysis was undertaken with two purposes in mind. The first concerned the magnitude of the effect of teaching problem-solving. The second examined the relationships among the variables or characteristics reported in each study.

Among the different theories and empirical studies examined in this meta-analysis, the variables that occurred most frequently were (1) learning conditions and (2) students'/behavior changes. Strategies of teaching were also reviewed.

One hundred twenty-three studies were located after examining available literature written during the period from 1967 to 1984. This was the time in which the effect of science and mathematics curricular reforms were beginning to have an impact on both research and practice. After applying criteria established by the investigator, the meta-analysis was done on sixty-eight studies. The remaining studies were not included for a variety of reasons, most notably poor research design. These sixty-eight studies produced a pooled sample size of 10,629 students and 343 effect sizes due to the fact that many studies reported more than one affect size, varying from one to twenty. Tukey's Jack - knife technique was used due to the non-independence of observations.

The average of the standard deviations was 0.54 and the corrected standard deviation was 0.59. The 95% confidence interval of the true effect size was established for each study and it varied from 0.37 - 0.71 in the group of research studies included in the meta-analysis. The fact that the confidence interval does not capture zero indicated a superiority of the new programs in teaching problem-solving.

The data produced by the meta-analysis allowed the author to draw the following conclusions:

1. When groups of students were given instruction in problem-solving, their achievement exceeded students not provided with instruction in problem-solving by an average of 0.54 standard deviations.

2. The duration of instruction in problem-solving is positively correlated with performance on problem-solving measures.

3. The most effective duration for instruction in problem-solving appears to be 5 to 10 weeks.

4. Problem-solving can be taught effectively in any academic topical area in science and mathematics.

5. The inquiry method seems to be one of the most effective strategies for teaching problem-solving.

SOME IDEAS RELATING TO THE PROBLEM OF TEACHING SCIENCE

Enrique Góngora Trejos
University of San Jose
San Jose, Costa Rica

Editorial Note: In this brief article, Góngora provides a critique of current practices in science education.

* *

Knowledge of science among middle school students in both developing and developed countries is on the decline, in spite of science being regarded as an instrument of survival. Although an outside observer may perceive an improvement in science teaching at all levels, this is not actually the case; in almost all cases, it has deteriorated. There is an increase in the number of university graduates, a proliferation of academic degrees, but there is a corresponding decline in the quality of educational programs.

Secondary students do not have adequate scientific background, but this can be remedied in the university. Study habits and motivation are extremely defective; these can only be rectified by teaching science,by going back to the basics of problem solving, instead of talking science in meta-language. At this point, two important factors interact: pedagogy and the set mind wich which the educational problem is faced. For science teaching to be effective, students must be taught to develop a scientific mentality.

Strange as it may seem to someone outside the profession, students graduating from high school today in both developed and developing countries do not know as much science as students did in the past. The implications of this for the future are frightening.

At the end of World War II science was recognized as the basic instrument of survival. If someone from outside our planet had been able to observe scientists and educators at work in the 1940's and 1950's, they would probably have reported that people on Earth were advancing scientificaly and technologically, and they were working hard to improve the teaching of science to insure their future.

If that same little green man were to return today, he would probably be shocked to see that not only were his predictions wrong, but that the teaching of science has actually deteriorated. He would find a far greater number of people holding high degrees in science, but the degrees themselves represented a much lower level of study than they did in the past.

What has happened? If it were merely a problem of students not having certain information, it would be a simple matter for university teachers to plug in what was missing. The problem, seemingly worldwide, is that the students do not have good study habits. They are not orderly and systematic; they do not concentrate well; they read badly and they do not express themselves well in oral or written form.

Science teachers alone were never meant to deal with such issues; these problems must be shared by the entire educational system. The only way teachers can insure that students learn science is by insuring that students study science. Instead of getting caught up in the verbage as some of us do, we need to structure our classes so that students learn to solve problems. We have to offer a systematic plan of study if we expect our students to learn scientific concepts.

Science is taught because it is thought to be needed in life, and because it contributes to one's personal development. Science is formative in that it leads one to understand and utilize the scientific method. People do not need teachers to teach them this method; it can be an acquired skill. If we want our students to have scientific minds, we need to have them actively involved in scientific activity.

There are two basic causes that have made us focus on meta-language instead of the scientific method in our classrooms. The first cause is our rush to educational reform. Someone in curriculum gets hold of a new fad, and it becomes a pet project until another one becomes fashionable, and the cycle repeats itself. A demonstration project is used as an example, but the teacher in the everyday classroom is unable to duplicate the project. In this way the classroom teacher's respect for new methods is eroded gradually, although sometimes, the problem is that the teacher has not received adequate training in the new method. What is needed is a little more common sense, but as Rene Descartes once said, "The one thing God seems to have distributed evenly among mankind is common sense since no one seems to want more than what they already have."

The second, and most damaging, cause is the educational mind set. Teachers forget they are supposed to teach science, and they want to teach creativity. No one knows if creativity can be taught, but we do know that science can be taught. We have an illustrious list of great scientists who learned science under the old methods. Who are our great scientists who were taught to be creative? In our efforts to forge citizens concerned with truth and beauty, we have forgotten our need to mold the leaders of tomorrow with a solid scientific background.

Education seems to be taking the path of least resistance doing whatever is easiest for the teacher and the student. The excuse is that science is difficult. Students have to memorize, to concentrate on what they are doing which is hard work. We need to change this mind set. What we are doing now cannot be called "studying" because study comes from the Latin "studeo" which means <u>to exert oneself</u>. Today students do not appear to be exerting themselves in the studying of science.

TEACHING SCIENCE

Pablo Rodas R.
University of San Carlos
Guatemala

Editorial Note: In this brief essay, Rodas describes a philosophical perspective which he calls "Lenardism" and applies it as a vehicle for reducing dogmatism in science teaching. He then calls for science instruction that helps students find joy, admiration, open-mindedness, and critical thought through science.

* *

To develop interest in science and to teach science effectively, several factors must be considered. Principally, student's capacity for admiration must be developed to prevent atrophy, which is a condition wherein students no longer find anything mysterious everything is a routine. The Students should be accustomed to enjoy seeking more knowledge regarding a topic in order to prevent them from learning superficially. Likewise, we should cultivate an attitude in our students of wanting to learn areas of human interest other than one's own field of specialization. Students of science must distinguish diadic from triadic schemes of learning, the latter being used by almost all modern sciences.

It should impressed on students an attitude of not relying solely on common sense, but on scientific theory. Refrain from being dogmatic, as most of the widely held dogmas of science and mathematics have been questioned and proven not to be absolute by the scientists themselves. Refrain from determinism because students of science must be able to accept new ideas which otherwise contradict already held conventions. Teach students to keep an open mind and not to disregard all concepts which science pretends to disregard. For example, the acceptance of the "packing effect" in Nuclear Physics, which otherwise is unacceptable in any logical situation.

Lenardism (after the scientist Philip Lenard) must be avoided. Finally, students of science must focus on the importance of structure. Doing all this, a student will develop a true scientific mind

> "I do not know what impression I make on the rest of the world, but I see myself as a small child playing at the beach. He enjoys what he picks up here and there whether a smooth stone or a beautiful shell while the open sea lays inscrutable before him."
>
> Newton

How can we as teachers help students develop scientific minds? Plato warned scientists that they needed to cultivate a sense of admiration for all things if they were to be true scientists. In his work, <u>Metamorphosis</u>, Ernest Schochter warns that atrophy will affect anyone who loses their sense of mystery and looks at everything as routine. A scientist should still be awed, while watching television, that the program is being transmitted by electronic waves.

Students should be encouraged to never lose their initial glow or the joy they feel as they learn to delve deeply into a given topic. Students should also be encouraged to remain curious about everything so that they do not become too limited in their interests. Jose' Ortega y Gasset in his work The University's Mission warns of this type of "barbarism" and suggests a structured cultural forum be offered at the university level to help scientists keep abreast in other fields.

Dogmatism should be avoided at all costs. One way to insure this is to use the triadic scheme rather than the diadic scheme. The diadic scheme sees science as studying only the objective and the scientific elements while the triadic scheme considers these two plus the symbols that man has invented.

Students need to be willing to question their own common sense. Alfred North Whitehead has written,"The new situation of actual thinking is born of the scientific theory which has advanced with respect to common sense. The introduction of the relative and the simultaneous have been a great blow to the language of common sense at the level of general scientific principle. In times past, science had refined only the common notions of the common people" (Frank, 1957).

This self analysis will help students confront others who might insist that one should not question what science has already "proven". For the true scientific mind, everything is open to revision. There are numerous historical examples from the fifteenth century's "proof" that the world was flat to the more modern dogma that as a science, math is quantitative, abstract, formal, exact and deductive. There are mathematical disciplines that do not study figures, that do not measure or add. Topology, for example, studies the relations where the amount is not always needed for accuracy. In mathematical exactness the relations are not always numerical, nor are they absolute. Some say that everything that we claim about mathematics, its perfect exactness, its generality, autonomy, its truth and eternity are, if you will pardon the expression, pure superstition." (Mannoury, G., Les fundements psycho-linguistiques des mathematiques.) Mathematics' deductive character has been rigorously denied by some, and even Euclidian geometry has been challenged.

The dogmas of the principles of contingency and objectivity exist, but the principle of contingency has been proven a myth through quantum theory. It shows that contingency does not exist in the subatomic world. There freedom rules; due to the freedom of will of the electrons, no one can predict what they will do. This has been well explained in Heisenberg's principle of uncertainty.

Marxists have long posited objectivity as a scientific dogma, although modern microphysics has shown that subjectivity also plays an important role. For example, the behavior of the electrons changes when they are observed, but as Pascual Jordon has said, this change in behavior has nothing to do with a defect in the instrument, but it is actually due to the nature of the particular electrons themselves.

Modern science has come to the conclusion that reality itself is immaterial. In the long run, the subatomic world is reduced to mathematical formulas without any more reality than those actual formulas. As was said before, mathematics is an invention of the human mind, for a triangle and a number have never met. Figures which have such forms may appear, but the mathematical concepts do not exist in reality. Scientifically, it is difficult to understand that the conditions of the equation of Schroedinger are more spiritual than the solutions of the differential equation from newtonian mechanics.

All these attacks against the dogmas of Physics do not come from idealistic philosophers as some might suspect, but from the physicists themselves. Those who attack are not minor figures, but the pioneers in the field, physicists like Einstein, Eddington, Jeans, Broglie, Jordon, Plank!

What criteria do science students use to deal with ideas that contradict convictions that are firmly held? The Pythogoreans provide one example. There was no room for the existence of irrational numbers in their mathematical concepts, but eventually the scientists had to accept their existence, and it destroyed their structure. Another example can be found in microphysics. There was a problem with the phenomenon of light where if they accepted the wave theory without question then they would have to reject the corpuscular theory, or visa versa.

Students must be able to take a fresh look at concepts which others have discarded. There is an anecdote about Herbert Spenser which illustrates this point. He is supposed to have laughed at a woman who, not wanting to pay for excess baggage, believed that if she packed her clothes as tightly as possible, it would make them weigh less. This attitude did not make sense to the English philosopher. Yet, today, Nuclear Physics has accepted this exact idea, and it is called the "packing effect". (Frank, 1957).

Philip Lenard, who influenced Einstein, was a Nazi who said that all physical science could be thought of as a totalitarian pattern. This author has coined the word "Lenardism" from this German scientist's name; it means someone who applies extrascientific patterns to scientific questions. Science students need to know how to avoid Lenardism. Beginning with Lenin, the Soviet scientists have fallen into Lenardism quite frequently. They say that all scientific contributions which do not line up with their political theories are not scientific. They confuse their readers by pointing out that such doctrines are reactionary simply because they go against the pre-established framework. In his Materialism and Empirical Criticism Lenin's famous attack on Mach (the same Mach whose work helped Einstein construct his theory of relativity) is based on the Lenardism that the positivism of the German physician did not line up with the materialistic plan of the politicians.

Students must learn to focus on structure in science. For instance, an element whose atomic structure changes in position stops being that configuration and converts itself into another even though they are the same elements. (Asti-Vera, 1967).

In sum, science students need to develop certain characteristics. They should approach all science with joy and admiration. They need to probe using a triadic scheme keeping their minds open to all kinds of revision. Dogmatism should not be allowed to develop. Criteria to judge a new idea, and the ability to reject old ideas which contradict the new one need to be taught. No idea should ever be presumed nor explained away. Students who learn all this will have truly scientific minds.

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CULTURE, COGNITION AND SCIENCE LEARNING

Ubiratan D'Ambrosio
University of Campinas
Campinas, Brazil

Editorial Note: In this paper, D'Ambrosio states that cultural diversity of students should be a major consideration in science curriculum design in order to rectify the deficiencies of current approaches to teaching science to youth. He bases this assertion on an analysis of the processes of learning and acculturation both in schools and outside of school. He suggests that formal, learned science is a closed body of knowledge, while ethnoscience denotes the study of scientific and technological phenomena in direct relation to the social, economic, and cultural background of the learners.

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Science education is going through a critical period in its long history. Science, recorded since Western classical antiquity, played a prominent role in Greek civilization with rationalism placed practially unmatched as the main root of modern science and technology, and in building up of the now universal model of an industrial society. Even the most critical periods in the history of education, which were the invention of writing and the adoption of Hindu-Arabic number systems in Europe, had a less dramatic and global effect in society as a whole than the period we are living through, with both the emergence of what might be called the electronic era, and the profound changes bound to happen in the social, political, and economic texture of the world. Through the universal concept of mass education, in a fast changing world science for all reaches an unprecedented dimension as a social endeavor, and it makes it urgent to question, in a much deeper and broader way than before, the place of science education in societies as a whole, as well as its socio-cultural roots. Being in such a privileged position in western thought, science may be, at the same time an essential instrument in building up modern societies and a strong disrupting factor in cultural dynamics, as well as a strong instrument in the unbalancing factor which threatens the needed equilibrium between those who have and those who have not, which has to be achieved if we want to look at our species as behaving in a more dignified way than it has been in its long history. If we hope for a better world, utopically without human beings massively exploiting and killing each other, we have to look into the role of science education in bringing up a new human dimension into relations between individuals, societies, and cultures.

This paper attempts to bring socio-cultural dimensions into science education. It is based on an analysis of the vast literature on human behavior and reflects work carried on for over two decades, in diverse cultural environments, with special reference to the perception of scientific facts and to abilities and uses of science in everyday life.

When we say perception, abilities and uses, we are placing ourselves in a position of looking at reality, as perceived by individuals who use their abilities, in the form of strategies, to perform actions which invariably have their uses in modifying reality. Hence, we are talking of human behavior as a cyclic model connecting reality-individual-acting-reality as characteristic of human beings.

We talk of a hierarchy of human behavior which goes from individual behavior, to collective (or social) behavior, to cultural behavior, and, finally, to cultural dynamics which is the result of transcultural behavior. Each of these hierarchical steps is characterized by an instrument of interaction between several individuals which can be explained in the context of cultural anthropology and which builds up to the human capability of reification and of language uses, of education and of communication and information as the decisive components in this hierarchy of behavior.

Children, as well as adults, have evolutive behavior in their learning which goes from individual to social to cultural behavior, and, we add, in an increasingly fast paced transcultural behavior. Quite often in developing countries, a child raised in a rural area will move to an urban area. This action, as well as the building up of new factories, new farms, and new social benefits, brings to different nations new patterns of behavior. This happens equally in the more developed countries and gives to this transcultural concept an important dimension in understanding the cycle reality - individual - action - reality. This is basic in our conception of education as action which fits particularly in this cyclic model (see Fig. 1.)

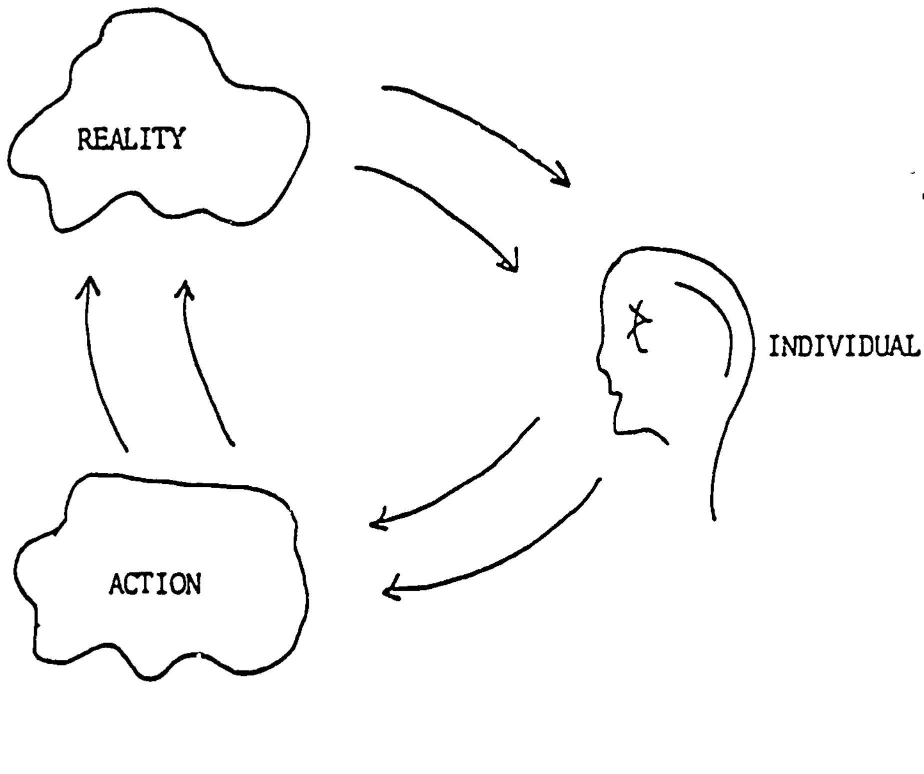

Fig. 1. The basic cycle of human behavior.

We also look onto knowledge as action in the framework of the cyclic model which we used to characterize human behavior in its several hierarchies: individual, collective, cultural, and trans-cultural. Indeed, we have to understand which role knowledge plays in allowing human behavior to include thought as well as action, which is impacted upon by reality and which brings about an action which modifies reality. We insist that action is inherent to human beings, in particular to children. There are no still or inactive moments, if we understand action in its most general sense, be it a material action or a purely reflective, intellectual, cognitive action. As long as there is life, there is action. We will return to this later.

Let us look into the effects of human action. Reality is in permanent change. Again, we talk of reality in a very broad and general way, as both material reality and purely cognitive reality, that is, an intellectual, psychic, and emotional reality. We understand action as a modifier of reality in these very broad and general terms.

Now, let us look into human behavior and knowledge in the context of this cyclic model, allowing for an action which will have an impact upon reality. Since we know more, we can have more influence as a modifier of reality. Children feel this as they grow. But in which sense are we using the concept of knowledge? What does it mean "to know", in this broad context of cultural dynamics?

"To know" has a dual sense if we look into the concept in several cultural ambiances. To know has always been understood as to clarify the cosmic and psychic order which are in the root of an idea. At the same time, "to know" is to create, to do something, which is in the root of the idea of art. This duality is well illustrated in the first four chapters of the Book of Genesis, which is an important tool in understanding the evolution of western thought to what may be its most strikingly characteristic endeavours, western science and western art or technic, and its brain-child which is technology.

The desire for cosmic and psychic order and the need to create lead to science, which is a pure act of knowing, and to art and technic, which are acts of doing. Science does not materialize, in the same way as art never becomes art if it is not conveyed. This complementarity of science and art, which finds in technology its most influencial results, as far as the modern world is concerned, is indeed the complementarity of knowing and doing. If one knows, one does, and to do, you must know. This is a high level of consciousness of the individual, as "Homo sapiens". Regretably, many of the attempts to make children behave in a certain way have, in recent decades, disregarded this. This has had a dameging effect in particular in science education and even more specifically in mathematics education. Unfortunately, it is still going on. Although very worried about the course which society is taking, our main concern as educators is the individual, and this individual is a complex of reactions, which are sensual, rational, and emotional, or psychic. Even children are this complex, although it is sometimes forgotten among educators, and children are immersed in a reality. But which reality?

We consider reality as both environmental, which comprises the natural and artificial, and as pure intellectual, emotional, psychic, and cognitive, which is the very intimate, abstract reality of ideas.

Thoughts and emotions are parts of reality which influence any individual in a very intimate way. Individuals are not alone; they are part of a society. Reality is also social. The interplay of the environmental, of the abstract, and of the social is a key issue in science education, yet again, unfortunately, it is often disregarded. The interplay of natural and artificial in building up environmental reality is probably one of the most critical areas in which science education plays a major role. The equilibrium between the natural and the artificial has much to do with the future of mankind, hence with education, hence with science education. Environmental equilibrium deserves to be a special concern of science educators and it fits perfectly well into the cycle reality - individual - action - reality.

Let us return to the concept of knowledge as action which involves the perception of reality, through the senses and through memory, which involves performing actions through strategies and models, and which causes a modification of reality, through the introduction into reality of objects, of things, or ideas. These are the results of the action of individuals, which have an impact upon reality. They are incorporated into the reality into which every individual is immersed through the mechanisms of the senses, and memory. From this, the individual designs strategies and models for action.

This comprises, in a global way, what has become known as art, technic, and science as modifiers of reality, and the mechanisms of information and codification. Although art, technic, and science have been the traditional domain or content of education, we want to concentrate a little more on information and codification, which indeed converge to give the possibility of action to knowledge. Information in this sense is, to me, the crux of what is going on in education, bringing to the individual both genetic and acquired memory through the mechanisms of the senses, and through the information mechanisms which are the essence of what we call memory. Let us relate information and education to what seems to be particularly appropriate in the era in which we are living where information through the concept of informatics has become a key issue. We will talk of both formal and non-formal education, which is taking place in both school and out-of-school environments.

Let us recall that information has gone, in the course of history, through an evolution from the spoken language to the written language, and to the more technological models of disseminating information through printed material, and through electronics, which indeed is a joint process of information and processing the information. (See Fig. 2.) Formal education is still dominated by written material and printed material, while non-formal education has a domineering role in helping individuals to speak in the modern world, mainly through the media, in generating skills in absorbing processed information. This is particularly important in science education, and it seems to be urgent that we bring our formal education to recognize the increasing pressure of our society for information processing devices, technology, and skills. This is probably the greatest challenge science educators still face in both developed and developing countries.

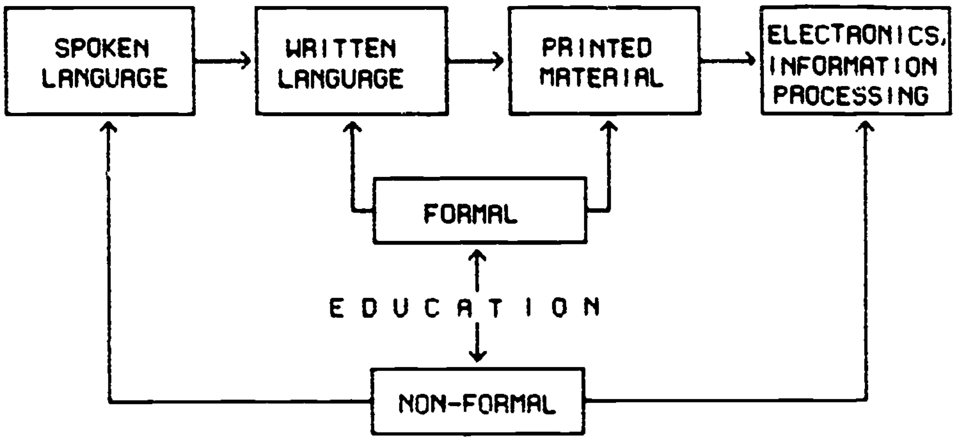

Fig.2. The (r)evolution of systems of transmission of information.

A full understanding of the evolution of the mechanisms of information systems both in the history of mankind and in the evolution of children, seems to be decisive if we want to look into the relationship between education and curriculum. Education has its key strategy in the curriculum. We adopt a concept of curriculum which brings into consideration the classical objectives, contents, and methods, but in an integrated way. It is impossible to consider each one separately and probably the main reason for the many failures identified in the so-called "modern math" movements has its roots in the breaking up of curriculum components into independent domains of research. Curriculum, as it has been agreed without dissent, should reflect what is going on in society. Curriculum dynamics always ask "where" and "when" does a certain curriculum take place, and the key problem in curricular dymanics is to relate the societal moment, time, and locality, to the curriculum, in the form of objectives, contents, and methods in an integrated view.

But the societal moment is more than simply time and locality, or where and when I bring to the picture an extra dimension, of a much more complex nature, that is cultural diversity. Same place, same instant, different cultural background makes the situation entirely different. If you have a classroom in a certain moment, a child coming from a family of working parents, or a child coming from a family of a professional father and a non-working mother, things are different. This difference is even greater when you have different ethnic background, which happens so often in both developed and developing countries. The big challenge in education in rapidly changing societies is how to bring this cultural diversity into curriculum design. This is particularly true when we look into science as a subject for all in rapidly changing societies. The key issue in curriuclum design for the years to come will be meeting this challenge.

Cultural diversity is very complex; it is like a mesh of attitudes and behaviors which has not been sufficiently understood in education, especially in science education, where these factors have practically never been recognized as important. Attitudes such as modes of thought, jargon, codes, interest, motivation, myths, build up to generating very definitive cultural roots, modes of production, modes of property, class conflicts, sense of social security, human rights, and so on. These are factors which comprise society, but are usually ignored in science education.

We are now faced with a concept of society which grows from individual behavior, and which has been the key issue in our recent concerns about science education, the relationship between science and society. But we look further at these considerations. Our considerations above depend on a concept of society out of cultural attitudes and cultural diversity; that is, different groups of individuals, who behave in a similar way because of their modes of thought, jargon, codes, interests, motivation, myths are grouped into a cultural frame. They constitute what we call societal groups, with clearly defined roots, modes of production and property, class structure and conflicts, and senses of security and of individual rights. All these constitute societal background for children. Several studies have been conducted on the social behavior of children which allows for identifying what we might call "children's societal arrangements."

We are also concerned in science education with this level of society which is the ground on which we work, as well as with societies in a general sense. These vertically hierarchized societal levels have, as a result of the interaction of their individuals, developed practices, knowledge, and in particular jargons. Jargon is the way they speak, the codes which clearly encompass the way they face nature, that is, the way they count, measure, relate and classify, infer, and explain phenomena. This is different from the way all these things are done by other cultural groups. Hence, we have the question, in dealing with the realtionship between science and society: Which science ? Are we interested in the relationship between learned science and society, or between ethnoscience and society, where "ethno" comes into the picture as the modern and very global concept of ethnicity both as racial and/or cultural, which implies language, hence codes, symbols, values, attitudes, etc., and which naturally imply science and mathematics practices?

We have to look more carefully into this concept of ethnoscience in this context, and the practices associated with it. These are practices identified with cultural groups, and which are taught, perfected, and reflected upon in a non-formal education system. These practices are not designed "ad hoc". They are the result of accumulation of knowledge and experiences of many generations. It is indeed a form of science. We could easily multiply this set of examples with situations drawn from developed societies and from industrial and commerical environments.

Let us recall that we call "learned science" the body of knowledge which is taught in our schools. Let us look into the ways learned science feeds itself with new knowledge, mainly in the course of science curricula in schools. It is indeed a closed body of knowledge, feeding itself with ideas taken from this same body of knowledge, while society has little or no influence in the evolution or building-up of scientific knowledge. Innovation, which is a key element in education, in particular in science education, practically ignores the results of the evaluation of scientific practices vis-a-vis of societal impact. In other terms, in talking of learned science, an evaluation of the impact of what is learned upon societal activities has practically no effect on innovation, or if there is an effect, there is an enormous time lag in this interaction. Of course, keeping alive the interest of children in new ideas, new concepts, innovation in general, is a very difficult step, making the results far from satisfactory. The enormous time-lag works against motivation. On the other hand, ethnoscience has an almost non-existent barrier with respect to society. This is like a porous system with permanent interaction. (See Fig. 3.)

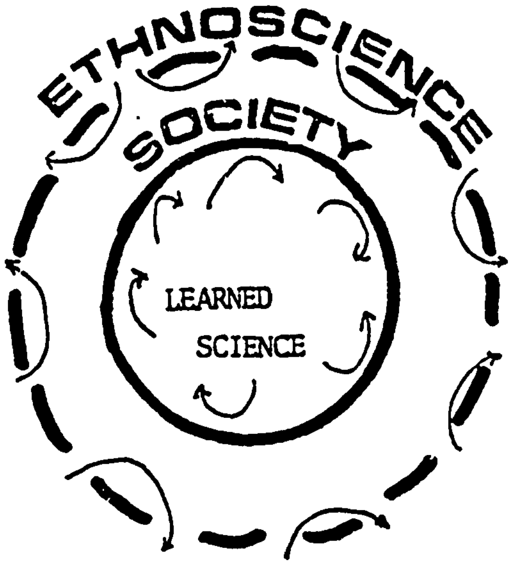

Fig. 3. The interaction between society and learned science and ethnoscience.

Evaluation of what is the result of an ethnoscience practice results from immediately changing it into societal practices, which in turn, feeds the body of knowledge, in this case ethnoscience, with innovation. The relationship between ethnoscience and society is characterized by a fast reaction, through a self-regulating system. This self-regulating system manifests itself in the building-up of motivation, an essential component in education. Indeed, this self-regulating system activates the basic cycle: reality - individual - action - reality upon which we have based our remarks on science education and a more dynamic relation of it with fast changing societies. It seems to me that to generate this dynamic is the key issue in science education in the years to come.

A bibliography on ethnoscience is beginning to build-up. The concept was first mentioned explicitly by this author in 1977, with a definition: "ethnoscience denotes the study of scientific and, by extension, technological phenomena in direct relation to their social, economic, and cultural background" (D'Ambrosio,1977, p. 267). More recently, a close connection between ethnomathematics and cognition in mathematics has been analysed (D'Ambrosio, 1984, a, b, c). A book by David F. Lancy (1983) seems to be one of the first systematic accounts on research on cross-cultural cognition in the field of mathematics. The research conducted by Jean Lave (1982) on cross-cultural cognition is also important. A recent book by R. Pinxten, I. van Dooren and F. Harvey (1983) explores the Natural Philosophy and Semantics of the Navajo. Far from covering what might be labelled as ethoscience, these references are only an indication of possible areas of research in this field.

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CHAPTER 4 PROGRAM DEVELOPMENT

Groups in nearly every nation are at work formulating science programs appropriate for today's youth. A broad range of concerns motivates various groups which are at work. In the six papers comprising this chapter, we see that range expressed. The chapter begins with a broad scale developmental effort described by Gutiérrez-Vásquez and Avilés in which the science education needs of youth and adults in Mexico are being addressed in a new program which is being formulated by teams of teachers and scholars. A different approach to program development, in Panama, is described in De Molina's paper. López then describes a biology program which emphasizes an ecological perspective for secondary students in Mexico. Rada and Calderín describe, a broad scale national effort for program development in Venezuela, while Pottenger describes a multi-national effort at program development among nations circling the Pacific. The chapter closes with a paper in which Ucbebor examines the relationship between science programs, program development, and educational policies of selected Caribbean nations.

These six papers describe and examine a variety of goals and strategies in program development. They also are governed by differing outlooks regarding the nature of science instruction, the character of students who will learn it, the teachers who will teach it, and the societal milieu in which it will occur. Each of the six papers addresses these factors in different ways, some explicitly, some implicitly. Readers should be alert to the ways in which each author, and each program, views the nature of science, students, teachers, and the societal milieu as a framework for making comparisons among the projects.

MICHOACAN CENTER FOR SCIENCE AND TECHNOLOGY EDUCATION

Professor J.M. Gutiérrez-Vázquez
María Victoria Avilés
Michoacan Center for Science and Technology Education
Pátzcuaro, Michoacán, MEXICO

Editorial Note: This project is based on the premise that educational programs generated by a central power (federal or state governments) lack the finer qualitative aspects which can be provided by members of the education profession. Working with scientists and technologists of high standing, educators hope to improve the teaching of science and technology at all levels in order to minimize factors which negatively affect the quality of life in Michoacan. Establishing a link between scientific/technological education and improved quality of life is of "paramount importance" in this project, and for this reason the program is to be approached in an interdisciplinary fashion utilizing teachers, scientists, and members of the community as program development team members.

The main objectives of this project are "to develop strategies, materials, and human resources to improve science and technology education" and once field work is completed and analyzed, a series of educational development projects will begin. These will include: workshops for improvement of teaching, periodic publications for children and teachers, development of educationl materials, and preparation of human resources on teaching strategies.

* *

The Problem

In Mexico, as in many other countries, science and technology education has not attained the desired effectiveness at any level of the educational system. This has a direct impact on the quality and the quantity of scientific and technological activity in the country. The fact must not be overlooked, however, that this state of affairs is part of a wider problem which has economic, social, and political characteristics; furthermore, numerous cultural factors influence both the educational process and scientific and technological activity itself.

Proposal and General Objective

This project will create a pilot, experimental center dedicated to systematically improving the teaching of science and technology in all educational levels in the state of Michoacan, one of the 30 states which make up the Republic of Mexico. After experimentation, evaluation, and adjustment, the model then can be disseminated to other states in Mexico.

Basic Principles of the Project

Although the project does not ignore the importance of initiatives and program generated by a central power (federal or state governments) in the solution of quantitative, gross qualitative, or structural problems of the educational system, it postulates that these central measures must necessarily be complemented by peripheral actions generated in the school itself. These peripheral initiatives modify the finer qualitative aspects and influence teacher-student and student-student interactions, the use of educational meterials, the implementation of innovations, the ambiance created in the classroom, and the generation of educational policies within the school itself.

The project also considers that if scientific and technological activities are to be improved both quantitatively and qualitatively, then the teaching of science and technology has to progress in all educational levels and not only in higher and post-graduate education. The founding of a few research institutions of a higher academic level is necessary but obviously an insufficient measure. In order to accomplish the above mentioned progress in all educational levels, the project considers indispensable the participation of scientists and technologists of high standing in the academic development of educational institutions at lower levels including primary and secondary schools.

Scientific and technological illiteracy, demonstrated in many sectors of the population, is playing an important role in the misuse of natural resources, in environmental deterioration, in malnutrution, in the high incidence of communicable diseases and accidents, and in non-planned population growth. Because of this, the project considers it to be of paramount importance to establish a link between science and technology education in school and the problems affecting the quality of life, the problems of every day life, and the culture and way of life of the community. On the same lines, the project plans not to confine science and technology education to schools, colleges, and universities, but to extend it through a diversity of non-formal education activities to the adult population, including illiterates.

Educational development projects based only on the improvement of educational contents and teaching methodology have shown limited success. The project insists on the idea that a true educational development program should be approached in an interdisciplinary way by a team in which, teachers, experimental scientists and technologists, social scientists, and members of the community actively participate.

The project is based in creative conceptions both of science and technology. The former not only consists of an established set of knowledge, but also of the methods and procedures to generate, validate, and use new knowledge. The latter is not reduced to the utilization of established technologies or to the use and maintenance of tools, machines or equipment; it will consist of the creative utilization of knowledge and the resources available for the practical solution of specific problems identified by human needs. To educate on these bases, it is indispensable to find the educational process in the study of reality, in the idea that theory emerges from the study of reality to become a powerful tool to go back and study reality again.

The project will try to eliminate, or at least moderate, the extreme asymmetry so pervasive in educational interactions. Such asymmetry is always trying to divide us into those who teach and those who learn, those who talk and those who listen, those who are to "improve" the rest and those who have to be "improved." Asymmetry conceals the possibility for the teachers to learn from their students and for the students to participate in the design of the educational process. The project also respects the recovery of the knowledge of "common" people and the procedures they followed to acquire and validate it. In the same context, everyone involved in the project will find opportunities to participate in the design, organization, implementation, and evaluation of their own tasks and the materials used.

A Suitable Location for the Project

To be consistent and to fulfill the criteria of the above mentioned basic principles, the project will be based at the beginning in a very small village (Tzurumútaro, population 1,000) and it will involve the nearest important urban center (Pátzcuaro, population 45,000).

Development of the Project

In the same manner, by "direct contact," always by invitation, the project will develop to gain influence in all the state of Michoacán, after a working period of three to four years. At the beginning, efforts will be directed to preschool and elementary education, to include later non-formal education, middle education, and finally, higher education, also after a working period of three to four years.

Particular Objectives

The main particular objectives of the project are to develop strategies, materials, and human resources to improve science and technology education.

The strategies will include those developed to teach specific topics in the classroom, in the laboratory, in the workshop, and in the field; strategies for the teaching of a whole course and for curriculum development; stategies for policy generation within the school; stategies for the improvement of education in a federal entity; strategies for the implementation of innovations; strategies for the professional development of teachers; and stategies for non-formal science and technology education.

Materials will include all types of educational aids, printed materials, audiovisual aids, laboratory equipment and apparatus, and others, to be used both in schools by students and in workshops by teachers.

The development of human resources will include work with in-service teachers and with students both in school and outside of school. Human resources will be developed to open branches of the project in different municipalities of the state of Michoacán as well as to develop similar projects in other states of the country.

Structure and Academic Activities of the Center

The Center itself, when fully developed, will consist of five units (four devoted to science; preschool and elementary, secondary, non-formal, upper middle and university; and one to technology). Each unit will develop seven lines of action as follows: (a) recording and evaluation of activities, (b) diagnostic studies, (c) teachers' centers, (d) science or technology clubs for youth, (e) experimentation in schools, (f) inservice workshops for teachers, and (g) research and development projects. The staff of each unit will include two experimental scientists (or technologists), one social scientist. and four or five teachers.

Supporting Services

When fully developed, the Center will have an administration office, a resource center and library, carpentry shop, electromechanical shop, editorial shop, audiovisual shop, vegetable garden, and animal farm.

Financing

Economic recession is adversely affecting virtually all activities in every country. In Mexico, funding of educational projects has been curtailed due to lack of funds caused by a severe national economic crisis. In these conditions, how can we bring into existence a new educational project, a new Center? First, we must convice top government officials that investing in educational innovations may be essential to bring the country out of its current crisis because present educational programs may contribute further to the crisis. Second, we must use the resources already available. The Center for Advanced Studies is sending me, my research assistant, and my secretary as well as some basic books and journals from our library; universities and technological institutes are sending one or two scientists or technologists each; the peasants of Tzurumútaro are lending an old abandoned school and their social center; CREFAL in Pázcuarao offers its editorial facilities and carpentry shop; the government of Michoacán is providing the teachers; the Ministry of Education and the National Council for Science and Technology are considering some basic funds. Third, there are things that now are really expensive for us such as imported books, laboratory supplies, and audiovisuall equipment. The project has not enough money for this, so we are asking some foreign foundations not for money so we may acquire these items. The British Council, for example, has already donated some 120 books for our Resource Center and Library.

Introduction

The Michoacan Center for Science and Technology Education started its activities in June, 1983. The first phase was supported by the government of Michoacan, the Ministry of Education, the National Council for Science and Technolgy, the Center for Advanced Studies of National Politecnique Institute, the National Council for Biological Teaching, the Educative Promotion Fund of C.H. Bank, and the community of Tzurumútaro.

The Location of the Project

The Center is located in the old Primary School building in the central part of the village of Tzurumútaro. The building is made of adobe walls and a roof of red tiles. It has wide corridors around a big garden.

The building has been unused since 1981. When the Michoacan Center started in 1983, the school was rebuilt by us, trying to keep the original architecture. We began to repair it gradually; the task hasn't finished yet. By now we have three big rooms for offices and one as a science lab; wide corridors and a very nice garden.

The Staff

After several meetings, interviews, and curricula review, the team of work was structured. Seventeen staff members began the project and five more were added in September of the current year, that includes three pre-school teachers, seven primary school teachers, two secondary teachers, four researchers in Science Education, one photographer, one artist two secretaries, one janitor, and one guard. The Ministry of Public Education, through their different departments, has supplied 15 of the staff members working on the project.

The Center's activities have improved the development of a team capable of involvement in projects of educational research and development. The strategies for the group development have included periodic workshops for training in techniques of educational research and development.

Diagnostic Study of the Science and Technology Teaching

In the first year of the work, the Center made a diagnostic study of the Science and Technology Teaching in pre-schools and primary schools in the state of Michoacan, because diagnostic data would permit us to develop actions based on actual needs.

The sample included different biogeographical and socioeconmic facts: schools from the sea level to 3,500 m. of altitude; from schools with freezing temperatures in winter to schools with temperatures of 26 degrees C; from very dry places to places with heavy rainfall; from over-crowded industrial towns to small villages with little communication and subsistence agriculture as the only economic activity.

Finally, the sample included 38 primary schools and 13 pre-schools. The goal of this study was diagnostic research on the education system inside the schools, made through individual interviews with prinicipals and teachers; collective interviews with children from first to sixth grade in primary school and pre-school children; observation of Natural Science and Technology classes; and analysis of contents from notebooks of children.

Fieldwork

The fieldwork was started on September 19, 1983 and was finished on April 13 of 1984. It was made by four teams of two people each: a primary school or a preschool teacher, and a "specialist" of the Center.

Science Club

A Science Club was started on May, 1984, at the Center. Approximately 50 children of the Tzurumâtaro community attend daily. At the Club, they conduct experiments proposed by them or suggested by pictures and participate in field trips organized by the Club.

What Do We Expect to Get?

Once the fieldwork has been finished the information is going to be analyzed and a technical report will be ready at the beginning of 1985. A series of projects on educational development will be started to support the work of teachers and students.

These actions are:

Workshops for improvement of teaching.

Periodic publications for children and teachers.

Development of educational materials.

Preparation of human resources on teaching strategies.

A DIDACTIC STRATEGY FOR THE TEACHING OF NATURAL SCIENCES IN PRIMARY SCHOOL

Elizabeth de Molina
University of Panama
Panama City, Panama

Editorial Note: In a school called ICAP in Panama, we have designed and implemented a project called "A Didactic Study for the Teaching of Natural Science in Primary School". This is a dynamic, didactic strategy whose main purpose is to help the student acquire the skills and abilities necessary to do scientific investigation, and to develop in the student an integral vision of the world through the proper structuring of scientific content.

The Problem

As in many Latin American countries, Panama has a large number of students who are not achieving successfully in subjects such as Spanish, Mathematics, and Natural Science. It is also clear that what is being taught in these courses requires only low level learning. Since so much emphasis, in Natural Science at least, is given to the content, there are obviously some very fundamental weak points in the actual learning by the student of the skills and abilities needed for scientific investigation.

There are a number of reasons for this situation; some are internal and others are external to the educational system. There are a number of roots for this situation if one looks at the situation from the viewpoint of the curriculum planner, the administrator, and others. Limited supervisory work is done; many teachers have a poor background and little preparation, especially in the specialized fields; despite revisions, there are outdated programs that still reflect problems such as a predominance of cognitive versus affective objectives, an overemphasis on the scientific product, and little attention is given to processes of scientific investigation.

Students were given a pre-test of their scientific skills at the beginning of the school year at ICASE (Instituto Centroamericano de Administracion y Supervision de la Educación) in Panama. The results of this test are alarming. Student performances indicated extremely low levels of scientific achievement.

The teaching situation can best be characterized by a large amount of talking by the teacher to passive students. The curriculum is presented by the teacher as it is given in the text without consideration of the students or the community in which they live. Testing emphasizes memory and repetition of facts, deeds, and parts of concepts, with little or no regard for the actual skills needed for scientific investigation.

This situation is an important challenge facing Panama's educational system. Where will the leaders of tomorrow come from to help us solve the urgent problems we now face? ICASE has designed an innovative, didactic strategy to help insure the creation of such leaders.

A Didactic Strategy for the Teaching of Natural Science

We have designed and are now implementing a program called "A Didactic Strategy for the Teaching of Natural Science in Primary School". It is a strategy that attempts to offer students the opportunity to acquire the skills and abilities needed to do scientific investigation and to help students acquire an integral vision of the world through the proper structuring of scientific content.

Because this project is just beginning, we are well aware of its defects. At the same time, we are aware of the many limitations of our given circumstances, of the realities of our situation, the characteristics of our Panamanian students, the conditions of our schools, the lack of resources available, as well as our inadequate physical infrastructure.

The didactic process consists of getting greater student participation through the use of a number of diversified bibliographies, group work, independent study, opportunities to put the scientific process into practice, and the use of the discovery method of teaching by the use of questioning, dialogues, etc.

The didactic strategy was used in a research project that involved three area schools during this past year. There were two experimental schools and one control school. In each of the experimental schools there were 4 groups of 5th grade students for a total of 185 students and 10 teachers.

Our goal is to organize this strategy with the express purpose of being able to increase the use of the project by offering it to the entire educational system. We had to take into account our national reality, the reality of the communities where the schools are located, the national school programs and all their limitations, the fundamentals of curriculum theory, and a modern teaching/learning theory as developed by Piaget.

Objectives

The project had the following objectives: (a) to develop the necessary scientific skills and abilities a student would need to become a self-taught learner; (b) to awaken in the student a conscious awareness of how science is one of the basic needs of man, both as an individual and as a member of society; (c) to foster in the student the progressive formation of scientific concepts as a basis for a more rational and integral understanding of the world situation.

Parallel to these objectives, although it is not a fundamental goal of this project, is that the strategy of the project should bring about a change in attitude on the part of teachers; since no innovation can work unless there is a change in teachers' attitude and focus. If teachers participated fully in this work, it is probable that they would become aware of the problem and their role in the bringing about of a solution.

Curriculum Organization

The emphasis of the strategy is on the methodology and in the administration of the curriculum. If one has a conception of an integrated curriculum, there is an obvious need to look at all facets of the curriculum before implementing it. In this way the organization of the strategy can be developed in three separate steps.

First, one must have a plan, for that it is necessary to make a diagnostic study of the community, school, and its students as well as the national program. This material is then analyzed and the curriculum elements are selected and organized into units for each of the two semesters. Second, this process can be accomplished in a workshop-seminar before the beginning of the school year. Under the guidance of a specialist, teachers should actively participate in the development of the units. Third, during the year, teachers will use and test this plan with weekly or monthly follow-up meetings to refine it.

Once the plan is finished, components can be developed such as study guides for experiments, group work, tests and other evaluation instruments that will measure achievement of content objectives, abilities, and science skills.

The teachers' role is that of facilitator and guide. Teachers introduce themes, synthesize, and offer different points of view. The students' role is an active one. They observe, measure, classify, etc. They are the principal participants in their own learning. Group work will become important as will independent library research. Question and discussion periods will be used to insure self discovery.

The advisor will make a number of visits to the classes and to labs during the year where he can offer feedback and suggestions to teachers. Thus, there is a permanent process of evaluation. This evaluation is not just comments about the product, but the process and elements of the curriculum are examined. In other words the entire process is seen and treated as a whole. The teacher also receives acceptance and participates in the development of scientific evaluation instruments. At the end of the process there are more meetings for evaluation and feedback.

DEVELOPING EFFECTIVE SCIENCE PROGRAMS ON ECOLOGY

Luz María López de La Rosa
Universidad Autónoma de Mexico
Mexico City, Mexico

Editorial Note: Ecology is one of the most important topics for science classes in Latin America. The reasons seem obvious. For one thing, there is an immense variety of rich natural resources: tropical rain forest, vast grasslands, snow topped mountain peaks, Atlantic and the Pacific coasts. Another reason is that the curriculum should be designed to give future citizens a rational attitude toward the control and conservation of their natural resources. The goal of this paper is to define the criteria needed to introduce ecological problems at the secondary level.

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This paper describes a process for creating a unit to introduce an ecological problem to a beginning group of secondary science students. The particular problem being studied has to do with the regeneration of a forest.

The science program is best developed by a congenial team of teachers. They need to develop lesson plans that will incorporate an ecological theme. This will help focus on the need for continuity, sequence, and integration of the subject matter. The group should be aware of common goals as they work in an environment of mutual concern. Roles should be well defined ahead of time, and the working situation should be one of mutual respect and empathy.

Before constructing any hypothesis, the group should be sure the problem is based on a question directly observable in nature as well as well founded in theory. An hypothesis needs to be structured after going through a stringent questioning period. A good illustration of this process can be found in Vazquez-Yanez and Smith's (1982) work in physiological ecology. Using an ecological point of view, they tried to determine the role of light in the germination of plant seeds in the Tuxtlas Forest of Veracruz (Mexico).

They used two plants (Cecropia and Piper) from the rain forest. These plants grow abundantly in the forest clearings; they form around the mature trees where they act as a kind of healing vegetation as Schnell (1981) calls it. The hypothesis posed by Vazquez-Yanez and Smith was: How do different wave lengths of light affect the germination of the Cecropia and Piper seeds? Their hypothesis was based on previous research and used sound scientific principles.

(1) So long as the floor of the forest remains unchanged, the Cecropia and Piper seeds remain ready to germinate depending on the relationship between the red and infrared wave lengths. The strength of the light is directly related to the germination of the seeds.

(2) The phytochrome, a pigment within the seeds, plays a role in the germination process as well. It detects the composition of the light spectrum forcing the seeds to germinate when they grow in the clearing.

Thus the working hypothesis is developed from a previously stated provisional explanation of the problem which includes what was learned from the experiment. The hypothesis includes some consequences that are predictable, given certain factors in the study. In this case, the working hypothesis is: If the red and infrared sunlight influences the germination of the Piper and the Cecropia seeds, then there will be a greater number of seeds to germinate if they are placed in the center of the clearing.

The experimental proof and the testing of the hypothesis are done in the following way. First, the researchers picked a recently formed clearing in the Tuxtlas forest. They had to verify that the light came from the east in the morning. The clearing measured 4 meters and was located near the roots of a fallen tree.

The researchers put the Piper and Cecropia seeds in different petri dishes and then in plastic bags to prevent their flooding during the rains. Each experimental group had 3 boxes of seeds. Group #1 put their seeds, in the center of the clearing; Group #2 put their seeds on the perifery, and Group #3 put theirs in a shady, undisturbed area surrounded by trees 25 meters tall.

The germination count for each group was taken 15 and then 30 days after the planting. The researchers found that: 85% of the seeds in the clearing germinated within 10 days; 60% of the seeds on the periphery germinated within 14 days, and the seeds in the shaded, undisturbed area did not germinate at all.

The researchers, using good experimental principles, reached the following conclusion: Seeds placed in the clearing, where there was a change in the red and infrared light intensity, germinated rapidly, and those on the perifery germinated slowly. They could call this a controlled situation because the seeds in the clearing germinated in a situation where the light changes were determinable. This situation worked well because the seedlings were able to germinate at a time and place where a number of other plants were growing together. The seeds in the shaded area represent control where a working hypothesis was formed and tested against the experimental condition. The researchers used more than one kind of seedlings, and these were important, ecologically speaking, to the area.

By using this unit, students get a better understanding of how scientists work and gain some knowledge of ecological principles.

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ACTIVITIES OF CENAMEC: THE IMPROVEMENT OF SCIENCE TEACHING IN VENEZUELA

Saulo Rada
Tania Calderin de Guedez
Cenamec Caracas, Venezuela

Editorial Note: On August 6, 1973, Presidential Decree No. 1365 created the National Center for the Improvement of Science Teaching (CENAMEC) of Venezuela. It's goals, objectives, and activities are within a general framework of research, experimentation, and innovation in the field of education. This paper gives a brief background on CENAMEC's beginning days, and a quick sketch of its achievements up to now as well as its plans for the near future. CENAMEC's experiences illustrate how joint action by educators and scientists can result in the improvement of the teaching of science.

* *

In many less developed countries, there has been little coordination among the organizations that shape the scientific and technological system; their actions have been divorced from local needs and resources, and greatly subjected to foreign dependence. A significant contribution towards the improvement of this condition in Venezuela was the creation, in 1967 of the National Council for Scientific and Technological Research (CONICIT), an organization that initiated the establishment of interinstitutional consulting bodies. Since scientific and technological development needs highly qualified human resources, and this must be developed at the lower levels of the educational system, CONICIT approached the Ministry of Education in 1970 with the goal of instituting a National Center for the Improvement of Science Education (CENAMEC).

On April 21, 1971, CONICIT appointed a committee of educators and scientists from the Ministry of Education and two UNESCO specialists. The members of the committee were: Dr. Olinto Camacho, Chairman, Ruth Lerner de Almea, Carmelina Reggio, Tania Calderin de Guedez, Gisela de Martin, Yolanda de Badillo, Laura Castillo de Gurfinkel, Betty Hachim, Carlos Guevara, Dr. Roberto Callarotti, Dr. Luis Cortes and from UNESCO, Dr. Naum Joel, and Dr. Oscar Dodera. They started the country's first diagnostic assessment of science teaching which was to be used as the foundation of the project. The group also prepared an operational, technical, and management plan.

The proposal prepared by the committee was carefully screened by the Board of CONICIT, initially chaired by Dr. Marcel Roche and later by Dr. Miguel Layrisse, by its own National Council and by authorities from the Ministry of Education. It was finally submitted to the President of Venezuela, Dr. Rafael Caldera, who signed the Decree establishing CENAMEC.

In October of 1974, Dr. Federico Pannier was appointed Director, and Professor Estrella Benaim Giral was appointed Deputy Director of CENAMEC. Several months later Dr. Pannier took charge of directing another program, the DIDACTRON, and Professor Benaim took over the leadership of the institution until the end of 1982, with Professor Saulo Rada acting as assistant director. Since the beginning of 1983, Professor Rada and Professor Tania Calderin de Guedez have been, respectively, Director and Assistant Director of the Center.

Two articles from the Presidential Decree illustrate very clearly the rationale upon which the institution was organized:

A 'National Center for the Improvement of Science Teaching' is created with the objectives of providing continuous and systematic attention in an organic fashion to the improvement and updating of the teaching-learning process in science."

"The Center will operate and conduct activities at all educational levels with the objective of attaining the improvement of teaching methods and media, and the training and improvement of teachers, to stimulate teachers and students alike to develop creative, inquiring and active minds."

From the beginning, the fundamental strategy of CENAMEC was to promote and attain the joint effort of scientists and educators, and to involve in its activities all sectors related in any way to this endeavor; the Executive Board, the Consultant Council to the Ministry of Education, CONICIT, the Venezuelan Association for the Advancement of Science (ASOVAC), the Venezuelan Institute for Scientific Research (IVIC), the National Board of Universities, the Chamber of Industry, the Academy of Physical and Natural Sciences and Mathematics, and the Military Academies.

To fulfull the functions stated in the creating Decree, the Executive Board agreed on the following policies:

1. CENAMEC is an institution which, with the goal of improving science teaching, will conduct research, create experiments, and do evaluation in the area of science teaching.

2. To ensure the availability of a qualified scientific human infrastructure CENAMEC will work towards the training and improvement of science education.

3. To facilitate experimentation and the generalization of the experimental results, CENAMEC will become an institution that will introduce innovation and promote changes in attitudes toward science.

4. CENAMEC, based on its activities in research, experimentation, and evaluation, will guide the decision making process related to national science education policies.

5. As a product of research, and within the scope of its experimentation and evaluation, CENAMEC will produce prototype materials for science teaching.

6. CENAMEC will stimulate and promote scientific vocations through systems of formal and non-formal education.

7. CENAMEC is an institution that engages in the spread of scientific knowledge through education of the general population and particularly of those who receive a formal education. Its objective is to disseminate those experimental methods which improve teaching to change attitudes towards science.

ACHIEVEMENTS

The achievements of CENAMEC during its ten years of existence comprise of short, medium, and long range activities, with the goal of improving the quality of education in the areas of Mathematics, Physics, Biology, Chemistry, and Earth Science. Some of the main achievements of the institution are listed here.

1. Twenty works of research have been, or are presently being conducted, including diagnosis, evaluation research, and field experiments related to science teaching. One highlight among them is the project for the improvement of Mathematics Teaching for the Common Basic Cycle of Middle Education (presently seventh, eighth and ninth grade of Basic Education), initiated in 1975 with a national diagnosis of conditions of mathematics teaching. It was based on a heuristic methodology of learning with an interdisciplinary, practical, and scientific attitude approach. In 1979, after four years of experimentation with groups of teachers distributed nation wide, and after the verification of the qualitative and quantitative improvement of the teaching of Mathematics at that level, the results were forwarded to the Ministry of Education. The Ministry, after an evaluation of the results, made the decision to extend progressively its application to the whole country with the result that in the 1982 - 1983 school year approximately 3,500 Mathematics teachers are using the new approach.

   It should be emphasized that was the first time for Venezuela that this method of elaborating a program of studies was accomplished. Traditionally, such programs were prepared by Ministerial commissions which, after consulting with some specialists in the field, went ahead and designed their programs without prior experiments.

   Many products of the design and experimentation phases have been applied to the Basic Education Project, which consists of curricular reform in response to requirements of the new Education Law which extends the period of compulsory schooling to nine years. The experiment is presently under way in approximately 1,500 schools throughout the country.

   A project was initiated with the Venezuelan Institute of Scientific Research (IVIC) with the goal of defining the scope of Mathematics and Science teaching for Basic Education in Venezuela. Descriptive documents on the current status of Science and Mathematics were produced as well as documentation related to new teaching trends.

   During the last few years, the Ministry of Education has given CENAMEC the assignment of developing the syllabi in Natural Sciences and Mathematics for Basic Education. Two versions of the new syllabi for Natural Sciences and Mathematics were produced and CENAMEC had an active participation in implementing these programs. Currently a research program is under way to assess the resource needs of Basic Education teachers for teaching in both the cognitive and affective domains. For this purpose a sampling of trial schools was selected in 15 educational areas throughout the country, and at present the analysis of the data obtained through this project is being completed.

CENAMEC is currently in charge of the development of a curriculum project for teaching Science and Mathematics in Middle Education, which is a coherent extension of the work accomplished for Basic Education. The project, which will take five years to be completed, is at present in its initial phases, during which a wealth of information on over 500 books and documents related to the Diversified Cycle has been compiled. Surveys, have been sent to at a national teachers and the schools, on a national level, to find out the potential of laboratories and libraries. The results have been applied and processed after having been validated through a significant sampling of Diversified Cycle schools. There have also been a number of interviews carried out with technicians, high school teachers, and persons connected with the administration of field work for students of the Diversified Cycle.

After four years of design and experimentation, another project, has been selected by the Ministry of Education for gradual implementation at the national level; it is the use of educational technology in the teaching of Earth Science. Classroom teachers participated in designing learning units with the final goal of restructuring the current syllabus. The project intends to be socially relevant through the study of environmental problems at the regional level. The modular units consist of four handbooks: student handbook, reading handbook, teacher handbook, and evaluation handbook. These are discussed in intensive training workshops programmed for all the teachers involved in the tests.

2. CENAMEC, as such, is not a professional improvement institute; it is rather an institution devoted to the experimentation of educational models, which, once tested and evaluated, are recommended to the organizations whose objectives are the implementation at the institutional level. In this sense the labor of CENAMEC is fundamentally one of support and not of competition. The experimentation process of the various projects has allowed, nevertheless, a direct and continuous interaction with teachers from all over the country; to date, 359 courses and workshops have been conducted with the participation of 10,789 teachers from across the nation. CENAMEC has also organized a number of meetings and seminars related to science education with participants from higher education institutions, both national and international.

3. The promotion of activities to increase the awareness and to support the interest of youngsters, educators, and the general public in science and technology is another role of CENAMEC. One of the traditional activities of CENAMEC in this area, is the Venezuelan Mathematics Olympics. This contest is to help Middle School youngsters use their creative, operational skills and

their capabilities to transfer mathematical knowledge to new situations. It also promotes and increases the interest of students, teachers, and the general public in mathematics and its teaching. To date, CENAMEC has organized nine Mathematics Olympics with 193,303 participating students from all over the country. Also, CENAMEC has been represented by participants at two International Mathematics Olympics (Washington, 1981, and Budapest, 1982). In addition, through the Mathematics Olympics a great deal of data has been compiled which makes it possible to evaluate various aspects of the Mathematical learning process in young people as well as their attitudes towards this discipline.

During 1983 and 1984, the first two Chemical Olympics were held in the metropolitan area of Caracas on an experimental basis. Activities in these events, besides the contest, included teacher training, student training, field trips to industries, games and other activities devoted to the improvement of the teaching of Chemistry.

CENAMEC has also contributed to the Juvenile Science Festival, organized by the Venezuelan Association for the Advancement of Science (ASOVAC). The project has been devoted to the training and development of promotion and assistance in adolescent scientific activities. Besides the workshops and camps for teachers and students, CENAMEC has provided individual assistance to more than 500 Middle School students involved in research projects.

Since 1975, CENAMEC has produced the radio program "Life and Science" with the objective of promoting science, its teaching, values and personalities. It is broadcast daily by the Venezuelan National Radio and eight radio stations in the interior of the country. 1,177 original programs have been broadcast to date. They have also been used as a learning resource in Biology and Spanish Language classes within the scope of the project "Science and Communication".

Within the area of Earth Science, we have initiated a project on the interaction of the community and the school in the solution of environmental problems. Its objectives are: (a) to appreciate the importance of community participation in the learning process; (b) to value the need to extend the educational activities into the community; and (c) to contribute to the improvement of earth science teaching. To attain these objectives a series of interinstitutional educational contests are conducted with the goal of reaching solutions to environmental problems with the participation of the whole community.

4. In the numerous workshops and seminars organized by CENAMEC for the improvement of teaching, sixty nine models and prototypes for science teaching have been produced and tested: Production and the use of learning resources for Mathematics and Science for the elementary school; Creative science; The Aquarium as a learning resource; Interdisciplinary Environmental Approach Towards Earth Science Teaching; Middle Education Physic Teachers' Improvement;

Energy Education; The Environment; A Learning Resource for Chemistry; and Learning Units In Chemistry These activities are in compliance with one of the functions assigned in the Decree of creation: "To assist the Ministry of Education in the production of teaching-learning materials, after an adequate testing and evaluation of the prototypes for textbooks, laboratory materials, audiovisual materials, and others". Production has reached 90 programs, with 22 of them addressed to teachers. Some of them with a relevant general scope have been broadcast, the other 68 are addressed to Middle Education populations to eliminate deficiencies in Mathematics, Physics, Chemistry, and Biology teaching and programs.

5. In terms of printed materials, 69 different titles have been published, including: "The Aquarium: A Learning Resource," "A Challenge to Youth;" "Retrospective 1973 -1981," "An Ausubelian Approach to a Physics Curriculum," "The Escape of the Birds," "What happened to Uncle Cachicamo?" "Activities Accomplished," and 30 Bulletins with approximately 180,000 copies. Other mimeographed materials of limited distribution have also been produced.

PROJECTIONS

In this short summary, we have seen how CENAMEC, during its first ten years, has contributed to the improvement of the human resources required for national development. This effort has been carried out through the creation of appropriate environments, both within and outside of schools, with projects oriented toward: the improvement of teacher's performance; the modification of objectives, plans, and syllabi; the improvement of methods and techniques; teaching materials; and all the variables implicit in the teaching-learning process. The multiple activities have made a more mature institution, widely recognized nationally and internationally within the educational community. We think that it is now time to obtain a full diagnosis of science teaching in the country. It is also necessary to emphasize the production of prototypes of textbooks, laboratory materials, and other resources.

All this must be done without forgetting the task of in-service teacher training and public programs that have been successfully carried out by the institution. This should be done with an objective of guiding through research, experimentation and evaluation, the decision making process for national policies in science education. Currently, in conjunction with the Planning Office of the University sector (OPSU) we are developing national diagnosis of the achievement level in Biology, Physics, Chemistry, Earth Science, Mathematics, and Instrumental Utilization of Language for students in the third year of Middle School, which will provide important data not only for the revision of the Basic Education curriculum currently under test, but also help with other studies to establish the foundations for the Science and Mathematics curricula for the Diversified Cycle. To carry out this study, a sample of 30,000 students throughout the country was selected. Two validated diagnostic tests were made. Data are being transcribed at present. It is also our intent to diagnos the human resources available for teaching science in the rural area of Venezuela, so as to have at our disposal the information required for improving professional teaching standards.

Later, we expect to conduct research on the influence of improving professional teaching standards in the teaching-learning process. The results and conclusions of this study will allow us to make recommendations and provide guidelines for the implementation of plans to improve teacher effectiveness.

This year, to cover the first phase of the project, 38 people were trained to do a survey which identifies strategies and instruments practiced by teachers in order to compile a national directory of extracurricular scientific activities. This survey revealed over 800 different activities from around the country, supported by both the government and private sectors.

Finally, our goal is to increase the production of prototype materials for science teaching and, particularly, to initiate the national production of laboratory materials that respond to our needs, interests, and uniqueness. With this purpose in mind, we have under way a project involved in the production of learning resources. Work on the 1984 project involved the elaboration of a taxonomy of learning resources suited to the project's features. Psychological, cognitive, and pedagogical characteristics were determined, and classified in accordance with the parameters of learning science and mathematics at the "Basic Education" level. Criteria and instruments for resource evaluation were established. Diagnosis and inventory of existing resources within the country were begun. This work has made it possible to establish, design, and elaborate requirements on designing learning resources.

PACIFIC CIRCLE OCEAN FISHERIES MATERIALS: AN EXAMPLE OF MULTINATIONAL CURRICULUM DEVELOPMENT

Francis M. Pottenger, III

Curriculum Research and Development Group
University of Hawaii
Honolulu, Hawaii, USA

Cross-national adaptation of curricular materials has a long and successful history, particularly in science. Since World War II, translation, adaptation, and testing of curricular materials developed in a foreign country have been major functions of universities and national educational centers, and adapted materials have greatly upgraded science curriculum worldwide. In the same period, a number of successful efforts have been made at binational development of curricular materials. Many of these materials have been designed for use in social studies courses, where there is concern for cultural, demographic, and historical factuality.

Examples of multinational cooperation in curriculum design and development are rare. Logic would suggest that such development would result in per nation reduction in outlays for personnel and other resources, greater assurance of the accuracy of content describing the national and regional interests of participating agencies, and a sociological value of providing children a common school experience. Therefore, when a multinational curriculum emerges, it is worthwhile to give consideration to why such an effort was undertaken, the structure of the materials, how it was inaugurated, what design features enabled its execution, and the kinds of problems encountered. Discussed here will be multinational work of the Pacific Circle Consortium in the creation of Science-Technology-Society materials for the study of Pacific Ocean fisheries.

The Pacific Circle Consortium was established in 1977 as a program of the Center for Educational Research and Innovation of the Organization for Economic Cooperation and Development. Its charter members were the Curriculum Development Center of Australia, the University of British Columbia of Canada, the National Institute of Educational Research of Japan, the new Zealand Department of Education, and the Curriculum Research and Development Group, the East-West Center, and the Northwest Regional Educational Laboratory of the United States. Since its beginning, five other curriculum agencies have joined the consortium. It is the purpose of the Pacific Circle Consortium to promote international understanding through improvement in teaching about people and nations of the Pacific and the Pacific Ocean itself. This is done through the sharing of ideas, resources, information, and personnel in cooperative development of curriculum and educational support services.

Over the seven years of existence of the Pacific Circle Consortium, the cooperating agencies have created a wide variety of materials, most of which were developed binationally. In 1981, a conference/work session was held in Honolulu to explore the feasibility of creating materials that could be developed by cooperating Pacific Circle Consortium members and then commonly used in their areas of service. This is a truly multinational project. Present were scholars, curriculum specialists, and classroom teachers who would have the responsibility of crafting materials. This effort became known as the Ocean Project. From the outset, the Ocean Project has had two component projects, the primary level study of Bays and Harbours of the Pacific and a secondary level study of Pacific Ocean Fisheries. Coordination of the project was charged to the Curriculum Research and Development Group of the University of Hawaii.

Rationale for Pacific Ocean Fisheries Materials

Both practical and research interests propelled the undertaking of Pacific Ocean Fisheries. At the level of practicality, there was a consensus of the agencies involved that materials are needed that give students an understanding of the importance of commercial fishing to national economies. Further, the study of fisheries could be packed to carry the themes of the interaction of science, technology, and society; management of ecological resources; and the Law of the Sea--all of which would provide a fit within existing environmental and social studies curricular requirements of the constituencies to be served.

Several research questions motivated the formulation of Pacific Ocean Fisheries. First, an underlying tenet of the Pacific Circle Consortium has been that sharing common and divergent perceptions is a necessary step to developing an understanding between peoples and nations. Since much of the stock of perceptions that the young gain in life first comes through formal education, it makes sense to structure the materials of the school to reflect the perceptions of different people authentically. Pacific Ocean Fisheries offers a chance to address the question of whether materials designed intentionally to balance commonality and distinction and identify explanations reflecting the cultural and political views of the nations involved will over time enhance understanding between nations. As important, can such a work pass through the filter of national interests?

Fisheries issues are a growing source of intranational and international conflict. Australia, Canada, New Zealand, and the United States find themselves involved with fishing disputes between indigenous peoples, recreational users, and commercial users. All the nations of the Pacific find conflict between fishing interests and other industrial users of wetlands and the ocean. At the international level, the economies of sophisticated electronic industrial fishing technologies are pitted against those of traditional small-scale canoe and sampan operations. There are widely differing perceptions among users and nations of conservation and appropriate harvesting practices. All this conflict is cast against a backdrop of need for an international ethic concerning finite resources in fragile ecologies that are subject to the uncertainties of global climatic variations.

Second, because of the large amounts of money needed to undertake curriculum development, it has been the hope of Pacific Circle Consortium members that collaborative development would reduce the costs of development projects by sharing resources. Pacific Ocean Fisheries will permit the Pacific Circle Consortium to get some information on relative costs per agency for collaborative development versus costs for a comparably developed local product.

Third, the big unknown from the beginning has been whether materials such as those developed in Pacific Ocean Fisheries could be designed jointly and or developed at all. Probably Pacific Ocean Fisheries most important research contribution will be the taxonomy of problems that were encountered and how these were overcome or otherwise dealt with. It was found that the style and temperament of primarv personalities in the project were important determinants of success, there are many factors that must be accounted for to ensure a satisfactory outcome of a project.

Fourth, and as yet a futuristic question, what will happen to Pacific Ocean Fisheries materials once completed? Will they get into the schools, if so, how and at what cost to their original intent?

Structure of Pacific Ocean Fisheries Materials

Pacific Ocean Fisheries are intended for use in upper secondary social studies or environmental education courses. They are suggested for use from the 10th to 12th years. The materials make up a flexible package constituting 6 to 16 weeks of study designed for the normal range of students found in schools served by the developing agencies.

There are three parts to the materials: a local/national component, a generalizing component, and a computerized simulation game. It is the role of the local component to describe conditions and problems within national and regional areas known to students. The generalizing component then describes the similarities and dissimilarities of conditions and problems of other nations and regions of the Pacific. As a summarizing experience, students are involved in a simulation game, the economics and environmental variables of which have been computerized. The function of the game is to give students an opportunity to grapple with some of the problems identified in the materials, but in a dynamic environment of decision and consequences. Local materials exist for Australia, Japan, New Zealand, and four states of the U.S. -- Alaska, Hawaii, Oregon, and Washington.

Materials are organized into four units. Unit 1 is titled "Fish Systems"; Unit 2, "Fish as a Resource"; Unit 3, "Conflict Over Resource Use", and Unit 4, "Fishery Management."

Unit 1, Fish Systems, begins by providing an ecological study of local marine environments, the kinds of fisheries resources they support, and how environmental conditions tend to enhance or reduce the productivity of those resources. By using the generalizing materials, local conditions are compared with Pan-Pacific conditions. Case studies drawn from various parts of the Pacific illustrate similarities and dissimilarities in the way natural events and human intervention affect fisheries resources.

Systems diagramming, a tool used to map the intricacies of science-technology-society factors bearing on the problems of fisheries, is introduced in Unit 1. Through the use of systems diagrams, it is possible to give complex issues a pictorial as well as a verbal presentation and thereby provide special support for students with a more visual orientation to learning.

Unit 2, Fish As A Resource, addresses the question of how fish and other harvested fisheries organisms are perceived as a nutritional, an economic, a religious-cultural, and an aesthetic-recreational resource by different groups of people throughout the world. Central to the discussion is why and how various people set values on fish and fishing. As one of the valuing mechanisms, the economics of harvesting, processing, and marketing fish is studied in detail. Included is a study of maricultural practices. To contrast and compare local conditions with conditions globally, a rich selection of international case studies is provided in the generalizing materials. Systems diagramming is employed in the analysis of the complexities of economics.

Unit 3, Conflicts Over Resource Use, seeks to identify the kinds of conflicts that arise over fisheries interests, why these conflicts arise, and what is the status of these conflicts today. Covered locally are a wide variety of conflicts ranging from the exclusion of commerical fishing from sacred waters of indigenous peoples to conflicts over resource use in the 200-mile economic zones. A range of international problems is presented in the generalizing materials. Unit 3 lays the groundwork for the last unit where management is presented as a mechanism to regulate potential conflict situation.

Unit 4, Fisheries Management, looks at methods used by indigenous communities, both historically and currently, and by local, national, and international governing bodies in controlling the exploitation of fisheries stocks. Management methods now in use to regulate the interests of multiple users are described, and students are involved in both essay analysis and role-playing exercises to highlight the complications bearing on equitable and wise allocation of coastal wetlands and open ocean space among users. Here, in addition to a variety of case studies, the generalizing component offers a history and study of the proposed Law of the Sea agreement and its implications for Pacific-wide fisheries management.

A Simulation Game is used as a culminating activity. The computerized game has been constructed to summarize the ecological, economic, conflict, and management dimensions of the program. Students play the role of governmental officials within countries that possess differing resources, populations, nutritional needs, levels of technology, and environments. A scenario of interaction is presented to which student groups respond by making decisions concerning volume of fishing and enactment of laws governing trade, environmental protection, and pricing. In debriefing, players further review the content of the four units.

Organization for Development

It has taken four years to develop the Pacific Ocean Fisheries materials to a point where they can be tested as a complete package by developing agencies. The work rhythm of both the Ocean Project was synchronized to the work rhythms of contributing agencies and thus had to reflect the seasonal opposites of the Northern and Southern Hemispheres. A simple pattern evolved. Institutional team leaders met in May of each year in Honolulu where they conferred with project consultants, shared and evaluated work done, jointly produced outlines and draft materials, and got direction for work to be undertaken during the at-home writing-testing period. It should be noted that in all cases team personnel devoted no more than 10 to 15 percent of their work time to Pacific Ocean Fisheries.

A brief description of the evolution of this process as it evolved in the yearly joint working sessions is informative.

1981 Conference/Work Session

The project was launched at a four-day conference held at the East-West Center in Honolulu to which some twenty experts in various aspects of oceanography, ocean technology, ocean law, ocean commerce, ocean resource management, ocean transportation, marine biology, and anthropology of Pacific peoples presented papers addressed to the theme, Wise Use of Ocean Resources. These experts came from throughout the Pacific Basin. Also present were primary and secondary curriculum specialists and teachers who would become team leaders of Bays and Harbours and Pacific Ocean Fisheries.

Immediately following the conference, primary and secondary teams met to draft outlines of potential content and the charge for the first years' at-home work period. The Pacific Ocean Fisheries group directed its member teams to identify existing audiovisual and other resources, to refine their working content outlines, and to develop and test prototype materials. A schedule of conference calls using PEACESAT, a no-charge public service satellite systems, was drawn up.

1982 Work Session

The second work session brought together the materials gathered and produced by each team, the most ambitious of which was a comprehensive draft of a larger work for a geography course developed by the new Zealand team. It was this latter work that provided the core of the refined outline of Pacific Ocean Fisheries. During this work session, the two-art (local and general) component structure evolved as well as a set of simple systems diagrams designed to organize the content development of each team. Curriculum Research and Development Group was specially charged to write a first draft of a generalizing component and create a prototype simulation game.

1983 Work Session

By the third work session, all teams had produced a substantial package of local materials. In addition, the prototype generalizing materials and a noncomputerized version of a simulation game had been written. The most spectacular product at this work session was the Alaska State Department's local materials which were delivered in a videotape-workbook format. With draft materials in hand, it was possible to look at the total program, make adjustments in sequence, and suggest both revisions and needs for flushing out the materials. Teams returned home to revise and test materials. Australia's team took on the task of computerizing the simulation game.

1984 Work Session

In this, the fourth year of the program, the ten days of the work session were devoted to shaping existing materials into the common generalizing component. This jointly compiled work was reviewed during the months of June and July with corrections sent to an editing team that met in Brisbane in August 1984 to refine the work further. The edited materials were to be field tested in February and March, 1985.

1985 Work Session

Teams met in May of 1985 to evaluate results from the testing of materials and to edit the final package.

Problems Encountered

In the process of developing Pacific Ocean Fisheries, suprisingly few problems have arisen, but those that did are basic and will be informative to those interested in engaging in multinational curriculum design. Discussion will be handled under four categories: project and institutional support, selection of common targets, communication, and other problems.

Project and Institutional Support

Initially, the most pressing problem was financing the activity. An attempt was made to get some eleemosynary institution to provide a development grant of $350,000 to support the development. Two years of futile search almost aborted Ocean Project. However, the importance of testing the work-ability of a multinational project continued to dominate the thinking of Pacific Circle Consortium. This resulted in a reconsideration of scope and developmental time frame which in turn inspired a reconceptualization of the project.

Each center agreed that one or more individuals could be assigned 10-15 percent time to work on the project without adversely affecting existing projects. Centrally located, the East-West Center in Honolulu volunteered no-cost housing, while Curriculum Research and Development Group picked up secretarial and other support charges. Consultation was provided by noncompensated scholars from the East-West Center and the University of Hawaii. This left airline tickets and per diems--an average new money cost of about $1,000 per person per year which participating institutions were able to cover. Six persons from outside Hawaii have attended the four May work sessions for about $24,000. Actual costs were, of course, much greater, but these were absorbed in already-existing operational budgets.

There have been some compromises. A project that would have been completed in a year and a half under the original proposal will take five years. Each institution will be responsible for reproduction of local materials. Generalizing materials will probably still be produced by one institution with the exception of the Japanese version. Art and photography work in the final volume will be less abundant, but in the main the product will look much as it would have looked had we been successful in grantsmanship.

Selection of a Common Target

The grand theme, Wise Use of Ocean Resources, and decision to create materials for primary and secondary schools had been made prior to the initiating 1981 conference. All agencies had earlier identified ocean resource utilization as being broadly covered under science and/or environmental education, and/or social studies syllabi. Left to the

Pacific Ocean Fisheries team leaders was the finding of one or more specific courses open to the introduction of new materials, determining which of the many science-technology-society themes would be acceptable to the clientele served, and setting parameters on the size of the final product.

Identification of course offerings that could accept science-technology-society materials was a more difficult task than identification of particular content. The potential content associated with the grand theme of ocean resource utilization is voluminous, varied, and has the potential for providing the informational base for any number of courses. However, finding common elements in existing course offerings of the schools served that would be able to accommodate new materials, would be within the same grade level range, and would be addressed to students of comparable ability was a knotty problem. Constraints on selection included:

1. The degree of flexibility and specificity of national, state, and/or local school syllabi.
2. The existence or nonexistence of state or national examinations.
3. The existence of elective or exploratory courses.
4. The presence of science-technology-society references in syllabi.

In practice, it turned out that Japan, with its nationally established curriculum, had one opening in the social studies program at the senior level in a course dealing with societal problems. Content for this course is flexible, but generally determined by nationally certified texts. There is, however, a group of experimental and special schools that have greater flexibility in their programs, and ocean resource materials could be relatively easily accommodated in the courses of these schools. There looms the possibility that on the next writing of the national syllabus, ocean resource materials could be inserted. The lesson here is that there must be a long- and a short-term plan for the ultimate dissemination and use of multinational curricula.

The New Zealand team found language that supported the grand theme and a way of embedding it in a newly authorized 11th year geography course. Accommodation to the New Zealand examination system will come later. Australia, too, found the grand theme acceptable to the syllabi of most of its states and concluded that under their system of teacher-controlled curriculum ocean resources materials could be readily incorporated.

The United States' experience was as diverse as the states represented. Alaska already had social studies materials dealing with fishing in design under a grant from the Alaskan fishing industry. Oregon and Washington team leaders reported such varied school practices that almost any program developed would have some potential for use. Hawaii, because of its centrally controlled system, is less flexible, but has a social studies elective course in marine problems for students in their 11th or 12th years that has a science-technology-society slant and can accommodate resource utilization materials. As a conclusion, the area of social studies was targeted with materials to be developed for years 10-12.

Identification of content was heavily influenced by Alaska's already-emerging design of fisheries materials and the Japanese team's interest in developing materials that would reflect Japan's great reliance on protein from the ocean. Fisheries as the focus of study became almost an automatic selection, with the only real question being whether other resources should also be included. The latter question was quickly answered in the negative when the magnitude of potential fisheries issues became apparent.

From the beginning, it was realized that students should be introduced to both the local and international dimensions of fisheries issues. Organization of materials into topical units was done during the second work session after teams had had a chance to digest the potential of the grand theme.

Instructional time that could be allocated for presentation of new materials was another variable, ranging from 6 to 16 weeks of study. This wide range called for design flexibility that was facilitated by expandable and contractable local materials. At its most essential level, the program could be reduced in content to the generalizing materials.

Ability levels of the intended student audience also varied. New Zealand and Australia both have a large exodus of students after the 10th grade, with the result that the better students tend to remain. The United States, by contrast, still has a wide student ability range resident through the 12th year. This problem had to be handled in the generalizing component and has been resolved by having a variety of case studies of varying reading levels along with graded exercises.

Communication

Communication during the course of developing the materials has been an unresolved problem. As alluded to previously, attempts were made to communicate through the public service PEACESAT system. These attempts were complicated by the need to use a mix of telephone and satellite transmissions. It was concluded that to be of value, telecommunication conferences must have a specific and tight agenda, with all parties prepared ahead of time for involvement.

The best communication vehicle turned out to be airline courier services and direct telephone communication when needed. International mail service is uncertain. It was found that if the assignments are carefully stipulated, a minimum of communications is needed during any at-home work period.

Other Problems

It is important that every effort be made to ensure that the same team members are retained throughout the project. It takes time to develop rapport, and even single-member changes can result in much loss of time and potential misinterpretation of assignment. Once a project is launched, it may be better to have an institution drop and and wait for the project to be completed rather than introduce a new participant.

Probably the greatest difficulty was satisfying impatient agency directorates. They often wanted the same immediate product that they felt they could get if the work were done under home control. Here the project had to rely on the head of the sponsoring Pacific Circle Consortium agency to keep directors satisfied. Directorates have an insatiable desire for documentation that must be handled with a sense of balance or satisfying their wants will take up the entire creative time of team members. This problem was solved in part by the yearly report of the coordination center, Curriculum Research and Development Group, which traded on the assumption that clarity and brevity of description was what was essential to advance the project.

A major problem not yet satisfactorily resolved is translation of materials into Japanese. This comes for the fact that all generalizing materials are in English. By agreement, English has been the language of common contributions. This means that the Japanese team must translate all generalizing materials.

Conclusion

The Ocean Project fisheries materials are still in their final stage of testing and revision, and any declaration of complete success would be premature. It can be said, however, that multinational curriculum materials can be constructed relatively inexpensively. In the judgement of the Pacific Circle Consortium, this first effort has been sufficiently successful to spawn active designs for a second round of multinational projects.

SCIENCE EDUCATION IN SCHOOLS - THE CARIBBEAN EXPERIENCE

Andrew Ucbebor
Tocooa, Georgia, U.S.A.

Editorial Note:

An overview of Science Education in the Caribbean is presented. By and large, upgrading the quality of science teaching from the primary to the secondary level has been a national concern, but financial constraints have led to a number of difficulties in attaining these objectives.

Two basic factors contributing to low performance in the area of Science Education are: (a) inadequate and unstable staffing situation, and (b) inadequate physical laboratory infrastructure. To overcome these problems, it is suggested that the schools must rely more on the graduates of the Colleges of Education to teach science. The Ministries or Colleges of Education should conduct periodic workshops as well as to upgrade the scientific proficiency of the teachers not only in the subject matter, but also in the use of scarce resources available.

As an example, the organizational structure of the educational system of Surinam is presented. The aims of the curriculum, the targeted goals, and suggestions for the advancement of Science and Technology Education are analyzed. Based on the present situation, new perspectives for the improvement of the program are suggested: redirection of the goals, methods and contents of science teaching, and manpower shortage. A new direction in Science Education in the Caribbean is imperative.

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Overview of Science Education in the Caribbean

All secondary school students take 2 to 3 years of general science covering Chemistry, Physics or Biology. Laboratory work comprises a significant part of the curriculum, with the laboratory work in the science programs providing essential, visual education for promoting thought and inquiry.

There is a strong movement toward integrated science in secondary schools presenting science as a whole, as intricately intertwined and integrated. The overall aim is to have students view science in as broad a scope as possible.

Science classes typically include 25-30 students, as dictated by laboratory space. Even with this class size, the number of students is usually too large for effective teaching to take place.

Many of the science courses are repeated with abstractness and irrelevancy. Formal courses do not generate self-motivation on the part of the students. On the contrary, many young people are inadvertently turned away from science with sad consequences for the future science and technological potential of the countries.

Aware of the need for science, educators and policy-makers have been led to examine science teaching in both elementary and secondary levels to give direction to curricular reform.

A high percentage of elementary school teachers are without formal training in science and, as a result, lack confidence in their ability to teach science. The need for improving science orientation for these teachers now is being addressed, however, by teacher education institutions.

There is a search for new visions in science teaching and new curricula which will reflect the cultural and humanistic roots of science, its social implications, and its application to the solution of daily problems.

Government policy moves in support of educational excellence in Caribbean countries. There are also aims to promote scientific literacy through programs of "Popularization of Science. The interest in the quality and quantity of science education has become a national concern everywhere.

Greater importance is now attached to giving the majority of students a good science knowledge. Skills training and work related training constitute new focal points in science education. There is a great desire among science teachers to halt and reverse the decline in physical science enrollment at the colleges. Schools and industry are teaming up to produce skilled personnel with sufficient scientific background to meet manpower needs. Science field trips are becoming an important means of supplementing classwork, particularly in schools with inadequate laboratory and science equipment. Increasing use of educational technology is being made for making science teaching more effective. Large scale use, however, has been constrained by limited financial resources. These financial restraints require science educators to search for the least expensive ways for providing the most enriched curricula.

Most science teachers would benefit from joining professional science teacher organization science most of them have as their objectives: (a) improvement of science education generally and (b) provision of information on the latest ideas and innovations in the teaching of science. The new objectives of science teaching will not only be to train future producers of science but equally important also, to help produce a nation of intelligent consumers of science. Science educators, therefore, face increasing challenges as greater demands are made on science and technology to respond to the national socio-economic objectives. The Caribbean, in recent years, has demonstrated a renewed attentiveness to science.

<u>Factors Contributing to Low Performance in Science Education</u>

Two basic factors can readily be identified as contributing to low performance of schools in the area of science education: (1) inadequate and unstable staffing situation, and (2) inadequate physical laboratory infrastructure or facilities. It is estimated that in country after country in the Caribbean the number of science teachers is critically below the required level. Many teachers do not have the necessary education and the quality of their performance is correspondingly below that desired. The yearly entry of university graduates into the system has only a marginal effect on the improvement of the situation. Also, as a result of resignations for more lucrative jobs in industry and transfers or promotions out of the classroom, the staffing situation in many schools is in a state of flux with consequent adverse effects on science education.

The constraining factor of inadequate laboratory and associated workshop facilities in most schools has severely limited the scope and quality of science education in the countries of the Caribbean; and has helped to entrench the popular fiction that science is a difficult subject. This state of affairs is brought about, among other factors by the very low priority accorded development of facilities for science teaching by our educational planners.

Suggestions for a Solution

While it is true that various Caribbean governments have improved the conditions of teachers in general, the fact still remains that because of better prospects in industry and other sectors of the economy, science graduates are unlikely to be attracted to teaching.

It would seem that any realistic solution to staffing deficiencies in science must rely more on graduates of Colleges of Education than on the products of Liberal Arts Colleges, unless the latter take specific education courses leading to teacher certification. It would also be advisable for the Ministries of Education or Colleges of Education to organize and conduct workshops periodically for inservice teachers to encourage them to update their knowledge of science delivery and to provide instruction on how to use the scarce resources available in the laboratories to maximize the effectiveness of their teaching.

Summer-Vacation Approach to Staffing

Perhaps, the science departments of universities and institutions of higher learning can put on a "crash" program based on the mobilization of knowledgeable and willing undergraduates for teaching in schools during long vacations. Students can be identified during the session in the colleges and universities and given theoretical and practical instructions during term time by members of the regular faculty on selected portions of the science syllabus. Then, during the regular long vacation, they would be deployed to designated schools to teach science to students in secondary schools.

Depending on the level of payment, quite handsome remuneration can be paid to the undergraduate instructors. Government subsidy will be necessary, however, to prevent the program from catering mainly to the children of the rich.

Organization of Science and Technical Programs in Surinam

Some countries have an educational system which separates students at an early age into vocational or academic streams with built-in flexibility of movement from one to the other. Surinam provides a good example of this.

Educational Structure and Development

Surinam has a somewhat categorical educational system. The structure is one offering six years of primary or elementary education followed by three years of junior secondary education. The structure is, therefore, one of 6+6+3 with a slight variation at the upper end, preceded by a two-year pre-elementary stage and leading various post-secondary and higher courses. It is reported that about 35% of the population are enrolled at different educational levels.

The curriculum at the elementary or primary level consists mainly of traditional subjects. Science has not been considered necessary at this stage. During the final year, all pupils take a compulsory general achievement test. The test lays heavy emphasis upon acquisition of knowledge and the type of schools in which pupils are directed, based on the results of the achievement test are: Middle General Secondary (MULO) - the academic stream and the most highly esteemed; General Vocational Oriented (LBGO), and Junior Technical (LTO).

About 40% of the pupils tested enter MULO schools. The curriculum at the MULO, the academic stream of the junior secondary education, is general, broad-based, and examination oriented. It has two main streams, the "A" stream, which concentrates on the Arts and "B" stream, which concentrates on the Sciences, notably Mathematics and Physics. At this stage, science is taught as a special subject to be taken by those who will eventually pursue careers in science. Those opting for stream "A" may complete their secondary schooling without exposure to science. This early streaming into Arts and Sciences does not advance the goal of literacy throughout society. Hence, science education for all students, of necessity, becomes a goal to be addressed by policy-makers of the nation because there are many indications that the quality of science instruction in schools should be increased.

In addition to the schools already mentioned, there are also, in operation, a number of schools offering technical education. Exclusively again, the categorical system is followed and it includes the Lower Technical School (LTS) and the Middle Technical School (MTS). The latter operated in a two - tier basis for some four years: (a) the T- stream (predominately theoretical training) and (b) the P - stream (predominantly practical training). Eventually the two - tier system was discontinued. It was substituted by a more balanced system including both theory and practice.

Targeted Goals of the Lower Technical Training

The training given at these institutions emphasizes a sound basis of general education including science to enable the students to adapt to other vocations in their later career. Important skills taught at this level include the ability to prepare a simple technical report and the ability to read and understand a scientific text.

Instrument for Advancing Science and Technical Education

A science and technical education board coordinates activities in technical education schools. The schools are usually under the supervision of the school directors, but the Board works very closely with the teaching staff in each school on all matters affecting their teaching programs. The Board advises on matters of policy and maintains liaison with industry and other private sectors. The training of scientific and technical personnel is, then, fully coordinated by the Board. It also advises on the training and retention of teachers for science and technical education in its human resources development program.

Situation Analysis of the Science Program (The Textbook Approach)

The science programs offered in the Caribbean schools can be described as an attempt to cover a logical organization of a science primarily through the medium of a textbook. Related activities, such as laboratory and field work, are designed to help clarify the facts and concepts developed in the text. The teacher's chief responsibility is to make the science content as developed by the textbook, as appealing and meaningful as possible to the students.

A major criticism of this approach to science education is that textbooks form the science program, determining both content and instructional method.

Attempts by teachers to cover the material prescribed in the book results in a swift race that permits little time for reflective activities and results in superficial, verbalistic learning for most students. This has resulted in a heavy emphasis upon the acquisition of facts rather than an emphasis upon increasing the power of students to obtain facts or use them intelligently in making decisions. There is very little time to deal with real problems, doubts, and skepticism. The textbook approach limits development of critical thinking.

Also, some textbook problems are abstract and foreign to the types of real life problems that can be solved through scientific techniques and knowledge. This leads to boredom and lack of interest on the part of students.

Admittedly, good teachers add to the textbook account from their own experiences, draw on the students experiences, and develop interesting and challenging courses.

New Perspectives

1. Redirection

   Dell Wolfe states the following:
   "From the minds of men come future scientific discoveries, future works of art and literature, future advances in technology and social organization, in short, all future progress. Since there can be no argument over this proposition, the practical problem becomes one of devising the best means of nurturing the talent which exists in the population" (America's Resource of Specialized Talent, New York: Harper and Brothers, 1954, p. 283).

A broader curriculum is needed than the present one; teaching procedures should be designed largely to develop critical thought in students. The teacher must be convinced that the goals of science teaching should always include development of reflective thought and the acquisition of durable and usable knowledge. The goal of helping to make a society scientific, in the intellectual sense, should be pursued.

A Word of Caution

Curriculum developers should address curriculum reforms that make science interesting to a wider variety of pupils. The basic issue is not the current insufficiencies of science education, but the more fundamental question of the place of science in the wider context of life.

The emerging vision for an education in the sciences is that science and technology must be brought into the real life of the student.

2. Method of Teaching

Dissatisfaction with science teaching at all levels stems from course content as well as from teaching methods. F.W. Fox observed: "A good science teacher is one who endeavors to teach at a higher level of performance, giving his students opportunities to read, discuss, investigate try out, argue, take trips, look at, listen to, improvise, etc. This method or approach offers students opportunity to compare, discriminate, reformulate, interpret, predict, discover, create and apply, thus performing at a higher level. The teacher resourcefully departs from the traditional and the routine for creating new and imaginative approaches to both content and method of teaching, always searching for unique ways to solve teaching problems.

There is more to any profession than intellectual mastery of the facts and principles of the field. There is art and technique. Sound mastery of science discipline is not sufficient for effective teaching of young people. The child is complex, as is the process of learning. The teacher must add to his understanding of science and understanding of young people and how to work with them in such a way that his instructional goals are achieved. The science teacher must be highly skilled in resolving the problems of his work. Most of all, he must master the art and technique of guiding learning activities. A higher level of inquiry teaching is associated with greater student-directed activity.

3. The Problem of Manpower Shortage

In some of the Caribbean countries there is a critical shortage of science and mathematics teachers. A frequently advocated incentive for overcoming the manpower shortage is extra pay for teachers teaching the subjects just mentioned. Besides extra (or higher) pay, other solutions considered are: retraining of teachers, industry employees serving as part-time teachers, and non-repayable loans given to teachers who sign a contract to teach. One of the better solutions is to improve the attractiveness of the teaching profession generally and give proper career guidance to prospective teachers who can be guided to shortage areas of science and mathematics.

Conclusion

Ronald Simpson of the University of Georgia summarized the direction science education should take: (1) Science must receive more attention in the elementary schools; (2) Science in the secondary school should be relevant to the lives of the adolescents; ((3) Science in schools should be taught consistent with the nature of science; (4) Both scientists and educators should become more concerned about communicating science to the masses; and (5) Governments should do everything possible to improve in the stature of teaching as a career.

Features of An Exemplary Science Program Suggested by NSTA Also Provide New Direction

1. A focus on social problems and issues.
2. Practice with decision making strategies.
3. Concern for career awareness.
4. Local and community relations.
5. Application of science.

References

Some of the ideas developed in this paper were gleaned from the following sources.

Education, Vol. 194 (1983).

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Reading in Science, Hans O. Andersen, (New York: McMillan).

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Note: The full length paper has an addendum entitled:
SCIENCE EDUCATION POLICY IN THE CARIBBEAN

CHAPTER 5 EDUCATING TEACHERS FOR CULTURALLY DIVERSE STUDENTS

Three papers in this chapter describe different approaches to teacher education in Chile, Brazil, and Panama. Salame's paper is a historical description of teacher education in Chile. He describes from a philosophical perspective a rationale for science teacher education. Bottaro-Marques then describes a national program for teacher education in Brazil which is designed to meet that nations' vast needs for preparation of elementary science teachers. The chapter closes with a description by Deyanira Barnett of the current program for preparation of secondary school science teachers in Panama. In this paper she describes efforts at reform and further changes that are viewed as essential. These papers provide a background for readers on the diverse issues confronting teacher educators and those who formulate policies about teacher education.

THE TRAINING OF SCIENCE TEACHERS

René Salamé Martín
Ministry of Public Education
Sa.tiago, Chile

Editorial Note: Professor Salamé's article was prepared for the Inter American Seminar on Science Education and, at the last moment, he was unable to attend. The version presented here is a condensation of a larger paper available in Spanish. It carries a subtitle "A task that implies training of integrated persons."

* *

This paper summarizes the experience of a group of science teachers in Chile who were trained according to the rational positions of French ideology and who then taught within the educational tradition of American behaviorism. In this paper, the writer presents some of the fundamental conditions that need to be met in order to prepare science teachers from a humanistic perspective.

With great concern, we have been observing how the academic and professional quality of young teachers graduating from college has deteriorated over the years. The confusion they show when they try to apply concepts and principles to specific and concrete situations is a matter of concern. This confusion was understandable since many years ago we supposedly gave up on the underlying classic schemes of the traditional educational system; i.e., styles, methods and forms of doing the job that led to an encyclopedia and passive teaching, devoid of creativity. To commit ones' self to a discipline is to adopt an attitude that allows appreciation of natural phenomena and also the activities that take place in the extensive field of the humanistic sciences. To be a professional in a discipline implies an attitude of respect for mankind, for human welfare, for the truth, and for the beauty around us. Coincident with this attitude, is the aspiration of every teacher to transmit to his students much of what he knows.

These substantive conditions to train teachers for development are not present in today's teachers and students. What has happened? The dynamic and accelerated development of technology has led us to plan an educational process far away from a humanistic conception. Science is taught for the science itself, devoid of context and alien to the people to whom it should be addressed. This is the product of an excessive movement towards specialization. The priority lies on specifics with very little emphasis on general formative aspects of education. As a consequence, the young professional looses the global vision required in his profession of teaching.

It is necessary for a professional who, besides deeply knowing his discipline, is able to create new situations, and to plan and administer them. Furthermore, it is required that this professional be able to transform new generations, to grow as a person within his own context, and to find himself and others. This way we can assume a good orientation toward, and effective action in, the educational process. This, in turn, will allow for the development of professionals capable of leading today's changing world as well as tomorrow's accelerated one.

<u>The Training of Science Teachers</u>

What conditions should be met in the process of training science teachers so that they show these behaviors? As a minimum, it is necessary that the following conditions be attained:

1. A methodology that truly points at the objective already stated above and which means:

   a. A genuine possibility for the students to inquire into the actual process of knowledge creation. This will permit the cultivation of the basic discipline's essential values with adequate conceptualization and not with disarticulated pieces of information. The student will acquire an ample world vision centered around mankind's problems.

   b. An emotional participation in the process. The inquiry process develops students' curiosity which has, as a substantial element, the wonder of nature and, as a catalytic agent, the emotion. If we look carefully at the lives and work of great scientists, it can be observed that it is not possible to develop an idea, unless there exists an emotional element in the process. To develop this attitude, the discipline must be taught through its own development--transmitting the emotions of its own creators.

   c. The incorporation of a truly interdisciplinary work. Even though it is true that the recent development of disciplines has determined an excessive knowledge fragmentation and led to specialization, today people feel the need for more cooperation and collaboration; acknowledging the importance of interdisciplinary work and breaking down the disciplinary schemes.

   d. Intense and profound cultivation of humanistic dimensions. In spite of the mechanization and technological processes currently found in society, we must remember the importance of the development of individual talents and personality. This is very important to human advancement because it occurs only through the development of persons that are part of the whole human community.

2. The second condition concerns the academic disciplines. Academic disciplines are a necessary part of a prospective teacher's background because they provide the conceptual basis for understanding present knowledge and how it was formulated. Moreover, understanding the disciplines in their present form is essential for success in creating new knowledge and in teaching youth.

3. The third condition is academic freedom to interpret the surrounding world. Mechanistic, and cognitive teaching generally leads us to frustrations and astonishment. Students must be given the opportunity to speculate about the possible structural changes that might take place

in the disciplines. This way, students will be prepared to understand the knowledge as currently introduced and taught, and to face later revisions in the discipline that inevitably will occur.

4. The fourth condition is incorporation of a creative process. Future science teachers will be immersed in objective situations with diverse types of problems to solve. The teacher education process, even in its theoretical level, must not be detached from that reality. In this sense, we must try to prevent future teachers from adopting textbook schemes that are removed from this reality. We must direct students to a truly creative labor by making use of other people's investigations to generate new situations and move on to new levels of excellence.

5. The fifth condition is to allow for a process of maturation. Time for mediation is the fundamental stone for the future teacher to confront the systematic culture and be able to understand it. The maturation process helps us to develop a predisposition and love for new knowledge and a natural curiosity to conduct investigations. It is not enough to pour scientific knowledge into students' minds; it is necessary that knowledge becomes a part of their lives. This process will permit future teachers to enjoy doing science in search of the unknown.

6. The sixth and last condition is the active participation of qualified educators. A true educator is the one who constantly feels the tendency to give of himself, to make himself know, and who brings knowledge to his students through his own experience without being dogmatic or ostentatious. Both educators and students can grow simultaneously thanks to the communication channels that can be established in a humanistic educational process. This process implies an extremely demanding, moral responsibility.

Conclusion

From the foregoing arguments we conclude that we should strive to educate teachers who are more than merely competent; we should strive to educate teachers who possess wisdom. When we try to prepare a professional that is knowledgeable about everything, we end up with disarticulated human beings who also transmit the same disarticulation to their own students. To educate teachers appropriately is to prepare a professional capable of delivering the huge amount of available teaching materials with love and affection.

How can this scheme be expressed concretely in an effective and definitive action? This requires many efforts and conformities from those that have responsibilities in the educational process: the authorities, the academic community, the teachers, and the students. As these groups become aware of their own responsibilities in enriching cultural harmony by virtue of dynamic and creative processes in search of truth, then we will be in a better position to search for new trends that lead us to expected values.

BRAZIL'S PROJECT FOR IMPROVEMENT OF SCIENCE AND MATHEMATICS EDUCATION

Gladis Bottaro Marques
Ministry of Education
Brasilia, Brazil

Editorial Note: The "Project For The Improvement of Science and Mathematics Education" is part of the "Subprogram Science Education," established by CAPES, through ordinance no. 04, dated April, 23rd, 1983, integrated in the "Support Program for Development of Science and Technology."

With an estimated period of five years and resources in the order of US$44,000,000.00 the Project will support the creation, diffusion, and application of knowledge and specific methodology in this educational area.

It will cover six areas: research in science education, curriculum development, teacher training, in-service training, and out-of-class and extra curricular activities.

Projects may be submitted by teachers, researchers, State Secretariats of Education, Universities, and Foundations.

Priority will be accorded to multi-dimensional subprojects aiming at the identification and training of leaders for the improvement of science and mathematics education in elementary schools and which also attempt to coordinate efforts on the part of individuals and institutions involved in the improvement of this kind of education.

* *

Introduction

Science teaching in Brazil has not met our expectations. Texts are poor in content and highly theoretical. Laboratory instruction is inadequate. Classroom instruction is mainly expository. Candidates for universities are poorly prepared.

One of the fundamental reasons for the deficiencies of science teaching at the elementary and high school levels is the ridiculous salary paid to the teachers, which does not pay for even their basic necessities. The low social status of the teacher is also naturally associated with their salary. However, the solution of this problem is not within the scope of this project. Our work is to stimulate subprojects which include some initiatives for the improvement of working conditions concerning these teachers.

What are the other problems?

The science elementary school teacher is poorly prepared for his functions, both regarding content and methodology. This training deficiency is multiplied when confronted with the excessive number of students in the classroom, the lack of physical space, and the lack of time to prepare for the classes (especially experimental classes).

Insufficient training makes teachers feel insecure, this then becomes the main reason for resistance to changes or curriculum innovations (even though in most cases the teacher has enough freedom to establish or modify his own curriculum). This also causes teachers to use exaggerated verbalism, which is worsened by a pseudo-scientific language totally uncomprehensible to the students.

The content of the knowledge transmitted, is frequently extraneous to the real world in which the students live and, to make the situation worse, it is presented at an abstract level beyond their cognitive abilities. Textbooks (many times absent because the families cannot afford them) are usually of low quality, contain frequent conceptual errors, and describe situations unrelated to local realities. Experimentation is absent in the classroom and it is often substituted by (or confused with) the mere observation of a phenomenon, or even worse, a photograph found in the textbook. The methodology of the science teaching at this level presents, therefore, deep flaws and thus contributes to students' lack of interest, absenteeism, and eventually school dropout.

The root of the problem, as far as the teachers are concerned, goes back to the university. With few exceptions, Brazilian universities have not acknowledged the problems of science teaching, particularly in the elementary school, until now. Research in science teaching, and the development of curricula (what to teach? why teach? how to teach?) has neither "status" nor financial resources for historical, structural, and institutional reasons. However, the present situation of science teaching shows the necessity for a deeper reflection in order to define the content to be included in basic education (with local and regional variations), and in order to better understand which is the most appropriate way to teach this content to the children (with the variations determined by the different social levels).

The lack of communication and coordination is one of the major obstacles encountered by individual initiatives in order to improve the teaching of science and mathematics. The deficiencies are not restricted to isolated cases. University professors from the basic sciences departments often ignore the activity of a Science Center associated with the Faculty of Education. The Secretariats of Education are many times disassociated from the efforts of the Science Center. The communication mechanisms among the Science Centers are often deficient.

It is imperative to have a coordinator at least at a local or at regional level:

- that may attend to the dissemination of individual efforts and of the institutional activities;

- that tries to keep the communication channels open and accessible to the school system;

- that may initiate assistance, or offer assistance when requested;

- that may eventually integrate or articulate the efforts around a common objective or task;

-that participates in the dissemination of the sciences in the community.

Proposed Solutions

Priority for Science and Mathematics Teaching In The Elementary School

A diagnosis of science teaching in Brazil has shown the precarious state of science teaching in the university, and shows almost a calamity at the elementary and high schools levels. To solve the deficiencies at all levels and in all the Brazilian territories would require programs of much greater magnitude than that proposed here, and the dedication of many generations of educators. It is important, therefore, to establish priorities.

It was decided to focus the emphasis of this project toward the teaching of science and mathematics in the elementary school. The reasons for this choice are many and quite obvious. As if the existence of seven million children between ages 7 and 14 (32% of the Brazilian population in this age group) who do not attend school (according to the 1980 census and the "Anuario Estatistico" of 1981) was not enough, it still can be mentioned that more than 13% of the 850,000 elementary school teachers in Brazil did not even finish elementary schools themselves, and only 33% have a college education. This fact explains why the children who actually do attend school receive such poor quality teaching.

The social benefits resulting from priority given to teaching science and mathematics in elementary school is not out of the question. In the present Brazilian economic situation, the majority of jobs are filled by individuals who have at the most, an elementary school education. An improvement in this area would consequently result in the improvement of productivity for a considerable portion of the population.

Finally, it has been proven that investments in elementary schooling offer the highest rates of return.

How to Improve Science and Mathematics Teaching

By investing in human resources and in the identification and training of leaders:

(a) through the education of researchers in science and mathematics teaching;

(b) through the appropriate training of teachers;

(c) through in-service training of present teachers;

(d) through the direct involvement of children in scientific activities and through the diffusion of science in the community.

a. Support to Research

An incentive to conduct research in science and mathematics teaching and to develop curriculum should be the first priority. It is imperative, for instance, that before implementing curriculum in the classroom, that research be conducted regarding the adequacy of the proposed activities of the curriculum in relation to the human and socioeconomic reality in which it will be carried out. A lack of tradition and the interdisciplinary characteristics of the subject make research in science and mathematics teaching a complex undertaking. It is imperative to count on active leadership. The shortages of resources justifies sponsoring people for graduate studies, either at a masters or doctorate level in Brazil if possible, or abroad if necessary. It is hoped that as soon as research groups are able to consolidate themselves both structurally and institutionally, they will be able to generate knowledge and new human resources.

b. Strengthening the B.A. and other teachers' programs

The undergraduate programs for the education of teachers must be updated and strengthened. The various types of programs existing in Brazil for the training of teachers (short, complete, experimental, or partial B.A.'s) do not contain unique solutions. Diversity is advisable due to the diversity of social and human conditions existing in the country.

There are two flaws, however, which are common to all of the programs:

- A lack of content is widely responsible for the insecurity felt by teachers and has deep consequences for students. Appropriate training, as far as specific content is concerned, is a necessary condition (although not sufficient) for satisfactory performance in future teaching activities.

- Inadequacy of methodology. Experimental and practical abilities are not well developed. This deficiency must be corrected so that the future teacher may be able to develop creative experimental activities with his students.

c. Improvement of the efficiency of in-service training programs

These include the retraining programs for teachers already working, and may be concentrated during summer vacation or distributed during the school year. In-service training programs constitute one of the main activities of the Science Centers, along with a few universities and higher education institutions. Some pre-conditions for the success of these programs include:

(1) the existence of qualified staff;

(2) the availability of technical consultantship, through interaction with universities;

(3) the availability of trainees through cooperation with State Secretariats of Education;

(4) adequacy of content and methodology to the needs of the program and to the aspirations of the trainees;

(5) the existence of mechanisms which will allow the teachers a more satisfactory performance in the classroom, using the abilities acquired during the training period.

d. Incentive for extra-school and extra-curriculum activities

These activities, which follow the format of science clubs and science fairs, are generally performed by the science centers. Thanks to the flexibility in their structure and the linkages with the universities, State Secretariats of Education and the school system, centers have the possibility of performing tasks usually extraneous to the formal education system (in-service training, organizations of fairs and science clubs, individual consultantship to the teachers, distance (extension) training, elaboration of educational material, disseminating of science information to the community, etc.).

These same characteristics make the centers the appropriate units of articulation, and of coordination, ideally for the individual or institutional efforts, aiming at the improvement of education in the sciences, in the region of their operation. Support for science clubs (whose operations depend much less on the financial resources than on the leader's enthusiasm, on the group's creativity and on some educational material or instruments) also must be channeled through the Centers. The same can be said of science fairs.

The Means: Education for sciences Program

The Education for Science Program, promoted by CAPES and in accordance with the goals of the Sectional Plan for Education, Sciences, and Sports from the Ministry of Education and Culture aims to implement the proposed solutions through the Project for the Improvement of Science and Mathematics Teaching. The Project aims to encourage the search and the implementation of new strategies and to consolidate initiatives already existing and proved efficient, with the purpose of improving the teaching of Science and Mathematics in Brazil.

The project objectives which will be outlined next, should be attained through local or regional actions, articulated into subprojects elaborated by teachers, researchers, higher education institutions, Secretariats of Education, Science Centers, foundations, the school network system, etc., and presented to CAPES for possible approval and financing.

a. Objectives of the Project

1. To identify, train, and support leaders at all levels so that the strategies and activities aiming at the improvement of science and mathematics teaching may have short and medium term effects. It also should secure the continuity, the diffusion, and the multiplication of efforts employed.

2. As a first priority, to improve the teaching of science and mathematics in elementary schools.

3. To improve the training of science and mathematics teachers.

4. To promote the search local solutions in order to improve the teaching of science and mathematics, through:

(i) the adequacy of curricula to the local conditions and to the students' level; and
(ii) an effective local coordination of the individual and institutional initiatives aiming for the improvement of science and mathematics teaching.

5. To encourage research and the implementation of new technologies in order to improve teaching science and mathematics.

b. Areas of activities of the project

The activities through which the project intends to reach its objectives are distributed into four areas:

Research in Science teaching: development of curricula-implementation of pilot programs.	Teacher training (B.A.'s and Normal Schools)	In-service training programs	Activities of the Science Centers
(1)	(2)	(3)	(4)

The responsibility for the project pertains to the Ministry of Culture and Education and its establishment is due to CAPES. For this reason CAPES will receive suggestions of subprojects for assessment, financing and attendance.

Central coordination at CAPES is advised by a Counselor Commission composed of 9 members. These are chosen from among experts in science and mathematics education for elementary and secondary levels, with at least three regular teachers (two elementary level teachers and one secondary teacher).

An annual report is published each October 31 in order to bring forth proposals for subprojects which contain details related to the standards of eligibility; general and specific counseling; priority fields and rules of evaluation.

The evaluation of the subprojects is done in two steps:

-individual evaluation, which is simultaneously preceded by two counselors.

-competitive education which is undertaken with the participation of a commission of counselors.

The basic criteria for eligibility are as follows:

-relevance of the subproject (20 points)

-efficacy of the subproject (10 points)

-efficiency of activities (process) (10 points)

-feasibility (10 points)

The subprojects which have been approved, rejected, or reformulated by the Commission of Counselors will be forwarded to the head Commission of CAPES for further evaluation. The above institution will communicate with the proposer by means of a copy of the Commission's report on the project. Following up the selected subprojects is done by means of visits and studies of semi-annual reports and on matters as they develop. The final evaluation will be done on a visiting basis and will take into account the initial evaluation of the process. These visitations will vary according to the specifics of each field.

Current Situation of the Project

Document no. 1 was sent in October 1983 to nearly 1,200 institutions (universities, education and science departments, state secretaries of education, and involved personnel). This document contains directives and advice for the presentation of proposals.

At the beginning of 1984, the Coordinator of the Project received 146 (67%) of the selected proposals (28) were for group activities in two or more areas of the project. The final situation, according to each area is as follows:

1. Research, curriculum development, establishment of pilot-curriculum: 14

2. Teaching Certification, teacher training courses: 14

3. In-service training, support to public school teachers: 29

4. Out-of-class and extra-curricular activities, support to science clubs, museums and centers: 16

Area 1: Research Curriculum Development, Establishment of Pilot-Curriculum

Since the end of the previous decade, teachers have been concerned with what may be called "concepts" or children's spontaneous "performances."

"The student on arriving at school has his own ideas about the world around him;

-the student changes his way of thinking only when he thinks.

-teaching should begin at the present stage of the student's development.

-thus, the teacher should have an open mind and observe the student before starting his education."

Enhancing and enriching this type of research in Brazil, was at the center of the activities of these subprojects. The Federal University of Pernambuco's Cognitive Psychology Group intends to organize strategies for science and mathematics education at the elementary levels using themes familiar to the children and having as a reference data collected through clinical observations. The Federal University of Campinas uses the spontaneous knowledge of children as the key note of activities which aim to solve such problems as the critical transitions from pre-school to the 1st grade and from the 4th grade to the 5th grade.

The other subprojects of Area 1 are concerned with the development and setting-up of curricula. The Science Education Center of Sao Paulo (CECISP) for Mathematics and the University of Amazon for Science and Mathematics are concerned with the first section of elementary school while the University of Brasilia is interested in developing a Mathematics curriculum for the second section.

The Federal University of Parà (UFPA), the University of Sao Paulo (UCS) and the Federal University of Bahia (UFBA)/PROTAP suggest working directly with those in the Teaching Certification Program.

Area In-Service Training and Support to Teachers of the Public School System

Among the 29 subprojects which will apply to this area one sees a concern with avoiding errors in planning or performance that have led the majority of the traditional training courses to failure. The participation of school supervisors in training is a suggestion found in the majority of the projects. There is also an expressed need for forming local leaders who will work to reinforce goals. One will also note that participation of trainees in course planning and o.k. care used to avoid teacher withdrawl from the classroom allows the simultaneous training of various teachers from the same school which is another step enabling the trainee to achieve their aims.

The majority of the proposals submitted recommend that some sort of assistance should be given to trained teachers after the end of the course.

Four institutions direct their activities to the first section of the elementary school. Some subprojects adopt a type of "action-research" in which trained teachers work mini-projects together with those in-charge of the course.

Out-Of-Class and Extra-Curricular Activities, Support to Science Club Centers and Museums

The proposals are divided into three categories:

-Support to organizations which already exist such as: The Museum of Bahia, the Science Center of Minas Gerais and the Science Club of Professor Nilza Braganca Vieira.

-Support to Centers which are under recovery such as: The Science Center of the Northeast, Pernambuco, which is being restructured after many years of near inactivity.

-Support for the creation of new Centers such as: The Science Center of Parana that already counts on Parana's Training Center infra-structure;

The Science and Mathematics Education Center of UFRJ; "Espaceo Ciencia Viva" in Rio de Janeiro presently in activity; The Science Center of Campinas with the expected establishment of a planetarium and a Science Museum; The Nucleus of Environmental Education of the Science Center, IBECC. Some centers will begin their activities at the following places:

-The Federal University of Piaui

-The Federal University of Sergipe

-The Cultural and Research Foundation of Ceara

-The State Secretariat of Education and Culture of Roraima

-Support to Scholarly Journal and Symposiums.

The Commission, as has been requested by the Brazilian Physics Society and the Brazilian Mathematics Society, advises that financial aid should be granted to the publication of the "Revista Brasileira de Ension de Fisica" and "Revista do Professor de Matematics" (Brazilian Journal of Physics Education; Journal of the Teacher of Mathematics). The same Commission is also in favor of granting support to the Federal University of Santa Catarina for the holding of the South Brazilian symposium on Science Education.

Conclusion

CAPES is an important project in Brazil's future. Work on five major fronts to improve elementary science for the nation's youth represents a major effort and expenditure and the results will be watched closely to determine effectiveness of this project and as guidance for future actions.

SCIENCE TEACHER TRAINING IN PANAMA

Deyanira Barnett
University of Panama
Panama City, Panama

Traditionally the Republic of Panama has placed much emphasis on educating its youth. Since the beginning of the Republic, the Ministry of Education has had the responsibility for training elementary school teachers and the University of Panama the training of secondary school teachers.

Problems exist in teacher training in Panama just as they do in other Latin American countries. At various times, international organizations, such as UNESCO, have urgently called out to the different entities responsible for the training of teachers to abandon their traditional methods, their routine habits, and to dedicate themselves to look for new methods of training students (UNESCO, 1969).

In Panama the training of the secondary science teacher has always been the responsibility of the Faculty of Science in conjunction with the Faculty of Philosophy, Letters, and Education. The Faculty of Science offers the courses necessary for obtaining a Licentiate (Licenciatura) in Biology, Chemistry and Physics. While the Faculty of Philosophy, Letters, and Education confirms a teaching certificate once students have completed their requirements as licentiates and have taken the required educational courses in that Faculty.

For two decades (1945-1965) the Faculty of Science conferred a dual degree in Biology and Chemistry, Chemistry and Physics or Mathematics and Physics. In respect to this, Professor Delfin Galvez in his series entitled "The History of Our Faculty" writes:

> ". . .this was how a teaching staff was formed with a vast scientific and pedagogical culture to efficiently serve the secondary school system" (Galvez, 1977).

Around the middle of the 60's, the Faculty of Science reorganized its different schools and stopped conferring the dual majors. From then on the faculty conferred degrees either in Biology, Chemistry, or Physics.

While changes were occurring in the Faculty of Science to reinforce the culture of science that should be imparted in classrooms, the School of Education maintained its program for training secondary school teachers which consisted of a first year of general studies and eight courses in education. All the courses on theory met weekly for three hours each. Once the student has completed these requirements together with the student teaching, then he is conferred the title of secondary school teacher.

Current Practice

In actuality, there are more than 400 teachers in Panamanian secondary schools that are grouped into the first 3 years of secondary school which is mandatory for all accepted students; and a second component called "diversified cycle" that lasts two years for academic students and three years for technical students.

The training of secondary science teachers is a two-phase process. The first phase is the undergraduate work which includes general education, major, and professional courses. The second phase includes post graduate courses and inservice training. The science teachers of Panama (Biology, Physics, and Chemistry) are given a fairly good preparation in their major disciplines. Courses which are taken by future teachers are the same ones that are taken by students who will do postgraduate work or go into professional schooling. However, classes tend to be very large with laboratories structured in such a way that the teacher has few opportunities to participate in open laboratories or meaningful dialogues or to ask and respond to higher order questions. Perhaps this situation explains the reason that high school science teachers do very little laboratory work. It could be that practicing teachers had very few chances to engage in laboratory work themselves during their university training.

As has been mentioned above, professional training of the future science teacher includes a series of educational and psychological courses which are taken in the School of Education with the Faculty of Philosophy, Letters and Education. In general, the students take these courses in their third or fourth year and it is not rare for them to finish this coursework while writing their thesis and by taking eight courses in one year. Student teaching in most cases is an experience which lasts about one month.

We have mentioned earlier that inservice teacher training is part of the second phase of the teacher training system in Panama. Since very recently, we have been planning different types of activities to give teachers experience in both content and methodologies.

The importance of continuing education for science teachers cannot be stressed enough. The tremendous increase in scientific knowledge, the need to incorporate recently learned knowledge in the curriculum, and the pressure to use new educational technology constitutes curricula problems which are sufficient to justify the necessity to institutionalize continuing education programs for the training of teachers. It can no longer be expected that the teacher works effectively with only undergraduate training. As Pharis said,

> This is a society which changes so rapidly that human beings can be as out of date as machines (1966).

Projections

In many countries there has been criticism regarding how the training of teachers does not take into account the realities of the classroom.

University professors have been accused of living far from the national reality. Panama has not escaped this situation.

Educators at all levels are reacting to this criticism by changing, improving, and introducing new methods in teacher training programs.

The School of Education should echo these concerns. Perhaps this responsibility will fall upon the future members of the faculty of education who will develop new programs for future secondary school science teachers. The future faculty members should realize that the basis of teacher training programs is to produce teachers that possess the necessary strategies, expertise, and willingness to facilitate learning in any educational environment.

To the future faculty in education, we recommend a revision of the teacher training programs with input from the faculty of science, since this is a shared responsibility of both faculties. We make this recommendation because we are primarily responsible for the training of science teachers. We have observed that a great percentage of students in the school of science who take education courses, do so in their last years. Towards the end of their studies, and when they do not see any possibility for jobs as biologists or chemists, these students decide to take their educational courses and "become" teachers. After all, there is always a necessity for certified teachers in the Ministry of Education. There are few who after receiving the teaching credential have the satisfaction in knowing that they have realized a fixed goal.

However, I would like to make clear that in principle, I am in agreement with the model used for the preparation of science teachers in Panama. I believe that the science teacher should have a solid foundation in the sciences, but I also believe that one can develop a science teacher training program in which the future teacher receives more than eight courses and student teaching experience more than which is a month long. There is a need to incorporate courses on simulations, decision making, and even practice using microteaching. Furthermore, future organization of science teacher training programs should include a teaching laboratory which permits one to practice diverse teaching strategies as well as to use educational technology. We are preparing the teachers who are going to teach in the 21st century and we cannot do this by , ing antiquated methods.

I would like to now refer to another aspect .. teacher training and it is the inservice training phase.

The University of Panama has always fulfilled its responsibilities in contributing to the improvement of teaching through its summer programs and various seminars, given at different times of the year, which are developed in coordination with the Ministry of Education. We have already discussed how rapidly scientific knowledge is increasing and the necessity of those teachers which have only fulfilled the requirements for undergraduate work, to continue in postgraduate work.

In this regard, the Dean for Postgraduate work and Research has not only organized a series of postgraduate courses for secondary school science teachers, but also has under study the possibility of establishing a year long program for training specialists in the teaching of biology. These future specialists will have an opportunity to do additional work in biology, science education, testing and measurement, and educational research. We hope that the Dean of Postgraduate studies and Research succeeds in establishing this program.

I have tried to present to you a panorama of the training of science teachers in Panama. Through this presentation I have let you know about our frustrations and our expectations, desires, and projects to make our secondary school science teachers well qualified professionals, capable of responding to the needs of future generations of Panamanians which will be the citizens and professionals that will have the responsibility to develop Panama.

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CHAPTER 6 REPORT OF THE WORKING GROUPS

Participants were divided into four working groups corresponding to the four conference themes to facilitate more thorough discussion of topics of more specific interest. Each group was assigned a Leader who was fluent in both Spanish and English and two Rapporteurs, one where primary language was English and the other whose primary language was Spanish. The composition of the working groups were as follows:

Nature of Groups

Working Group I: Culture, Cognition and Science Learning

James Buschman	Leader	U.S.A.
William McIlwaine	Rapporteur	U.S.A.
Armando Contreras	Rapporteur	Venezuela
Audrey Champagne		U.S.A.
Frederick Erickson		U.S.A.
Garnett McDiarmid		Canada
Mary Ellen Quinn		U.S.A.
Martha Villavicencio		Peru

Working Group 2: Theories, Goals, Strategies

Eduardo Luna	Leader	Dominican Republic
Joseph Cliburn	Rapporteur	U.S.A.
Eduardo Hess	Rapporteur	Chile
Bill Aldridge		U.S.A.
Jose Curbello		U.S.A. (Puerto Rico)
James Gallagher		U.S.A.
Enrique Góngora		Costa Rica
Carolyn Kessler		U.S.A.
María Luz López		Mexico
Edward Ortleb		U.S.A.
Elizabeth Petrovich de Molina		Panama
Pablo Rodas		Guatemala

Working Group 3: Program Development

Alejandro José Gallard - M.	Leader	U.S.A.
Nasrine Adibe	Rapporteur	U.S.A.
Saulo Rada	Rapporteur	Venezuela
Gladis Bottaro Marques		Brazil
Patricio Daowz		Mexico
Max Maddox		Australia
Victoria Moreno		Mexico
Francis Pottenger		U.S.A. (Hawaii)
Murray Smith		Canada
Pedro Turina		Chile
Andrew Ucbebor		Dominique

Working Group 4: Teacher Education

Sarah Gonzáles	Leader	Dominican Republic
Jerry Skoog	Rapporteur	U.S.A.
Heraclio Ruival	Rapporteur	Chile
María Victoria Aviléz		Mexico
Deyanira Barnett		Panama
George Dawson		U.S.A.
Vincent Lunetta		U.S.A.
Marta Pernambuco		Brazil
Sylvia Núñez		Panama

Discussions centered over the duration of the conference for a total of approximately 6 hours. The Working Group members including the group leaders and rapporteurs were charged as follows:

1. Attend and participate actively in all Working Group sessions.

2. Apply ideas developed in the prepared papers to their respective theme by

   a. determining the problems, issues, and changes needed to improve education in this thematic area.

   b. identify activities in progress related to this theme in (1) research, (2) development, and (3) practice.

   c. identify obstacles to research, development, and improved practice in this thematic area. (We understand the money problems, so focus your attention on other obstacles.)

   d. identify available human resources and other relevant resources in your state, nation, or internationally.

3. Contribute to an oral report.

Following deliberations and discussions, rapporteurs and the group leader prepared an oral report which was presented at the closing session of the conference and a written report which follows:

<u>Group 1: Culture, Cognition, and Science Learning</u>

Based on experiential knowledge and research data, it was evident to group members that learned cultural background can have a serious impact on learning and understanding in science. Moreover, it was recognized that many teachers have limited awareness of this relationship, and even though it is of considerable importance, few teachers utilize knowledge about students' cultural background in planning and implementing science lessons. Students' viewpoints on topics in science, which may derive from their cultural beliefs systems largely are ignored even though their viewpoints have an important effect on their ability (or willingness) to learn science content. Such awareness is not addressed in most instructional materials nor is it addressed in teacher education programs.

Four main problems were identified by the group members:

1. Generally, in the educational community, there is little awareness of the influence of cultural forces in classroom learning.

2. There is a reluctance on the part of science teachers, scientists and leaders in science education to consider the influences of students' cultural background on science learning because of the international (cultural) nature of science.

3. There is need for increased awareness of, and attention to, cultural considerations in science learning and for classroom techniques in helping students from different cultural backgrounds.

4. There is a paucity of curricula and support systems to educate science teachers appropriately regarding the needs identified in #3.

Parallel to the foregoing problems, the group identified some obstacles that are essentially sociological and epistemological in nature. The most obvious social obstacle is that teachers usually act as 'gatekeepers' to knowledge; that is, they control not only students' access to scientific information, but also disallow a flow of information about 'science' from the students. Furthermore, implicit within the framework of gatekeeping, there is the ultimate authority of political groups. The epistemological obstacles can be viewed as a lack of knowledge of both science and cognition. In addition, there is a lack of a clear understanding of cultural conflicts and boundaries in the classroom micro-culture.

In order to use fully some of the existing resources, two areas must be recognized by teachers, researchers, and policy makers. First, they must generate some ideas on how to overcome the social and epistemological obstacles encountered in teaching science. Second, they must strive for cultural interchange within the framework of each other's views.

One example of ongoing activities which should be viewed as resources is the inclusion of courses in anthropology and international education in teacher training programs. Another resource available for researchers is to pay particular attention to the work of international researchers such as McDiarmid, Smith (Canada), Villavicencio (Peru), and Kessler and Quinn (U.S.A.) who were able to document the effectiveness of incorporating students' cultural perspectives in existing science curricula. Also schools should provide a setting in which multilingual learning can take place possibly modeling the approach used in San Antonio, Texas.

<u>Group 2: Objectives, Theories, and Strategies of Science Teaching</u>

The discrepancies among (a) science as practiced by scientists, (b) science as taught in schools, and (c) science as popularized by different cultures (including the media) served as a complex framework for initiating Group 2's discussions. Science as practiced by scientists is open-ended, tentative, and subject to change in the face of new evidence.

One of the challenging tasks facing teachers of science at all levels is to help students comprehend the tentativeness of scientific knowledge when so much scientific knowledge exists.

Complicating this difficulty is the practical reality that much of science is taught in a very dogmatic manner. This style of teaching results in a modification, on the students' part, of the nature and significance of science. Furthermore, this modification serves as an obstacle to the teaching of science.

There are many causes that promote dogmatic teaching. One is that dogmatic teaching is relatively easier for teachers. It also serves as a vehicle to mask inadequacies of knowledge in science. Dogmatic teaching also relieves the teacher from taking into account individual learning styles and cultural diversity. Further, elementary and secondary teachers are the products of institutions which teach dogmatically.

There are many solutions to the problem of teaching science dogmatically. For example, workshops can be initiated in which teachers may look critically at, and reflect about alternatives to dogmatic teaching.

Another problem which affects the teaching of science derives from the ethnic differences of people. Not only do ethnic differences occur from town to town and community to community, but also between the instructor and the student. These ethnic differences result in conflicts of communication which in turn incites negativism between learning and teaching.

Group 3: Program Development

Group 3's discussions were hampered by the complexities inherent in developing science programs for diverse audiences with varied systems of beliefs and values, which frequently are at odds with the values which underlie science. Group members agreed that a theoretical framework appropriate for guiding program development was needed. This framework should include those forces which program developers must consider and act on including students' background knowledge, values, and beliefs; society's expectations and needs; students' special needs within that societal framework; teachers' values, beliefs, knowledge, and skills; the changing nature of science and technology; and the resources available to formulate and deliver the program.

The group recommended establishment of a network of program developers to exchange information and ideas. The group itself could serve as a nucleus but members recognized the need for strengthening existing professional organizations and intergovernmental agencies such as ICASE, NSTA, and OAS to provide vehicles for better communication among science program developers and researchers from relevant fields. Models for networking which could provide both data and organizational patterns included the British Council, SEMEO (South East Asian Ministries of Education Organization), and APEID (Asian Program for Educational Innovation and Development).

As the discussion progressed in the group, critical issues to program development that have not been adequately resolved or researched were identified. These are listed below:

1. Selection of science content to be taught, its organization, and sequencing.

2. Clarification of the objectives of teaching science.

3. Development of effective teacher education programs for conceptual understanding of science.

4. The need for adult education in science in addition to the formal education of science during school years.

5. The need to synthesize findings of research in Anthropology, Communication, Linguistics, Neurobiology, Psychology and Philosophy and to examine their relevance to science education.

6. The need for raising consciousness and awareness of the public to the importance of science education.

7. The need for educators and policy makers to recognize cultural diversity of the learners and their communities and to take necessary actions reflective of this new awareness.

Group 4: Teacher Education

Science teacher education is an essential element in the development of scientific literacy. The education of science teachers has come a long way in many countries in the Americas over the past several decades as we have moved away from the apprenticeship training and toward the education of competent professionals. However there is need for further improvement in teacher education programs. This report identifies some specific problems relevant to both preservice and inservice science teacher preparation and to the certification of science teachers. It also outlines a series of recommendations to improve the quality of teaching in the introductory sciences.

General Problems

1. Talented university students frequently do not contemplate careers in secondary science teaching due to the low status of the profession and to salaries not competitive with other forms of employment open to science graduates.

2. For many students enrolled in science teacher preparation programs, school teaching is not a first career choice.

3. Science teacher preparation programs frequently suffer a low status relationship with other programs preparing university students for careers in science.

4. Many persons in decision-making positions in science teacher preparation have an excessively narrow view on what science teacher preparation ought to be.

5. Programs of science teacher preparation frequently lack adequate

links with schools, local communities, and departments and ministries of education.

6. Science teachers often do not have adequate understanding of the fundamental science concepts and processes they are expected to teach.

7. Science teacher preparation does not provide an adequate understanding of the nature and the history of science.

8. Teachers usually have better preparation for teaching concepts and principles of science but lack the background for teaching applications of science.

9. Selection of teachers for particular teaching positions often is not sufficiently based upon competitive qualifications.

10. Programs in teacher preparation should have depth and stability, but all too often they show excessive resistance to change.

Recommendations

Specific actions should be undertaken by departments and ministries of education and by professional associations of teachers to address the problems identified above. To improve science education and its public image, changes should be initiated in both preservice and inservice programs. In this respect, the following actions should be seriously considered:

1. To improve the image of public education and the status of teachers generally and science teachers in particular, departments and ministries of education and professional association should: Improve communication channels between schools, teachers, and the public; provide recognition of and monetary incentive for science teachers; develop media programs to illustrate the importance of science teachers; promote continued professional growth among science teachers; and develop programs to promote the social importance of teaching.

2. Promote professional associations among teachers to enhance and strengthen the communication channels between science teachers and educational researchers in the Americas through the use of publications, meetings, networks, and other appropriate means.

3. Improve preservice and inservice science teacher education through the implementation of special programs, workshops, etc. which address applied and basic science; ethnic, sociological, and psychological issues related to science teaching; theories of learning and teaching; and other topics which can enrich teachers' background and skills.

4. Enhance the knowledge, skills, and resources of science teachers through the use of communications media, international and national conferences on science and science education, and internships in schools in other locations and in other nations.

CHAPTER 7 SUMMARY AND PROJECTIONS

This seminar marks an initial step in two new and important directions. First, it is a beginning in cooperative action between science educators in Latin America and their English speaking counter-parts in the U.S., Canada, and the Caribbean. Up to now, we have not worked closely to seek solutions to common problems. Language differences have constituted a barrier which can be overcome as we move forward to address concerns about more effective instruction in science for youth.

This seminar has demonstrated the ease with which science educators can work together. In spite of differences in language and cultural backgrounds, science educators share other cultural bonds which made communication easier and more productive than we had anticipated. We share a knowledge base and a belief system which are based in science and technology. In addition, we share a knowledge base and belief system that are founded in our background, education, and experiences as teachers of science. We also share a commitment to the future; as scientists and educators, we are doubly committed to the future because both science and education are future-directed.

In spite of the language differences, the participants in the seminar found communication easier than expected for another reason: We all are Americans and the same spirit and vision which lead our ancestors to the New World (whether it was one generation ago, or ten, or more) still pervades. Moreover, that spirit and vision which permeates American thought and life also is compatible with and enriches the values and belief systems which we all share as scientists and educators.

Therefore, the participants in the Seminar learned quickly that cooperative work across national and linguistic boarders could occur and would be productive. Before the Seminar came to a close, two important projects were initiated, one between science educators in Panama and the U.S. and a second between science educators in Dominican Republic and the U.S. Both of these projects have continued to develop during the time since the Seminar ended. Moreover, additional projects have been initiated and other science educators from seven nations, who were not able to participate in the Seminar have asked to be involved in cooperative efforts and in subsequent Seminars.

The second important direction to emerge from this Seminar in which initial steps were taken concerns the Seminar Theme -- The study of relationships between cultural background of youth and science learning. Through papers and deliberations comprising this Seminar, we learned about important work in Canada, the United States, Mexico, Panama, Venezuela, Brazil, and Peru which enhances our understanding of the connections among cultural background of youth, their cognition, and the learning of science.

For several years, now, scholars in various parts of t world have been studying children's naive conceptions, misconceptions, . entry level knowledge and skills pertinent to learning science. Howeve., only a few of these scholars have looked beyond learners' knowledge, to study how attitudes, values, and beliefs about nature, natural events, and causality influence learning. The differences between the work of the scholars who study children's misconceptions or naive conceptions and other scholars who are concerned with understanding the relationships among culture, cognition, and science learning may seem slight, on the surface; but they are profound! In the former case, there has been a tendency to eschew the students' knowledge as invalid, needing to be corrected. In the latter case, students' knowledge, values, and beliefs are considered a resource which can be built upon, at least as an alternative view, to enrich understanding.

The work of contributors to this Seminar, including that of Fred Erickson, Martha Villavicencio, Murray Smith, María Avilés, Juan Gutiérrez-Vásquez, Garnett McDiarmid, Audrey Champagne, and Ubiratan D'Ambrosio, represents new visions of how we can utilize students' entry level knowledge to increase the effectiveness of science instruction. However, we must hasten to recall that this work, as exciting and promising as it may seem, is only in its infancy. The depth of knowledge of any one cultural group on which science educators can base their work is very limited now. And at this time, we know very little about the transferability of understanding of the relationships among culture, cognition, and science learning from one group to another. For example, to what extent can the work of Smith with Canadian Plains Indians, and McDiarmid with Eastern Canadian Indians living in urban settings be of utility to helping us, in Detroit, or any other urban center, understand how to be more effective in teaching science to Black students whose culture blends both rural and urban traditions? Or how can the knowledge acquired by Avilés and Gutiérrez-Vásquez in Mexico and by Quinn and Kessler in Texas benefit other science educators? What principles and guidelines can we extract from the accomplishments to date? What additional research is needed? The Working Group Reports (Chapter 6) constitute some tentative answers to these questions, and we can be sure of one principle at this time: Instruction which shows regard for and builds upon what learners already know and believe will be more effective than instruction which is intolerant of learners' knowledge and beliefs.

We also can be sure of another point: More research, developmental work, and teacher training are needed if we are to realize the potential of this line of endeavor. Moreover, the work may need to be culture-specific until we learn more about valid means of transfer of understanding about teaching and learning from one cultural group to another.

To enhance these early successes which surrounded this first Inter-American Seminar on Science Education, the Editors of this publication offer the following recommendations for future actions:

1. Exchange of information about science education research, development, and teacher education needs to occur among scholars, developers, Ministries of Education, and universities throughout the Western Hemisphere. Mechanisms for exchange of information need to be established and maintained including:

   - A regular Hemispheric Congress on Science Education that could occur each 3-5 years. A second Inter-American Seminar on Science Education is already being planned for Washington, D.C. in March, 1987 which could serve as a foundation for a larger, more extensive, long term plan for a recurring Hemispheric Congress.

The purposes of this Hemispheric Congress would be to promote research and development in science education and science teacher education in individual nations and to enhance these efforts through information exchange.

- Science education journals normally printed in English could prepare and disseminate abstracts of articles in Spanish for distribution in Latin America; conversely, Latin American science education journals could prepare English abstracts for dissemination in the U.S., Canada, and other English speaking nations. ERIC and REDUC could serve as dissemination vehicles.

- Science education journals normally printed in one language (e.g. English) could prepare one edition per year in another language (e.g. Spanish) highlighting a topic of particular interest. The Japanese Journal of Science Education is already printing one issue per year in English to make Japanese research more widely available to scholars around the world who also read English. Spanish, Portuguese, and English speaking scholars could enlarge their audiences by following this initiative.

- The Network of Science Educators (Appendix 3) and the List of Journals (Appendix 4) can serve as a starting point for larger networks and resource lists that will need periodic updates. A first step in information exchange is to know the resources and the persons involved. These appendices represent small initial steps in these directions that will need much further work.

2. Research on the connections among culture, cognition, and science learning needs to be enlarged and given more visibility. It should not be limited to small groups in remote centers. It is equally pertinent in understanding and improving science education for Black students in U.S. cities, Arab and Asian immigrants who come to our schools in many parts of the Americas, rural "immigrants" to cities where ever they may be found, religious fundamentalists, and any other group whose background knowledge, values, and beliefs are different from those on which contemporary science and technology are based.

3. Science educators in each nation must work with other scholars from related fields and with leaders from government, business, and other influential groups to determine the directions for science education needed for the people of their nation. The goals and directions of science education which have guided us in the past need careful examination because the world of tomorrow--the world in which today's youth will live--will require knowledge, skills, and values not adequately engendered through current programs. Therefore, people in each nation should give careful thought to the purposes and goals of science instruction in the schools and to the policies which influence its implementation.

4. As each nation establishes renewed purposes and goals for science education, it is inevitable that new programs will be needed as each nation in the Americas strives to serve a wider segment of their youth, many of whom have had little access to instruction in science and

technology. Therefore, program development, course development, and preparation of new instructional materials for teaching science and technology will be essential. Such projects may best be done by groups on a national basis, but the possibilities of cross-national program development efforts in science and technology should be explored.

5. As we learn more about teaching science to youth from different cultures, and as the goals and purposes of science education change, the education of science teachers must also change. Therefore, projects for science teacher preparation and for the continuing education of teachers in service will be of increasing importance. The task ahead is not merely to provide sufficient numbers of science teachers for schools. The task will include development of teachers who possess understanding of both science and technology and who also understand how to teach science and technology to youth whose values, beliefs, and background knowledge may differ from theirs. In developing new programs for education of prospective and practicing teachers new developmental projects will be needed. These projects may be based in single institutions, or they may take on a national or a multi-national character.

In closing, the writers call for action! Members of the science education community in the Americas see the needs which confront us. Now we must begin, each in our own way. The collective work of this seminar has helped all of us see the way more clearly. It has also given us new allies with whom we can join forces across national boundaries. We now must begin with research and development in curriculum planning, instructional design, teacher education, and policy formulation. We must begin to share information, ideas, and personnel more frequently. Above all, we must begin. . . .

APPENDIX 1

INTERAMERICAN CONFERENCE ON SCIENCE EDUCATION

LIST OF PARTICIPANTS/SEMINAR PLANNERS

Nasrine Adibe
Professor of Science Education
Long Island University
Greenvale, NY, USA

Bill Aldridge
Executive Director
National Science Teachers Association
Washington, D.C., USA

María Victoria Aviléz
Professor of Science Education
Centro Michoacano Para la Enseñanza de la Ciencia
Patzcuaro, Michoacan, Mexico

Deyanira Barnett Herrera
Professor of Science Education
Estafeta Universitaria
Panama, Republic of Panama

Minerva Jiménez de Baptista
Ministry of Education
Panama, Republic of Panama

Gladis Bottaro Marques
Education Coordinator
Ministry of Education and Culture
Brasilia, Brazil

James Buschman
Director Latin International Studies Center
Kalamazoo College
Kalamazoo, MI., U.S.A.

Audrey Champagne
Project Manager
American Association for the Advancement of Science
Washington, D.C., USA

Joseph Cliburn
Graduate Student in Science Education
University of Southern Mississippi
Hattiesburgh, MS, USA

Armando Contreras
Graduate Student in Science Education
Michigan State University
East Lansing, MI, USA
(On leave from Universidad de Los Andes, Venezuela)

Jose Curbello
Professor of Science Education
Universidad de Puerto Rico
Puerto Rico

Patricio Daowz
Division of Educational Planning
Ministry of Education
Mexico D.F., Mexico

George Dawson
Professor of Science Education
Florida State University
Tallahassee, FL, USA

Frederick Erickson
Professor of Teacher Education
Michigan State University
East Lansing, MI, USA

Carmen de Fanilla
Professor of Chemistry Education
Universidad de Panama
Panama, Republic of Panama

Alejandro Gallard
Bilingual Consultant
Genesee Intermediate School District
Flint, Michigan, USA

Enrique Góngora
Professor of Mathematics Education
Universidad Estatal a Distancia (UNED)
San José, Costa Rica

Sarah Ines González-Sued
Professor of Science and Mathematics Education
Universidad Catolica Madre y Maestra
Santiago, Dominican Republic

Eduardo Hess Mienert
Professor of Science Education
Ministry of Education
Santiago, Chile

Carolyn Kessler
Professor of Bilingual Education
University of Texas
San Antonio, Texas, USA

Luz María López
Professor of Science Education
Universidad Autónoma de México
México D.F., México

Eduardo Luna Ramia
Professor of Mathematics Education
Universidad Catolica Madre y Maestra
Santiago, Dominican Republic

Vincent Lunetta
Professor of Science Education
The University of Iowa
Iowa City, Iowa, USA

Maxwell Maddox
Professor of Science Education
University of Newcastle
New South Wales, Australia

Garnet McDiarmid
Professor of Curriculum Theory
Ontario Institute for Studies in Education
University of Toronto
Toronto, Ontario, Canada

William McIlwaine
Professor of Science Education
Millersville University
Millersville, PA, USA

Sylvia Nuñez
Professor of Chemistry Education
University of Panama
Panama, Republic of Panama

Edward Ortleb
Science Education Supervisor
Saint Louis Public Schools
Saint Louis, MO, USA

Marta Pernambuco
Professor of Science Education
Universidade Federal do Rio Grande do Norte
Brazil

Elizabeth Petrovich de Molina
Professor of Curriculum
Universidad de Panama
Panama, Republic of Panama

Francis Pottenger III
Professor of Science Education
University of Hawaii
Honolulu, HI, USA

Mary Ellen Quinn
Coordinator of Bilingual Education
Alamo Heights School District
San Antonio, TX, USA

Saulo Rada
Professor of Mathematics Education
Centro Nacional Para el Mejoramiento de la Ensenanza de la Ciencia
Caracas, Venezuela

Pablo Rodas Ralón
Professor of Philosophy and Psychology
Universidad de San Carlos
Guatemala

Heraclio Ruival
Professor of Physics
Universidad de Buenos Aires
Buenos Aires, Argentina

Gerald Skoog
Professor of Science Education
NSTA President
Texas Tech University
Lubbock, TX, USA

Murray Smith
Mathematics and Science Consultant
Frontier School Division
Dauphine, Manitoba, Canada

Pedro Turina
Director Science and Technology Education
Organization of American States
Washington, D.C., USA

Andrew Ucbebor
Educational Policy Consultant
Department of Scientific Affairs
Washington, D.C., USA

Martha Villavicencio Ubillus
Professor of Science Education
Instituto Nacional de Investigación y Desarrollo de la Educación (INIDE)
Lima, Peru

APPENDIX 2

CONFERENCE PROGRAM

PANAMA, DECEMBER 10-14, 1984

MONDAY, DECEMBER 10

5:00 p.m. Registration, Informal Introductions

7:00 p.m. Seminar Opening ATLAPA Conference Center
Master of Ceremonies: Pedro Turina, OAS - Washington, D.C.
Welcome: Ramon Tello, Deputy Director, OAS - Panama
Bill Aldridge, Executive Director, NSTA
Introductions
Opening Addresses
Pedro Turina, OAS. . . . . . . Problems of Science Education in the Americas
James J. Gallagher . . . . . . Educating Youth for a World of Advancing
Michigan State University Technology

9:00 p.m. Dinner

TUESDAY, DECEMBER 11

9:00 a.m.Plenary Session. . . .ATLAPA Conference Center
James J. Gallagher. . . . . . .Presider
Frederick Erickson. . . . . . .Cultural Differences and Science Education
Audrey Champagne. . . . . . . .Children's Ethnoscience: An International Perspective
Saulo Rada. . . . . .Activities of CENAMEC: The Improving of Science Teaching in Venezuela
René Salamé. . . . . .The Training of Science Teachers

11:30 a.m. Discussion Groups
Group A - Theory. . . . . . . .Audrey Champagne - Presider
Group B - Practice. . . . . . .E. Hess - Presider

12:30 p.m. Lunch

2:30 p.m. Concurrent Paper Presentations ATLAPA
Group A: Theory. . . . . . . .María López - Presider

Mary Ellen Quinn and. . . . . .Bilingual Children's Cognition and
Carolyn Kessler Language in Science Learning

Murray Smith. . . . . .A Model for Teaching Native Oriented Science

Group B: Practice. . . . . . .Sarah Gonzalez - Presider

Gladis Bottaro Marques. . . . .Brazil's Project for Improvement of Science and Mathematics Education

Vincent Lunetta . . . . .Teacher Education and Development

4:00 p.m. Plenary Session

George Dawson . . . . .Assignments for Working Groups

4:30 p.m. Working Groups

Theme 1 - Culture, Cognition, and Science Learning
Leader: J. Buschman
Rapporteurs: W. MCIlwaine, A. Contreras

Theme 2 - Goals and Strategies for Science Teaching
Leader: E. Luna
Rapporteurs: J. Cliburn, E. Hess

Theme 3 - Program Development
Leader: Alejandro Gallard
Rapporteurs: N. Adibe, S. Rada

Theme 4 - Teacher Education
Leader: S. González
Rapporteurs: J. Skoog, H. Ruival

Open Dinner

WEDNESDAY, DECEMBER 12

8:30 a.m. Plenary Session . . .ATLAPA
George Dawson . . . . .Presider
Garnett McDiarmid . . . . . . .Curricular Pluralism Requires Cultural Pluralism
Edward Ortleb . . . . .Instructional Strategies for Teaching Science to Students with Diverse Cultural Backgrounds
Jose Curbello . . . . .The Effects of Teaching Problem Solving Instruction on Students' Achievement in Science and Mathematics: A Meta-Analysis of Findings
Maxwell Maddox. . . . . .Developing Better Science Education Programs: Culture, Alienation and Attitudes

12:30 p.m. Lunch

1:45 p.m. Depart for Tour of. . . .Marriot Lobby
City and Canal

THURSDAY, DECEMBER 13

8:30 a.m. Plenary Session . . .ATLAPA
Pedro Turina. . . . . .Presider
Ubiratan D'Ambrosio . . . . . .Culture, Cognition and Science Learning
Eduardo Luna. . . . . .Brief description of the "Teaching and Learning of Mathematics in Dominican Republic"

10:00 a.m. Concurrent Paper Presentations

Group A: Theory. . . . . . . .James Buschman - Presider

Enrique Góngora . . . . .Some Ideas Relating to the Problem of Teaching Science

Pablo Rodas . . . . .Teaching Science

Elizabeth Petrovich de Molina . . . . . .A Didactic Strategy for the Teaching of Natural Science in Primary Schools

Group B: Practice. . . . . . .Armando Contreras - Presider

Heraclio Ruival . . . . .Report of the Argentinian Project for Improving Science Teaching

Juan M. Gutierrez - Vasquez (Read by M. Victoria Aviléz) . . . . . .Michoacan Center for Science and Technology Education

Martha Villavicencio. . . . . .Implementation of Methodological Alternative for the Teaching of Mathematics to Children From Rural Communities of Puno, Peru, Using Their Language and Culture as a Base

12:30 p.m. Lunch . . . . .Marriot

2:30 p.m. Working Groups - Themes 1, 2, 3, 4

7:00 p.m. Dinner . . . . .National Folklore Ballet - Marriot

FRIDAY, DECEMBER 14

8:30 a.m. Plenary Session . . .ATLAPA

Pedro Turina. . . . . .Presider

Francis Pottenger . . . . . . .Pacific Circle Ocean Fisheries Materials: An Example of Multinational Curriculum Development

Deyanira Barnett. . . . . . . .Science Teacher Training in Panama

Andrew Ucbebor. . . . . .Science Education in Schools - The Caribbean Experience

10:00 a.m. Groups Reports . . .James Buschman - Theme 1
Eduardo Luna - Theme 2
Alejandro Gallard - Theme 3
Enrique Góngora - Theme 4

11:30 a.m. Conference Summary .James Gallagher - Presider
Pedro Turina
Frederick Erickson

12:30 p.m. Lunch

Conference Adjournment

APPENDIX 3

INTER-AMERICAN SCIENCE EDUCATION NETWORK

One of the objectives of the conference was to establish a network of science educators. The following is a list which contains the names and addresses of conference participants and other educators suggested by them. If there is anyone you feel should be part of this network, or anyone reading this list and would like to be included, please contact James Gallagher.

Doménica Abramo
Dpto de Ciencias Naturales
Universidad Católica Madre y Maestra
Santiago, Dominican Republic

Dr. Herb Addo
Institute of International Relations
University of the West Indies
St. Augustine, Trinidad & Tobago

Nasrine Adibe
HOME ADDRESS: 43 Mist Lane
Westbury, NY 11590 USA
BUSINESS ADDRESS: School of Education
C.W. Post Campus of LIU
Greenvale, NY 11548 USA

William Aldridge
BUSINESS ADDRESS: NSTA
1742 Conneticut Avenue NW
Washington, D.C. 20009 USA

Imelda Alvaréz
Universidad de San Carlos
Ciudad Universitaria, zona 12
Guatemala

Raúl Alvarado
Departamento de Ciencias
Universidad Católica Madre y Maestra
Santiago, Dominican Republic

María Victoria Avilés
HOME ADDRESS: Libertad #7, Depto. "O"
61600 Patzcuáro
Michoacán, México
BUSINESS ADDRESS: Apartado Postal 178
61600 Patzcuáro
Michoacán, México

Charles (Andy) Anderson
Michigan State University
College of Education
329 Erickson Hall
East Lansing, MI 48824-1034, USA

Mrs. Carolyn Bally-Gosine
Naparima Girls High School
LaPique Road
San Fernando, Trinidad & Tobago
HOME ADDRESS: 156 Rushworth Street
San Fernando, Trinidad & Tobago

Deyanira Barnett Herrera
HOME ADDRESS: Apartado 4196
Panamá 5, República de Panamá
BUSINESS ADDRESS: Universidad de Panamá
Estafeta Universitaria
Panamá, República de Panamá

Dr. James Barufaldi
Professor of Science Education
Education Building 340
Science Education Center
University of Texas at Austin
Austin, TX 78712

Susana de Souza Barros
Instituto de Física
Universidad Federal do Rio de Janeiro
Rio de Janeiro, Brazil

Jeannette Lejter de Bascones
CENAMEL
Av. Arichuna/Calle Cumaco
Edificio Sociedad Venezolana de Ciencias Naturales
Apartado 75055,
El Marqués, Caracas 107, Venezuela

Estrella Benain de Bello
Apartado Postal 75055, El Marqués
Caracas 1070-A, Venezuela

Gladis Bottaro Marques
HOME ADDRESS: Higs 712 Bl. P C.45
Brasilia DF 70361, Brasil
BUSINESS ADDRESS: Ministerio da Educacao E Cultura
Espl Ministerio
BL-L. 6 Andar S/611
Brasilia DF, Brasil

Workley Brathwaite
University of The West Indies
Faculty of Education
P.O. Box 64 Cave Hill, Barbados
10 Prior Park
St. James, Barbados

James Bushman
BUSINESS ADDRESS: International Studies Center
Kalamazoo College
Kalamazoo, Michigan, USA.

Dr. David Butts
Chair: Department of Science Education
Aderhold Hall
University of Georgia
Athens, Georgia 30602 USA
145 Deerfield Road
Bogart, Georgia USA

Ms. Maria Byron
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Tania Calderín de Guedez
Apartado Postal 75055, El Marqués
Caracas 1070-A, Venezuela

Emma Calderón Alzati
Explanada 726, Lomas Virreyes, México 10, D.F.

Douglas Campbell
Michigan State University
College of Education
205 Erickson Hall
East Lansing, MI 48824-1034, USA.

Agustín Campos
Dirección de Formación Magisterial
Ministerio de Educación, Av. Abancay
Lima, Perú

Cesar Carranza
Universidad Católica, Dpto de Ciencia,
Fondo Pando
Lima, Perú

Audrey Briggs Champagne
HOME ADDRESS: 3100 Connecticut Avenue NW
Washington, D.C. 20008 USA
BUSINESS ADDRESS: AAAS
1776 Massachusetts Avenue NW
Washington, D.C. 20036 USA

Rebecca Cimet
Chalchihui 200. Lomas
Reforma, México, 10, D.F.

Joseph W. Cliburn
HOME ADDRESS: Box 43, Station A
Poplarville, MS 39470
BUSINESS ADDRESS: Pearl River Jr. College
Box 43 Station A
Poplarville, MS 39470 USA

Michael Cole
Laboratory of Comparative Human Cognition, D003
University of California at San Diego,
La Jolla, California 92093 USA.

Victor M. Comparini
Universidad de San Carlos
Ciudad Universitaria, zona 12
Guatemala

Armando Contreras
HOME ADDRESS: 1570I Spartan Village
East Lansing, MI 48823 USA
BUSINESS ADDRESS:
Nurr-Universidad de los Andes
Departamento de Física y Matemáticas
Trujillo, Edo Trujillo-Venezuela

Celia Ana Cortés
UNESCO
0 Calle 17-19 zona 15, Col. "El Maestro"
Guatemala

Leonard Cox
St. Clair Presentation College
Chaguanas, Trinidad & Tobago
19 Murray Park, Old Southern Main Road
Carapichaima, Trinidad & Tobago

Mingrelia Crespo Olmos
Instituto Universitario Pedagógico de Caracas
Dpto de Física y Matemáticas, Av. Páez-El Paraíso
Caracas-102, Venezuela

Jose Curbello
HOME ADDRESS: RR 142, Buzon 181-R
Cactuas, Puerto Rico 00625
BUSINESS ADDRESS: Box "E"
Universidad de Puerto Rico
Puerto Rico 00625, USA

Florene Dalgetty
50 Earth Court
LBI East Cost
Demerare, Guyana
BUSINESS ADDRESS: Ministry of Education,
68 Brick Dam
Georgetown, Guyana

Ubiratan D'Ambrosio
Universidad Estadrial de Campinas'
Caixa Postal 1170
13100 Campinas-SP-Brazil

Patricio Daowz
HOME ADDRESS: Res. Flores Magón
Edif. I López Rayon/6-327
México DF, México
BUSINESS ADDRESS: Subsecretaria de Educación
Conjunto Pino Juárez
Edif "F" (Cuarto Piso)
México DF, México

George Dawson
ISCS EDU 209
Florida State University
Tallahassee, FL 32306 USA

Daniel De Lima
26 Coblentz Ave.
Cascades, Trinidad & Tobago

Mr. Raphael Douglass
Ministry of Education
Alexander Street, St. Clair
Port of Spain, Trinidad & Tobago

Luis Dunstan
Departamento de Física
Universidad de Santiago
Santiago, Chile

David Eck
Education Office
P. O. Box 33
Belize City, Belize

Frederick Erickson
HOME ADDRESS: 1125 Portage Path
East Lansing, MI 48823 USA
BUSINESS ADDRESS: 207 Erickson
Michigan State University
East Lansing, MI 48824 USA

Dr. Juan Esquivel
Director of IIMEC
University of Costa Rica
San José, Costa Rica

Angela de Fabrega
ICASE
Universidad de Panamá
Facultad de Humanidades
Panamá, República de Panamá

Carmen de Fanilla
ICASE Estafeta Universitaria
Universidad de Panamá
Panamá, República de Panamá

Rafael Ferreyra
Unesco
Quito, Ecuador

James J. Gallagher
HOME ADDRESS: 2136 Riverwood Drive
Okemos, MI 48864 USA
BUSINESS ADDRESS: 327 Erickson
Michigan State University
East Lansing, MI 48824 USA
PHONE: (517) 355-1725

Alejandro Gallard
HOME ADDRESS: 1450 A Spartan Village
East Lansing, MI 48823
BUSINESS ADDRESS: 2413 W. Maple Ave.
Flint, MI 48507 USA

Carniola de Garcès
Universidad de Panamá
Escuela de Matemática, Estafeta Universitaria
Panamá República de Panamá

Sergio Núnez Giménez
Centro de Perfeccionamiento, Experimentación
e Investigaciones Pedagógicas, Casilla 16169
Correo 9, Providencia, Santiago de Chile, Chile

Dr. Joyce Glasgow
Teacher Education Development Department
Faculty of Education
University of The West Indies, Mona
Kingston 7, Jamaica
HOME ADDRESS: 36, College Common, P.O. Box 75
Kingston 7, Jamaica

Dr. Bruce Godsave
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Maria del Carmen Gómez
Apartado 219, La Paz
Baja California, México

Enrique Góngora Trejos
HOME ADDRESS: Apartado 2717
San José, Costa Rica
BUSINESS ADDRESS: UNED, Apartado N.2
Plaza González Víquez
San José, Costa Rica

Lucila Góngora
Escuela de Historia
Universidad Nacional
Heredia, Costa Rica

Sarah González-Sued
HOME ADDRESS: Jacuba #8
Santiago, Dominican Republic
BUSINESS ADDRESS: Centro de Investigaciones
Univ. Católica Madre Y Maestra
Santiago, Dominican Republic

Rolly Greenidge
South East Port of Spain Senior Secondary
25 Nelson Street
Port of Spain, Trinidad & Tobago
HOME ADDRESS: 24 Agra Street, St. James

Juan M. Gutiérrez Vázquez
CMECT
Apartado Postal #179
61600 Pátzcuaro, Michoacán, México

Mr. James A. Halliday
Assistanct Registrar
Measurement and Evaluation Division
Caribbean Examinations Division
The Garrison
St. Michael, Barbados
Clevedale Road
Black Rock
St. Michael, Barbados

Ernest Hamburger
IFUSP
C. Postal 20516
Sao Paulo, Brazil

Jarlena A. Hamilton
School of Education
University of West Indies
Kingston 7,
Jamaica, West Indies

Dr. Mariene Hamilton
Department of Educational Studies
Faculty of Education
University of The West Indies, Mona
Kingston 7, Jamaica
Apt. #43 Manor Court News
Kingstion 8, Jamaica

Claudia Harvey
Ministry of Education
Curriculum Division
Hayes and Alexandra St., St. Clair
Port of Spain, Trinidad & Tobago

Gerhard Hausser
Ministerio de Educación - PERME
Managua, Nicaragua

Waltraud Heidenreich
Ministerio de Educación - PERME
Managua, Nicaragua

Elizabeth J. Henry
Grenada Boys Secondary School
Tanteen, St. George's, Grenada
Tyrrel St., St George's, Grenada

Jorge Hernández
Escuela de Biología Marina
Universidad de Baja California Sur
La Paz, B.C. México

Eduardo Hess Mienert
HOME ADDRESS: Los Almendros 4142
Santiago de Chile, Chile
BUSINESS ADDRESS: Ministerio de Educación
Lo Barnechea S/N
Santiago de Chile, Chile

Eustace Hill
Science Coordinator
Ministry of Education
St. John's, Antigua
Radio Range, St. John's, Antigua

Susan Hubert
Holy Name Convent
2, Queen's Park East
Port of Spain, Trinidad & Tobago
4, Brathwaite Lane, Belmont
Port of Spain, Trinidad & Tobago

Bobby Irby
Dept. of Science Education
University of Southern Mississippi
Hattiesburg, MS 39401

Willard Jacobson
Department of Science Education
Teachers College
Columbia University
New York, N.Y., USA.

Minerva Jiménez de Batista
HOME ADDRESS: Camino Real, Betania #9130
Aptdo 6-8198
El Dorado, Panamá, República de Panamá
BUSINESS ADDRESS: Ministerio de Educación
Avenida "Justo Arosemena"
Edificio Poli
Panama, Republic of Panama

Carol Keller
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Carolyn Kessler
HOME ADDRESS: 2500 Jackson Keller #208
San Antonio, TX 78230 USA
BUSINESS ADDRESS: Bicultural-Bilingual Studies
University of Texas at San Antonio
San Antonio, TX 78285 USA

Willett Kempton
Center for Energy and Environmental Studies
Princeton, NJ 08544, USA

Brent Kilbourn
OISE, 252 Bloor St West
Toronto, Canada

Arthur King
University of Hawaii
1776 University Avenue
Honolulu, Hawaii 96822, USA

Dr. Irma King
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Maynard Kong
Universidad Católica
Dpto de Ciencia
Fondo Pando; Lima, Perú

Myrian Kraschilshik
R. Itapicurie - 817 - No.61
Sao Paulo - SP., Brasil

Dr. Peter Kutnick
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Celso Luis Ladera
Universidad Simón Bolívar
Departamento de Física, Sartenejas - Baruta
Edo Miranda, Venezuela

Sharon Laurent
Committee on Science and Technology in Developing Countries
Regional Secretariat CARIRI
Tunapuna Post Office
Trinidad & Tobago

Anthony Lazzaro
Department of Physical Sciences
California University of PA
California, PA 15419, USA

Sylvia Leith
Faculty of Education
University of Manitoba, Winnipeg, Canada

Bob Lepischak
Neepawa, Manitoba, Canada

H. Levine
Graduate School of Education
UCLA, 405 Hilgard Avenue
Los Angeles, CA 90024, USA

Mr. Victor Lookloy
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Altagracia López
Departamento de Matemática
INTREC
Santo Domingo, Dominican Republic

Luz María López
HOME ADDRESS: Callejón de Pino 18
Chimalistac San Ángel
México 20 DF, México
BUSINESS ADDRESS: Facultad de Ciencias
Circuito Exterior, LINAM
México DF, México

T.M. Lowe
Faculty of Education
University of Guyana
Turkeyen, E.C. Dem., Guyana

Eduardo Luna Ramia
HOME ADDRESS: Calle 5, Esq. Ave.
Cerros Gurabo
Santiago, Dominican Republic
BUSINESS ADDRESS: Univ. Católica Madre y Maestra
Autopista Duarte Km. 1.5
Santiago, Dominican Republic

Vincent N. Lunetta
HOME ADDRESS: 1717 Muscatine Avenue
Iowa City, IA 52240 USA
BUSINESS ADDRESS: Science Education Center
University of Iowa
Iowa City, IA 52242 USA

Mr. Claude Lutchman
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Maxwell Maddock
HOME ADDRESS: 39 Kimian Avenue
Waratah West
New South Wales, Australia 2298
BUSINESS ADDRESS: Faculty of Education
University of Newcastle
Newcastle, New South Wales
Australia 2308

James Mahan
321 Education Building
University of Indiana
Bloomington, Indiana 47401, USA

Dr. Dow Maharajh
Chemistry Department
University of The West Indies
St. Augustine, Trinidad & Tobago
60, Gordon St.
St. Augustine, Trinidad & Tobago

Douglas Sharon Mangroo
%Ministry of Education
Alexandra St., St. Clair
Port of Spain, Tinidad & Tobago
36 Mandrin Circle
Santa Rosa Heights
Arima, Trinidad & Tobago

Diana Marinez
Michigan State University
100 North Kedzie Hall
East Lansing, MI 48824-1034, USA

Carlos Gehlert Mata
Univerisdad de San Carlos
Ciudad Universitaria, zona 12
Guatemala

Garnett McDiarmid
HOME ADDRESS: 102 Highland Ave.
Toronto, Ontario M4W 2A6, Canada
BUSINESS ADDRESS: Ontario Inst. for Studies in Educ.
University of Toronto
252 Bloor St. West
Toronto, Ontario M5S 1V6, Canada

William McIlwaine
HOME ADDRESS: 53 Brenner Street
Millersville, PA 17551 USA
BUSINESS ADDRESS: Dept. of Elementary Education
University of Pennsylvania
Millersville, PA 17551 USA

Luis Carlos Meneses
Instituto de Física - USP
Universidad de Sao Paulo
Sao Paulo, Brasil

Barbara Mieres
Sangre Grande Junior Secondary
Graham Crown Trace, Djoe Road
Sangre Grande, Trinidad & Tobago
Junction Road
Sangre Grande, Trinidad & Tobago

Hugo Mora
IIMEC
Universidad de Costa Rica
San José, Costa Rica
P.O. Box 4981
San José, Costa Rica

Victoria Moreno
Universidad de Panamá
Escuela de Física, Estafeta Universitaria
Panamá, República de Panamá

Marco Antonio Moreira
Instituto de Física
Universidad Federal de Rio Grande do Sul
Porto Alegre - Rio Grande de Sul, Brasil

Mrs. Jeanette Morris
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Ivan Navarro
Rector
Instituto Profesional de Estudios Superiores Blas Canas
Curico 465
Santiago, Chile

Miguel Nevarez
Pan-American University
Edinburg, TX 78539, USA

Sylvia Núnez
HOME ADDRESS: Apartado 8019
Panama 7, Republic of Panama
BUSINESS ADDRESS: Escuela de Química
Universidad de Panama
Estafeta Universitaria
Panamá, República de Panamá

Edward P. Ortleb
HOME ADDRESS: 5663 Pernod Avenue
Saint Louis, MO 63139 USA
BUSINESS ADDRESS: Science Office
Saint Louis Public Schools
5910 Clifton Avenue
Saint Louis, MO 63109 USA

Fausta Pajares
INIDE, Van de Velde 160
Urb. San Borja, Lima
Perú

Herma Perkins
The Science Education Center
University of West Indies
Kingston 7,
Jamaica, West Indies

Marta Maria Pernambuco
Departmento de Educacao
Univ. Federal Rio Grande del Norte
Caixa Postal 1611, Agencia UFRN
59000 Natal-RN, Brasil

Elizabeth Petrovich de Molina
HOME ADDRESS: Urbanización Marcasa
Calle D #60B
Panama, Republic of Panama
BUSINESS ADDRESS: Universidad de Panamá-ICASE
Campus Universitario
Edificio de Humanidades 5 Piso
Panamá, República de Panamá

Lester Philip
4 A Todd St.
San Fernando, Trinidad & Tobago

Francis M. Pottenger III
HOME ADDRESS: 426 Portlock Road
Honolulu, HI 96825 USA
BUSINESS ADDRESS: CRDG
University of Hawaii-Manoa
1776 University Avenue
Honolulu, HI 96822 USA

Mary Ellen Quinn
HOME ADDRESS: 2500 Jackson Keller #208
San Antonio, TX 78230 USA
BUSINESS ADDRESS: Alamo Heights High School
6900 Broadway
San Antonio, TX 78209 USA

Saulo Rada
HOME ADDRESS: Res. City Part
Apto. 11, Av. Páez
El Paraíso, Caracas 1021, Venezuela
BUSINESS ADDRESS: CENA EC
Apartado 75055, El Marqués
Caracas 1070A, Venezuela

Dr. Medhat H. Rahim
13828 133 Ave.
Edmonton, Alberta
Canada T5L 3T4

Mr. Mohan V. Ram
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Adan Aníbal Ramírez
Universidad de San Carlos
11 Calle A 11-36, Zona 12,
Guatemala

Carlos Ramírez
Secretaria de Educación e Investigación Tecnológica
Conjunto Pino Suares, Edif "F", 4 piso
México, D.F.

Samuel Ramírez
ICASE
Universidad de Panamá
Estafeta Universitaria
Panamá, República de Panamá

Mrs. Lois Ramsay
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago
78 Seventh St.
Barataria, Trinidad & Tobago

Sundardays Ramtahal
Naparima College
San Fernando, Tin?dad & Tobago
Perserverance Village
Couva, Trinidad & Tobago

Ms. Judy Reay
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Dr. Ian Robertson
Faculty of Education
University of The West Indies
St. Augustine, Trinidad & Tobago

Pablo Rodas Ralón
HOME ADDRESS: Arco 5-6 N 62
Jardines Asunción, Zona 5, Guatemala
BUSINESS ADDRESS: Universidad de San Carlos
Edificio T "11"
2 Nivel Ciudad Universitaria
Guatemala

Nancy Rody
University of Hawaii, 1776 University Ave.
Honolulu, Hawaii 96822, USA

Jose Alejandro Rodríquez
Montalbán, Transversal 31
Quinta Galaxia, Caracas 102, Venezuela

Gerald Rose
Faculty of Education
Inservice Teaching Section
University of The West Indies
Cave Hill, Barbados

Heraclio Ruival
HOME ADDRESS: Terrero 271
Buenos Aires, Argentina
BUSINESS ADDRESS: Facultad de Ingeniería
Univ. de Buenos Aires
Buenos Aires, Argentina

Ricardo Eliseo Salas
Fgta. Puente Sarmiento 840
Buenos Aires - 1405
República Argentina

Prenita Saltes
Trinity College, Moka
Maraval, Trinidad & Tobago
6 St. Lucia St., Federation Park
Port of Spain, Trinidad & Tobago

Gaston Samayoa
Fa. Calle 2-36 zona 1
Guatemala

Gilda Sánchez
Apartado 6-1965, El Dorado
Panamá 6, República de Panama

Ricardo Sánchez
Ministerio de Educación - PERME
Managua, Nicaragua

Hans Schmidt
Ministerio de Educación - PERME
Managua, Nicaragua

Gerald Skoog
HOME ADDRESS: 3214 67th Street
Lubbock, TX 79413 USA
BUSINESS ADDRESS: College of Education
Texas Tech University
Lubbock, TX 79409 USA

Edward Smith
Michigan State University
College of Education
330 Erickson Hall
East Lansing, MI 48824-1034, USA

Murray R. Smith
HOME ADDRESS: Rural Route 3
Gilbert Plains, Manitoba ROL OXO, Canada
BUSINESS ADDRESS: Frontier School Division
121 1st Street NW
Dauphin, Manitoba, Canada

Valerie Stoute
Chemistry Department
University of The West Indies
St. Augustine, Trinidad & Tobago
Flat 19, Bergerac Road
Maraval, Trinidad & Tobago

Beverly Taylor
Ministry of Education
P.O. Box N 3914 or 3913
Nassau, Bahamas

Harold Thompson
Ministry of Education
Alexandra St., St Clair
Port of Spain, Trinidad & Tobago

H. Torrez-Trueba
Bilingual Cross-Cultural Education
Graduate School of Education
University of California
Santa Barbara, CA 93106, USA

Pedro Turina
540E OAS building
1889 F Street NW
Washington, D.C. 20006 USA

Andrew Ucbebor
HOME ADDRESS: Defoor Road
Tocooa, GA 30577 USA
BUSINESS ADDRESS: Department of Scientific Affairs
Organization of American States
Washington, D.C. USA

Martha Villavicencio Ubillus
HOME ADDRESS: Parque Almagro 195, Dpto. 201
Jesus Maria
Lima, Perú
BUSINESS ADDRESS: Dirección de Invest. INIDE
Van de Velde 160
Urbanizacion San Borja
Lima, Perú

Evhan Uzwhyshyn
Department of Education
1181 Portage Avenue
Winnipeg, Manitoba, Canada

Donald Young
University of Hawaii
1776 University Avenue
Honolulu, Hawaii 96822, USA

Jao Zanetic
Instituto de Física - USA
Universidad de Sao Paulo
Sao Paulo, Brasil

APPENDIX 4

SCIENCE EDUCATION JOURNALS AND DATA SOURCES

Introduction

The following is a list of periodical sources suggested by conference participants as relevant to research on science education. Address of the publisher, number of issues per year, cost, and a brief annotation are listed for each periodical. Cost of journals may vary for international mailing or for individual or institutional subscription. If you are interested in any of these publications, write to the publisher for current cost information.

If you know of journals from your own country that publish papers on science education research or related fields, please let us know so that we can share this information with other network members. Information on periodicals should be sent to:

Prof. James Gallagher or Prof. George Dawson
327 Erickson Hall
Michigan State University
East Lansing, MI 48824 USA

Prof. George Dawson
Stone Building
Florida State University
Tallahassee, FL. 32306 USA.

American Biology Teacher

8 issues/year. $30 U.S.A., $48 foreign.
Published by the National Association of Biology Teachers.

Subscription to:
NABT
11250 Roger Bacon Drive
Reston, VA 22090, U.S.A.

It reports on recent advances in biological research and provides teachers with new ideas for classroom, laboratory and field exercises.

American Journal of Physics

12 issues/year. $91. Published by the American Association of Physics Teachers.

Subscription to:
Subscription Fulfillment Department
American Association of Physics Teachers
5110 Roanoke Place, Suite 101
College Park, MD 20740, U.S.A.

This journal is devoted to the instructional and cultural aspects of physics. It publishes articles on both experimental and theoretical physics research as well as physics education research at high school and college levels.

American Mathematical Monthly

10 issues/year. $55. Published by the Mathematical Association of America.

Subscription to:

Mathematical Association of America
1529 Eighteenth St. NW
Washington D.C. 20036, U.S.A.

Dedicated to the advancement and promotion of college mathematics. It publishes expository-didactic articles on "well known" parts of mathematics to make them better known.

Anthropology and Education Quarterly

4 issues/year. $25 individuals, $30 institutions.
Published by the Council on Anthropology and Education.

Subscription to:

Anthropology and Education Quarterly
Council on Anthropology and Education
1703 New Hampshire Ave. NW
Washington D.C. 20009, U.S.A.

It features articles and papers concerned with the application of anthropology to research and development in education at different levels and contexts.

Curriculum Inquiry

4 issues/year. $46. Published by the Ontario Institute for Studies in Education.

Subscription to:

John Wiley and Sons, Inc.
605 Third Avenue; New York, NY 10016, U.S.A.

It features reviews of curriculum theory, evaluation, development, and administration world-wide

Environmental Education and Information

4 issues/year. Write to publishers for cost. Published by the Environmental Institute of the University of Salford-England.

Subscription to:

Taylor and Francis, Ltd.
Rankine Road, Basingstoke, Hamps. RG24 OPR, England

This journal includes papers on the environment with special reference to environmental education at all levels in both formal and informal contexts.

European Journal of Science Education

4 issues/year. $50 individuals, $96 institutions.

Subscription to:

Taylor & Francis Ltd.
Rankine Road, Basingstoke, Hamps. RG24 OPR, England

This international journal publishes articles and reports on applied research in science and teaching education at different school levels.

Science Education

International Wildlife
Bi-monthly. $12. Published by the National Wildlife Federation.
Subscription to:
National Wildlife Federation
1412 16th St NW
Washington D.C. 20036, U.S.A.

This journal publishes reports and papers on the wise use of the world's natural resources.

Journal of American Indian Education
3 issues/year. $12 U.S.A., $14.50 foreign.
Subscription to:
Journal of American Indian Education
Center for Indian Education
Farmer 302
College of Education
Arizona State University
Tempe, AZ 85287, U.S.A.

It publishes papers related to the education of North-American natives. Emphasis is on experimental, historical, and field study research reports.

Journal of College Science Teaching
6 issues/year. $32 individuals, $42 institutions.
Published by the National Science Teachers Association.
Subscription to:
NSTA Headquarters
1742 Connecticut Ave. NW
Washington D.C. 20009, U.S.A.

Devoted to the discussion of contemporary issues concerned with college science teaching.

Journal of Cross Cultural Psychology
4 issues/year. $25 individuals, $54 institutions.
Published by the International Associaton for Cross-Cultural Psychology.
Subscription to:
Sage Publications
275 South Beverly Dr.
Beverly Hills, CA 90212, U.S.A.

This journal publishes, exclusively, cross-cultural research reports with emphasis on empirical studies of individual differences and variation across cultures.

Journal of Environmental Education
4 issues/year. $40 U.S.A., $46 foreign.
Subscription to:
Heldref Publications
4000 Albemarle St. NW
Washington D.C. 20016, U.S.A.

This journal features case studies of relevant projects, evaluation of current research, and discussions of public policy and philosophy in environmental education.

Journal of Geological Education
5 issues/year. $24 individuals, $32 institutions.
Published by the National Association of Geology Teachers.
Subscription to:
Christine Niemoeller
Journal of Geological Education
Box 368
Lawrence, KS 66044, U.S.A.

This journal includes reviews of papers and recently published books as well as original articles concerning geological science and education at both high school and college levels.

Journal of Research in Mathematics Education
5 issues/year. $12 individuals, $17 institutions.
Published by the National Council for Teachers of Mathematics.
Subscription to:
NCTM
1906 Association Dr.
Reston, VA 22091, U.S.A.

It publishes reports on empirical studies on mathematics education as well as summaries of current mathematics research studies.

Journal of Research in Science Teaching
9 issues/year. $90. Published by the National Association for Research in Science Teaching.
Subscription to:
John Wiley and Sons, Inc.
605 Third Ave, New York, NY 10016, U.S.A.

This journal is devoted to the description of empirical studies and reflective analyses of research on the teaching of science at all educational levels.

National Wildlife
Bi-monthly. $12. Published by the National Wildlife Federation.
Subscription to:
National Wildlife Federation
1412 16th St NW
Washington D.C. 20036, U.S.A.

This journal is dedicated to the wise use of U.S.A. natural resources.

Physics Education

6 issues/year. $70 U.S.A., Canada, Mexico, £39.50 others.
Published by the Institute of Physics.

Subscription to:

Physics Trust Publication
823-825 Bath Road
Bristol BS .4 5NU, ENGLAND

This magazine publishes papers and reports on curriculum methodologies and diffusion at both elementary and high schools. It covers most curriculum disciplines.

Ranger Rick

12 Issues/year. $12. Published by the National Wildlife Federation.

Subscription to:

National Wildlife Federation
1412 16th St NW
Washington D.C. 20036, U.S.A.

This journal contains colorful illustrated nature stories for children 6 to 12. It emphasizes child's reading skills and the development of a positive attitude toward conservation of nature.

School Science and Mathematics

9 issues/year. $19 U.S.A., $22 foreign.

Subscription to:

School Science and Mathematics Association, Inc.
126 Life Science Building
Bowling Green State University
Bowling Green, OH 43403, U.S.A.

This journal publishes articles dealing with contemporary research in science and mathematics education as well as papers on curriculum development and evaluation.

Science Activities

4 issues/year. $35 U.S.A., $41 foreign.

Subscription to:

Heldref Publications
Helen Dwight Reid Educational Foundations
4000 Albermarle Street NW
Washington D.C. 20016, U.S.A.

This journal is a storehouse of activities and projects for the classroom science teacher. It covers disciplines such as biology, physics, chemistry, and behavioral science.

Science and Children

8 issues/year. $32 individuals, $42 institutions.

Published by the National Science Teacher Association.

Subscription to:

NSTA Headquarters
1742 Connecticut Ave. NW
Washington D.C. 20009, U.S.A.

Devoted to the improvement of science teaching from pre-school through middle school.

Science Education

5 issues/year. $54.

Subscription to:

John Wiley and Sons, Inc.
605 Third Ave, New York, NY 10016, U.S.A.

This journal publishes articles and reports on research in learning, teaching, and teacher education and essays on new trends in science education.

Science for the People

Bi-monthly. $15 individuals, $24 institutions.

Subscription to:

Science Resource Center, Inc.
897 Main St.
Cambridge, MA 02139, U.S.A.

This magazine features critical and position articles dealing with the application of contemporary scientific and technological knowledge to current societal problems. Occasionally it publishes papers on curriculum and the social implication of science.

The Arithmetic Teacher

12 issues/year. $35 individuals, $36 institutions.

Published by the National Council of Teachers of Mathematics.

Subscription to:

NCTM
1906 Association Dr.
Reston, VA 22091, U.S.A.

This magazine is for elementary school teachers and teacher educators. It features practical information and teaching ideas to be used in the classroom as well as mathematics education articles.

The Mathematics Teacher

12 issues/year. $35 individuals, $36 institutions.

Published by the National Council of Teachers of Mathematics.

Subscription to:

NCTM
1906 Association Dr.
Reston, VA 22091, U.S.A.

Journal for secondary school and introductory college mathematics teachers. It features articles on research studies on current mathematics topics as well as papers on practical ideas to help teachers teach more effectively.

The Physics Teacher

9 issues/year. $60. Published by the American Association of Physics Teachers.

Subscription to:

Subscription Department
American Association of Physics Teachers
5110 Roanoke Place, Suite 101
College Park, MD 20740, U.S.A.

This journal is devoted to the strengthening of the teaching of introductory physics at high school and college.

The Science Teacher

9 issues/year. $32 individuals, $42 institutions.

Published by the National Science Teacher Association.

Subscription to:

NSTA Headquarters
1742 Connecticut Ave. NW
Washington D.C. 20009, U.S.A.

A journal of secondary science teaching with articles on a wide range of contemporary science topics as well as innovative ideas and experiments for the classroom teacher.

Biología

2 issues/year. 250 Mexican Pesos.

Subscription to:

Luz María López
Collejon del Pino 18
Chimalistic, San Angel, MEXICO

This journal is published in Spanish and it is devoted to the improvement of biology teaching in Mexico and Latin America.

Biología

4 issues/year. Write publisher for cost. Published by the Consejo Nacional Para la Enseñanza de la Biología.

Subscription to:

CNEB
Apartado Postal 70-268
Código Postal 01070, MEXICO, D.F.

This journal features papers on different fields of biology and on biology teaching at different school levels. The emphasis is on applied research to improve the practice of biology teaching.

Boletín de Enseñanza.

4 Issues/year.

Subscription to:

Centro de Enseñanza de la Física
Dpto de Física
Facultad de Ciencias
Universidad Nacional Autónoma de México (UNAM).
Apdo Postal N-70-542
México DF 04510. México.

This Journal contains articles that discuss research, projects and methodological issues in the field of science Education.

Boletín Informativo Cediac

12 issues/year. Free.

Subscription to:

CEDIAC
20 de Noviembre No. 18
C.P. 62000
Colonia Centro
Cuernavaca, Morelos, MEXICO

This bulletin features scientific and technological research in Mexico. It also publishes articles on the teaching and history of science.

Chispa

12 issues/year. 260 Mexican Pesos.

Subscription to:

Innovación y Comunicación S.A. de C.V.
Tlacopac N-6
MEXICO 20 D.F.

This magazine introduces children to science by having their experience mature through plays, puzzles, etc. Papers on scientific topics, at the level of school children are included.

Ciencia Hoje

6 Issues/year. U.S. $40.00, S$9000.
Subscription to:
Sociedade Brasileira para o progresso da Ciencia - SBPC.
Av. Wenceslau Braz 71, Fundos
Casa 27 Cep 22290.
Rio de Janeiro, Brasil.

This is a Journal of national and international scientific research.

El Barco de Papel

4 issues/year. Free. Published by the Centro Michoacano para la Enseñanza de la Ciencia y la Tecnología.

Subscription to:
CMECT
Apartado Postal 179
61600 Pátzcuaro, Michoacán, MEXICO

This is a children's journal where the main concern is to motivate children to get interested in science through activities such as: plays, small research projects, science clubs, etc.

Magister.

U.S. $2.00, R.D. $3.00
Subscription to:
Dpto. Publicaciones.
Universidad Católica Madre y Maestra
Santiago de los Caballeros, República Dominicana.

This Journal features articles on mathamatics and physics as well as on the teaching on these disciplines.

Naturaleza

3 issues/year. Write to editor for details on cost.

Subscription to:
Dirección de Comunicación de la Ciencia
Merchor Ocampo 266
Coyoacán, MEXICO 21, D.F.

It publishes reports and research articles related to the natural sciences.

Redes

4 issues/year. Free. Published by the Centro Michoacano para la Enseñanza de la Ciencia y la tecnología.

Subscription to:
CMECT
Apartado Postal 179
61600 Pátzcuaro, Michoacán, MEXICO

Journal for high school and college teachers. It publishes practical information on new trends and approaches for science teaching as well as articles on the application of science to other disciplines.

Resúmenes Analíticos en Educación.

2 Issues/year. U.S. $5.00, R.D. $5.00.
Subscription to:
Centro de Documentación e Investigación de la Educación (CEDIE)
Universidad Católica Madre y Maestra
Santiago de los Caballeros, República Dominicana.

It publishes analytical summaries of studies in education conducted across the nation.

Revista Chilena de Educación Química

3 issues/year. $12. Published by The Ministry of Education.
Subscription to:
Centro de Perfeccionamiento, Experimentación e
Investigaciones Pedagógicas (CPEIP)
Área de Comercialización
Casilla 16162, Correo 9, Providencia
Santiago, CHILE

It publishes research papers on chemistry and chemistry education at both high school and university levels. The journal features new developments on chemistry teaching and laboratory activities.

Revista de Educación

10 issues/year. $31. Published by The Ministry of Education.
Subscription to:
Revista de Educación
Nicanor de La Sotta 1623
Santiago, CHILE

This publication in Spanish features papers on scientific, technological and pedogogical themes addressed to the needs of pre-school and elementary school teachers.

Revista de Enseñanza de la Física

Subscription to:
Asociación de Profesores de Física de Argentina (APFA)
Revista de Enseñanza de la Física
Suipacha 531 2000 Rosario, República de Argentina.

This is a brand new Journal that publishes articles in the field of Physics Education.

Revista de Ensino de Ciencias.

4 Issues/year. U.S. $30.00, S $6000
Subscription to:
Fundacao Brasileira para o Desenvolvimento Do
Ensino de Ciencias.
C. Postal 2089. Sao Paulo, Brasil.

This Journal feature articles that suggest activities to improve the teaching of science in Brazil.