THE UNIVERSITY OF ALBERTA

A CRITICAL ANALYSIS OF THE JUNIOR HIGH SCHOOL SCIENCE CURRICULUM IN THAILAND

BY

© ALISARA SIRISRI

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF SECONDARY EDUCATION

EDMONTON, ALBERTA

FALL, 1986

ISBN 0-315-32529-1

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR: Alisara Sirisri

TITLE OF THESIS: A Critical Analysis of the Junior High School Science Curriculum in Thailand

DEGREE: Doctor of Philosophy

YEAR THIS DEGREE GRANTED: Fall, 1986.

Alisara Sirisri
....

PERMANENT ADDRESS:

383/ 2j Soi Baipolnum
Amphoe Muang, Chonburi
Thailand, 20000.

Date: Sept 5 1986

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "A Critical Analysis of the Junior High School Science Curriculum in Thailand", submitted by Alisara Sirisri in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

....
Supervisor

....

....

....

....

....
External Examiner

Date: 1986

DEDICATION

To the memory of my beloved daughter, Alisa.

ABSTRACT

The primary concern of this study was to critically investigate the junior high school science curriculum in Thailand. The question calling for such an investigation was whether the science program currently presented in the Thai school was relevant to or in the context of the needs and the characteristics of the Thai society and Thai people. The emphasis was given to the form and organization of the curriculum rather than what is actually taught.

The study gave attention to the social situation and cultural attitudes of the country. The frame of reference in this study was informed by an understanding of critical theory and historical hermeneutics. Critical theory made it possible for the author to question unquestioned issues of the school science program and to make problematic the taken-for-granted beliefs that underly the curriculum. The research orientation also included an historical stance which emphasized the understanding of meaning as attributed to situations by individuals. People were not viewed as separate from this world, but as influencing and being influenced by their surroundings. The affinity between critical theory and hermeneutic understanding also suggested a need to look at history and the social context as well as distancing oneself from the situation. As a result this study brought in the history of scientific thought and the

history of Thai education, in particular science education. The history provided the author with an opportunity to grasp how the program originated and what influenced it. In this position the author was in a position to achieve better understandings of the junior high school science program.

Habermas' work on <u>Knowledge and Human Interests</u> was brought in as a reference to view the kind of knowledge presented in the curriculum: What was the recognizable knowledge and what was neglected or left out from the curriculum.

As the analysis of the school science developed, it revealed that the program heavily emphasized a positivistic image of scientists, scientific method and the scientific principles such as laws, theories, definitions and concepts. Scientific knowledge was presented in a static form. Laboratory work was used as a course activity and as a path to reach preset concepts. The curriculum also adopted the notion of "control theory" in order to achieve a level of success set by the curriculum developer. Pre-specified means were assigned to achieve the pre-determined ends as each pedagogical step was strongly suggested. This resulted in a rigid curriculum that deprived the teachers and students of an opportunity to bring their own lived experience into the classroom and give full meaning to the situation in which they found themselves.

Acknowledgements

To acccomplish this study, I am deeply indebted to many individuals. I would like to take this opportunity to express my gratitude and my appreciation to those who supported and encouraged me during the study.

I would like to extend my thanks and appreciation to my supervisor, Dr. K. G. Jacknicke, for his patience, understanding, assistance and guidance through the course of my study.

I am also very grateful to Dr. W. Brouwer and Dr. W. Samiroden for their comments and suggestions on various aspects of the study since the beginning of this project. I also wish to extend my gratitude and appreciation to Dr. T. T. Aoki, who was a member of the supervisory committee at time of my candidacy.

Thanks to Dr. J. Blakey and Dr. M. MacNay for sharing their thoughts and valuable time in reading the study and attending the final examination. Special thanks to Dr. R. Lawson of the University of Calgary, who so kindly gave of his valuable time to act as external examiner. His suggestions are greatly appreciated.

I would like to thanks my friends and colleagues for their support, encouragment and sharing the continuing dialogue. Special thanks to Mary Wagner who has helped editing since the early draft of this study.

This is a special occasion to express my appreciation to my mother for loving, caring and supporting me all through my life.

Finally, special thanks to my husband, Somchai Chuchat, for his support and sacrifice. The last year he has taken full responsibility of being the only parent for our son, Ake Chuchat, in order for me to finish this task.

TABLE OF CONTENTS

Chapter I

INTRODUCTION

Introduction to the Study

In today's world science and technology are everywhere; in every country, society, and community. In many nations, scientific and technological education may help citizens to overcome superstition, animism, and technological ignorance. Thus, science and technology need to be seen as contributing to a way of life.

In the vulnerable situation created by the influx of science and technology, a country like Thailand inevitably finds itself confronted with something of a dilemma. Science may offer numerous advantages, as exemplified in the areas of agriculture, medicine, and pharmacology, where advanced scientific knowledge and technology definitely become a great asset. On the other hand, within the very same areas, science and technology may cause an undercurrent or unpredicted though implicit problems.

Berano mentioned that:

> New technology creates new opportunities for men and societies and it also generates new problems for them. It has both positive and negative effects and it usually has the two at the same time and by virtue of each other. (1980, p.17)

Science and technology have provided humanity with longer lives, more leisure, and increased food, but they have also contributed to insecurity of the state by challenging traditional ways, by increasing interdependence, and by providing the possibility of mass annihilation.

However, for the last ten years the public, such as educators, scientists, professionals, and laypeople, are becoming more aware of the interaction of science, technology, and society. Popular problems, for example, acid rain, genetic engineering, and the use of atomic energy are three examples of issues involving science and technology that affect the interests of many societies. Such issues have resulted in a re-evaluation of the objectives of science education. A trend seems to be developing in which there is a turning away from teaching science as a discipline towards teaching it in a social matrix. Agin and Pella (1972) stated the trend is towards teaching science in such a way that science-society interactions, societal implications of science, and the social responsibilities of the scientists are studied.

This study is grounded in the mundane, in the practice of my own lived-experience, in my search to better understand the kind of science education which should be offered in Thailand secondary schools. It expresses my hope that we, as human beings in community with other human beings with similar concerns, beliefs, and hopes, continue to strive to make the world in which we find ourselves more humane; that is, calling into doubt the taken-for-granted, by critically reflecting and posing new problems and solutions.

Basic to these endeavours is a belief in the potential of informed praxis for emancipatory activity and a belief in not only the potential of, but the need for, science education in such a project. Implicit in all of this is the need for an awareness of self and the possibility of informed thought and action.

The research question being raised here evolves from the contradictions that have occurred in myself. Science education which was the main focus in my past educational background is rather westernized in its orientation. The belief that science education is a universal knowledge is very prevalent. A majority of Thai people, including myself, would normally "accept" knowledge that has been imported into the country as a commodity (a typically positivistic view of knowledge). After studying at the University of Alberta for a period of time, I started questioning, "Does science education in Thailand really offer knowledge that is relevant to the nature of Thai society? Does the process of developing science curriculum that has been borrowed from the West also adopt the notion of teaching science education from the point of view of western tradition as well?" The Science Council of Canada study on science education has provided me with further information regarding the interrelationships among science, technology, and society, or in other words "science in the Canadian Context" (Science Council of Canada, 1984). This study encouraged me to examine science education in Thailand. What kind of knowledge is being presented in Thai school science and from what perspective? Is it relevant to the Thai society? Is it in the Thai context? and What other important knowledge should be included in the Thai school science program?

From observing my society, Thailand, and being a Thai citizen concerned with the relationship among science, technology, and society, I have felt that there have been several contradictions in the Thai culture. First of all, within the Thai culture, science is often seen to be fragmented, value-free, divorced from people's lives and the cultural relations of which science is a part. Thai people are seemingly not aware that science is a human enterprise, that every individual has a potential for developing scientific knowledge and technology. They do not view science as being conducted by human beings of varying abilities and personalities. Myths about science and scientists have occurred in the minds of the Thai people.

Second, there appears to be an apparent lack of critical consciousness regarding the serious implications in the current and generally accepted notion of the meaning of science. Most Thai people view science as something miraculous that can cure all human problems. They tend to accept anything that is the product of science and technology.

Finally, school science education is seen as being preparatory to post-secondary science education. It is probably time for our people to recognize that science can exist outside the current elitist framework of school science and that it's significance lies in the everyday world. It must be addressed as having significance for understanding everyday life rather than being hidden under its present mantle of mystification grandeur.

Jungwirth and Dreyfus (1980) mentions that school science is of necessity based on the notion that it enhances the development of certain intellectual skills which are then transferable to, and thus usable, in everyday situations. Education in science is an essential component of the education of all people living in this world, a world increasingly shaped by the application of science through technology. Above all, this also shapes our thinking as we perceive problems in particular ways. The central concern is not only for those people who are going to choose a career in science, but for the large "public for the future" who will be farmers, planners, bankers, lawyers, legislators, and ordinary industrial laborers.

Thus, there is a need for making sense of this phenomenon called "the Thai school science curriculum." This study attempts to make such concerns the issue for understanding, taking science education as the problematic means of addressing science in Thai society, the implication being that the issue of science, as part of society, begs the issue of science in education. An attempt will be made to show that for educational purposes and social relevance, certain directions are more legitimate than others for science education in Thailand.

Portrayal of Science and Technology in Thai Society

Thailand, which has been categorized as a developing country, is situated in South East Asia and has primarily an agricultural base. Basically, the economy of the country, and approximately forty-five percent of the income, depends on exporting agricultural products. Thailand is one of the major world-wide producers of many products such as sugar beets, rice, pineapple, cassava, and corn. But by the international standard of income and living, the majority of Thai people are still "poor." This evaluation in part reflects the current social situation created by the influx of science and technology, where the labor emphasis has shifted to closely resemble the economy of the West. However, traditionally, Thailand was considered a self sustained and a prosperous society.

Kidd & Kumar have shown that since the late sixties, the demand for increased food production in the Third World has been heavily emphasized by international development agencies and the rich industrialized countries (1981). This external influence dictated an increase in production, which the land could not accomodate, resulting in an increase in investment on technologies which are expensive to obtain and maintain. They also become expensive in other long term effects, such as through causing soils to become infertile.

Thai people who are directly involved with these new technologies have a limited knowledge of how to use them. Those importing the technologies don't appear to have enough awareness of the possible socio-economic and other related effects. Consequently, instead of benefits, there are often harmful side effects. As Radhakrishna (1979) confirmed, noting that technology has been used many times inappropriately. However Thailand also faces a more general dilemma of technology. What seems safe today may suddenly be identified as hazardous and yesterday's successes may become tomorrow's problems. Many of the certainties of our "safe" world have dissipated.

Agriculture is not the only domain in which problems caused by the advancement of science and technology occur in Thailand. Similar problems have been knon to occur in medical science, pharmacology, industries, and with food-additives, and household appliances. For example, in 1984, there was a conference in South East Asia concerning the importation of drugs from Western countries. The conference agenda was "How can we, the people in developing countries, prevent the importing of leftover, post-expiry date, or prohibited drugs?"

In general, peolple in Thailand can easily obtain any kind of therapeutic drugs, or prescription drugs, for example, antibiotics, contraceptive pill, or tranquilizers such as valium. There are pharmacies on every corner in every city. People can obtain a prescription on recommendation from a salesperson who is not a pharmacist. And in spite of the presence of a pharmacist in most drug stores, drugs are easily obtained over the counter. People tend to value the convenience over safety. It could be that they are not aware of the long-term effects of pharmacological and chemical products. For example, almost every house in Thailand uses DDT or other kinds of pesticides or insecticides without any breathing protection.

The social values and standard of living have taken on a materialistic attitude with an emphasis on the products of new technologies. A newly built house in Thailand must have western architecture which is not appropriate to the tropical climate and usually requires air-conditioning to make it habitable. A color television, not black and white, becomes the basic need of many households even in remote areas of the countryside that have trouble receiving broadcasts. Washing machines are the latest fashion in unnecessary household appliances, which along with other such products have become highly valued commodities to people who hardly use them.

Industry is another area that reflects similar problems. Some industries that were prohibited from operating in developed countries have been established in Thailand. Many of these industries or factories can cause a high level of pollution if there are no strict controls to regulate them. There are many cases in which factories have mismanaged their waste products containing substances such as mercury, sulpher or oil, by releasing them into the air, the land and the nearby water resources causing widespread pollution of the environment. The workers in these industries do not have sufficient knowledge about the health risks in the workplace, to force the government to enact legislation governing working conditions.

These problems occur in other developing countries as well. However, for Thailand, we can raise the question: "How can science education help our people to become aware of these problems, to become conscious of the application of science and technology in our society and to live in a safer world?" And more constructively, "how can science education contribute towards educating people so that they themselves may improve the world they live in?" Should not the school science program play a part in this responsibility?

Setti (1969) has stated that schooling in Thailand took people further away from agriculture. The education provided did not enhance knowledge concerning agriculture nor help people reach a better understanding of their country's needs. Many farmers have left their farms expecting to find a better life in a cosmopolitan city (especially Bangkok, the capital city). They have sold their land, partly because their way of life and income from the farm, especially rice farming, could not provide them with the new life of a modern society.

The failure of education to educate youth to appreciate the farm life has created a certain social and cultural crisis. Farming is a fundamental and essential way of life in the rural areas and it is considered to be an occupation that directly aids or supports our nation's economic condition. When these people leave their farms in order to seek a better life in the city, the opposite occurs. Many of these youths are becoming poor laborer in factories, while the farming stagnates.

The Thai people place a great deal of trust in education and have mythologized it. They believe that education is a path to a high standard of living, and that it can provide them with a convenient life: light work (free from physical labor) and a modern house. The parents expect their children to grow up and become people with position and authority, such as government officials or other white collar workers, because these positions are prestigious and do not require great physical effort (labor). The following examples from the interviews done by Lamaimas and Chancha reflect attitudes which are very prevalent:

> I hope my child will be smart in school, I'd like her to do as well as this friend who studied book-keeping and now gets a good salary. That way, my child will be comfortable and won't have to work hard like me. She won't have to dig and hoe all the time like I do.
>
> or
>
> I want my kid to study a lot. I'd like him to be a lieutenant, a colonel, a governer. Working for the governor is good -nice light work. If he studies a lot, the kid won't have to plow fields. (1973, p. 49)

These opinions reflect the belief that children need education to keep up with others and to progress as much as they can in order to attain what they perceive to be as "good life."

Recently, these attitudes have shifted and now working for the private sector with a better salary is more highly prized. The idea of doing light work and gaining prestige in the society has become prevalent. The ideal life is one of ease, one in which food and comfort could be abtained without a struggle and one will prestige, high rank, and power. At the same time, people gradually tend to hold work which requires physical effort in low regard since such work, they feel, is inferior.

Education, especially science education and school science, must contribute and take this responsibility for educating children to appreciate traditional values as well as preparing future citizens who are able to appraise information and adapt themselves to the need of society and to a world which [illegible] becoming increasingly interdependent, scientific and technological in its orientation. Future citizens should be able to criticize and should be aware of the effects of scientific and technological progress.

Lutterodt (1980) offered the thoughtful view that through formal and informal education, schools are the most effective media for transmitting ideology and for preparing students to enter adult life and the labor market. The author's contention is that the interrelationships among science, technology, and society should form a significant part of school curricula, particularly in the science curriculum.

Question to Be Asked

It may be pertinent to ask the questions of what "school science" has been considered appropriate and why? Behind both questions lie issues of social and intellectual change, pressure group arguments and justifications, and power relationships (Waring, 1979).

Recently, there have been several studies that have attempted to point out the current situation of science education in terms of social context. Studies by Aikenhead (1980, 1983), Orpwood and Alam (1980), and the well-known case studies of Olson and Russell (1980) were initiated by the Science Council of Canada, partially as a response to public criticism of the lack of relevance in science education to Canadian context. An extensive survey by Orpwood and Alam (1980) showed that low priority had been given to understanding the role and significance of science in modern society.* It was ranked by high school teachers as sixth after factual content, process skills, appropriate attitudes, practical applications, and reading skills. Junior high school teachers ranked it fourth, while elementary teachers ranked it ninth.

This contention is supported by Aikenhead (1973) where he indicated that the current Canadian school science curriculum is designed for pre-professional training. Aikenhead further stated that such courses are unrealistic for the majority of students as only 5-10 per cent of high school students train for scientific or technological employment. These statistics are paralleled in the Thai situation as less than five per cent of high school students will continue to study science at post-secondary levels. That means less than one per cent of students entering elementary school go on to pursue science at post-secondary levels.

In Britain it was found that there has been insufficient emphasis on up-to-date uses and applications of science. The teaching of science has not been properly linked to the society in which it is taught and in which it is influential. Elton raised an appropriate point in science teaching by stating that:

> ...To my mind, science is part of our culture, and should be taught for that reason... During this period of time (1900 up to now) we have had, without doubt, the best teaching science for the most able pupils that the world has ever seen..., we have produced a splendid body of leading scientists including many Noble prize winners. But the economy of the country has suffered. (1978, p.12)

Elton is very explicit that science teaching, as it has been done, does not contribute to the development of a country. This contention is confirmed by Symons who stated that "the present education in science is out-moded and irrelevant to the majority of students and society" (1975, p. 83).

Over sixty years ago Dewey lamented that "formal education... easily becomes remote and dead, abstract and bookish," and that traditional education, in its formal development was in very specific danger of separating the "subject matter of the schools... from the subject matter of life experience." (Dewey, 1966, p.9-10) Vandervoort pointed out that for Dewey, "Education was the soundest instrument of social, political and moral progress" (1983, p. 40) Dewey saw the necessity of promoting inquiry and creativity in the science classes as a method of preparing students for active participation in the democratic process by developing in them the tools for making sound social and moral judgements.

Did Dewey's ideas have any influence on science education in the thirty years since his death? His argument now becomes a crucial issue in discussing the situation of current science education. A summary of Project Synthesis (a study in the U.S.A. which attempted to answer this question) by Harms and Yager (1981) suggests that Dewey's concerns about science education are as applicable today as they were fifty years ago, and that science education has not yet accepted responsibility for education in the science, technology and society domain.

Aikenhead informs us that science educators are giving urgent attention to the relevancy of science curricula. "Relevant science teaching," according to Aikenhead, "acknowledges that students will encounter science in a social context, and aims at developing interpretive skills and decision-making capacities that enable students to participate effectively in their scientific and technological society" (1983, p.1). Okey (1983) suggests that in the eighties we need a new consensus of science education goals, one which would reflect the real-world of today and the problems students will face tomorrow.

Magoon claimed that "science programs are too often presented as a form of reconstructed logic which supports an epistemology separating knowledge from the knower ahistorically, and without reference to the social interactions that led to its creation" (1977, p. 651-693). Presentation of school science in this approach is not acceptable within an orientation seeking to understand science as a social activity. If we are to regard science education as a social activity, we must, as Young (1974) suggests, ask and attempt to answer questions such as the following:

1. What knowledge is to count as school science?
2. Who will decide what knowledge is acceptable as school science?
3. Why do we educate students in school science (i.e. whose interests are being served)?

The basic question in this study will be for the most part, concerned about "How should we teach science in the secondary school science programs?" to give the Thai students a fuller meaning of science activity within social context?

Purpose of the Study

As an educator, I wish to take the phenomenon described above, as problematic in education, in particular as it applies to the Thai secondary school science program. As I mentioned in the previous section, school science programs should take responsibility for educating the young Thai people to cope with the rapid influx of science and technology from outside the country in a holistic way. That is to teach them to evaluate all scientific and technological issues from all perspectives not just the scientific paradigm.

Thus, the focus of the primary interest in this study is guided by the following motives: To understand fully what is understood as science education-as-planned in the current junior high school curriculum in Thailand. A necessary remark at this point is that I am focusing only on the curriculum-as-planned, not the curriculum-in-use or its implementation. However the attempt to understand this program calls for:

1. A critical analysis of the curriculum-as-plan that reveals the underlying assumptions of the junior high school science curriculum that is being presented in Thai schools at this time (What knowledge is being presented in or dominates the school science curriculum?).
2. Examining within the situation of science curriculum in Thailand, the relevance of the program to Thai society.
3. Emerging from this critical understanding, the rationale for an alternative perspective which could be presented in the school science program in Thailand.

Limitations of the Study

The focus of this study was placed on the junior high school science curriculum in Thailand. (The educational system in Thailand employed the term lower-secondary school. For the convenience of the reader, I referred to the "lower-secondary school" in this paper as junior high school.) The analysis of the curriculum-as-plan is based on documents, such as students' textbooks, teacher's guides, curriculum guides, and other related materials. The effort of this study is to understand school science curriculum-as-plan in the form of texts, and will not consider curriculum-as-experienced by teachers or students.

Chapter II

FRAMEWORK OF THE STUDY

Organization of the Chapter

In this chapter, I would like to outline the framework within which an exploration of science curriculum in Thailand could be possible. Critical theory, particularly as derived from Habermas and the Frankfurt School of thought, will be employed as the investigation stance for this study. It will be considered as a substantive idea as well as a model for interpreting and understanding the curriculum. The notion is useful in the sense that this theory, taking an historically oriented approach to social phenomena, is intended to bring into consciousness the taken-for-granted ways of thinking.

This approach will be used to question the school science curriculum in Thailand, it will be helpful in understanding the underlying meaning in the curriculum, and it will enable one to freely reflect upon the curriculum. My intent has been to go beyond to adopt a problem-solving stance, typically used in most curriculum research, in order to make problematic the assumptions about the curriculum planning as a problem to be solved.

Kempa supported this point by stating that:

> What is needed, it would appear, is more decision-oriented research, i.e., research which

> gives rise to findings on the basis of which positive decisions about instructional strategies, curriculum content and other issues concerning the effectiveness of science education can be taken. (1976, p. 98)

The organization of this chapter will be composed of two parts: the conceptual framework and the theoretical framework or model for interpreting the school science curriculum in Thailand. The conceptual framework will be divided into four sections. The first two sections will deal with the portrayal of the general idea of critical theory and the Frankfurt school, its development, and its essence. This will then be followed by the idea of Habermas' critical theory and its implemention in the field of curriculum. The last section will discuss the affinity between critical theory, hermeneutic interpretation, and how hermeneutic understanding is involved in this study. The second part will have an emphasis on Habermas' work, <u>Knowledge and Human Interests</u> (1972), that discusses three types of knowledge. This will be a frame of reference for looking at the knowledge presented in the junior high school science curriculum in Thailand.

Conceptual Framework

This section will re-examine suggestions from the current educational theorists in considering the usefulness of critical theory as an analytical approach for dealing with the current educational problems and the historic social structure that influences the program.

Why Use This Approach?

The reason for employing this approach in the area of education is that there is some interest among the curriculum theorists in moving away from the narrowly technical problem-solving approach. These interests implicitly acknowledge the boundaries of the different approaches for dealing with problems of curriculum. Simultaneously, these interests anticipate the argument for the usefulness of Habermas' critical theory in the sense that his theory takes an historically oriented approach to social phenomena and is intended to bring into consciousness the taken-for-granted ways of thinking. Habermas does not restrict himself to using any particular model or approach in solving or critiquing the ideology, but rather uses any argument or explanation that can explain to people their false consciousness and lead them to emancipation.

In empirical curriculum theory, theorists adopted the theory of natural sciences. Frequently empirical theory included statistical analysis for describing the particularities of social phenomena in the hope of dealing with the complexity of everyday school reality (Eisner, 1979). The shift to mathematical language emphasized the use of a technical approach that talks about social action as a shift, however, also marks a further movement away from the attention to the historic socio-political aspects of educational problems.

This same movement toward a technological approach is seen when writers like Gay (1980) described technical views of curriculum in ordinary language in order to organize the different proposals for developing curriculum. She focused on proposals that presupposed agreed-upon ends. While she asserted that practical circumstances would require an eclectic approach to the proposals for them to be useful, she disregarded studies that attempted to comprehend the need for an eclectic approach. Studies that would bring reason and self-reflection to the social, political, and communicative aspects of historical educational problems that are implicit in the development of an instructional program.

To give attention to these disregarded aspects of educational problems in curriculum theory, theorists like MacDonald (1975) took direction from Habermas' critical theory. Molnar and Zahorik (1977) acknowledged a range of logical processes and points of view that enter into devising different types of curriculum for different possible uses. Like Eisner, they pointed out a progressive movement away from instrumental reasoning and technological interests in the educational arena, and emphasized the need for other interests and modes of thought.

There are some other educators, who noting the discrepencies between the theory of curriculum development and its practice, questioned the usefulness and adequacy of such a narrow technical theory for developing curriculum. Quite often the presentation of events and the orientation of the discussion were taken for granted and the nature of the problem was accepted as given. And for the most part, these proposals left unasked questions about the origins, for example, the structure conditions in the school, the beneficiaries of the existing conditions, or the interests that shaped the events.

Like other empirical proposals, these suggestions tended to propose an analysis of curriculum that presupposed an absence of theory and to disregard the political relationships that structure institutional imperatives.

The need for critical theory

> One kind of critical response is born in an interest in assisting the work under scrutiny to become more complete, more sophisticated. This is the criticism of a pedagogic who offers criticism which is usable, which can be integrated into the work, improving it...
>
> There is a second kind of critical response which does not wish the other work, which is not interested in the improvement of his work. It is not born in a pedagogic interest, but in a cathartic one. It is ill-tempered, results not in the development of the others' work, but in silence...
>
> Conversation cannot occur unless the participants are willing to maintain a minimal civility, a

> pedagogic orientation and a willingness to be changed by the others. With such conditions present, a vital conversation, indicative of a vital field can occur. (Pinar, 1980, 199-205)

I am interested in the critical of the first sense. I believe that the notion of "critical" in this sense, should take an important and an essential role, as action in the field of curriculum.

In 1979, Elliot Eisner called for new ways to conceptualize the educational problem. He asked, "Why do the schools, so often, pursue simplistic mechanistic solutions to the complex educational problems" (p. 17). He called attention to the roots of Tyler's "model of a rational systematic approach," that lie in the early twentieth century's interest in a scientifically based technology of educational practice. He saw the need for a method which would describe, interpret, and evaluate the complexities and significant qualities of educational life in the broader perspective. Eisner called for an analysis and critical appraisal of the images of education, schooling and teaching.

More recently educators have looked to broaden the view of the curriculum. Their efforts are associated with the use of different approaches to curriculum development and with the call for attention to theory. Their concerns point to an interest in moving away from a narrowly technical view of curriculum and call attention to the need for analyzing curriculum, and thinking about curriculum differently.

Lawn and Barton (1981, p. 16) suggested that what is needed in curriculum studies is a critical appraisal of the way the area is described, an assessment of purposes or intentions, and a critique of superficial analysis and easy solutions, with emphasis on the hidden assumptions that must be revealed and evaluated.

Joel Weiss compared various ways of developing curriculum in order to devise a way to organize and classify different approaches for evaluating the curricula. He asked many questions about the "current curriculum theory," which lead him to consider how can hermeneutics and critical theory help the educators address the issue of work at the classroom level (1980, 176-195). Richard Pratte (1981) suggested that there is a need for a theory to make sense of the phenomenon called the curriculum including its origin, development, and influence.

Aoki (1985) referred to practices such as curriculum development, curriculum improvement, curriculum implementing, curriculum evaluation, curriculum piloting, and curriculum policy making. In the past these practices usually succumbed to a means-ends interpretation, because of the technological ethos that prevails and enframes these areas. However, recently, an increasing number of educators, who have refused to surrender to the taken-for-granted of these curriculum practices, have made these very terms problematic.

It is hoped that this study will be the medium for initiating the dialogue between a curriculum design group and the author to come to understand what should be the essence of the junior-high school science program in Thailand. Hopefully by employing critical theory as the evaluative framework to mediate the dialogue, the effort will also disclose the underlying perspective embedded in the school science curriculum, and open alternatives with which the curriculum may move towards new horizons.

Critical Theory and the Frankfurt School

Before discussing the idea of critical theory further, it should be emphasized that it does not form a unity; it does not mean the same thing to all its adherents. The tradition of thinking which can be loosely referred to by this label is divided into at least two branches- the first centered around the Institute of Social Research, established in Frankfurt in 1923, and the second around the more recent work of Jurgen Habermas (Jay, 1973; Connerton, 1977). The Institute's key figures were Max Horkheimer, Theodor Adorno, and Herbert Marcuse. Jurgen Habermas' recent work in philosophy and sociology recasts their notion of critical theory.

The idea of critical theory can be traced back to the writings of Kant, Hegel, and Marx. Martin Jay (1973) writes that the critical approach to social phenomena has its genesis in German thought of the 1840s, and has developed through dialogue with other schools of thought and with a changing social reality. Critical theory is defined in the work of critical theorists and explicated by them in debate with empirical sociologists. It is developed in the writings of Habermas and earlier members of the Frankfurt School as an attempt to reconceptualize social science theory. They attempted to link their theory with the development of post-industrial society. They have attributed the need for rethinking earlier theories of society and personality both to events marked by the irrationality of the twentieth century European thought and socio-political development, and to the failure of social theory to reflect on the ends it postulates through the use of instrumental reasoning.

The critical theorists of the Frankfurt School who preceded Habermas in the period between the 1930s and the 1950s directed their attention to the contradictory characteristics of the enlightenment of a technological perspective, and to the aspects of modern scientific theory that were inconsistent with the accompanying claims of validity in social theory (Jay, 1973; Held, 1980). They emphasized the importance of the subjective conditions for the revolutionary transformation of social thinking.

In the later years of the Frankfurt School, the theoretical contributions of its most eminent members crystallized in the critique of instrumental reasoning. The concept of instrumental reasoning refers to the adequacy of specified means for the attainment of predetermined ends, and explicitly precludes any reference to the worthiness of the ends themselves. This concept of reason thus contains its own form of irrationality, a contradictory conclusion which is the historical product of the Enlightenment (Thompson, 1981).

During the second World War, writers like Adorno, Marcuse, Horkheimer, and later Habermas saw the critique of instrumental reason as a necessary condition for both the emancipation of the individual from restrictive presuppositions and for any movement beyond totalitarian relationships. Members of the Frankfurt School have contributed to the critique of instrumental reason in such diverse forms of theory as dialectical materialism, psychoanalysis, and hermeneutics (Berstein, 1978).

In the post war period, attention was directed to logical aspects of systematic inquiry that restrict self-reflection, open-communication, and interest in producing a better life (Apel, 1972; Mendelson, 1979; McCarthy, 1978). They placed history at the center of their approach instead of philosophy and society. Yet the issues they addressed went beyond a focus on the past and embraced future possibilities as well. They were aware of the many obstacles to radical change and sought to analyze and expose them. They were thus concerned both with interpretation and transformation.

Each of the critical theorists maintained that although all knowledge is historically conditioned, truth claims can be rationally adjudicated independently of immediate social interest. They defended the possibility of an independent moment of criticism.

The Idea of Critical Theory

The very heart of the critical theory is its criticism of ideology. It claims that ideology is what prevents persons in the society from correctly perceiving their true situation and their real interests; if they are to free themselves from social repression, people must rid themselves of ideological illusion (Jay, 1973; Geuss, 1981).

Generally speaking, ideology is a "world-picture" which stabilizes or legitimizes dominations or hegemony, by virtue of the fact that it supports or justifies reprehensible social institutions, unjust social practices, relations of exploitation hegemony, or dominations that are a form of consciousness. Ideology is a delusion or false consciousness, of certain beliefs, attitudes, and dispositions.

However, Habermas (1971b), in contrast to the earlier members of the Frankfurt School, does seem to use this word to refer to the personal beliefs held in a society. Thus, any critical research program must be initiated by the observation that the people in the society are deluded about themselves, their position, their society, and their interests.

The notion of critique in this framework implies a reconstruction (theoretical) of the conditions of possible knowledge and a critical-reflection (practical) that make unconscious factors conscious in such a way as to imply action (Connerton, 1976b; Held, 1980; McCarthy, 1978). Such a radical stance would allow one to go beyond analysis of the problem to indicate potentially new human possiblities and some direction toward their reality. The critical interpretation allows one to question the fundamental beliefs which inform everyday experience and in which the emancipatory praxis is implicit.

Werner (1979) pointed out that critical reflection forces persons to examine their previously unquestioned views. In the past, I never did question the presentation of the school science curriculum in Thailand, or any other educational matters. It is my intent in this study to adopt a critical stance towards my own presuppositions about the ideology of school science programs and thus emancipate myself from these presuppositions.

Habermas' Critical Theory

Habermas' (1971b, 1979) main concern is emphasized within the public sphere. Implicit in his work is the notion that humanity must not only survive but has to pursue a good life.

In his early work, Habermas explicitly critiques instrumental reason. In his essay on The analytical theory of science and dialectics (1976, pp. 131-162), Habermas describes the five characteristics that distinguish critical theory from empirical theory. These characteristics point to the usefulness of critical theory that both moves away from a narrowly technical approach to educational problems and examine the way this view comes about in current practice.

First, Habermas considers the relationship of theory to its object, a view of the world to its everyday reality. He writes that dialectical theory replaces the objectifying hypothetico-deductive system of statements in empirical theory with the hermeneutical explication of meaning. Those discrete and given categories are replaced with categories whose meaning is gradually determined as the context is developed and theory is seen as a movement of the context to be analyzed. Instead of expressing only interdependent functions concepts are now capable of expressing both function and substance at once. The theories themselves are but a moment of the objective context subject to further analysis.

Secondly, he describes the changed relationship of theory and experience, the view of the world and its experienced reality. Experience as controlled observation of physical behavior is broadened in dialectics to include experience that accumulates outside of scientific observation and interests. A dialectical theory thus drawn upon "the education acquired by the total human subject," and experience through which it articulates itself and against which it verifies itself anew.

Third, this leads Habermas to compare the difference in the relationship of theory to history, the view of the world to its accumulated experienced reality. Historical laws of movement refer to the particular phenomena that are defined in terms of an irreversible process of development and "fundamental dependent relations," rather than to predictable functional relationships between unchanging categories of phenomena. This type of movement points to social developments that are mediated through the consciousness of individuals which gradually come to predominate. At the same time, the direction of movement reveals what society is from what it is not. In dialectical theory, the explanation of any particular phenomena, including historical laws of movement, is dependent upon the totality. The dialectical proceeds both hermeneutically and critically. Thus, the meaning drawn from the consciousness of acting individuals is examined from a sociological perspective that also transforms the concepts brought from other orientations into those the individuals have of themselves.

Fourth, Habermas attends to the relationship of science to practice, of systematic inquiry to practical action. Dialectical theory is intended to remove the strict distinction between fact and decision that characterizes an empirical study of history. Since empirical studies are restricted to causal explanations of individual events, their immediate value is retrospective. Further value can be derived when there is knowledge of empirically proven law-like hypotheses and ends are pregiven. In these instances, limited prediction is permitted and can be translated into technical recommendations but the prediction would hold only under isolated conditions when development (experience) has ceased. The dialectical theory must points out the discrepancy between practical questions and the accomplishment of technical tasks. Here, meaningfulness of practicality would relate to the arrangement of an aspect of everyday life and bring to consciousness its restrictive aspects, while contradictions would refer to this totality and its historical movement.

Finally, he examines the relationship of "value freedom" to the historical and the theoretical research, the notion of separating interests and concern from the production of knowledge. Dialectical theory criticizes empirical scientific theory which separates cognition from evaluation, presupposing that human beings can rationally direct their own fate to the extent to which they uitilize social techniques. The empirical emphasis is on practical interests (understood as agreed upon ends) in the domination of objectified social processes. This emphasis masks both the historical and political nature of processes like instruction and the controlling interests that ground social techniques. the interest in control makes problematic the presupposition that social techniques are inherently freeing. On the other hand, dialectical theroy that proceeds hermeneutically is intended to serve practical and emancipatory interests by criticizing analytical empirical modes of procedure in light of the claims made by them.

The five characteristics with which Habermas distinguishes critical theory from empirical theory raise questions about the thinking implicit in the current science program in Thailand, with particular reference to the perspective presented in the program. How does the program designer group present their view in the curriculum and does the school science program present a particular world view to the students?

Habermas presents "ideology" as fundamentally false consciousness of basic epistemic dimension. The "falsity" in question being "reflective unacceptability" (1971b). Geuss (1981) further elaborated that a form of consciousness that it is reflectively unacceptable ascribes to it a 'genetic' property, that could only have been acquired under conditions of coercion.

An ideological from of consciousness "requires" ignorance of false belief about its own origin or genesis in the sense that given its epistemic principles, emancipation would reject that form of consciousness; namely if one knew that it could not have arisen in conditions of free dimension.

Young (1971) also suggested that ideology is a set of social practices through which partial views or accounts are presented as if they had some claims to universality. A typical example is the way public figures refer to "the national interest" or "the needs of industry."

In this context, critique is a discourse in which the level of consciousness is made problematic. In a critique, the discrepency in level of consciouness leaves open the possiblity that the analysis might be emancipatory by succeeding as an ideology critique in a particular historic content. The aim of critical theory is to bring to a person's awareness the unconscious determinant of their consciousness and behavior, in order to reveal to them that their own coercive social institution is determining them to adhere to their ideological world-picture.

In the initial stage agents falsely think that they are acting freely in accepting the world-picture and acting on it; critical theroy shows them that this is not the case by pointing out social determinants of their consciousness and actions of which they were not aware. In this way, a critical theory makes the subjects in the society aware of their origins.

To enlighten the subjects about their own genesis or origin is just to explain to them how they have become the subjects they are with the beliefs, attitudes, and norms they possess (Geuss, 1981). Critical theory shows them under what conditions and in what "context" they acquired these beliefs, attitudes, and norms, and how they came to hold their basic world-picture.

A critical theory is supposed to induce self-reflection nad thereby produce enlightenment and emancipation.

Self-reflection in critical theory

a. dissolve 'pseudo-objectivity' and 'subjective illusion',

b. makes the subject aware of its own origin,

c. brings to awareness unconscious determinants of consciousness and behavior (Geuss, 1981, p. 70).

By inducing such self-reflection critical theory leads people to realize that the coercion from which they suffer is self-imposed, thereby dissolving the "power" or "objectivity" of that coercion and bringing them into a state of greater freedom and knowledge of their true interest.

Habermas (1971b) did not claim that critical reflection alwasys lead to a rejection of what was originally accepted on authority. It may well lead one to accept it. But his point is that even if one does accept it after reflection, it will no longer be accepted on the basis of authority. A basic relation to it will have been altered. A reflected prejudice can no longer function as prejudice, although it can certainly still be adhered to. This is the emancipation. Critical theory according to Habermas, can overcome an ideological form of consciuosness by reflecting on it's genesis, basing the interpretations on critical theories.

It is necessary to distinguish between those inevitable preunderstanding which are derived simply from one's participation in a culture, and those false preconceptions which are anchored in a systematically distorted form of communication. Critical theory hopes to elicit a self-reflection in which the addressee penetrates and dissolves the latter. It is true that by self-consciously constructing a theory and methodology and by using these to guide its interpretations, critical theory does aim at achieving a certain degree of control over its preunderstanding, however this type of control is fundamentally different from that of ordinary speaking (Thompson, 1981).

Furthermore, Habermas (1971a) argues that even for the theoretically self-conscious aspects of its preunderstanding, critical theory cannot claim a "monological self-certainty." Instead, such a theory must ultimately prove itself by guiding interpretations in which the addressees can recognize themselves.

Habermas rejects the claim to universality which philosophical hermeneutics makes in accordance with its ontological self-understanding and demands that hermeneutic understanding be mediated through critical theory. There are two steps to his argument:

a) The objective context within which our heritage is appropriated contains more than just "cultural tradition." Tradition as a network of symbols and meanings is dependent on actual conditions of social development which are more than just structures of symbols. Therefore, tra[illegible]on is [illegible] a comprehensive category but must be grasped in its [illegible] to other moments of the social context.

b) Given these limits, Habermas goes on to argue that sociology cannot confine itself to verstehen (understanding) procedures, but requires a theoretical reference-system. An effective-historical consciousness would have to become a theory of society which would integrate the history of tradition with that of the other structures with which it is entwined (Mendelson, 1979). Such a theory would become a critique of ideology to the extent that by grasping tradition as but one moment of an objective context, it would be able to penetrate its ideological functions. Such a theoretical frame of reference would transcend the limits of verstehen and make possible a type of causal explanation.

Thompson (1981) clarified the notion of reflection as a reconstruction that refers to the quasi-Kantian exercise of elucidating the conditions which make possible a form of knowledge or a mode of action. In basing the interpretation on history the analyst employs a theoretical reconstruction to reveal the repressed experiences.

Reflection in the sense of critique is concerned with a subjectively constituted illusion which objectively constraints the social actors. The dissolution of such an "illusion" through a theoretically induced enlightenment leads to the emancipation of the subject from previously unconscious constraints (Geuss, 1981). As Habermas (1971b) explains, this criticism is characterized by its ability to make unconscious elements conscious in a way which has practical consequences. Criticism changes the determinants of false-consciousness, whereas reconstructions explicate correct know-how, for example, the intuitive knowledge we acquire when we possess rule-competence, without having practical consequences.

Even though the distinction between these two types of reflection is explicit, it does not imply that they are unrelated. On the contrary, a social science which aspires to a critical stance cannot avoid, in Habermas' view, the exercise of rational reconstruction. For if critique accepts as its task the explanation of a systematically distorted communication, then it must have mastery over the idea of undistorted communication or reasonable discourse, and unfolding the idea of undistorted communication is the reconstructive project of the theory of communicative competence (Heller, 1974).

An immanent critique would still seem possible and desirable to a critical theory which takes seriously hermeneutic insight into the relation of reflection to tradition, of theoretical to practical reason (Thompson, 1981).

Hermeneutic Understanding of the Text

Habermas' main concern in the process of understanding largely depends on the historical consciousness. Because of the nature of this study, Habermas' critical theory provides a fundamental idea for looking at the science program from its origin, influence, and also looking at the history of scientific thought and its influence on the science education program in Thailand. However, an examination of its history, its origin, and its influence is only one part. The other part is an attempt to examine the curriculum-as-plan, which is presented in the forms of programs of study, curriculum guides, texts, lesson plans, and unit plans. Thus it is necessary to bring hermeneutical stance to bear on this study as well.

There are substantial affinities between hermeneutics and critical theory. Habermas incorporates hermeneutic concepts not only on the epistemological-methodological level but also builds them into his philosophy and social theory. The essence of critical theory is self-reflection which needs interpretation as a kind of hermeneutic. The critique of ideologies can fulfill its projects only if it incorporates a certain regeneration of tradition. On the other hand, Ricoeur (1974) sees that reflection is interpretation. He demonstrates that a hermeneutic tradition can only fulfill its program if it introduces a critical distance, conceived and practiced as an integral part of the hermeneutic process.

Ricoeur compares the relation between historical-hermeneutical science and critical-science as contrast between understanding and explanation. For him, understanding would be the portion of the first science, and explanation the lot of the second. If the communication of the past heritage takes place under the condition of distanciation and objectification, then explanation is a necessary step for understanding. That is, we always explain in order to better understand. A text must be explained in its internal structure before being understood in its relation to the interest it arouses and to which it responds. In order to explain it has to have some understanding. But the opposite is also true. If understanding passes through explanation, explanation is complete in understanding. Thus these methodologies are inferred in each other.

The ideological phenomenon is only provisionally irreducible to prejudice or prejudgement, which hermeneutics makes an aspect of preunderstanding, that is, of our finite condition and of our irreducible perspective due to our belonging to history. However, the basic experience from which hermeneutic raises up its controversial claims to universality constitutes in modern consciousness sort of "alienating distanciation" that appears to be the presupposition of every human science. This alienating distanciation is more than a feeling. It is the ontological presupposition which underlies the objective conduct of the human sciences. The methodology of these sciences necessarily implies a taking of distance, which in its turn expresses the destruction of the primordial relation of participation without which there would not exist a relation to the historical as such (Bourgeoise, 1972; Ricour, 1973b).

The notion of alienating distanciation and the experience of participation, makes possible a certain rehabilation of prejudice, authority, and tradition. A person would discover that in fact each person situates within a tradition. In my case, because history precedes me, and my reflection, because I belong to history before I belong to myself, prejudgement also precedes judgement, and submission to tradition precedes the examination.

Therefore if we cannot extract ourselves from the historical becoming, or place ourselves at a distance from it in such a way that the past becomes an object for us, then we must confess that we are always situated within history in such a fashion that our consciousness never has a freedom to bring itself face to face with the past by an act of sovereign independence. It is rather a question of becoming conscious of the action which affects us and accepting that the past which is part of our experiences keeps us from taking it totally in charge and accepting in some ways its truth.

One of the notions that this study would like to use for understanding and analyzing the school science program in Thailand, is Ricoeur's notion of distanciation and participation. His critical hermeneutics reflects the mutual implication of subject and object by altering and emphasizing the human existance as participation and distanciation from the social world (Ricoeur, 1973b). Therefore taking his notion, my situation as a participant in the science curriculum must be augumented by a distanciation from my social world, my society. I need to stand back in order to have a clearer picture about the object of study, that is, the curriculum. I am willing to be objective but at the same time I cannot detach myself from history, from my former social world, and the social reality in which I participate. This is the part that I cannot separate, the part of prejudice, bias, and preunderstanding.

Paul Ricoeur has reconciled the notion of participation and distanciation through new insights into the activity of interpreting the text. These new insights are helpful in such a way that they institute a dialogue between ontology and epistemology, and thus help to re-address the question of validity on new grounds.

Ricoeur points out that the text serves as a model for distanciation which is necessary in all communication. He shows this by tracing the primary distanciation which occurs in speech between meaning and event through its inscription in written texts and the eventual appropriation of its meaning by the interpreter.

For Ricoeur, the critical interest only makes sense through its immersion in the practical situation which it seeks to change. In this sense it carries into being and owes its existence to a tradition within which it finds itself. All human sciences start off by referring back to a lived experience, if only an implicit one, and they provide a certain understanding of this. The intention of hermeneutics is to re-interpret the situation, and the boundaries or horizons of the interpreter are a critical part of this process of understanding. The scheme of analysis does not attempt to re-construct the author's meaning and then interpret or explain them. The intent is to examine the meaning the text has for me and to disclose the text's inherent meaning.

The interpreter must understand the text in a new and different way in order to apply it to the concrete situation. This is like the translator, who must bring the text into an intelligible relation with one's own culture. The past must be conveyed into and applied to the present. In this process our preunderstanding is transformed.

My Interpretation of the Text

When I speak of interpretation, I am describing the interaction of the interpreter and the text. This suggests that I am not acting as a neutral observer; rather, I enter into the text and in a sense re-form the text. There must be some initial understanding of both the subject and the horizon of meaning (Taylor, 1971). It may seem contradictory to speak of "understanding" prior to "understanding in a hermeneutic way." The intent, however, is clear. Before an interpreter begins to interpret the text, the interpreter must be able to create a question which allows the interpreter to enter fully into the interpretation. When we reflect upon the school science program, what is concealed is the perspective of knowledge which underlies it. Habermas (1972) explains this point of interpretation in that the world of traditional meaning discloses itself to the interpreter only to the extent that his or her own world becomes clarified (1971). Something which is unclear is open to the interpreter. It is not possible, however, to know it as if it were some concrete object. Rather, it is only open to further interpretation. This implies that the meaning of a text or texts standing in possible relation to one another may be illuminated only by differing perspectives. In this way interpretation may be viewed as a circle, a hermeneutic circle (Hoy, 1978).

A further point must be made. If something in a text is not clear, then in its illumination we are beginning to bring it from hiddenness so that it may be more fully known. There is, in other words, a dialectic present within the hermeneutic (Gadamer, 1975). The dialectical sense of hermeneutic is the relationship between that which is known and that which is not. The dialectic becomes an important part of the hermeneutic interpretation since it further opens the horizon of possibilities. When I talk about the school science program in Thailand, I should have an idea of the intent of the program, but by no means could I claim to understand the meaning of the program in this context until I investigate further. The 'school science program in Thailand' has some meaning to me, but this meaning is largely placed against a landscape of the unknown. The dialectical sense of the hermeneutic is brought to the surface.

Entering into the interpretation suggests that the interpreter begins to understand differently; there is a transformation taking place. What we may initially expect to find may not appear. We understand not so much what we know partially already, but rather where it is that we have not understood as we should have. The continual interpretation which shows us where we have understood wrongly invites us to return again to that which is already known in a different way (Palmer, 1969).

Schleiermacher (Palmer, 1969) confronted the attempt to analyse and inquire into the possibilities and limits of the process of understanding. Given adequate historical and linguistic knowledge, the interpreter is in a position to understand the other better than she or he has understood herself or himself. The interpreter is viewed as entering into a dialogue with the text; a dialogue with a particular text becomes, in a dialectical sense, a dialogue with other interpretations of the text, for example, the tradition which surrounds the text itself. The dialogue seeks to understand the historical dimension of the text and the influence of past interpretations, both embedded in the text or made in terms of the text (Gadamer, 1975). Thus, the present interpretation of a particular text is not simply reading what is there, but the act of entering into it. Hoy (1978) suggested that it is possible for the interpretation to become relativistic to the text. Anything I say about the school science program may be incorporated as part of the text.

An interpretation of the text must therefore be open to criticism if it is to be considered valid and legitimate. Criticism may be related to understanding through interpretation. Understanding in this sense is closely related to self-understanding of a situation. From self-understanding it follows that there must be self-criticism (Ricoeur, 1974). It is within self-criticism that we should recognize that it is not self-criticism in a dogmatic sense, but rather in a hermeneutic sense. My study of the Thai school science program could not stand as my interpretation of "school science in Thailand" alone, but must also be an interpretation situated within a community discourse. The purpose of the discourse is not to uncover the weak point in the text but rather to let the meaning of the words emerge (Barett, 1979). In a very real sense the emergence of the meaning is in terms of an open horizon (Gadamer, 1975; Schutz, 1978). This text must be read and interpreted within the context of discourse and curriculum in order that the full sense of the dialogue be rational.

It is hoped that this conceptual framework for the study is not rigid, but evolving; not imposed on the research activities, but reciprocally dependent on the practical inquiry. In disclosing these specific guiding interests for the investigation, I hope to illuminate for the reader(s) any particular biases which may be reflected in the account. I will hopefully move toward a critical analysis that will offer both the possibility of insight into the concerns and the potential for ensuing action.

Framework for Analysis of the Curriculum

Based on the conceptual framework, the study attempts to understand the curriculum-as-plan of the junior high school science program in Thailand. This analysis will be preceded by an examination of the history and development of both general education and science education in Thailand. The procedure for analysing the curriculum will be undertaken through the examination of available documents such as teachers' guides, students' textbooks, and other related materials. It is hoped that in this context, the conceptual perspectives and the nature of the science program in Thailand will be brought to light.

Officially defined goals are often part of the curricula along with knowledge, methods, and evaluation which reflect them. It is possible to investigate these in terms of various paradigmatic views of knowledge (Garfinkle, 1980). In terms of analysing the school science program in Thailand, the intention is not only to discuss the kinds of knowledge presented in the conventional way, but to look at the curriculum in the root orientation. Aoki (1978) mentioned that in general education, educators in this decade called for the need to probe into the deep structures underlying curriculum research thought. He elaborates further that no program can be evaluated in its entirety, but we can increase our vision of what ever we are viewing through the employment of as many perspectives as we can find appropriate and utilize them for our purpose.

In this part, the emphasis will be placed on the work of Habermas, concerning the "knowledge-constituted interest." In his critique of ideology, he analysed knowledge and human interests from the critical theory perspective, which he has distinguished from the perspective of empirical scientific theory by its relationship to social phenomena (Habermas, 1976). In his book Knowledge and Human Interests (Habermas, 1971a) he describes the orientation of different types of analytic social theory for producing knowledge. He also examines the different traditions of inquiring; he describes theory as a way of looking at the social world that manifests a cognitive interest in producing knowledge. In this context, the emphasis will be placed upon Habermas' notion of knowledge and human interests. In his critique of ideology, he analyzes knowledge and human interests from the critical perspective, which he has distinguished from the perspective of empirical theory by its relationship to social phenomena. Each theory would include a characteristic methodological approach with criteria for applying the theory to reality. The application of valued criteria produces one of three possible categories of knowledge: information, interpretation, and analysis.

He relates knowledge to three kinds of cognitive interest, "knowledge-constitutive interests," where he associates (a) technical interests with control, (b) practical interest with mutual undertanding, and (c) emancipatory interests with self-reflection. According to Habermas, these three interests are given to all human activities.

Habermas further provides us with an example of how the various conceptions of knowledge may be used to create tension between different world views. Each view has a particular vision of man contained within it. In the first instance, man is viewed as a passive being, while in the latter two, man is viewed as an active being. The tension between these views creates what Berstein (1975) has called the "new being."

This conflict has the potential to allow the uncovering of new possibilities for probing further into our ways of knowing. Without such possibilities we would stagnate in terms of understanding. It is the uncovering of the new that is important for it has the potential to deflect our interests towards looking beyond what we take for granted in our everyday life or beyond those goals for human action which may be officially defined by various institutions (Berger, 1963).

Habermas begins by turning his attention to the conditions of possible knowledge today by analyzing the context in which possible doctrines originated. He provides us with an example of how the various conceptions of knowledge may be used to create tension between different world views, and how different fundamental cognitive interests shapes the different theories, emphasizing its valued category of knowledge (1971a).

Each of these three interests constitutes a transcendental condition for a certain sphere of meaning in that it determines the a priori conditions for the apprehension of a certain type of objects. In his analysis of the connections between knowledge and human interests, Habermas attends to totality dialectically as he looks for what is emphasized and what is not taken into account. For instance, his analysis draws upon knowledge in different disciplines and different approaches to inquiry, and proceeds systematically to reconstruct historically repressed cognitive interests.

His work has been applied to the area of education especially in the field of curriculum theory. Such work has taken his notion of knowledge and human interests, from the book of the same name, in order to evaluate or as a model for the investigation of the kind of knowledge that is presented in the curriculum. In 1978, Aoki took the three differing orientations, or forms of knowledge of sciences (strict science, hermeneutic science, and critical science), and expanded them into the area of curriculum.

The dominant orientation within society has been termed empirical-analytic: where the primary interest lies in establishing predictive control in technical situations. This orientation leads one to approach the world objectively with the primary interest of controlling objects. Knowledge gained is based on observation and experimental evidence. It separates theory and practice with the formulation of a hypothesis, as a component of theory, to guide the practice of an investigator who believes that the theory illustrates an ideal state of affairs. Thus, we tend to think that knowledge is derived by empirical analytical means and that other sources of knowledge are misleading.

From this orientation, the curriculum is considered to be a prescriptive package of means-ends relationships, in which methodologies have been devised to attain certain formulated objectives considered to be indicators of desired student achievement (Rowell, 1983). The curriculum is defined by the content of the course and the recommended instructional approach for achieving the specified objectives.

The second orientation is termed historical-hermeneutic, the primary interest of which is associated with the understanding of meaning as attributed to situations by individuals. People are not viewed as separate from this world, but as influencing, and being influenced by their surroundings. Each individual gives meaning to his or her own particular situation, and these meanings may vary from one to another according to their interpretations. Within this orientation, most of the knowledge, including that of the scientific disciplines, is socially derived and socially approved by the scientific community. Kuhn (1970) states that if the usual tradition of research is altered, and the community of researchers shifts its way of knowing, then the members of the community must be "re-educated."

The curriculum may be considered in terms of multiple meanings, perceptions, and assumptions held by the participants. For each individual, a particular set of meanings for the program will emerge and evolve. There is no one program, as defined by the master curriculum plan, but as many programs as there are groups interpreting and experiencing something they refer to as a "program" in different situations (Werner, 1979).

The third orientation is termed critical-theoretical in which emancipation and concern for the human condition is most important. Implicit within this orientation is a demand for action which will improve the human condition (Habermas, 1971a). Persons are viewed as an integral component of this world. This orientation has a broader base than the first two orientations. The critical orientation is interested in asking questions which probe, uncover, and make explicit, in order to reveal the underlying tacitly held intentions and assumptions. It is from this critical stance that Paulo Friere (1972) engaged in a dialogical involvement with humans around the world. He conceives of education as the practice of freedom, in which individuals discover how to participate in transforming the world. The essence of such a practice is the creative encounter called dialogue (Rowell, 1983).

In this orientation, the curriculum is viewed as a set of assumptions, beliefs, and values. It is shaped not only by the interests of individual participants, but by the broader interests of societal groups subject to diverse economic, political, or cultural attachments.

From an analysis of the curriculum based on Habermas' model, it should be possible to point out the different aspects of curriculum and education that are not accounted for in the existing secondary school science program in Thailand. It should also contribute towards establishing the usefulness of hermeneutics and critical theory in education. I am quite aware that this view of scientific knowledge may be quite different from the dominant empirical and positivistic one. Most problems in science (including the developing of a science program in Thailand), are dealt with in practical ways without questioning the choice of meaans or ends beyond that which has immediate application.

Chapter III

REFLECTION ON THE NATURE OF SCIENCE

Introduction

Various intellectual and moral tendencies are currently combining to dethrone natural science from the sovereignty of reason, knowledge, and truth which it has enjoyed since the seventeenth century. Far from being the paradigm of objective truth and control which will make us free from all natural ills and constraints, science is increasingly accused of being a one-sided development of reason, yielding not truth but a succession of mutually incommensurable and historically relative paradigms, and not freedom, but enslavement to its own technology and the consequent modes of social organization generated by technology.

Today the position of science, which was unquestionably accepted in the Western countries for the last three hundred years or so, has been challenged by different groups of people. Even in the last thirty years, there seemed little doubt about the status of science in the society (Barnes, 1972a, 1974). Most people believed that science provided reason, evidence, and meaning for rational discourse. Science was viewed as a dominant force in shaping our material existence and personal beliefs. It was believed that the scientific attitude fostered the development of free society (Feyerabend, 1975).

The question arises Is there any relationship between science and society or the community? This question was rarely discussed until about 1940s (Capra, 1982). But since then, gradually rather than suddenly, it has become a major issue. What justification is there in scientific studies having no visible practical use? It was assumed that such studies served their own purpose, namely, the advancement of knowledge, the discovery of knowledge simply for the love of truth. Do we still fully accept this view? Do we still accept that it is proper for a scientist to pursue knowledge for its own sake, regardless of any advantage to the welfare of the society? We are forced here to turn to a radically utilitarian attitude reflecting the general philosophical trend of our time.

The social function of science vis-a-vis ideologies is first to try to understand them; What ideologies are underlying?, How do they work?, What gave rise to them? And second to criticize them, to force them to come to terms with, but not necessarily to surrender to reality. Closely knitted with critical theory in order to understand and transform science, we need to really know how it developed, what was its origin, and its impact or its influences.

Feyerabend (1975) asserts that the history of science does not just consist of facts and conclusions drawn from them. It also contains ideas, interpretations, mistakes. What we learn from the history is not only past evidence, but also the "what the ancestors thought and concerned themselves about," differed from our time (Kuhn, 1963).

Associated with the trends which see a link between science and society, there have been cases where the emotions of the participants have influenced our thinking about the contribution of science and technology. Paul Hurd (1970) indicated that the lack of understanding between members of society and scientists is due to the lack of communication. He stated "a majority of adults are unaware of, or are misinformed about the meaning of science and its influences on the material, social, and intellectual life of our time. As a result they have little insight into the meaning of problems which plague mankind today" (1970, p. 13). What is needed then is a shift of emphasis in science, particularly in science education, to demands that are placed on the "coming to understand the nature of science."

The Scientific Revolution of the Sixteenth Century

The important revolution in the philosophy of science was brought about by Francis Bacon. He presented a new scientific method which advocated a purely inductive method, directly opposing the deductive method of the early time. His method of inquiry involved a mathematical description of nature and an analytic method of reasoning. The pure Baconian method involved scientists employing insight or intuition to generate, through the process of induction, tentative hypotheses that are in agreement with observed facts; then through a process of deduction the consequences of hypotheses were determined and tested by observation or experimentation (Feibleman, 1972). If the tests indicated discrepancies, the Baconian method implied returning to the hypothesis stage and working through the method repeatedly until a hypothesis was found that was in agreement with the original observed facts as well as those generated by the experiments.

The next movement in the philosophy of science took place during Galileo's time. He attempted to combine scientific experimentation with the use of mathematical language to formulate the laws of nature he discovered. These two aspects, empirical and mathematical description of nature, became the dominant feature for science in the seventeenth century and have remained an important criteria of scientific theories up to present time (Crossland, 1971).

In order to describe nature mathematically, scientists restricted themselves to studying the essential properties material bodies which could be measured and quantified. Other properties were merely a subjective mental projection and were excluded from the domain of science. Thus, Galileo set up the scientific process that we call "designed problem," in which problems were delimited according to experimental, deductive and inductive methods (Dampier, 1971). This method became known as the scientific method.

The period of mechanistic view of science arose through a combination of factors related to the work of Galileo, Rene Descartes and Isaac Barrow (Benson, 1984), causing a shift in philosophy from scholasticism, where nature is made for man, to that of empiricism, where man is part of nature. Barrow believed the objective of science was to study the world that is perceptible to the senses; particularly aspects of the world that demonstrate quantitative changes. Newtonian mechanics developed the observer-observation relationship, which was adhered to during and after the development of terrestial dynamics, and in which the mind was capable of perceiving a moving mass in absolute space and time (Robinson, 1969). In such a world, an observer is one who is in the center of the universe surrounded by objects that can be perceived by the senses and understood by the mind. By adopting this mechanistic view, qualities were reducible to mechanical ones and permitted scientists to assign numbers to them. The fact that the qualities had a mathematical value, made it possible to understand the world within the assumed formalism.

As can be seen the medieval outlook of science changed radically in this period of time. The notion of an organic, living and spiritual universe was replaced with that of the world being a machine, a metaphor that is dominant in the modern era. Where the ancients' goals of science were wisdom, understanding the natural order and living in harmony with it, since the Baconian times the goals of modern science have been to seek knowledge that can be used to dominate and control nature.

Science of the Twentieth Century

In the last half of the nineteenth century, the mechanistic view began to break down. This culminated in 1930s when a new view of science evolved out of the Vienna Circle. Since then, this view has had a significant impact on philosophy of science. The positivist philosophers of the Vienna Circle developed a philosophy known as logical positivism which maintained that science was a strictly logical process (Joergensen, 1970). The goal of this group was to concentrate attention on the certainty of the results of science (Neurath, 1971). Wade stated that logical empiricism "deliberately ignored the historical context of science as well as the psychological factors which many people would consider important in science, such as intuition, imagination, and receptivity to new ideas" (1977, p. 143).

Since the development of logical empiricism, a group of contemporary science historians and philosophers have recognized that the scientific enterprise is influenced by a logical structure as well as human factors. The analysis of scientific thought by Feyerabend (1975, 1982), Kuhn (1963), Polanyi (1958, 1969) and Medawar (1969) have amply demonstrated that the scientific enterprise involves nonrational procedures as well.

Polanyi (1969) in his essay "The Unaccountable Element in Science," showed how intuition was important to the scientific discovery and the possession of scientific knowledge. Based on the evidence of perception, he argued that scientists pay attention to foreground and background information of a particular situation as well as the total picture. Once these perceptions are acquired the skill of intuition is employed to see the hidden patterns of the problem. A nonrational aspect of science is thus involved in the recognition of a problem. Polanyi (1969) termed this intuitive leap "illumination," and explained it as a process where a logical gap exists. The gap is seen differently or not at all by most different members of the community, and as a consequence, distinctive and different conclusions are generated. Thus, from a public framework, scientists make intuitive leaps that are not necessarily seen as being logical. Medawar (1969) called intuition the "generative act."

Thomas Kuhn (1970, 1985), the science historian and philosopher, demonstrated that the scientific enterprise has a logical structure but human factors drastically influence the direction of science. Kuhn developed the position that scientific endeavours are heavily influenced by nonrational procedures, which produce new theories that supplement rather than replace contemporary theories, in that they do not bring science any closer to the truth. In fact, a possibility exists that science moves tangentially to the current scientific beliefs.

Feyerabend (1975) supported the nonrational position of science and suggested that a potential reason for the public's image of science is the way most of the science now being presented in the schools is adopted from the neo-mechanistic view that is directly influenced by the philosophies of the critical rationalist and logical positivist. The critical rationalist takes a falsificationist position seriously, argues for an increase in scientific content; avoids ad hoc hypotheses and attempts to be honest in all scientific reasoning. The logical positivist gives an inaccurate account of science because science is much more chaotic and irrational than her or his re-constructed methodological image suggests. According to Feyerabend (1975), their assertions are neither clear nor true, since there is not one specific form of logic that reveals the logical structure of various disciplines. Their ideas neglect the physical, historical, and emotional conditions that generate scientific change, making science rigid and dogmatic. Science is presented as being more rational and precise than it actually is.

Objectivity of Science

Modern science began with the radical idea that knowledge can be gained through observation and experimentation. That this was indeed a novel idea is evident if we consider the amalgamation of religious and Aristotelian thought in the Middle Ages, with its emphasis on teleology and qualities of experience. From the beginning of the modern era, there have been two main views of how to formulate ideas about reality. Francis Bacon promulgated the inductive method, by which one reasons from specific to general hypotheses. Descartes argued that one can intuit hypotheses directly. In either case, one obtains a hypothesis with which to make deductions that can be verified by experimentation.

The above distinction breaks down in actual practice, as both methods are employed simultaneously by most scientists. Nevertheless, there is a tendency to view induction as consistent with the empirical approach. Induction and hypothesis formation are not only scientific methods but also primitive theories of thinking. As methods, they describe the way in which one develops new ideas, and as theories of thinking, they refer to how this development is accomplished. One can even argue that the inductive and Cartesian methods are modes of behavior that operationally define how scientists think. The difficulty with this approach is that scientists rationalize their thought so as to achieve within their own community conformist attitudes, denying their own creativity in their commitment to empiricism.

The high degree of formal rigor in science then, can be achieved because it abstracts from the existing intersubjective communication in scientific practice, and can thereby methodologically bracket the ambiguities inherent in ordinary language communication. Apel (1972) attempts to criticize scientism precisely by returning to this suppressed dimension of "the priori of communication" underlying science.

Apel's concern is in the context of a planetary ecology crisis which inquires into the prospect of a "philosophically grounded political ethics that is adequate for that crisis" (1972, p. 82). The major difficulty that such ethics must confront results from the unprecedented power and global expansion of modern science and technology. A dilemma occurs in that at the same time as the global effects of modern science and technology make political ethics more necessary than ever, the hypothesization of scientific rationality as the only valid mode of rationality appears to preclude the formation of such an ethic. Consequently, the desire for communications theory is the desire to dissolve the blockage to rational ethics caused by the hypothesization of scientific rationality and the formulation of a positive doctrine of ethics.

Scientific discovery is not merely the result of idle guesses but active hopes filled with enthusiasm. According to Democritus, the Greek philosopher, mental qualities and senses are secondary only by convention. In his view, taste, such as sweet or bitter, and color, such as blue or green, exist only by convention, with no attributes of real physical objects. Only "atom" and the "void alone" exist in reality and the world of everyday experience is, therefore, an illusion. The "atoms" and the "void alone", cannot be directly observed, leaving a physical world that cannot be directly apprehended by the mind and a world of subjective experience that cannot be explained in the language of matter theory. How, then, can the scientists gain knowledge of reality? Scientists using the inductive method looked into the abyss and pulled back, asserting that the origin of knowledge is direct experience.

It must be kept in mind that the inductive method has its root in this dilemma. It is a method based on sense experience. The scientist formulates mathematical theories about the physical universe on the basis of observations that belong, in principle, to every human's world of subjective experience. A person converts the "quality" of experience into mathematical quantities that are "real," in the sense that they refer to postulated properties or relationships in the physical world. In different forms, this is the "mind-body" problem, the problem of epistemology, and the problem of creative thought. The inductive method is a useful method for acquiring knowledge about the "physical reality," but it may not be an exact theory.

The concept of strict separation of fact and value, or "positivism," puts emphasis on the objects of knowledge almost to the extent of excluding the role of the knowing subject. The subject is seen as an isolated contemplative individual without social dimensions or historical situation. This is an atomistic concept of validation which isolates bits of knowledge in comparison with individual fragments of reality.

The rise of logical positivism, from the Vienna Circle, retained the nineteenth century conception of an objective scientific method, but stressed the process of validation rather than that of discovery. The logical empiricist, using mathematical logic as a model for natural science, sought a precision of expression and a rigor of agreement, only with the methodology of validation of the assertions produced by science. The scientists developed the techniques of discovery, or the process of science, and the logical positivists because of their strictly validative concerns, the rigorous structure of scientific theories, leaving the question of the origin of scientific ideas masked.

Recent work has, however, moved away from this view. Particularly important in this trend have been writers who are concerned with describing concretely the actual process of scientific investigation and evaluation. Kuhn (1963) and Polanyi (1958, 1969) both concluded that scientific evaluation involves far more than just the application of general criteria derived from the scientific method.

Polanyi stressed the way in which esoteric beliefs and standards are tacitly involved in all scientific judgements. He pointed out that in many instances scientists are not able to render these tacit elements explicit. Kuhn (1963, 1970) too, stressed the presuppositions inherent in scientific evaluation. He pointed out how rapidly processes involving dogmatic transmission of concepts, ways of looking at things, esoteric problem-solving techniques and so on, can be identified in science education.

These elements operate together with a disciplinary paradigm reinforced in science education which mediates the scientist's perception of an experience. What is to count as a problem, a solution, a successful experiment, a failure, a discovery or an anomaly, is mediated by the received paradigm which involves an entire system of presuppositions to which the scientist is committed.

Both Kuhn's and Polanyi's concern is to demonstrate the essential role of the presuppositions in science. Polanyi and Kuhn in their philosophical writings attack empiricism and the idea of neutral observation language. Historically, science is seen as a revolution in method, and sociologically through recent awareness as technical norms in evaluation processes (Hesse, 1973; Kuhn, 1970, Mulkay, 1969).

Presuppositional views of science command assent through the way they directly come to grip with concrete scientific practice, but such an assent abandons the attempt at making scientific method a sufficient source for external evaluation of truth and error. Znaniecki (1969), in his book, The Social Role of Man of Science, introduces the role of the "social circle" the audience or public to which a thinker addresses herself or himself. This circle imposes important influences on the thinking of the intellectual. In the logical ideals of scientific method, there is frequently no distinction between self-knowledge and arriving at a public consensus. There are strong social pressures on the scientist to address herself or himself to a scientific audience. There are many personal biases and distortions that play a role in scientific creativity, which do not assist in the persuasion of other scientists, who also clearly differ in their personal prejudices. Once the scientists start attempting to convince other people outside science, they must strive for objectivity or at least for the avoidance of purely personal scientific prejudice.

Jurgen Habermas's (1971) concept of modern scientific knowledge, which he sees as the predominant current form of technical, instrumentally-oriented knowledge, is typically the product of communities of interacting persons who operate and perceive reality, not idly and contemplatively, but in terms of particular instrumental, manipulative and predictive "interests." Such "interests" are adopted a priori into the process of knowledge generation and evaluation. What scientists mean by the validity of their knowledge is predetermined by these interests. What scientists take to be facts or data is determined by the pragmatic preorganization of experience implied by the existing system of instrumental activity.

All areas of scientific knowledge are bound-up with systems of instrumental action that relate to each other. They constitute an overall body of knowledge available in the execution of goal-oriented, instrumental action, and a general interpretation of reality within a view encompassing possible forms of technical control and prediction. The tendency by scientists and others to treat interest as an adverse influence upon knowledge, and to represent science as the product of disinterested contemplation, although justified in it's distrust of particularly narrow individual and social interests, perpetuates their rationalizations and ideology. More importantly, this has led them to an incorrect understanding of the general relationship between knowledge and interest.

Habermas (1971) asserts that 'a priori' interest structures inform the dimensions within which the human species evolves and allow the governing of the various forms of human knowing and acting. In as much as modes of scientific activity have been different in the course of evolution which represent methodologically rigorous means of pursuing these interests, transcendental reflection can also proceed through an examination of the methodological a priori of the various scientific domains. Habermas wants to oppose the objectivistic misconception of science through reflection on the conditions of the science. His criticism of the objectivist understanding of science is that objectivism dogmatically assumes the validity of first order scientific knowledge without reflection on the presuppositions of that knowledge.

For Capra (1982) human consciousness plays a crucial role in the process of observation. In atomic physics, human consciousness determines to a large extent the properties of all observed phenomena. The crucial feature of quantum theory is that the observer is not only necessary to observe the properties of an atomic phenomenon, but also necessary to bring about these properties. One's conscious decision about how to observe an electron will determine the electron's properties to some extent. For example, if we ask a particle question, it will give a particle answer. The electron does not have objective properties independent of the mind. In transcending the Cartesian method, modern physics has not only invalidated the classical idea of an objective description of nature but also challenged the myth of a value-free science.

The patterns scientists observe in nature are intimately connected with the patterns of their minds; with their concepts, thoughts, and values. Thus, the scientific results they obtain and the technological applications they investigate will be conditioned by their frame of mind. Although, much of their detailed research will not depend explicitly on their value systems, the larger paradigm within which this research is pursued will never be value-free. Scientists, therefore, are responsible for their research not only intellectually but also morally. This responsibility has become an important issue in any one of today's sciences.

It has been accepted since Kant that experience is partly constituted by theoretical categories. Morrover, Kuhn (1970) and Feyerabend (1975, 1982) and others, have in various ways, made it increasingly apparent that the descriptive language of observables is "theory-laden." That is to say, in every empirical assertion that can be used as the starting point of a scientific investigation and theory, we employ concepts that interpret the data in terms of some general view of the world. This is true, no matter how the empirical reference of science is apparently-rooted in "ordinary language."

Feyerabend has drawn the explicit conclusion that scientific theories and arguments are closely analogous to the circular reinforcement of beliefs, documents, and conditioned experiences that may be found in some religious groups (Hesse, 1973).

In the early period of modern science it was plausible to believe, and indeed it was believed by both Bacon and Descartes, that natural science would be a continuously progressive, cumulative, and convergent approach to truth, where truth was understood as correspondence between a system and objective knowledge of the real world. The kind of knowledge that issues from the technical application and it's cumulative character cannot be in doubt. Thus, the claim of science to yield objective knowledge comes to be identified with the cumulative possibilities of instrumental control rather than with theoretical discovery.

In Feyerabend's (1975) view, the external truth and the objectivity of scientific theory are damaging, since they easily degenerate into dogmatism by circular reinforcement of theory through experience conditioned by theory. In natural science the interest is evident in exploitable technical control, and the character of natural science as "objective", "detached", and "value-free" is itself a value-characteristic derived from the human decision to develop a form of knowledge which is thus technically exploitable.

The separation of the mind from the emotion, characteristic of the scientific thought, has resulted in a narrowed basic logic, that omits the social consequences. Science in this sense is a closed system that creates and perpetuates its own rules and beliefs, most importantly the belief in its own neutrality and objectivity.

Science and Culture

How is it possible to gain an objective stance on human life so that its regularities may also be deduced and structured like those of the physical world?

Over and over science is presented to us as a "value-free" activity, independent of the rest of the society, a source of rationality in a chaotic and difficult world. It is believed that science will solve our environmental problems, will give us the correct information about what humans are like and will also contribute to our welfare by finding new knowledge that is useful to us. When a difficult situation arises, we are told, science will take care of the problems by providing a scientific solution.

With the rise of modern science the classical constellation of theoretical, practical, and productive knowledge was drastically altered. Theory came to mean logically integrated systems of quantitatively expressed, law-like statements and through empiricism, in which the inherent logic of the physical world may be deduced and structured through observation, experimentation, and explanation, regularities in natural laws came to be developed (Barnes, 1972). Today scientific knowledge constitutes a highly regulated system seeking within it's own ranks quality, coherence, and organization.

The knowledge of natural science has been established through its claims to objective and absolute methods. This has been generalized by some to mean all knowledge, and to claim that there is an absolute independence of the process of establishing validity, from the social origins of belief. This usually stressed the progressive and positive character of science, and the importance of an objective scientific method, in which the orderly collection of scientific facts was followed by their systematic expression in description or theoretical laws. By stressing objectivity in discovery as well as validation, there seemed to be no room left for social factors in conditioning the thought of natural science (Dolby, 1971).

However, human intentional activities are presupposed in the constitution of experience as well as in the process of interpretation of experience and thus, lead to an acquisition of knowledge and a sedimentation of knowledge that is becoming subjective. The nature of science therefore must be subjective and contain social facts.

Scientists work from models acquired through education and through subsequent exposure to the scientific literature often without knowing or needing to know what characteristics have given rise to the form and the status of these community paradigms. Because they do so, they do not need to enqui further. The coherence displayed by the research tradition in which they participate may not imply the existence of an underlying body of rules and assumptions that additional historical or philosophical investigation might uncover. That scientists do not usually ask or debate what makes a particular problem or solution legitimate tempts one to suppose, that at least intuitively, they know the answer. But it may only indicate that neither the question nor the answers are felt to be relevant to their research. Paradigms may be prior to, more binding, and more complete than any set of rules for research that could be unequivocally abstracted from them (Kuhn, 1970).

An almost exclusive reliance on textbooks is not all that distinguishes scientific education. Students in other fields are, after all, also exposed to such books, though seldom beyond the second year of college and even in the early years not exclusively. But in the natural sciences, different textbooks display different topic matters rather than, as in the humanities and many social sciences, exemplifying the different approaches to a single problem field. Even books that compete for adoption in a single science course differ merely in level and pedagogic detail rather than in substance or conceptual structure.

The relationship between science and its community has been rarely discussed. But since it occurred, it has become a major problem. What justification is there in scientific studies leaving no visible practical use? Until recently it used to be assumed that such studies served their own purpose, namely the advancement of knowledge; the discovery of knowledge simply for the love of truth.

Social developments do not determine the content of scientific developments, simply because they do not determine natural facts, but they may well open the eyes of the scientists to natural facts which, though pre-existent and always there, had not been discovered before. Polanyi (1969) realized that the relationship between science and society was undergoing a significant and painful change.

Veblen (1960) observed that the faith of Western culture in science was unbounded, unquestioned, unrivaled. The revolt from science which then appeared was so improbable as to concern only the timid academia who would ponder all contingencies, however remote. Scientists have become more aware of social consequences of their work, especially after the nuclear bomb at Hiroshima.

Polanyi (1969) has tried to show that there is an inner connection between scientific thinking and how scientific activity is supported by society. It seems that scientific discovery requires an atmosphere of free inquiry, constrained only by the scientist's own sense of truth and the opinion of her or his scientific peers. At the same time as science must secure the objectivity of its statements against the pressure and seduction of particular interests, it deludes itself about the fundamental interests to which it owes not only its impetus but the conditions of possible objectivity itself. An example is that the field of genetic engineering or the research on cloning or "test-tube babies" would not be possible without social support.

Hesse (1972) stated that all knowledge is made by men from existing cultural resources; old knowledge is part of the raw material involved in the manufacture of new. Hence, whatever the interests which guide knowledge generation, socially-sustained consensus and a cultural modification of existing meanings will always be involved in the process. Habermas, like Lukacs, ignores this essential connection of scientific knowledge with its cultural antecedents, and this constitutes the crucial formal inadequacy in his account (Barnes, 1977).

Polanyi (1969) gave a very clear argument that modern science is a cultural tradition and is not easily transmitted from one place to another. Capra (1982) elaborated further that countries such as Australia, New Zealand, South Africa, Argentina, Brazil, Egypt, and Mexico have built great modern cities with spacious universities, but they have rarely succeeded in founding important schools of scientific research. The total current scientific production of these countries before the war was still less than the single contributions of Denmark, Sweden, or Holland. Those who have visited the developing parts of the world where scientific life is just beginning, know of the backbreaking struggle that the lack of scientific tradition imposes on the pioneers. Their research lacks stimulus and runs astray in the absence of any proper directive influence such as scientific granting agencies (for example, National Research Council in Canada). Politics and business play havoc with appointments and granting of subsidies for research. In the end, however rich the fund of local genius may be, such an environment will always fail to bring it to fruition.

Rarely, if ever, is the final acclimatization of science outside Europe achieved until the government of the overseas country succeeds in forming a tightly knit group of people belonging to some traditional scientific circle and allowing them to develop and mould scientific life according to their own standards. This demonstrates perhaps most vividly the fact that science as a whole is based, in the same way as the practice of any other single research school, on local tradition, consisting of a fund of intuitive approaches and emotional values which can be transmitted from one generation to the other only through the medium of personal collaboration.

Barnes (1974) makes a parallel argument to Polanyi insisting that all knowledge is actively produced by humans with particular technical interests in particular contexts. Its significance and its scope can never be generalized to the extent that no notice is taken of those contexts and interests. Thus, scientific knowledge is also the product of a historical development.

Social standards and values that are accepted in a particular culture always emerge from the existing resources and history. Rational humanity in different cultures may represent reality in different, even contradictory ways. Any group of humanity believing in some set of real universals can take these universals as the best available rendition of reality, and use them to evaluate in these ways. But so do those in other cultures, and so did the intellectual ancestors in the Western culture. If one is to regard her or his own evaluations as true, one must be able to show that their favoured explanatory process and agencies are inherently superior to, or better grounded than anybody else's, that they really are closest to the real state of things.

It is well known that as scientific knowledge developed, theories have been postulated and successively set aside. Recent historical studies, however, in particular those of Thomas Kuhn (1970) demonstrated that fundamental theoretical transitions in science are not simply rational responses to increased knowledge of reality, predictable in terms of context and independent of standards of inference and evaluation. Such transitions make good sensical responses to perceived practical problems only as correlates of technical and procedural reorganization within particular scientific communities. They are intelligible when referred to the actual social situations where new findings or new instrumentations are emerging. To this extent, they certainly are not manifestations of scientific irrationality, or mysterious emotional reorientations. But they do not possess the kind of general features which would be required by the progressive realism we are considering. It cannot be said that there is less to be explained after such a transition, or that part of the world is finally explained, even if scientists perceive themselves as having fewer problems afterwards. Nor are we ever in a position to say that scientists could not have done otherwise. Particular theoretical change cannot be established independently of context. It is never unambigously clear that other theories could not have reasonably been maintained or produced with just as much evidence to recommend them.

The diverse real universals postulated at different times and in different cultures and contexts, should be regarded alike as inventions of the mind, sustained within the context that they are found. Sociologists of science see beliefs and aspects of culture as both prerogative and genuinely explanatory in the naturalistic sense. It has been admitted that people bring their cultural resources and cognitive proclivities to bear to solve authentic, direct problems of prediction and control.

It is a very common form of legitimation to claim that a belief follows from or is strongly supported by the normal procedures of some valued institution, in particular, science or one of its constituent fields, for example, modern medicine. Given the strongly defined procedures and clearly marked-off cultural resources of modern scientific disciplines, it is often practically possible to ascertain where such beliefs depart from normal scientific practice and hence where they may be the products of concealed interests masquerading as scientific results, such as, nuclear energy and agriculture.

A connection between knowledge and interest is asserted to be sure, but not internally or logically. Rather it is claimed that interests inspire the construction of knowledge out of available cultural resources in ways which are specific to particular times and situations and their overall social and cultural contexts. Barnes (1977) mentions that we must recognize that the study of particular groups of individuals, their beliefs, and their activities, is of importance. The existance of social structure, and of the public representations and shared competences we call knowledge, becomes apparent to us through the study of individuals, their utterances, and their actions. The properties of social structures are always inherent in particular concrete context via the behavior of particular people.

Reflection on Science, Technology, and Society

Most societies today have come to rely on science and technology for their development. Societies, whether industrialized or not, are enslaved and addicted to them. The majority of people have faith in them and believe that they ultimately benefit humankind regardless of the disadvantages and inconveniences introduced by the artificiality of existence in technological civilization. It has been believed that each technological conquest of a natural process or phenomenon as a confirmation of human power and inequity, or the right of humankind to do as it pleases with nature.

Advances in science and technology have emphasized international ties. All nations, developed and developing, feel they will gain substantially from cooperation rather than from isolation. There is a strong technological bias for the great increase in international ties that have taken place over the last twenty five years.

The "pur[illegible] "utilitarian" conceptions of science are, however, freq[illegible] perceived as conflicting. Indeed tension between them is evident in the writings of the scientists themselves (Barnes, 1972a). The utility of science is manifested through technology. However, currently science has attracted great concern as a potential source of social change, a force capable of changing, transforming whole areas of life-experience. Scientific knowledge has become a necessity to modern economics, and whole industries have been based on innovations made possible by basic scientific discoveries. At the same time, science by its own internal development, has become even more specialized, esoteric and inaccessible (Barnes, 1972a).

After three centuries of exponential growth, science exists as a major institutional complex in all modern societies. Science has its institutions, departments, libraries, journals, and often its own language. Its cultural and economic significance is now universally recognized and indeed, it is the key to understanding the characteristic features of "advanced" societies.

Science has become tied up with technology and now grows with it. The advancement of science and technology offers humanity both costs and benefits. It offers great comfort and convenience in almost every aspect of life, however, at the same time, hidden harmful effects underlie it's seemingly benevolent nature. The following discussion concerning the effect of science and technology brings some of these hidden issues to the surface.

Our relationship with science and technology can be observed in areas that are part of our everyday life, yet vaguely understood by the average person, for example the medical science and the more abstract area of energy. The important discovery of penicillin in 1928 ushered in the era of antibiotics, one of the most dramatic periods of modern medicine, which culminated in the 1950s with the discovery of a profusion of antibacteria agents capable of coping with a wide variety of microorganisms. These medical "advances" illustrate the success as well as the shortcomings of the biomedical approach. Countless people have since become victims of overuse and misuse of drugs.

The overuse of drugs in contemporary medicine is based on a limited conceptual model of illness and is perpetuated by the powerful pharmaceutical industry. One remarkable example in the area of medicine occurred in 1960. The drug involved a certain hormone called "Norlutin," which was found to have harmful effects on some fetuses when taken during pregnancy. This drug was eventually banned in the developed countries, but its use continued in the Third world areas.

This is not an isolated event. Antibiotics are probably some of the most abused drugs prescribed by physicians and probably the most dangerous drugs prescribed to patients. In Thailand, there is no regulation for controlling antibiotics. There is no public information about the adverse effects of antibiotics, and people can obtain them "over-the-counter" without prescription. In fact every time people go to the drug store in Thailand, the salesperson promotes the sale of antibiotics for commercial reasons.

The 1960s witnessed a limited success in human transplant operations using heart and other human organs. With these developments medical technology reached an unprecedented degree of sophistication and became all-pervasive in the modern medical research era. At the same time the dependence of medicine on high technology raised a number of problems that are not only medical or technical in nature but involve much broader social, economic, and moral issues.

Despite the staggering health costs over the past three decades, and continuing claims of scientific and technological excellence by the medical profession, the health of the human population does not seem to have improved significantly (Capra, 1982). Although medicine has contributed to the elimination of certain diseases, it has not necessarily restored health. There has been a substantive increase in life expectancy, and this is often cited as an indication of the beneficial effects of modern medicine and health care. However this argument is quite misleading. Health has many dimensions, all arising from the complex interplay between the physical, psychological, and social aspects of human nature. Hence, those who say that medicine has made little progress could have a point. Organ transplants tend to make us forget that many of the patients would not have been hospitalized in the first place if preventive measures had not been neglected.

To produce manufacturable consumable goods such as food additives, synthetic fibers, plastics, drugs, and pesticides, resource-intensive technologies were developed. Many of these technologies are heavily dependent on complex chemicals. As production and consumption increased, so did the chemical wastes that are inevitable as by-products in manufacturing processes. Thus, while the production and consumption accelerated at a hectic pace, the appropriate technologies to deal with these unwanted by-products were neglected.

The food industry represents another outstanding example of health hazards generated by commercial interest. Although nutrition is one of the most important factors of health, it is not emphasized in the system of health care. The food should be poison-free, that is, free of poisonous chemical residues and harmful additives. Our dietary requirements are simple, and yet almost impossible to attain in today's world. To improve their business, food manufacturers add preservatives to their products to increase shelf life; they replace healthy organic food with synthetic products, and try to make up for the lack of nutritious content by adding artificial flavoring and coloring agents and vitamins. Such over processed, artificial food together with alcohol and cigarettes are heavily advertised on billboards and television.

The influence of the pharmaceutical industry on the practice of medicine has an interesting parallel in the influence of the petrochemical industry on agriculture and farming. This influence has created major problems in modern agriculture. For the farmers the immediate effect of new farming methods was a spectacular change in agricultural production. The farmers were able to triple their corn yield per acre, cut their labor by two-thirds, and at the same time the amount of energy used to produce one acre of corn was increased fourfold (Commoner, 1977). The growers of edible foods, who at one time took pride in feeding the world's population, have turned into producers of industrial raw materials to be processed into commodities designed for mass marketing. Thus today corn is converted to starch or syrup; soybeans become oils, pet food, or protein concentrates; wheat flour is made into frozen dough or packed mixes. For the consumer the tie of these products to the land has almost disappeared, and it is not surprising that many children today grow up believing that food comes from supermarket shelves.

Farming, as a whole, has turned into a huge industry in which key decisions are made by "agriscientists" and passed on to "agribusiness" or "farming technicians." Farmers have to deal with a chain of agents and sales people, losing almost all of their freedom and creativity, and becoming, in effect, consumers of production techniques. These techniques are determined by the commodity market, and farmers can no longer grow or breed what the land indicates, nor what people need; they have to grow and breed what the market dictates.

Excessive technological growth has also resulted in an environment problem in which life has become physically and mentally unhealthy. Polluted air, irritating noise, traffic congestion, chemical contaminants, radiation hazards, and other sources of technological pollution have become part of everyday life for most of us. These manifold health hazards are not just incidental by-products of technological progress. They are integral features of an economic system obsessed with growth and expansion, continuing to intensify its high technology in an attempt to increase productivity.

The hazard of chemical waste is another crucial issue. In the developed countries, this causes widespread environmental pollution. It was found that in the United States and other developed countries, chemical wastes are not treated properly and the hazardous waste products or materials do not receive appropriate disposal. For many decades the chemical industry dumped its wastes into the ground without adequate safeguards, which has now resulted in thousands of dangerous chemical dumpsites that are likely to become one of the most serious environmental threats.

The problem of safe disposal of nuclear waste has never really been solved. Each reactor annually produces tons of radioactive waste that remains toxic for thousands of years. No human technology at present can create safe containers for such an enormous time span, and indeed no permanent safe method of disposal or storage has been found for nuclear waste. Similar problems do occur in developing countries.

Non-renewable energy derived from fossil fuels powers most of the production processes, however, because of the higher consumption rate it has become a scarce and an expensive resource. The generation of electricity from coal has caused more hazards and pollution than energy production from oil. Underground mining causes severe damage to miners' health, and strip mining creates conspicuous environmental consequences, since the mines are generally abandoned once the coal is exhausted, with huge areas of land left devastated.

Coal-burning plants emit vast quantities of smoke, ash, gases, and various organic compounds, many of which are known to be toxic or carcinogenic. The most dangerous of the gases is sulfur dioxide, which can severely impair lungs. The sulfur and nitrogen oxides emanating from coal-fired plants not only are hazardous to the health of people living in the plant's vicinity but also generate one of the most insidious and completely invisible forms of air pollution, the acid rain. The gases released by power plants mix with the oxygen and water vapour in the air and through a series of chemical reactions, turn into sulfuric and nitric acids. When acid rain falls on lakes and rivers, it kills fish, insects, plants, and other forms of life. Eventually the lakes die completely from acidity they can no longer neutralize. Entire fabrics of life that took thousands of years to evolve are rapidly disappearing.

Thus the relationship with science today extends to almost all areas of life. Nuclear energy as an alternate source of energy, introduced in response to the crisis of non-renewable energy, has in some sense brought this relationship to an accute point. Not only has reliance on nuclear power increased the immediate human and environmental problems, but it represents today the most extreme case of technology that has "gotten out of hand." Nuclear power plants release radioactive substances that contaminate the environment, affecting all living organisms, including humanity, and pose potential nuclear catastrophies such as meltdowns that at once devastate huge areas of land indefinitely and cause other irreparable, world-wide ecological imbalances that destroy life in general.

It has been claimed that scientific theories do not "anticipate" their own use in society. Even if it is rational for anyone to use them, scientific theories do not themselves contain assertions to that effect. That is, no scientific theory states how the discovery ought to be adopted for practical use. However, today science is under criticism as science and technology are seen to have some harmful consequences. Serious questions have therefore been raised concerning the scientist's traditional autonomy to pursue knowledge for its own sake.

Barnes (1977) refers to Lukacs who in his famous polemic <u>History and Class-Consciousness</u> (1923) contemptously rejected contemplative positions and asserted that consciousness and thus knowledge, of all kinds, in all contexts, was necessarily related to human interests. It was always the product of the activity of particular groups of people, rationally generating it in the course of furthering their interests.

Yet the effort to examine science's internal structure, and to systematically investigate its relationship with wider society still remains a hope for the future (Barnes, 1974). The increasing dominance of technological categories in the life-world of the industrial society, indeed connects the problems of technological development not only with those of social innovation, but also with moral-philosophical questions of the apparently unavoidable, irresistible compulsion or drive for realizing technological possiblities.

Robert Merton (1965), a leading sociologist of science, had laid down an approach which identified science as a social institution with a characteristic ethos, and subjected it to functional analysis. His theoretical approach still remains productive and influential today. However in practice the approach was limted in scope, as problems related to culture have been ignored. As Downey (1969) pointed out, no studies have been made of the general cultural impact of science.

Alternative theoretical perspectives have appeared and interest in cultural questions has increased. Thomas Kuhn (1970) spoke of the new way to appreciate and understand the internal process of science. At the same time, by contrast, he reveals how much of the existing sociological analysis of science depends upon a preconceived empiricist model of scientific activity.

It seems likely then that an examination of the problem of science from the sociological standpoint is bound to contrast sharply with that of others in the science inquiry field. What follows and what has been said earlier are not technical discussions centered upon the properties of esoteric scientific knowledge. They do not seek to assert the value and distinctiveness of such knowledge, as it could contribute to the idealization of science and the alleged demonstrations of special status of its knowledge. However, what will be emphasized is that all knowledge, scientific or otherwise, should stand symmetrically with the standpoint of sociological inquiry.

Chapter IV

EDUCATIONAL SYSTEM IN THAILAND

Historical Development

The present system of education in Thailand is the product of many forces and influences which have been forged and tempered over 600 years of Thai history. The first educational system in Thailand was quite similar to that of the monastic and cathedral schools of Medieval Europe. It had a religious orientation and was centered in temples. Historical evidence shows that the system was quite informal and offered only limited subject matter. The important matter in teaching was the five sacred precepts of the "Noble eight-fold path" that is the essence of Bhuddhism. Thus, the primary purpose of education was to provide moral and religious instruction as well as prerequisites for responsible adulthood. For all practical purposes it was designed to train only the male members of the society. Vocational training was carried on in the family units. Young boys were taught how to farm, hunt, fight, and develop some of the basic skills in handicrafts. Girls were given training in farming as well as domestic skills. Only the children of the aristocracy could expect to receive training in arts and other areas associated with "higher education."

In vocational training or as it was then called "folk-knowledge," the teacher was the ultimate authority in the transmission of knowledge. The teacher was a practitioner in that field and would choose students on the basis of their wit and moral worth. As the teacher assumed full responsibility for transmitting knowledge, she or he would carefully select a recipient who would not distort or jeopardize it. Thus the relationship between the teacher and student was always sacred. Obeisance to the teacher began and ended with every teaching session, a practice that is still part of the current Thai culture.

It could be said that education in Thailand had its first definite form during the Sukhothai period, particularly in the reign of Ramkhamhang the Great (A.D. 1279-1300), who in 1283 invented the first Thai Alphabet, inscribing it in stone (Swasdi Panich, 1966). Even though the alphabet underwent extensive changes, it is still used as the basis of current Thai alphabet.

Briefly, the education in this period could be categorized into two levels. The first one was education for princes and sons of nobles to enable them to fulfill the duties and services demanded by the country. The second was education for the common people to enable them to lead a good, productive, and useful life according to Buddhism.

This basic structure of education was continued through the Ayudthya (1377-1767), the Thonburi (1767-1782), and up to the early part of the Ratanakosin or Bangkok Dynasty (1851).

Reform and Modernization

At the beginning of Ratanakosin period, King Rama I (1782-1809) reformed the Buddhist temples which proved to have a far-reaching impact on the development of public education of the country. There was very little change in the periods of King Rama II and King Rama III, however, in the reign of King Rama III Europeans came and offered western knowledge such as their language, medicine, and mechanics. But this was limited to the Palace or else to the aristrocratic children. The modernization of education was significantly promoted by King Mongkut (Rama IV; 1851-1865), who set-up the first Thai printing press which helped accelerate the widespread use of modern knowledge, and contributed markedly to the advancement of education. People began learning English for the first time, not only to acquire new knowledge and new education, but to promote business and official contacts with the westerners.

This modernization policy was further pursued by King Chulalongkorn (Rama V; 1868-1910). His Majesty saw the need for better trained personnel in royal and government services, and universal literacy among Thai people. The result was a modern type school founded in the Palace. This school offered both academic subjects and bureaucratic practices. The "Command Declaration on School" (1871), issued for this purpose, signified the advent of formal education in Thailand and thus breaking priests' monopoly on teaching esoteric knowledge that with time became more and more secular.

This modern school was the first of its kind in operation and it differed from the other contemporary schools because they were dedicated simply to educating boys to be "well-read men of good behavior." The Royal Command School had regular hours for learning and employed laymen as teachers. It taught not only reading and writing but also arithmetic and other subjects which were required by government officials. In fact, the purpose of the schooling was for the preparation of the state examination, which was the selection process into the service of the monarchy. These motives were also the grounding for the attitudes of the Thai people towards education. Rural and urban people alike were eager to attain higher levels of education in order to become a government official of the King's service. The promise of a better life together with the desire to serve the King enticed many people to move to the major city, Bangkok, and pursue higher education.

King Rama V also set up an "English school" in the Palace to prepare princes and court children for further studies abroad. Also founded were a number of schools outside the Palace for the education of commoner's children. Another significant development at this time was the printing of a new series of government textbooks which were popular in all schools in Bangkok, and later in provincial schools.

Early Education Plan

In 1887, the King established the Department of Education to take full charge of education and the religious affairs of the entire country. Five years later, in 1892, it became the Ministry of Education and Morals. A new approach was employed to take the responsibility of cultural and religious affairs as well as 'popular education' or 'public education.' The purpose of public or popular education was to achieve literacy, good citizenship, and a better standard of living for the people. This was the introduction of a primary education program.

In 1898, the first Education Plan was announced. It claimed detailed plans for educational content, methods, and management, both for Bangkok and Provincial schools. A nation-wide system of examination was put into practice. The second Education Plan came out in 1902. It was based on the revision of the 1898 plan, combined with suggestions made by educationists who had undertaken a study tour of Japan. In 1910 the school system expanded outside the temples. In 1912, the first "Compulsory Primary Education" program was proclaimed and in 1916, the first University in Thailand was founded with four faculties: Medicine, Law and Political Science, Engineering, and Arts and Sciences.

The year 1932 marked the beginning of a new political and educational period in Thai history. The administration of the country had changed from "absolute monarchy" to "constitutional monarchy" (National Identity Office, 1984). "State Education" was put into practice. A National Educational Scheme was formulated and an emphasis on meeting the needs of the individual, especially individual educational ability was implemented.

The purpose of education was revised with the following objectives:

- To build into the population the proper knowledge and habit of modern nations (such as Britain and France).
- To instill love and respect of the nation.
- To promote deep loyalty to the nation above and beyond personal fealty to oneself.

The subject matter was still focused on the 3 R's plus morality, history, geography, scoutcraft, and science.

By 1960, compulsory education was extended to seven years. Secondary education was divided into two streams: a five year general academic education and a six year vocational education. The general secondary school was further split into three years at lower grades and two years at upper grades. (This is equivalent to three years in junior high school and two years in senior high school.) Upon successful completion of the lower secondary school, students were expected to have acquired enough knowledge and skills to enable them either to earn a living, to enter a teachers' college or to continue in the upper secondary or vocational school. In practice, most of the schools after this level of education were concerned with higher education rather than self-actualization. Graduates of the upper secondary schools were expected to be well prepared for university.

Vocational schools were designed to offer courses from one to six years in length, depending on the character of the trade or occupation to be taught. Some of the courses required as a foundation the education received in the lower grades of the general secondary school.

One set of common objectives or guiding principles was adopted for both lower and upper levels of vocational and general secondary schools. These objectives were as follows:

1. To provide general education appropriate for the maturity of the pupils and the conditions of society,

and to provide special programs to meet the abilities and interests of each individual.

2. To inculcate in pupils physical and mental health habits, and concern for the public health program.
3. To develop desirable citizenship attitudes and abilities in order to live and work effectively with others.
4. To help pupils acquire knowledge and skills necessary to earn a living, or the necessary foundations either for vocational training or higher education (Sawasdi Panich, 1966).

With the implementation of the 1977 National Educational Scheme, the education was changed from 7-3-2-4 to 6-3-3-4 whereby six years primary schooling was compulsory, followed by a three years at lower secondary and another three years at upper secondary for those who were occupation or college bound. The main administrative structure was controlled by the Ministry of Education which provided the budget for all public schools. The Ministry also had the responsibility of developing curriculum in all subject areas, including students' texts, teachers' guides, and all other education material necessary for course work.

Today, the Thai school system, or formal education is quite rigid, focusing on the individual as much as on academic disciplines. Students must wear uniforms and display acceptable grooming habits. Personal hygiene is regulated by teachers with daily morning inspections, especially at the elementary school level. The schools are organized into classes with a regular time-table. There is a predominance of single gender, or separate schools, rather than the co-educational schools, but a standardized compulsory examination system, with fixed curriculum, correlates all knowledge that is presently taught in the Thai school system.

Development of School Science in Thailand

There is not much detail about early education in Thailand. Most documents about the history of Thai education mention a profusion of subjects such as Thai language, including Thai literature, arithmetic, and knowledge that was suited for serving the Royalty and the government. More detailed questions pertaining to the subject matter that was offered during that time, remain unanswered. There is evidence that school science was offered in Thailand for the first time in 1895 (Archewaumroong, 1982; Chuapanich, 1982; Sroythurum, 1984).

Science was taught as a single subject in each year of the four years in the final level of a three-level programs. The first year covered natural phenomena, such as rain, thunder, earthquake; the second year plants and animals; the third year physiology; and the final year physiology, mechanics, and physics.

This curriculum was implemented for a period of 10 years. In 1905, the science program was revised and offered at the elementary level, as an elective, and as compulsary in the higher levels. The elementary division was divided into two levels, level 1 study for 4 years and level 2 study for 3 years. This time the curriculum was set up as topics in science and required at least 50 lessons for completion. The headmaster would choose from the curriculum 30 lessons and the teacher the remaining 20. At level 1, the lessons were directly taken from the student's everyday life with content discussing daily objects such as: rice, coconut, river, animals, silk, cotton, leather. For level 2, the curriculum was similar, including a few lessons on elements and human invention. The curriculum was very flexible and gave academic freedom to the principal and teachers. The teaching methods used mainly real objects which students observed and discussed. The main goal in teaching science at the elementary level was to teach students how to group, classify, and differentiate things through observation.

In 1911, the educational system was changed to 3-3-3-3, where the last three years were exclusively for boys. Practical physics was compulsory, and students chose chemistry or botany according to their interests. Two years later, there were some slight changes again in the school science program. The program divided chemistry into practical and theoretical subjects and the subjects studied were not set up according to any grade level, but were left entirely to the teachers' discretion to be arranged according to the type and the location of that school.

Between 1908 and 1930 the government hired an English teacher to be, what they called, "the head master of the school science program" (Archewaumroong, 1982). Although he worked only at one particular school, his responsibilities extended to all the other schools in Bangkok. One of the remarkable and lasting effects of this appointment was that English became the language of learning. Students had to learn, take notes, read texts, and write the examinations in English; and in fact, the entire program was followed according to the British tradition.

This particular incident consequently had a very strong influence on the education system in Thailand. After finishing their studies in these particular schools, many of the students were sent to study abroad, especially in Britain and Europe. When they came back, they were appointed as scientists working for the Ministry of Education, and some were promoted to positions of Minister, Deputy Minister, and Directors of many Departments.

The curriculum did not change radically until 1930 with the beginning of the production of texts in Thai language. Most of them were directly translated from English texts, creating numerous problems for many Thai students studying science. The science program emphasized the pure rather than applied knowledge. The texts adopted most of the technical terms without translation, and/or accomodated them with special vocabulary that suited those technical ends. A lot of the concepts, because of their presentation, became difficult to grasp as no effort was made to acclimatize terminology and language to the Thai students' cultural and educational background.

Until 1960, there was only a slight change in the content. The Ministry of Education at that time did not yet produce its own texts but provided a strict set of goals for each course, according to which the text had to be written in order to be approved by the Ministry for use in the school. Each school would choose a text from the various approved authorities and teach according to it. The only teachers' guide was produced by the Ministry to accompany the course syllabus planned by them.

Usually the authors of the texts were professors who were teaching in the faculty of science. The quality of the text would vary according to the interest of each author and her or his specialization. As an example, the two biology texts that were widely used in biology courses at the secondary level differed only in that one author was an expert in plant biology, thus in his text there was a great emphasis on the botany section. The other, who was teaching in the department of Zoology, stressed the animal and zoology content.

From 1960-1971, before the influence of the curriculum reform movement in the western countries, science education was compulsory for all levels from grade 1 to grade 10. There was only one science program at that time. At the senior-high level, science was separated into five subjects: (1) biology, (2) chemistry, (3) mechanics, (4) heat, light, and sound, (5) electricity and magnetism. A class-time of two hours per week was required for each course and students who took the 'science program' had to take four of the five subjects. In addition, there were 5 practical subjects (laboratory) in parallel with the theoretical subjects. These practical subjects also required class-time of two hours per week, but students had to select only two of them. For the non-science program, science was provided under the heading "general science" which was a combination of physical and biological science with class-time of four hours per week and no practical subject (laboratory).

In the year 1970-1971, UNESCO initiated a project for developing curriculum and instruction in science education in

Asia (Ketudhat, 1981). Bangkok was selected as the center for this project. At the beginning of the project, only chemistry and physics were involved. The project was regarded as very successful and was expanded to work with all science subjects and mathematics.

In 1972 the Royal Thai Government, in cooperation with United Nations for Development Project (UNDP) and UNESCO, established the Institute for the Promotion in Teaching Science and Technology (IPST) as a semi-autonomous agency attached to the Ministry of Education. There were many science educators and teachers travelling abroad to the United States. for short training courses in established programs such as Chem Study, Harvard Project Physics, PSSC (Physical Science Study Committee), BSCS (Biological Sciences Curriculum Study) and IPS (Introductory Physical Science). Courses were also taken in England under the auspices of the Nuffield Foundation.

The Institute (IPST) claimed that in producing its own science curriculum (textbooks) it would ensure relevance to the Thai society. In my opinion, 'relevancy' here refers strictly to the use of data and numbers based on samplings of Thai society. From investigating the general objectives of this project in teaching science, one can see that none of them expressed in practice a need for studying interrelations among science, technology, and society. In fact, one objective was stated as "to understand the effect of science on human beings and the environment," demonstrating an underlying value, accepting the power of science and technology over humans and nature.

The main objectives of science curricula developed by the IPST demonstrate the attempt to develop three main characteristics of science: (1) the gathering of scientific knowledge, (2) the practice of scientific processes, and (3) the development of scientific attitudes (Sroydhurum, 1982). The content of the courses comprised material considered to be both universal and local. Sroydhurum mentioned in this report that "the universal part contained topics similar to those in almost all traditional school science programs everywhere. ...It was agreed among members of the design teams that the universal topics could be borrowed, translated or adapted from other standard works, but the local topics were to be written in a manner that suited the needs of the country" (p. 10). The curriculum developing group, as it turns out, places significantly more emphasis on the universal part rather than the local, so it can further be asked in what content or context is universal knowledge perceived by this group?

In the current science program, the study of science is compulsory up to grade 9 and science credit must be earned at the senior-high level in order to graduate. About ten percent of instructional time is devoted to science, which is less than that alloted to language studies, mathematics, or social studies (e.g., in history and geography) but more than music, art, and health education.

In the elementary school, science is not separated out as a single subject, but is included as an integral part of a course "Life Experiences," which discusses many topics that are assumed to be related. At the lower secondary school level, science is provided as a distinct course, under the name "General Science." It is the only program for all students starting from grade seven, and the courses present several related disciplines in each grade. In the upper secondary school level, for the students who choose the science stream, science courses are divided into three subjects: biology, chemistry, and physics. For non-science students, science is provided in modular form in a "physical and biological science" course from which the student can select eight out of fourteen modules that deal with biological and physical sciences.

Although the IPST claims to have produced its own curriculum, science curricula in Thailand are not much different from those in many other developed and developing countries that have been strongly influenced by the western approach to science. In developing countries, science educators and those who have responsibility for developing curricula, often pattern programs after those of developed countries. I do not suggest abandoning the science curricula of developed western countries, however, I believe that the objectives of the curriculum in each country should relate to the country's own perspectives. This includes not only Thai sample, but also the particular cultural and social setting as a contribution to scientific activity.

Science curricula such as BSCS, PSSC, and CHEM Study, are being adapted and implemented throughout the world. These projects were part of the curriculum reform movement in the 1960s that led to restructuring of science curricula and teaching strategies in terms of structure and process skills. I would like to name this orientation as technical-analytic. This orientation limits students' connection with everyday experience, but it satisfies the pedagogical demands of the science educators (Jacknicke & Rowell, 1984).

Lutterodt (1980) argued that curriculum development work could certainly benefit from the success of on-going curricula like the BSCS and PSSC projects, however she noted that these projects did not and could not cater to the needs of every country. They needed to be translated before they could be used. In most cases, other changes were needed in consideration of different educational structures, environmental influences, societal needs, and cultural variances. In other words, if the available curricula are to be used to an advantage in settings different from those for which they were originally designed, they need to be modified or adapted.

Symons presented a very appropriate thought about science curriculum: "science is not just a set of laws; science is an 'activity' which involves people, attitudes, aims, and processes. It is as much a part of the cultural fabric of a nation as it is a pillar of technology. Scientific laws may be universal; scientific practice is not. Science is very much part of the culture of a country" (1975, p. 93). Thus, science curricula should be relevant for people in their own culture. Scientific knowledge or interest should emerge from the social and cultural needs or interests, not as purely imported from the other cultures.

Symons further described how Canada has imported technology without a critical analysis of its applicability to Canadian needs. There has been a failure to relate curriculum to the actual characteristics and needs of this country, leaving students with no realistic understanding of the distinctive Canadian character and its physical and social factors.

The problems that Symons raised are similar to those that have occurred in Thailand. The culture and beliefs of foreigners have swept into Thailand with great force. Thai people have not been able to respond or adjust their thinking and attitudes fast enough to keep abreast of all the new developments. The economy is moving towards modernization and diversification, although Thailand is still in sentiment an agricultural country.

The Development of Science Curricula in Western Countries.

In the early 1960's, there was a tremendous change in curriculum, especially in science education. The most significant change occurred in the United States during the period of 1955-1975. Wayne Welch (1979) and Garth Benson (1984) have provided an extensive summary of curriculum change during this time. In the early 1950s, scientists and science educators became concerned about the quality of science education in secondary schools. The reason was due to the decrease of high school graduates entering university science faculties.

In conjunction with the political climate and the appearance of a book on the supremacy of scientific manpower in the USSR, the United States government was stimulated to take action. The result was that the National Science Foundation (NSF) provided almost 700 million dollars for curriculum development and teacher-training. Curriculum series resulting from this reform were the Biological Science

Curriculum Studies (BSCS), Physical Science Studies Curriculum (PSSC), and CHEM Study, among others. These materials have been used in many countries all over the world, including Thailand. These curricula attempt to place emphasis on the nature, structure, and unity of the disciplines such as biology, physics, or chemistry (Schwab, 1964).

During the early part of the curriculum reform movement (1960's), knowledge and method were firmly established as important aims in science education. These aims were called "the conceptual schemes of science" and "the processes of science." Examining the organization of these aims can be a useful way of describing historical change in science education. For example, Tyler (1962) stated that society influenced the changes in science education during this major period of transformation. However, it was not completely so, for the "society" referred to by Tyler was exclusively made up of educators or policy makers. It was not a view derived from the public, which is genuinely aware of social problems or social concerns.

In the middle of the 1960's, new science issues in education referred to the problems of urban environment in relation to the culmination of massive population migration to the cities. Problems of the natural environment, such as population and pollution, became common themes. However, these were not the real problems to be solved, but rather an indication that human needs were not being met by the ever-increasing technological morass; there was a revolt of the diminished man.

In fact, the science courses developed in the sixties lacked social context and tended to overemphasize advanced theoretical concepts, ensuring perhaps excellence in the basic training of future scientist but taking for granted that common students should be subjected to the same degree of abstraction.

Many scientists have regarded school science as a fixed body of knowledge "related to and derived from 'real science' which young people need to know in order to understand the world in which they live"(Rowell, 1983, p. 25). Actually, curriculum reform at the time of the early sixties adopted a model of science education patterned after the work of Jerome Bruner (1963) in the <u>Process of Education</u>. His writing saw the science knowledge consisting of concepts that form the structure of the discipline. The prevailing notion was that if the students understood the structure of knowledge, the understanding would permit them to go ahead on their own. They did not need to encounter everything in nature, but by understanding some deep principles they could extrapolate to the particulars as needed.

Schwab (1964) encouraged this view by pointing out that curricula, such as BSCS, should focus on the nature, structure, and unity of biology as a discipline. MacDonald (1975) demonstrated that Schwab's conception of curriculum was an example of a technical orientation toward curriculum. The structure of the discipline became equated with the content in many National Science Foundation curricula reinforcing a technical orientation towards curriculum development.

However, ten years after the publication of The Process of Education, Bruner (1971) announced that:

> If I had my choice now, in terms of a curriculum project for the seventies, it would be to find a means whereby we could bring society back to its sense of values and priorities of life. I believe I would be quite satisfied to declare, if not a moratarium, then something of a de-emphasis on matters that have to do with the structure of history, the structure of physics, the nature of mathematical consistency and deal with it rather in the context of the problems that face us. ...We might put vocation and intention back into the process of education, much more firmly than we had it there before (p.21).

Bruner had given recognition to the inadequacies of existing curriculum inquiry modes but was unable at that time to suggest fundamentally new directions. But it seemed that people failed to recognize what Bruner mentioned in the seventies (Aoki, 1978a).

In 1977 Magoon indicated that many science programs today are predominantly theoretical and present findings ahistorically, suggesting an incremental progress of science.

It could be summarized that these science curricula are unrealistic because they stress "the structure" of scientific disciplines. This stance is also supported by Jacknicke and Rowell who stated that "science curriculum has adopted a technical approach to development, implementation, evaluation, and research that has narrowed our view as to what science is, and also has presented students with a misrepresentation of the reality of science" (p. 3).

Bybee (1977) suggested that the structure of science education may be conceived in terms of three major aims that underlie the organization of curriculum and instruction. The first aim is empirical knowledge of physical and biological systems. This aim includes the range of accumulated observation and systematic information about the universal, the structure of a discipline and the functional applications of knowledge, for example, technology. The second aim is the scientific methods of investigation. This aim encompasses the techniques of investigation, the required skills of problem-solving, the processes scientists use to produce new knowledge. The third aim is personal development of the student. This aim includes the intellectual, emotional, physical, and social requisites of the students for assimilating the knowledge and methods of science.

The organization of curriculum and instruction in science would be determined by the way in which the three aims a range of approaches can be implemented in classroom science teaching. It should be noted that the last aim mentioned above is usually ignored or ranked as the last priority in the objectives of science curriculum.

In summary, the late seventies and early eighties experienced a slight shift in the aim of science education from the traditions of the sixties. Science educators such as Aikenhead (1983) and Symons (1975) emphasize science in the cultural context as is so often supported in the monograph "Science in the Canadian context." Aikenhead also calls for a "science and society curriculum" that views science as a cultural phenomena and within the social context.

CHAPTER V

JUNIOR HIGH SCHOOL SCIENCE CURRICULUM IN THAILAND

Introduction

Critical theory and hermeneutic understanding put an emphasis on curriculum-as-plan. They question the technological presuppositions which underlie the social action in curriculum. The questions are: How can we possibly examine something we are using all the time or something that is so familiar to us? How can we analyse the terms in which we habitually express our most simple and straight forward observations, and reveal their presupposition? How can we discover the kind of world we presuppose, proceeding as we do? In this study, these questions are made possible by critically reflecting upon the junior high school science curriculum in Thailand, using a model of research informed by an understanding of critical and hermeneutic theory.

The first step in criticism of familiar concepts and procedures must therefore be an attempt to break the circle. We must invent a new conceptual system that suspends or clashes with the most plausible theoretical principles and introduces perception that cannot form part of the existing perceptual world. This is an attempt to imply an essential analysis, to be re-evaluated through the criticism of the consistency condition, even though this alternative to the accepted point of view shares with it its confining instances.

If we suppose that knowledge is socially constructed; that is, the meaning which we give to everyday language, arises from our interactions with others (Schutz, 1973), the meaning which we impart to the language reflects our way of being in the world; our own particular background from which we speak. Language, within this context, is not seen as being neutral but rather as reflecting the point of view of individuals or groups engaged in its use (Berger and Luckmann, 1967).

Neutrality itself may be viewed in terms of the particular group which seeks this particular vantage point; it is based upon the socially constructed assumption within the group or community who uphold the value (Schutz, 1973). Thus, curriculum developers inevitably will reflect their particular view of the program which they construct.

Officially defined goals, along with content, methods, evaluation, and others, which reflect the particular world-view, are often a part of curriculum. It is possible to investigate these in terms of various paradigmatic views of knowledge (Garfinkle, 1980). By using a paradigm as the form of reference approaching curriculum would focus on understanding program guides through the language that is used to describe the curriculum to the teacher. The investigation of the underlying meaning of these descriptions is an attempt to clarify the intersubjective meaning which the program developers used to describe the world for others, and how these meanings reflect the actual or lived experience of the student in the world. The image of knowledge being portrayed in a program may be disclosed through the language which has been used to convey the program to others.

Science Curriculum Reform: From the West to Thailand

Historically speaking, science education in most developing countries before the Second World War was patterned after the industrialized countries of the west. Many teachers came from foreign countries and took leading roles in establishing the science education program in these countries. Textbooks and equipment were imported for use at the secondary and tertiary levels. Science was taught with heavy emphasis on retention of facts without any concern for relevance. Examples and problems in science textbooks were those of the west. The few laboratory and experiment exercises, if they existed at all, were strictly for demonstration by teachers.

In the late fifties many developing countries began to expand their training programs especially at the tertiary level (Ketudhat, 1981), both in-country and abroad, in order to provide more qualified scientists, technologists, planners, and educators. This expansion of science education gave rise to a cadre of dedicated people who not only had at their finger tips the new scientific and technological knowledge, but who were also willing to challenge the long standing status quo of social conduct, for what they felt were the greater needs of the country.

The Sputnik shock in 1957 catalyzed a change in science education in the west which provided a spin-off effect in developing countries around the world by awakening a movement that further stimulated science reform. This chain reaction affected Thailand as well.

Many organizations, such as UNESCO, the Southeast Asian Ministers of Education Organization (SEAMEO), and the Asian Institute of Technology (AIT) played leading roles in providing forums for the exchange of experiences and stimuli for systematic reform and development. For the purpose of case illustration, the experiences of science education reform in Thailand will be cited here.

In 1965, at the invitation of the Science Society of Thailand and the Ministry of Education, a UNESCO sponsored Asian Chemistry Pilot Project for Secondary Education Level was started in Bangkok with the view to promote the improvement of teaching techniques and content of chemistry learning in secondary schools in Asian countries. The Chemistry Department of Chulalongkorn University, which was one of the oldest and best developed departments in Thai universities at that time, acted as the host institution while cooperation was given to the project by the National Research Council and the Science Society. Twelve countries, namely, Afghanistan, Burma, Sri Lanka, China, India, Iran, Israel, Japan, Korea, Malaysia, Phillipines, and Thailand participated in the Project; a team of eight international scientists served as the faculty of the Project and eight Thai chemists served as Project coordinators with the Thai agencies concerned.

During the course of the Project, the Thai scientists and science educators from the various institutions and universities learned, not only from the regional participation and experiences of the other Asian colleagues, but also from inter-agency and inter-institutional cooperation within the country. For the first time, these university science professors admitted the strong need to pool together their resources and efforts in order to help achieve the common goal of science education reform in Thailand. A joint request therefore was submitted to UNESCO to make a feasibility study and to help plan the establishment of the

Institute for the Promotion of Teaching Science and Technology in Thailand (IPST).

It could be said that this was a very significant event that occurred in the history of Thai education, especially in science education. But on closer examination, the project did not differ much from other such endeavors. It was set up and patterned after projects developed in western countries, including autonomy which they initially claimed to be their original concept. This concept was more or less adopted from the United States and the United Kingdom, countries already possessing their own specialized institutes for developing science curriculum independent of the State authority. Indeed, the Institute has been established by the motivation from without, especially UNESCO, rather than emerging from the recognition of the needs of the society or from the genuine interest of Thai educators. The real interest of these people was to emulate the western countries in modernizing the process of teaching and learning science in the Thai school.

The Institute for the Promotion of Teaching Science and Technology was supported by the Thai government and UNESCO from 1971-1978. In 1978, the IPST was re-organized under the Ministry of Education. Originally, the Institute was given a broad spectrum of responsibilities. Its Enabling Act laid down the following objectives:

1. to initiate, execute and promote the study and research of curricula, teaching techniques, and evaluation in sciences, mathematics, and technology at all educational levels;
2. to promote and execute training programs for teachers, instructors, lecturers, students and university students, on the teaching of sciences, mathematics and technology;
3. to promote and execute research, development and production of science equipment and materials for teaching of science, mathematics, and technology; and,
4. to promote and execute the preparation of texts, exercises, references(not done), supplementary materials, and teachers' guides on science, mathematics, and technology (Ketudhat, 1981).

These defined objectives were broad and ambitious, and difficult to implement immediately especially at the developmental stage or, as I believe, at any stage of the Institute.

To show that they were also unreasonable, I would like to point out first that the university administrations were independent from the IPST and usually regulated their own research of curricula, teaching techniques, and evaluations. The IPST could only act through the Ministry of Education, which itself was responsible only for education from the primary level up to and partly including tertiary education such as vocational education and teacher's college. It's claim to jurisdiction over all educational levels therefore was not substantiated. Finally, the IPST admitted shortage of staff both in quality and quantity, a problem which they attempted to remedy through the use of external consultants, advisors, and the funding of overseas study for its staff.

This indicates an unrealistic ambition of the Institute to control and assume too much responsibility in the given circumstances. I believe a more appropriate course of action would have been to pursue a cooperative atmosphere with the existing institutes which already in part addressed some of the objectives. A case at hand, is their objective to promote and execute training programs. This should have become the direct responsibility of the existing teacher training institutes, whose first responbility was to prepare both pre-service and in-service training, according to the education system of the country. The IPST should not try to duplicate the roles of these institutes which were already at that time fully capable of providing part of the service in question.

The IPST claimed that its functional group of key persons in curriculum development was composed of specialists from different levels ranging from school science teachers to university science professors. In fact the process of selecting the experts depended more on personal contact than the capacity and specialty requirements of the work. It is obvious that this process did not fulfill their ideal. For instance, the working group for the junior high-school science curriculum in grade 8 and grade 9 was composed of one science teacher from a secondary school, three educators from a select university, two from teacher colleges, five IPST members, and four professors from the faculty of science of another select university. That is, only one of them was from outside Bangkok, none of them was directly involved with junior-high school science education, and the majority of them were strictly discipline oriented in science.

Often the leaders in the working groups and in the subject teams (biology, physics, chemistry), usually seconded from the universities or the teacher colleges, had masters and doctoral degrees from leading American Universities. In addition to the Thai staff members, there were also foreign advisors, who as consultants had no real executive power or responsibility, but inspite of their advisory status, had a strong influence on all aspects of the project. White and Butts (1975) explicitly indicated that Gordon Aylward, former associate professor of chemistry at Macquarie University, had a long-term appointment as a Chief Technical Advisor with a predominant influence on the project. Other foreign advisors, such as Wenham from Nuffield Project Physics, and Miller and Chesley who worked with Harvard Project Physics and UNESCO Pilot Project on Teaching Physics, all cited in <u>Twelve years of development of science and mathematics education in Thailand</u>, (1984) are referenced in the IPST publications. These foreign advisors have often been chosen because of their connection with a particular project, and tended to mould the IPST courses in light of their particular backgrounds.

The project funded many fellowships for its staff to study overseas for Masters and Doctoral degrees, and to visit other curriculum projects in order to overcome its problem of scarcity of skilled people. The institute aimed at a more permanent solution by financing long-term studies for master or doctoral degrees. The short term solutions included few months at specialized institutes such as the Australian Center of Educational Research (A.C.E.R.), and the hiring of overseas consultants.

The general attitudes of the participants in the project towards the curriculum written in the West was very positive. The IPST curriculum began development in 1973 and was implemented in 1976. In their book on the development of the IPST curricula, the staff often referred to the curriculum development in the United States and Britain during the early 1960's, noting that the "focus on application and the integration approach gave more meaning to the learners" (IPST, 1984, p. 76). The curriculum used in these countries was termed "successful," inspite of the recent shift in United States science education to more community oriented science courses. In fact, the outline philosophy, aim, and rationale in setting the goals and objectives of the curriculum and teaching-learning strategy were all based on the data and information provided from the UNESCO workshop upon the suggestion of foreign advisors (IPST, 1984, p. 4).

At the same time there was only marginal effort in the project to incorporate Thai cultural perspective. Although it was acknowledged that science did originate in the West, it was accepted as universal (Ketudhat, 1984). Because of this the Institute believed that the ratio of the local content to the universal knowledge should be 30 to 70 in the Thai science program (Tamthai, 1984, p. 49). This was usually achieved by changing to Thai samples in the examples. The format of these examples remained the same.

According to White & Butts (1975) the Thai educators at the time of IPST curriculum development were not capable of effecting the difficult interpretation of learning theories that would suit the Thai temperament and the Thai cultural setting. This could be the reason why the IPST courses in their present form share their learning theory, objectives, and the philosophy in teaching school science with PSSC,

7

BSCS, and Nuffield Science Project and alternatives such as ASEP, IPCS, and Wisconsin Mathematics courses as all of these projects originated in the West (White and Butts, 1975). A serious effort must be made to translate the learning theory, which is implicit in these courses and especially tailored to the western way of life, if the curriculum is to have meaning in Thai context where the cultural and social way of life differs in many important respects. It is not enough to modify it by simply changing to examples using Thai samples as data. Without this effort I question the success Institute had in adopting the western curriculum.

For example, these courses incorporate a method of inquiry as one of its teaching techniques. The effectiveness of such method in the Thai classroom environment without modification is suspect. The Thai culture assimilates into its people a high sense of respect for seniority which each student brings with her or him into the class and the teacher, who still possesses in part the traditional authority, ultilizes this in her or his administration of knowledge and discipline. It is unlikely that the original intent of the inquiry method sought in western curricula can be reproduced under these conditions.

Finally, the overall effect of the issues raised above is clear. The predominant contact with foreign curriculum projects has influenced the team members in their view of what was possible. The discussion undertaken in the development of the Thai curriculum probably centered around various aspects of western science curricula and, as will be seen later, completely avoided the broader issues of Thai culture and the problems associated with implementing science in a Thai environment. The result of the IPST effort was a curriculum that did not differ significantly from the curricula employed in the United States and other countries, and as a result it failed to address important issues pertaining to the Thai society.

The problem at hand, it seems, is to re-direct the Thai science curriculum perspective back to Thai society and its needs. One way to do this is to dispell the current myths in the Thai community about science and to whom it belongs. Thai people must be aware that they too can practice science in a unique Thai way. To do science does not mean that they have to adopt the typical western stance of scientism, a stance that is presently being questioned in the west as well. It does not mean that the curriculum adopted must reflect the western curriculum in order to grasp the essential meaning of doing science.

Technical-Control Curriculum

The IPST devised a "system approach" to curriculum reform and put it on operational terms in 1976. The system initially adopted a top-down approach that was designed to synchronize and provide adequate preparation for the acceptance of the most important "output" and to provide clear insight into the most needed "input" and to oversee the sequential development tasks as a part of the total operation. The Institute planned to develop, test, and evaluate students' texts and teachers' guides. It also planned to develop and guide the production and distribution of science equipment, teacher training materials, evaluation procedures, and instruments.

The IPST attempted to keep the curriculum development as a continuing process which began with the defining of goals and objectives and was followed by deciding the themes, content, skills, and attitudes that should be developed in students. Criteria for the selection of content, activities, attitudes, and skills were determined by the design teams, which the IPST claimed was composed of "local" school teachers, teacher training college instructors, university science specialists, and educators. The material was written, and rewritten. Trials were conducted and teachers received two weeks of training provided by the IPST. The curriculum was revised, published, distributed, and implemented throughout the country. A school follow-up study was established (Sapienchai, 1982).

The first stage involved twelve trial schools, with programs limited to a full academic year of grade 11 in Physics, Chemistry, and Biology. The following year, the trial program expanded to include both grade 11 and grade 12 in the same subjects along with the grade 8 science curriculum. Students were provided with the trial edition of textbooks and with the required chemicals, glassware, and science equipment, including many pieces which were newly designed and produced by the IPST. The teacher received a detailed teachers' guide, evaluation instruments, regular visits from the IPST design team with regular feed-back, and complete backing from the IPST (Sapienchai, 1977; Tamthai, 1984).

The schools involved in the trials were chosen according to size, qualifications of staff teachers, and budget. All of them could be classified as "big" schools, with qualified staff and stable budgets. Ten of the schools were in Bangkok and the other two were just outside in the suburban areas. The intention was to to test the IPST curriculum in schools that were "ready." The same criteria for selection was also used when the trial runs were later extended into provincial schools which were chosen close to Bangkok, enabling convenient travel for members of the supervisory staff (Sroydhurum, 1984, p.7).

Nida Sapienchai the former director of the Institute at that time claimed, "The instruments of change are all at hand, a newly developed text for every student, a teachers' guide for every teacher, a set of science apparatus for each class of students, teacher training programs for teachers to get some experiences and insights into new courses" (1982, p. 8). This was a rather optimistic statement in light of the actual situation, especially in a country like Thailand.

Thailand is a developing country, with approximately 80 per cent of its population living outside the cosmopolitan area of Bangkok, mostly in rural agricultural communities. The schools in Thailand must deal with and therefore also in part reflect this special character of the country, diff[illegible] in size, quality, and the type of education they provide to their students. For example, many rural schools need to adjust to the local ethnic community, its geographical remoteness, and the interests of the students which in general are different from their metropolitan counterpart who will usually pursue a higher academic education. Thus, it is in this environment that the IPST must operate and meet its objectives. But as was pointed out earlier, the trials were effectively conducted in a metropolitan setting, more or less ignoring the distinct character of the rural school and the needs of 80 per cent of the Thai population.

The optimistic claims by the former director of the Institute were difficult to realize in the rural areas as the distribution of students' textbooks or teachers' guides was difficult at the best of time in the remote areas of the countryside, not to mention the distribution of the science equipment. And to assume that every teacher who received the training from the Institute would gain the needed insights into the new curriculum, especially in the brief two weeks that was provided for the in-service training and the type of curriculum that was introduced, was foolhardy.

In the end, the same general problems that plague other curriculum projects were also present in the IPST curriculum development. They are best described by Aoki when he referred to a case in Canada that is strikingly similar to what occurred in the process or "system approach" as the IPST called it, of attempting to bridge the gap between curriculum-as-planned, curriculum-in-use, and curriculum development.

> Within the curriculum branch of the Ministry of Education, someone in an administrative role as curriculum director summons a group of teachers and perhaps a university professor of education handpicked for their reputed exellence in teaching (not necessarily for excellence in curriculum development), sets them the task of developing a curriculum in a subject area. Usually there is included a token evaluation (piloting testing is the legitimated jargon) done usually by handpicked teachers. Minor revisions are made, band-aid fashion. (Full scale revisions are usually impossible because the timeline administratively pre-set prevents such an overhaul). Then, the massive undertaking of implementing the program in all schools of the province begun. ...The experts-in-the-know hop from school district (in this case IPST) providing "communiques" to assembled teachers who, under a high level of anxiety and

> frustration, attempt to understand it all in one or two day session. In the meantime, the Assessment Branch's psychometricians develop achievement tests to measure teacher effectiveness indirectly by measuring student learning directly (1983, p.4).

Forming the Thai Science Curriculum

Pinar and Grumet (1981) pointed out how the curriculum field originated out of an administrative need rather than an academic discipline. It developed as an atheoretical, ahistorical activity which addressed itself to managing and administering policies through the instrument of the school curriculum. The features of scientific management were adopted to schools using (i) definite and clear aims, (ii) efficiency of means for reaching the aim through a rationalization and standardization of the teaching process, (iii) an organization capable of achieving these aims, and (iv) strong management control of all educational process (Callahan, 1962).

The Tylerian model is a "prototype" of present curriculum theory and has a continuing influence on the curriculum field because it emphasizes "common-sense" practice. Its conceptual framework emphasizes the efficiency and effectiveness of the educational process and is especially suited for the formulation of science curriculum as the theory already espouses a science perspective as the sole curriculum approach. That is, it accepts and applies technological rationality. According to MacDonald (1975), control theory is based on a "linear aspect" model or design in that curriculum development is applied first by drawing-up specified goals, second by formulating content and learning activities that address these goals, and culminating in an evaluation of how the ends-means compliment each other. The primary value position is control.

There are four basic questions that the Tylerian model asks every developing course to consider and answer. These are:

1. What educational purposes should the school seek to attain?
2. How can learning experiences be selected which are likely to be useful in attaining these objectives?
3. How can learning experiences be organized for effective instruction?
4. How can the effectiveness of learning experiences be evaluated? (Tyler, 1949, p. 4)

The assumed neutrality of these four basic issues is however contested by many present day modern curriculum theorists. According to these theorists, the issues obscure the ethical and political conflict over which questions such as "What is the purpose of the school curriculum?" or "Who should decide the purpose and content of the school curriculum?" are resolved, by reducing these conflicts to technical problems.

In my approach to curriculum development, all these are important and must be incorporated into the program. I also view curriculum development in an "integrated" rather than "linear" form. Integrated in a sense of an ongoing process that poses it's own problems and it's own solutions, through the free interaction of different components in the system, without restricting the method, content and context. It is in this light that I examine the IPST curriculum and offer what I perceive are necessary additional critical steps in freeing it from the entrenching and circular scientific thinking of the west.

The Structure of the Junior-High School Science Curriculum

The nature of the IPST curriculum reform is text based. A single set of student textbooks accompanied by a teacher's guide are written in Thai language and produced for each semester. Each grade level has two prescribed texts and each text has a teacher's guide attached to it except grade 7 where one guide is used for two student texts. Thus in the junior high school science curriculum, there are 6 student textbooks and 5 teachers' guides.

The courses consist of 18 self-sustained units, each with a topic of study and a particular aim. A study topic requires one or more class periods for completion with suggested instruction-time indicated in the teacher's guides. The teachers are urged to spend as much time as is necessary to convey the content of each lesson, however, each classroom activity is accompanied with the suggested time for completion.

Teachers' Guide

The teachers' guide is the "comprehensive source" in studying science. It states the content every student should learn from the course, suggests teacher stimulated activities for the students to initiate in the classroom, and includes everything that a teacher "needs" to teach the subject, even material for the edification of the teachers themselves.

In it's broader form, the teachers' guide is structured to present the major components of an "inquiry approach" and the general content of each unit in a systematic way. Each lesson is composed of topics and sub-topics, organized around at least one experimental activity and made to correspond with the students' textbook. Additional details of pre-specified means and pre-determined ends are elaborated on to guide and direct the teacher in her or his presentation of the material. To illustrate this, a sample lesson taken from the grade 8 teachers' guide appears in appendix C.

Each lesson in the teachers' guide begins with a list of behavioral objectives, which are provided not only for the lesson, but also to accompany each experiment and each classroom activity. A table indicating the sequence in which the concepts are to be taught, and the type of interaction that is expected of the teacher and her or his students, follows this list. A summary, outlining the important concepts that students should learn, leads to the actual activities of each lesson and the instruction time needed to complete it. The classroom activities are regulated through detailed pedagogic strategies. They determine for example, what the teacher should use to introduce a lesson; such as asking specific questions, using pictures, or providing certain background information. Pedagogic strategies also list the materials, preparation techniques that the teacher uses to prepare experiments, and supplementary knowledge that should be given to the students.

Students' Text

Students' texts rely heavily on the supervisory function of the teachers' guide to fulfill its educational purpose. The IPST regulates all facets of education through the teachers' guide including what some present-day curriculum designers consider an important part of student's own personal orientation, such as supplementary reading sources. The information of the course in the students' text is kept to a minimum, while the format emphasizes a scientific approach composed of topics and sub-topics, where small amounts of detail are followed by teacher or text directed experiments and practice of scientific skills. A sample lesson from the students' text that corresponds to the selection made in the teachers' guide appears in appendix D.

The lessons in the students' textbooks are structured around the experiments. An introduction to the lesson provides the student with some background information and if necessary defines concepts used in the topic. At the end of the paragraph are statements in question form, suggesting in an inquiry mode, how to study, or what to study in the lesson. One or two short statements introduce the sub-topic which is structured either around an experiment or the practicing of scientific skills. Each sub-topic or experiment is usually concluded with questions pertaining to the material just covered and there might be a short paragraph of supplementary information related to the concepts just learned. To close the lesson there are exercises, often in the form of recall questions, that summarize the lesson material.

What is in the Curriculum-as-Planned

The official objectives of science education as stated in the document concerning the school science program in Thailand are:

1. To develop an understanding of the basic principles and theories of science.
2. To develop an understanding of the nature, scope, and limitation of science.
3. To develop a scientific attitude.
4. To develop skills important for scientific investigations.
5. To develop an understanding of the consequences of science on human beings and their physical and bilogical environment.

These are the only stated objectives for the science courses produced by IPST. They apply to all grade levels, from grade 7 to grade 12, to each subject, from general science courses in the junior-high school to Physical Science and Chemistry in senior-high school, and to the science courses in different vocational programs from accounting to mechanics. The priority goal of this program is to develop positive appreciations for science as well as to develop scientific attitudes and science process skills, in the hope that the current science curriculum can be applied to the program of individual life as well as the social welfare of the community.

How these objectives are pursued and to what degree they are actually realized in the content of the curriculum will be part of the following investigation. The investigation will be based on the existing teachers' manuals, students' textbooks, and other IPST publications. An effort will be made to reflect critically as is characterized by the critical evaluation. That is making explicit the foundations, unveiling the hidden, or questioning the taken-for-granted. Revealing the "meaning" by closely scrutinizing beliefs, assumptions, metaphors, and intentions that underlie the program.

In this task, we must focus on knowledge that is presented in the curriculum. What is recognized as knowledge? What has been selected and what has been neglected? A special attention must be given to language, which is seen as going beyond the definition of the term used. Kinneavy (1971) suggested that almost all language can be seen as persuasive in its intent. Terms and phrases are used for their relational impact, for their critical impact, and for their persuasive appeal. Much of the language we use has the purpose of persuading others so that we can and do identify with them (Burke, 1941).

Criteria in Selecting Content

The IPST drew up a criteria list to select content that best suited the objectives stated above. The criteria attempted to strike a balance between the demand on both the abilities of students and teachers, and the IPST's desire to present science as a more or less encompassing program, emphasizing scientific skills, scientific theory and the relevance to both natural and social phenomena in Thailand in the three majors areas of science (Physics, Chemistry, and Biology). Thus the criteria for selecting the content stressed:

1. The relevance to the modern scientific knowledge.
2. The continuity which shows the structure of scientific knowledge.
3. The scientific principles to explain natural phenomena.
4. The appropriateness to time schedule, students' ability, and age.
5. The appropriateness to the teachers' ability and the material avialable in the country.
6. The (Thai) sample in application of scientific principles to the developing industry, agriculture, and technology.
7. The promotion of creative thinking in individuals,

and the understanding of conservation and environment (Sapienchai, 1977; Tamthai, 1984).

The content criteria indicate that the concern of the curriculum developers was to present to the student "modern scientific knowledge." Further, this scientific knowledge is used to explain natural phenomena and to provide the student with examples of actual application in other areas of social life. That is, scientific knowledge is used as a means of understanding what is considered to be the true nature of reality and as an application to both natural and social worlds. Usually the "world" conceived under such formulation is mechanistic, predictable, and explainable in terms of scientific models that can be communicated to others, in this case the students.

Images of Science

A. Image of Scientist/Scientific Attitude

The course has been claimed as "inquiry oriented," employing many practical exercises referred to as the "practicing of scientific skills." They take the form of experiments, laboratories, or any other procedures that are regarded as part of the scientific method normally employed by scientists. That is, science is promoted through an image of a scientist which, as this section shows ,the curriculum carefully fosters in the text.

The very first topic in the junior-high school science course is set aside to describe some of this image under the heading of "How scientists work." It sanctions connection between the study of science in the curriculum and the actual work of the scientist.

> What is important and interesting is to know how scientist works. (Students' text, Grade 7)

> ...students should study how scientists work, so that they will be able to follow, practice, and implement the 'good method' that scientists use. (Students' Text, grade 7)

That is, it is suggested that students should practice science the way scientists do.

The text also distinguishes between two types of scientists in science. "The scientist of the first kind" who invents different things that directly benefit mankind (applied scientist) and "the scientist of the second kind" who provides the basic or fundamental knowledge for the first kind (pure scientist).

> There is another kind of scientist that students may not know. His/her work involves discovering and inquiring about "new" knowledge that provides the basis for the work of the "first" scientist. (Students' text, grade 7)

This distinction, although apparently harmless on the surface entails an assortment of scientific values, among them the assertion that "pure scientists" are not responsible to the society. They are viewed as working in a discipline that inspires interest for its own sake. The value of their work is derived strictly through the advancement of scientific knowledge which is used by the applied scientist to provide welfare to human beings. The image thus created depicts a group of dedicated scientists who through their interdependence are committed to the welfare of humanity.

> Physicians and Pharmacologists seek to discover cures to our illnesses, to keep us healthy and prolong our life expectancy. (Students' text, grade 7)

> Agriculturists want to feed the world population. (Students' text, grade 7)

The scientific attitude is also promoted as part of the scientific image. In the very same topic on "How scientists work" discussed above, the students are encouraged to adopt the following attitudes and habits.

> ...every student can become a scientist, if s/he is curious and likes observing, has an interest in the surrounding environment, is ~~accurate and~~ precise in his/her own habit, and loves to think, loves to experiment and has enthusiasm. (Students' text, grade 7)

> ...the important character of the scientist is his/her constant asking and questioning,... How to question? The question arises from curiosity, and this curiosity helps the scientist discover new knowledge. (Students' text, grade 7)

These attitudes and habits described above reflect what IPST officially calls a "good scientific attitude." That is the students in doing science should be concerned about their study, be aware of using evidence in discussion, make decisions by reasoning and explaining, and be interested in using numerical derivations and calculations for supporting the evidence. They should also display what could be called "good" human qualitities that are not directly necessary for the scientific activity but contribute to the work ethic of "doing science." For example, the students should listen to the opinion of others and change their own opinion if a more correct reasoning warrants it. They should be diligent, cooperative, honest, responsible, and ambitious. They should practice self-dicipline and admit their own weaknesses and mistakes. That is, they should bring a positive attitude into their study of science, which they can achieve by emulating a well defined image of "good scientist."

In espousing these values the IPST has created a certain conflict with the ethical values of Thai society. Buddhist thought teaches its followers to purify themselves from secular desires. Even if science is not seen as strictly a secular endeavor, such attitudes as ambition and curiosity are seen as an obstacle in practicing Buddha's teachings. This poses some special questions regarding the compatibility of science and Thai society, an issue that is given little thought in this course. Scientific knowledge and the scientist's image, as it is presented in the curriculum, are still controversial.

Setting aside the science-cultural conflict noted above, I still see the presented image of a scientist as problematic. It is enframed within a scientific method and attitude which the students are asked to imitate, so that some day they, too, can become a "good scientist." I find this definition too narrow and unnecessarily restrictive, and perceive the underlying tacit promotion of "good scientific method" and "good scientist" as negative. The inclusion of both the "good" scientific attitudes and method in defining the image of scientist may provide the act of "doing science" with a certain aesthetic which the students can grasp and feel good about, but at the same time the students are instilled with a quest to imitate a mythological being who has no real relevance to their everyday life.

As in every other discipline, scientists are people who differ greatly in character, skill, and method of "doing science." There is no "one" set standard, and portraying or even promoting them as aspiring to the same ideals is to misrepresent the true act of "doing science." Promoting a benevolent image of scientists may further create both a polarized view of their intentions and a false image of their capabilities. Scientists are categorized according to criteria that can be easily recognized but may be misleading in the attempt to describe the true nature of their work. Scientists are capable of both harm and good, and should be presented as such to students.

The qualities espoused by the Institute may be honorable in their attempt to instill in the student what many would consider as "positive qualities" that contribute to the welfare of not only science but society in general, but such an arbitrary appraisal sets a serious precedent to situations that need not operate along the same intentions, and could be manipulated for other purposes. Presenting a "benevolent" view of a scientist to the students can produce both an unwarranted trust in the scientist's "good will" and also, in part, because of this trust, may prevent the students from looking at their role in scientific progress realistically and participating in decisions which invariably affect them.

The promotion of a "good method of science" as the method that scientists use to "obtain knowledge," where "obtaining knowledge" is never really discussed beyond the scientific framework, gives a tacit reinforcement to the belief that inquiry and observation, as they are portrayed in this course, together form the unique method of seeking "true" knowledge. This portrayal limits the students' understanding of reality. Telling them to "imitate" behavior of scientists so they too recognize and then show preference for this mode of behavior is a myth, making the entire reduction of method more simplistic than it actually is (Nay & Crocker, 1970).

B. Scientific Method

Experimentation

The IPST expressed the opinion that "Thai" students have had a chance to study science for a long time, but were not provided with an opportunity to practice and learn it in a more cognitive setting so that they could apply their learned skills to "everyday life." They believed that "providing the student with an opportunity to handle, use, manage, and maintain science equipment and practice problem solving skills would enable them to acquire such knowledge. Experimentation thus became an important part of the science curriculum in that it was regarded as an essential contribution to the understanding of not only the scientific method and practice, but the scientific principles obtained therein.

The actual experimental activity however serves a more "modest" purpose. Experiments are used mainly to verify scientific results or concepts, practice scientific process skills, and reconstruct in part the logical scheme of scientific concepts used in the topic. A sample lesson provided in the appendix D shows, for example, that the laboratory activity confirmed the presence of different constituents in food through the particular reactions produced, and also introduced new concepts such as carbohydrates by telling the student that carbohydrates 'caused' the reaction. The value of information obtained in this way should be highly suspect to the more critical eye, as this type of laboratory activity is used mainly to piece together in a set way a specific relationship between concepts. Students "confirm" defined concepts and at the same time are "pointed to" the actual presence of a "new substance" through a "prescribed" activity "tabulated" in a table form, to facilitate not the inquiry process but the logical "reconstruction" of scientific knowledge.

Experimentation should allow for the hands on type of activity that brings the student close to what scientists do in their own field. It can provide an opportunity both for the teacher and the student to perform a truly investigative work and to interact with the actual situation under investigation. The teacher can suggest to students not only the steps to be performed in the experiment, but encourage them to modify the original means and ends. Instead the curriculum sets out rigid procedures to reproduce experimental results it views as worth reproducing.

Observation and Instrument

Observation forms an integral part of the scientific method and the text incorporates it into many different activities such as experiments or studying pictures that depict a particular scientific interest (for example, the ecosystem). The intent in the text is to point out both the benefits and limitations of a direct observation, telling the students how they can use their scientific knowledge to increase their ability of perceiving the world. This, the Institute believes, is achieved by instilling in the students "good observation habits" and providing them with techniques such as the use of tools (Students' text, grade 7).

The Institute also believes that an important attitude in observation must be to strive for objectivity. That is, students must separate themselves from their personal bias in perceiving natural phenomena. To do science is to be a detached observer who perceives the world coldly without any emotion or feeling. However, this type of attitude is not easily illustrated and the curriculum resorts to showing it as a method to be imitated.

> In observing the melting candle, students should report "the candle is melting" not, "the candle ~~is~~ melting because of heat." (Students' text, grade 7)

In fact the entire process of observation itself is not reducible to just pure detail in observation. Although the text encourages students to develop skills in perceiving the most minute of details in natural phenomena, as the example showing Michael Faraday observing 53 different characteristics of a burning candle indicates, it is difficult to convey to the students the exact process that helps the scientists pick out the "essential" data that is finally incorporated into a theory. The text pursues this problem by telling the students what and what not to observe.

Referring to the sample student's text provided in the appendix D, the text points out for students in experiment 8.1 not only the procedure with which they are to reproduce the predetermined results, but also what they should observe to be pertinent to the knowledge being presented or sought. Other observational detail is thought unnecessary as it could obscure the "real" purpose of the experiment.

The picture reading activities alluded to above are often presented as drawn reproductions of the actual natural or social phenomena that are under investigation. Naturally, these drawings augment the features that are considered essential to the topic discussed, thus turning what could have otherwise been a useful observational activity, if photographs were used, into a passive summary of content.

An important awareness in observation is the apparent limitation of the senses. The text deals with this subject in the very first topic of the course as it attempts to present to the students not only how their own sensory perception cannot be relied upon in "certain" situations, but also to show the worthiness of scientific techniques in the form of "tools." The first half of the lesson is devoted to disproving the value of sense perception.

> Can we be certain that sensory organs observe correctly? (Students' text, grade 7)

> Can we trust our sensory organs? (Students' text, grade 7)

The second half promotes the utility of a "tool" to carry on activities where the sensory organ failed.

> ...the magnifying glass will expand your sight to find and discover new things, that could not have been discovered otherwise. (Students' text, grade 7)

There is nothing wrong with introducing scientific instruments to the student in this form. However, care must be exercised when justifying the instrument's use in all areas of students' life,

> ...the instrument will give us data with least error, coming closest to the fact or reality. (Students' text, grade 7)

> ...from the experiment what would you conclude, thermometer or your hands, tell you more reliable result. (Students' text, grade 7)

It is not enough to indicate to them that the instrument "measures" the sensual experience more accurately, providing us with a closer "look" at the reality and the "real" truth, but a serious effort must be made to reconcile why "we" think that the instrument is able to produce such "valued" information. After all, the function and use of the instrument is not separate from our perception, it is a result of our perception. We must believe in our perception, before we can believe in an instrument.

However, the presentation of the tool in the curriculum is presented along a different line. The utility of the instrument in obtaining facts is never questioned. On the other hand, the usefulness of the sensory perception is left in a void. There is no attempt at reconciliation, the tool is brought in as a "savior," lauded by its ability to "measure" (a word that becomes as esoteric as the very activity of science), not qualities but quantities with the least amount of error. In this approach, the text promotes what I perceive is a faith in the scientific method.

The separation of the knowing from the knower is also manifested in another sense that is in some way more subtle and more infringing on the very activity of human thinking, because it precludes other forms of observational knowledge that may exist. Examples cited here stem from the attempt to discredit as unreliable some of the "folk" knowledge that is popular in rural Thailand. An example of "folk" knowledge involves the belief that when ants carry their eggs into shelter, heavy rain will ensue. The actual belief is not at stake here. What is important is that it may have been attained through genuine observational methods. The rejection of such knowledge as unreliable because scientific explanation of such phenomena will be more precise, and more complete in its description indicates the desire to reduce all thinking to a conformist attitude with the scientific principles. Such a desire is unwarranted, as it indicates that all "true" knowledge must be scientific.

Inquiry Process

The inquiry process is streamlined into the presentation of activities of the curriculum. According to IPST, "the text gives students an opportunity to set up the problem for the experiment and obtain data which is then discussed and 'led' to the prescribed conclusions" (Teachers' guide).

The setting up of the problem is usually done in the introduction to the experiment which is supposed to serve "to arouse students' interest" and "motivate their curiosity" in the subject. The introduction always ends in a question form, suggesting perhaps an ongoing activity in the inquiry mode.

The sample lesson provided in appendix D shows how such a situation is supposed to work in the classroom environment. Comparing both the students' text and teachers' guide, it is seen that the introduction, written in the students' text topic 8.2, does in some sense capture an inquiry oriented setting. The students are presented with a series of what seem to be open-ended questions. However, the discussion that follows about the kind of food and its classification shows their true intent. They are used to frame the mode of inquiry within the particular narrow logic that is necessary for reconstructing the concepts in the way this curriculum perceives important. The curriculum, more or less, "delineates" the reconstruction of particular conceptual linkage. The curriculum has an image of what knowing in this particular topic means, and sets out rigid procedures to reproduce it.

Turning to the teachers' guide, one finds that the control of the entire process is reaffirmed. The curriculum lists the behavioral objectives the class should attain, prescribes how the experimental activity should be carried out and how to make it more efficient, and instructs the teacher to lead the discussion to predetermined conclusions. The entire inquiry process was presented in a converging manner as to purpose, "to summarize that food is important in providing energy and stimulating growth," and the problem, "how are we going to use chemical methods to categorize food?" The experiment, of course, shows the students how such a categorizing is done. The discussion and questions after the experiment bring out the "important" aspects of categorizing food by using chemical methods, and also "introduce" new concepts that are found inherent in the material discussed, but the idea of "true inquiry" is lost.

What must be noticed here is that the intended activity of setting up the problem is actually reduced to just "giving the problem" to the student. The discussion before the experiment attempts in no way to deal with the actual method of chemical testing. Thus the setting up of the problem as originally claimed does not really occur. The emphasis and probably the only tangible use of all these activities that make-up what IPST claims is an inquiry method, is in the logical reconstruction of scientific knowledge. That is, there is a presentation of scientific material, as demonstrated by the example above in that the exposition mentioning many kinds of food, and methods of categorizing them, among which chemical testing is one of the more important, the performing of experiment and obtaining some qualitative information about the method and perhaps the results obtained therein, leading to or indicating certain other phenomena which are invariably defined not pursued, in some way does provide a logical path for the students to incorporate as an explanation, not understanding, of scientific knowledge.

Hypothesizing is listed as one of the activities of the students, but is seldom used in the curriculum and is invariably presented in a converging manner. For example, under the topic of agriculture the student is introduced to various problems of using fertilizers in farming. One of them is the shortage caused by the insufficient production of fertilizers in Thailand. A table indicating the import-export figures for years 1969-1973 is used to present the following "hypothesizing" opportunity.

> We have many fertilizer factories in our country, do you think they produce enough fertilizer for the farmer? (Students' text, grade 9)

> Why do we have to import fertilizer from other countries? (students' text, grade 9)

The student is expected to read the information provided in the table and conclude that Thailand industry does not produce enough fertilizer as the figures indicate. However, the two questions above appear in the text together. As a result not only is the above just a "table reading activity," it is a "table reading activity" provided with an answer.

C. Law/Definition

The curriculum, apart from emphasizing the scientific method and inquiry process, which are the priority goals for teaching science in Thai junior high schools, also stresses universal knowledge as laws, principles, and scientific facts. This is indicated in part by the objectives set in the criteria for selecting the content.

> ...to develop an understanding of the basic principles and theories of science

> ...the relevance to the modern scientific knowledge.

Implicit in these descriptions is the belief that science can describe natural phenomena or the "natural order" as a scientific truth in the form of laws and theories, and the idea that knowledge is universal or the same everywhere (Sroydhurum, 1982). Partly due to this, IPST also believes that universal knowledge should have 70 per cent representation in the course, compared to 30 per cent for local knowledge (Tamthai, 1984).

Thus, almost every topic contains statements of definition, law, and scientific facts, and principles. They are used not only as the result sought in the lesson activity, but often are the very means of obtaining other such concepts. For example,

> Food is anything that is consumable and provides benefit to the body. (Students' text, grade 8)

Almost all topics contain statements that connect concepts in cause-effect linear relationship and prescribe information in an ultimate form as indicated by the following:

> The population increases because we can control and manage the environment to suit our needs. (Students' text, grade 9)

> Application of agricultural knowledge, industrial and other technology, results in changing the process of food production. (Students' text, grade 9)

> Carbon-dioxide and water are compound substances. (Students' text, grade 7)

> Carbohydrates, protein, and fat are important for life. (Students' text, grade 8)

The hidden values in such a presentation of educational material, among others, are the legitimation of knowledge as ultimate, static, and unchanging, resulting in unquestionable, recognizable knowledge, (this value is further confirmed by the failure of the curriculum to provide a single subject area that has or is experiencing a paradigm shift in its discipline), and the notion that students must control nature in order to predict it, providing them with deductive logic rather than the holistic approach.

It is claimed by IPST that principles and concepts are derived from classroom activities and experiments. But this rarely occurs in the curriculum and quite often the concepts are told to the student directly throughout the text such as:

> Water used in everyday activities is in the liquid state. Next, we will examine two other states of water. (Students' text, grade 7)

or through the teacher,

> While the ice is melting, the temperature is constant because the "external" heat energy is used to melt the ice: changing states from ice to water. This heat energy is called "latent heat. (Teachers' guide, grade 7)

To make sure that the student learns these concepts, recall questions are employed in most lessons. That is, recitation is still a prevalent technique in learning the course material as indicated by the following examples:

> Give the meaning of the following words or statements; population, mortality rate, population growth, population census...(Teachers' guide, grade 8)

As a result this supports, together with the reliance on sanctioning authority to promote concepts and principles, the status of esoteric knowledge of science. Students are told to rely on someone's elses better judgement of what is or what is not relevant knowledge. For example:

> Biologists give definitions and criteria for studying population... (Students' text, grade 8)

Students are conceived of as being ignorant and are expected to separate their own bias from the study so that they too can achieve conformity with scientific understanding.

This type of learning, however, contributes to the acceptance of knowledge that would otherwise have little or no evidential support. This is especially true in a curriculum that attempts to incorporate scientific knowledge that is often intertwined with other forms of western epistemology. For example, some statements in the text indicate an acceptance of western epistemology as an ultimate authority even in situations that lack Thai context.

> Increasing population will affect the competition among the professionals in education, medical science, public health, economy, and society. (Students' text, grade 8)

The employment situation in Thailand is quite different from the one indicated above. Thailand is a developing country with a predominantly rural population that subsists on agriculture. There is a great need for all types of specialists who will bring services that are demanded by the special character of the Thai society into the remote areas of Thai countryside. Surely the Thai situation is different from the one presented above.

D. Science/Society

The Thai school science course attempts to bring the perspective of science and social context into the classroom as is stated in the objectives,

> ...to study the application of scientific knowledge to everyday life,
>
> ...to study the social and environmental implications of scientific and technological development.

The tacit underlying implication of these two objectives is the need to develop students' appreciation of science and technology and its impact on the Thai society. This attempt is very noteworthy in this course. However, implicit in these objectives is also the view that science is "applied to" rather than "integrated with" social needs, and that society has little to say about the scientific activity.

Throughout the courses, scientific concepts, laws, principles, and facts are presented in terms of their benefit in explaining natural phenomena in everyday life. For example:

> The student should be able to apply the knowledge of air pressure to explain the function of the level in construction. (Teachers' guide, grade 7)
>
> The student should be able to interpret the importance and the usefulness of weather forecasts in everyday

life. (Teachers' guide, grade 7)

The student should be able to apply, or use the knowledge about the properties of substance in everyday life. (Teachers' guide, grade 7)

...to apply the concept of induction, convection and radiation in everyday life. (Teachers' guide, grade 8)

Many of these applications to everyday life in Thailand are trivial rather than significant. These concepts and applications taken from western curriculum evolve around Western society and have few applications and therefore also little conceptual value to Thai students. That is, the students cannot relate them to their everyday life. As an example I will consider the first two behavioral objectives stated above.

The level is used in Thailand mainly as a practical tool in the construction industry. Since very little construction, in whatever sense, is initiated by the average Thai citizen, the accessibility of this tool to the student is questionable. In the same way, forecasting is not an integral part of the Thai way of living. First the moderate climate of Thailand does not demand such a dependence, as is seen in countries with more extreme climates, and secondly, the Thai people have not yet exhibited need for such a service. Teaching concepts with these practical examples tends to alienate the student from science. This does not imply that the knowledge and content of these applications is not important, but as long as the issues and concerns have no relevance to the Thai society and to the Thai student, the application of scientific knowledge to everyday life is not meaningful.

There is an attempt in the curriculum to present the "local content" in doing science. A lot of the material provided in the course is organized around an outline which suggests that careful attention has been given to the social issues as shown below in the selection of sub-topics for the lesson on "Environmental conditions."

> Environmental condition; Effect of population growth on the environment; Environmental adjustment for the benefit of living; Causes of environmental dilapidation; Causes and prevention for polluted water and air; Garbage and disposal; Polluted soil; Effect of energy utilization on the environment; Prevention and control of sound level; Maintaining natural balance

The topics themselves (for example, water, pollution, and agriculture) indicate a concern for incorporating subjects that have meaning in everyday living in Thailand. However, in these lessons the relation of science and technology to the individual and society is perceived only linearly, as science and technology explaining phenomena that are useful to Thai people. The presentation of the issues is always in the form of information, fact, and description.

> ...to explain the advantage of crop rotation (Teachers' guide, grade 9)

> ...to conclude that seed selection, soil adjustment, weed and pest control and fertilizer are important and useful to agricultural produce. (Teachers' guide, grade 9)

For example, the discussion about the silk worm is brought in to illustrate the details of a life cycle; to verify a scientific concept rather than evolving from genuine classroom interest. The lesson "Rock and Mineral" is written in a manner that preserves the structure of the discipline, introducing scientific explanation about the origins of earth, the different layers of earth and the categorizing of rock. This topic does include Thai content in that it describes the type of rock found in Thai countryside, but it is brought in after the "scientific inquiry," it is brought in as a Thai example. Science is viewed as a resource of knowledge that is applied to rather than used by the social needs.

This separation of science from society is evident in other topics and under different forms. The curriculum acknowledges harmful effects produced by technology, but it always lays fault with the layman who they claim does not know how to use technology properly.

> ...Thus, we should inform the farmers who use these chemicals, so that they understand the consequent harm and use it carefully (in the future). As a result, the population will live happily and safely. (Students' text, grade 9)

The solutions posed under such a formulation tend to be too narrow in their approach and fail to address the true nature of the problem. The problem here is not the farmer, it is technology. Pursuing solutions strictly at the "effect" level promotes a band-aid treatment which in itself is never a cure.

The curriculum also presents the history of scientific discovery, with few examples cited from the research pursued in Thailand. The main purpose is to reconstruct the factual events of the scientific discipline as to who discovered what and when.

> William Harvey, an English scientist, was the first person to discover the blood circulation and that it flows in one direction. (Students' text, grade 8)

There is no Thai scientist cited in the junior-high school science course, although the IPST's senior-high school biology course does mention the contributions of Dr. Choamchaloa, who worked on breeding of sweet brazil, and Dr. Wongsiri who studied one particular insect (in Thailand). These are good examples of the kind of scientific research going on in Thailand at the present moment that can be used to indicate the interaction between science and society, not only in senior but also in junior high school science. Both areas of investigation show a particularly strong cultural influence on the chosen field of scientific research. Sweet brazil, because it is an agricultural produce that is used extensively in the everyday life of Thai people, is especially suited for the type of science education taught in general science courses.

Dr. Choamchaloa's work in the senior high school biology course is used strictly to study Mendel's law. Again, the emphasis is on using Thai example to verify scientific knowledge rather than indicating the important relationship that exists between social interests and science.

The need to express the integrated science-society relationship cannot be over emphasized. Thomas Kuhn (1985) has noted that the progress in the new fields of science and technology was as much the result of the social, economic, and institutional forces as from reason and observation. The interaction of science and technology and society is therefore not a linear means-ends relationship, but an integrated whole that cannot be dissected if we are to have the full picture of reality. Students must perceive the complete relationship between science and society to appreciate their role in such an interaction. Curriculum must provide both views of this interaction in order to promote a participating citizen.

Although the text can be commended in its attempt to incorporate Thai issues into the study of science it failed to present the active social participation in scientific activity. There also remain two important points that need to be addressed at this time. First, the Thai data used in the curriculum were oriented towards teaching students in the Bangkok metropolitan area. Many of the classroom activities suggested are suited to the student living in the city rather than rural area. Second, more social areas that are important to the social welfare should be incorporated into the course, for example, public health and drug use. Curriculum of this nature, should focus on "problem" areas of life, especially the ones produced through the use of science and technology.

Myth of Benevolence

The Thai school science curriculum almost exclusively presents the science/technology and society (S-T-S) relationship in a very restricted format, considering solely the "application" of science and technology, usually as indicating a beneficial relationship to the Thai society. This view is prevalent among developing countries where a strong emphasis placed on modernization overlooks the negative aspects of linear s-t-s relationship. However, science and technology are not simply benevolent providers of harmless philosophy and products but carry with them serious implications that have to be considered in order to serve society. The Thai school science curriculum does not show awareness of these problems. These concerns are not reflected in a curriculum that attempts to instill in students a faith in scientific method and technology.

The "usefulness of science" is frequently presented under sanctioning statements similar to the ones presented here:

> ...this can explain... in your daily life
>
> ...student should use this knowledge...(in her or his life)
>
> ...it is very useful for students in everyday life

These cover up the real issues and relationships that science has to society or individuals. Science is seen as the provider of knowledge and as a benefactor to all human activities.

> Science and technology provide enormous benefit to all human beings. (Students' text, grade 7)
>
> Scientific discovery leads to the progress in technology which gives happiness to human beings. (Students's text)

However, the beneficial portrayal of science and technology, more often than not, is a stereotypic "fix." That is, science and technology are depicted as yielding infallible solutions to societal problems. Where socio-political benefits were considered, most benefits were reconstructed to the agricultural, technological, and industrial domains. These domains face some very serious problems in Thailand today because of the unregulated flow of science and technology.

In the context of the Thai curriculum, science provides the necessary technology to solve the indigenous problems, which I must point out, are in part caused by the very technology that was introduced to solve them. Sometimes these problems may require "social" rather than, as is emphasized in the text, "scientific" solutions.

An example that I wish to cite comes from agriculture. This area of Thai economy experiences many problems today because of the predominant influence of foreign technology. Among the problems created is the "new" dependence on fertilizer, necessary because of the erosion of soil and the now almost exclusive use of high yield grain. Because of the demand, there is presently in Thailand a shortage of quality fertilizer. This problem is compounded further by the introduction of low quality, imitation fertlizers. The farmers are often misled, and as a result do not properly cultivate their fields. An example from the students' text provides one solution.

> Farmers do not know enough about fertilizers and thus cannot tell the difference between the real and the imitation fertilizer. However, through observation and knowing how to test for quality, we can tell the difference. (Students' text, grade 9)

What is important here, however, is not the scientific solution per se, but the shift of emphasis on who solves the problem. The Thai society emphasizes social welfare, scientific solution above individual welfare. That is, focus is taken away from addressing the problem at the social level, as in culturing the proper [illegible]l attitudes in all social issues, towards strictly individual interests.

The blame for the situation is attributed to the farmer who is ignorant of scientific knowledge and cannot resolve the situation by testing the quality of the "fertilizer." "Naive" belief in benevolent science and technology, which the curriculum promotes, thus frequently obscures or covers up the real source of the problem. The text admits, that

> Technology creates pollution, population problems, environment concerns..., (Students' text, grade9)

but the fault, they insist, lies with the ignorant people or the user, not the technology.

The notion that science "improves," "increases," or "helps," is often carried beyond meaning in social context. Statements like "...technology will save time and labor" in subsistence agriculture where the laboring in the field is a way of life and not a commercial endeavor, does not address the real issues of social living. Suggesting a different leaf staple for the silk worm, so that it will produce "better" silk is devoid of any social meaning altogether. Silk is not esteemed because it is "better," silk is esteemed because of its "unique" qualitities.

In summary, this is the type of "providing" that Thai society must contend with. It must abandon the myth of benevolent science and technology and look realistically at all possibilities. All scientific contributions must be weighed carefully in light of the social perspective and decided on collectively. One way to do this is to educate the "young" to approach their natural world "critically."

Teacher & Student Control

The reason behind the development of a teachers' guide was to assist the teacher, in any way possible, in teaching the curriculum "sucessfully." "Successfully" in the sense of being able to reach the pre-determined ends specified in the course (Teachers' guide, preface; Sapienchai, 1984b). The ends are usually delineated in the form of behavioral objectives which emphasize the learning of set scientific concepts, skills, and procedures. The means usually involve experiments, reading data tables, or picture activities, followed by teacher directed discussions. The entire curriculum is organized around a spiral approach which, as Sapienchai (1977) remarked, is quite complicated and depends greatly on the teacher's ability for "success."

The IPST officially acknowledged that the curriculum presented is difficult to teach and that the teachers' guide must provide detailed instruction on how to teach and use the material, including evaluation in the course (Sapienchai, 1984b). What initiative or what input the teacher and the students are expected to produce within such an environment will be investigated further.

The student text reflects in part the intent of the IPST to produce an activity oriented curriculum, which would provide the student with a greater opportunity to participate in classroom activities and the doing of experiments. The aim of this participation was to expose the student to problem-solving skills and the scientific method. The IPST carefully selected the particular science related knowledge and activities, with the cooperation of experts at different higher education institutes, and claimed that it represented what all students should know and study. That is, IPST has adopted the position of ultimate authority of knowledge in writing its curriculum. The teacher, as will be seen, becomes the means of transmitting this knowledge to the student.

Essentially, the teachers' guide is the medium to instruct the teacher about "what to teach," "how to teach," and "how to supervise and monitor the student's behavior." Each lesson begins with behavioral objectives that summarize the type of behavior the teacher is to attain from the students. They are assigned not only to each study unit but prescribed with each experiment and even with the practicing of scientific skills. This reflects the IPST's belief that behavioral objectives make for more clearly stated general goals, since they determine if the required behavior of students is being properly developed and guide the teacher in producing or inculcating the desired behaviors in students.

There are many ways in which the curriculum regulates the learning activities. It begins with a prearranged sequence of concepts, that are grouped under a common topic and delineated in table form. For example, the lesson Water listed the following sequence of sub-topics as they are presented in the class.

> Water; Its importance; Its properties; States of water and the change of states; Melting point and boiling point; Latent heat of fusion and latent heat of vapourization; Water density; Ground water sources; Underground water sources; Manmade water sources; Dam; Reservoir; Other substances in water; Solution and suspensions; Solubility and concentration of solutions; Saturated solution; Crystallization; Soft water and hard water; Treatment of hard water; Distillation; Filtration; Precipitation; Pipe water; Polluted water; Prevention and treatment of polluted water. (Course Syllabus, grade 7)

The sub-topics are tied together with concepts or experimental results, which the later sections may use as an ongoing source of information. The connection between these sections is indicated by the teacher who is instructed by the teachers' guide as to how and when to relate them together.

> Teacher leads the discussion by using the graph demonstrating the relationship... by reviewing the meaning of growth rate...by using questions posed. (in previous section)(Teacher's guide, grade 9)

The sub-topics are regulated in the same table through the use of numerical sequence that specifies the exact order in which the activities are to be carried out in class. There are a total of 10 different activities, 4 designated for the teacher: providing information, discussion about the experiment, discussion about obtaining knowledge, teacher demonstration; and 6 for the student: experiment, drawing graph, obtaining data, calculation, hypothesizing, and examining sample graphs or pictures. This is a comprehensive list of all the activities used in the text and no opportunity is provided for the teacher to incorporate into the lesson other material than that indicated in the text. Actual class presentation will employ 2 to 5 of these activities, which are always accompanied with the suggested time needed for completion.

These two ways of regulating the curriculum are presented only in the teachers' guide. They show that the method of teaching and learning as it pertains to the selection of the type or order of topics and activities in each lesson is clearly predetermined by the curriculum.

In many ways the following example is representative of the way any new topic is introduced and moulded in the course. This activity is perceived as an opportunity for the students to "inquire" about the nature of things around them. They want the students to "see" the interaction of things in their environment and "infer" scientific concepts such as "air is substance." This is possible only because of the narrow logic introduced into the discussion.

> The teacher introduces the meaning of "atmosphere" through a discussion with students. Discussions can be initiated by asking students a question about the air. "What is it composed of?" The teacher might use

a picture with swaying tre es, for example, to suggest wind, along with questions that will enable the students to summarize that air is a substance.

For the teacher, the mode of questioning is suggested, the method of showing some of the properties of air is indicated, and the intent or ends of these questions is clearly specified. The students, on the other hand, have no real input into the ideas presented in the curriculum. The very nature of the questions, the very nature of the presentation of the material, is to lead students to prescribed conclusions. From the very beginning the students are moulded by the teacher according to predetermined objectives. This is necessary as otherwise the type of convergent thinking that IPST expects from such discussion would never be possible. The intent is for the students to reconstruct the logic inherent in the course rather than pursue the "true" inquiry process: the "unimpeded process of asking and discussing."

In conclusion, the students in such an environment are not allowed to interact freely with the curriculum presented, and are relegated to a somewhat passive participation in classroom activities. They are perceived as ignorant and are presented with an "approved" knowledge. They are told what to do, when to do it, and how to do it. Their behavior is closely monitored according to bahavioral objectives to which they have no real contribution.

The teacher's role, on the other hand, is reduced to the presentation of material according to the given format and within the specified time. They are frequently reminded during all activities what to do and when to do it.

> The teacher does not need to discuss at this point the properties of the air, as the intent is for the student to pursue this through experiment. (Teachers' guide, grade 7)

> It is not necessary for the teacher to perform the experiment at this time, but rather ask questions and carry on discussion in the classroom. (Teachers' guide)

> Teacher should prepare dirt of homogeneous content to prevent any problem that the students might have in categorizing the different types of substances. (Teachers' guide, grade 7).

> ...for experiments, the teacher should not tell the students the solution, because the objective of the topic is for students to observe things carefully. Otherwise the students will copy the answer and not do the experiments. (Teachers' guide, grade 8)

Since an efficient and smooth operation of the class further promotes an effective presentation of the course, the teacher is provided with many "helpful" hints in classwork activities such as experiments.

> ...to dry the bottom of the beaker before, and to measure the time immediately after putting the ice in. (Teachers' guide, grade 8)

> ...take the lamp out, when there are only few drops left in the beaker, and turn it off. (Teachers' guide, grade 8)

The teacher, for example, is told how to discipline her or his class as the following two samples indicate.

> ...teacher should distribute matches just before the students light the candle, otherwise students will play with them (grade 7)

An activity modelling molecular movement in water during heating uses beads in a clear plastic box to resemble the molecules of water in the container. The discussion before the activity mentions;

> Teacher must closely supervise the students and their activities to prevent them from shaking the box for fun as this will be a nuisance and will interrupt the other classes. (Teachers' guide, grade 8)

This disciplinary control is very prevalent in this curriculum, indicating the developer's mistrust of the students' responsibility and willingness to study science and at the same time doubting the teacher's ability to manage her or his class. It also reflects the zeal with which the staff and the developing group of IPST approached their project. The minuteness of detail that was put into each lesson and each experiment is impressive. The designer team not only sat down and wrote the curriculum, they performed and tested every activity and experiment presented in the course. They even specified the length of the candle needed in order to observe it burning for 4 minutes. Every effort goes into streamlining the entire teaching process, making the delivery of the curriculum as efficient and effective as possible.

> (Following the) teacher's guide will enable the teacher to teach effectively and smoothly. (Teachers' guide)

The teacher's role in this setting is to perform a pre-specified task, whose detail is already worked out by the teachers' guide. There is very little preparation needed by the teacher, aside from studying the teachers' guide and the students' text.

Summary

The curriculum adopted an expert position in its presentation of scientific knowledge. As was claimed by IPST, it contained all the knowledge that students should know and no other opportunity was provided to incorporate into the classroom activities other sources (of knowledge). To achieve the educational objectives it utilized control theory, which it applied to almost every aspect of learning. Both teachers and students were closely regulated in terms of their particular participation in classroom activities.

The teacher's role in the classroom was reduced to that of technician, who was told to perform pre-specified techniques to produce pre-determined results. The teacher was provided with the "approved knowledge" to be taught, the "approved techniques" to be used in teaching it, the "approved sequence" of activities to initiate the lessons and the time spent on them, and the "approved results and objectives" to be obtained after completing each lesson.

The students, on the other hand, were seen in the curriculum as [illegible] material that needed to be processed to the predetermined objectives. They were provided with the "approved knowledge" in learning, taught to be objective in directed experience, and manipulated by the teacher to reach acceptable standards of thinking and knowing. They were passive consumers in an educational process that strived to control all teaching variables to produce a "successful" product. They became "puppets" whose "motions" were carefully coordinated at each particular stage of the lesson, so that proper transmission of knowledge could be realized.

The knowledge presented was academically oriented, emphasizing concepts, laws, and principles of scientific disciplines. The scientific activities that provided this knowledge were structured as if it was possible to construct a path of logical thought between them. The path itself was seen as gradually accumulating scientific knowledge which became more and more complex. This reflected the Institute's intent to use a spiral approach in developing the curriculum. However, as was expressed by the then acting director, Sapienchai, an effort had to be made to overcome some of the difficulties inherent in such an approach. The result of this effort was a rigid, controlled curriculum that focused its attention on how to preserve the structure of the discipline, rather than accomodate the students' lived world.

Although IPST did claim in one of its official objectives that the curriculum was an ongoing affair and should change over time to reflect the dynamic nature of both scientific knowledge and Thai social and environmental issues, the course itself did not present one single event that would suggest conflicting or changing perspectives in these areas. Scientific knowledge was presented as certain and static, and as invariably applied to other activities in life. The harmful technological side effects were referred to as abuses through ignorance. The curriculum did inform students, in passing that scientific knowledge could result from the disagreement between fact and theory (paradigm shift) and that would eventually lead through a continuous adjustment to a description of truth and reality of nature. The meaning of this assertion however was lost when the students were confronted, almost exclusively, with ultimate knowledge and just one perspective. The students in such a situation may come to view science and the scientific method as a given.

A paradigm shift in science may serve as a concrete example of not only how scientific knowledge changes but also be a point of departure for some important discussion about the very nature of scientific activity. The social and scientific contributions to these changes in theory would provide students with much needed insights that encompass the whole situation, not just partial perspectives of formal science.

The main method for presenting knowledge in the curriculum was what the Institute refers to as the "inquiry process." However, the manner in which the inquiry was presented, the reconstruction of scientific knowledge rather than the active participation of students in all activities that partake in such a process was emphasized. The setting up of the problem was reduced to introducing the problem to the student in a set format, usually followed by procedural experiment that not only delineated what to do but also what to observe and record. The students were then led to the prespecified conclusions by answering convergent questions, and by the intervening supervision of the teacher who was under the instruction to affect preset behavioral objectives.

This type of activity was described by Schwab's concept of teaching science. The concept refers to the type of inquiry process utilized in laboratory work:

> Three different levels of openness and permissiveness are available for such invitations to laboratory enquiry. At the simplest level, the manual can pose problems and describe ways and means by which the student can discover relations he does not already know from his books. At a second level, problems are posed by the manual but the methods as well as answers are left open. At a third level, problems as well as answer and method are left open; the student is confronted with the raw phenomenon - let it be even as apparently simple a thing as a pendulum. He pushes and pulls, alters first one and then another of its aspects, begins to discern a problem to be solved, then moves toward its solution (1962, pp.

55-56).

Clearly the type of inquiry process employed by the Thai science curriculum corresponds to level one as described by Schwab. It is believed that such an approach is essential at the very beginning of learning science as students must acquire skills before they can be expected to pursue an inquiry process of science. Thus, the inquiry is presented as an "imitation" of methods and skills used by scientists, which, it is assumed, the students can consciously recognize and accept, and later implement in their own "discovery."

However, Kaplan (1967) has characterized this "imitation" of a method as a misconception of doing science and called it the "myth of methodology." He concluded that methodology is far from being a sufficient condition for scientific achievement and thus scientific activity, and especially scientific discovery, must include other contributing factors. This indicates that the emphasis given to the method of science in Thai science curriculum may not be enough to convey the true essence of science to Thai students.

Reflecting on the "levels of openness and permissiveness" one is further led to ask why should the students be initially exposed to a "level one" inquiry process if not to enframe their perspective of doing science within a discipline method? If it is admitted that inquiry can happen on level three where the controlling variables are minimized, should it not also be admitted that such an inquiry can be actualized at the learning stage of science? Is the inquiry always to be enframed within scientific process and discipline? The view that the present scientific paradigm is the only way to inquire about science should be reconciled with the more general notion of inquiry, where students' choice, self-direction, as opportunity to modify and direct their own activity, play a part in their doing of science. Shouldn't the "process of inquiry" rather than the "methods used" be the focus of scientific activity?

The Institute claimed that the inclusion of the "inquiry process" was to promote the understanding of science. However, in its form there was very little input by the teacher or the students aside from reproducing the predetermined results. How much students were able to assimilate and accomodate within such an activity, where their own lived-world was disregarded in favor of directed experience, becomes a serious issue.

> Curriculum as a search for understanding, a mediative thinking, is an attempt to deal with unity rather than bits and parts of additively. It is a theory experienced as a participatory phenomenon, where the person engages in dialogue with the theory, bringing each person's biography and value to the interpretation. The intention is not to explain (flatten out) for control proposes, but to interpret in order to provide greater understanding (Greene, 1978, p. 34).

The expert image was further enhanced by the practice of asking questions in such a way that it was obvious to students that there was one acceptable answer. This method of posing questions was dominant in the text. The use of recall questions in every lesson was a standard practice. Many times the paragraph following the questions posed, provided answers or clues on how to answer them. Many times the questions themselves were posed in such a way that they implied the sought after answer. The curriculum manipulated all inquiry activities to achieve the predetermined ends.

The IPST claimed that "the text contained questions and discussions" that were "diverging" in nature. The evidence indicated that there is very little of this activity. Edward & Furlong (1975) defined convergent questions as leading to specified information and answers that are predetermined, and for which the clues were provided to limit the potential answer. In this context the diverging referred to by the IPST probably meant the "diverging" topics presented under each lesson plan, as this would fit well with their philosophy of control. That is by providing "diverging" information, which they do in their sense of the word, through the incorporation of diverse sub-topics in lesson plans.

In conclusion, the adoption of the expert position in the curriculum promoted a distinct boundary between knowledge and ignorance. In this instance the expert possessed the "approved knowledge" in the form of specific information which was processed via the technician (teacher) into the raw material (students). However, according to Young:

> An implication of an expert image is that students may interpret scientific knowledge to be discrete pieces of information which we passed from one part to another and finally are taught together in the class. Scientific information becomes fact and fact comes to exist in reality in the same way physical objects exist. (1974. p. 53)

That is, this curriculum may lead students to misinterpret the actual scientific activity and values. The separation of knowing from the knower may promote an acceptance of scientific knowledge in the form that has little in common with actual reality. This concern is further augmented by the statements made by the IPST, both officially and in the curriculum, regarding scientific knowledge as universal and as a concrete entity that is to be tapped by human resourcefulness enframed within scientific method.

To support its expert position, the curriculum relied on Tyler's (1949) rationale as the major view of program development and evaluation. The curriculum contained all of the curriculum content. Behavioral objectives were used extensively in assessing the progress of the students. The emphasis in organizing knowledge, methods, procedures, and teacher-student participation was to provide an efficient and effective educational process or means to achieve the program aims.

This classroom management can be put another way: "quality control." Standards constructed along the lines of technological metaphor. A linear, means-ends relationship, every teacher applies the same strategies in teaching to guarantee the same pre-determined ends. The teaching has become technical, the teacher a technician, and the students raw material. If the teacher follows the instructions provided, she or he will produce the needed outcome: student's behavior. The view that education is sometimes spontaneous, unplanned, or instigated by both teachers and students has vanished.

The approach can thus be compared to what Apple (1979) called "technical control." That is, the notion of "industrial" emphasis on the efficiency and effectiveness of the curriculum. The jobs, the process, and the procedure should be described as precisely as possible on the basis of the management's, not the worker's, control over the specialized knowledge that is needed to carry it out.

An Alternative School Science Program

We live in an era most accurately described by its scientific and technological progress. Science becomes broadly integrated into all phases of our culture and into every part of our everyday life. Most people view it as a path to modernization of the society, as a world civilization, and as a solution to solve all human problems today.

In the past two decades, there has arisen a new public awareness that seeks to fuse social purpose and human welfare with scientific research and technological innovation in ways that are most likely to enhance the quality of life. Science and technology is a human's tool, not otherwise. Since the seventeenth century, science has been viewed as a servant to society. This was expressed by Francis Bacon when he wrote, "The ideal of human service is the ultimate goal of science effort" (Quote in De Hurd, 1986).

J.D. Bernal (1939), a physicist, shared this view and declared his position on science education with, "...the effectiveness of any scheme of science education is shown by the place that science takes in everyday life" (1939, p. 86). Symons (1975) also insisted that the work of the school is, in practice, limited in scope if problems related to culture are ignored.

The purpose of science education is for the society as well as the individual. Gregory Bateson (1972) argued that this relationship should be used as a basis for all definitions, and that this should be taught to children of all ages. Everything, he believed, should be defined not as a thing in itself, but in its relation to other things.

Conant (1951) supported this transfer from the scientific context to everyday life situation, but noted that it may not occur easily for scientists and for science students. Part of the problem may be the unspecified role which personal judgement plays in making both scientific and everyday decisions. Science programs are too often presented as a form of reconstructed logic which supports epistemological separating of knowledge from the knower, ahistorically and without reference to the social interaction that led to its creation. This is partly due to the nature of scientific knowing that is concerned with the external or outwardly visible social interaction, the behaviors that may be defined by detached observations, objectivity, value-free (neutrality), and universality (Magoon, 1977).

But how scientists think cannot be divorced from their social reality. Habermas (1971a) in his work, Knowledge and Human Interest, has already indicated that all human activities, including science, are determined by their interest. Thus, if we accept this theory as accurate, then it becomes obvious that science is no longer neutral, nor objective, as is commonly believed (Jacknicke & Rowell, 1984). Polanyi (1958) affirmed that scientific knowledge is not detached and impersonal, but rests ultimately on belief. Individual's beliefs and interests determine the relevant system that is being imposed by situational and social interaction.

Individual interpretation of the existential world depends on historically oriented, personal experience, and teachings. It is logically consistent only in that a small part of an individual's knowledge originates in personal experience (Schutz, 1970). The majority of knowledge is socially derived from friends, parents, teachers, and teachers of teachers. Science is conceived from sources other than personal experience. This could imply that a scientist's knowledge which is formed in precisely the same manner cannot escape the social circle. For example, it is generally neglected that scientists exhibit uniquely (in their research activities), their own attitudes, appreciations, and biases which have led them to choose the particular area of study and the framework of their discipline, and therefore their knowledge.

All science is dependent on the questions that scientists pose and the subjects they choose to study. Their choices, in turn, partly depend on the cultural environment. The interests, practices, and values of scientists are very much influenced by the society in which they live. This is the case with Newton, Galileo, and Copernicus (Capra, 1982, Dampier, 1971). Their discoveries must be put within their existent social and scientific conditions for it is within this environment that their theories and discoveries were forged. Reality is socially constructed and not "out there" waiting to be discovered. It is dependent on the biographical features of an individual and her or his interpretations of events.

We often forget that our meanings of social situations are not necessarily the same as for others, for as people and events move together there are many ways in which the events may be interpreted. The interpretation of a situation is a continuing process in our experience and these interpretations differ from individual to individual, from student to student, from teacher to teacher (Schutz, 1973).

This means, therefore, that students should be involved in examining social issues as well as reflecting on how their own beliefs, values, attitudes, and knowledge have influenced their understanding of the issue. In turn, they may clarify society's reflection on the problem concerned. The commitment to a particular perspective which the students take within a situation must be considered. Students are thus involved in exploring the social world as a unity rather than isolating and dissecting particular phenomena (Young, 1974).

Taking the meaning Aoki (1978a) gives to "critical reflective meaning" we should be concerned with the unconscious world that surrounds us, the meaning we give to each situation. Every activity we perform, speech we make, or value we hold, is based on some tacit assumptions which we make about the social world. Reflective thinking is oriented towards making these tacit assumptions conscious. Criticism as a way of knowing that helps free an individual from dependence on taken-for-granted assumptions, becomes a major force in this approach. To make this happen demands the active involvement of both teachers and students within their on-going situation.

Presenting curriculum in this way will lead students to acquire new life skills in their pursuit of understanding "their" reality. However, education in school, to which science education also belongs, must be perceived only as one part, although a special and intensive part, of a process of life-long learning, learning that for the majority of Thai students today stops after grade six. Junior-high school provides the last opportunity for many of the remaining students to study a science program; students who will become consumers of science and technology rather than scientists. The general science course provides science for these students and should take "their" needs into consideration. Teaching an academic science course to students who will have little use for it except as an immediate "intellectual challenge" reveals a patronizing attitude toward students and life itself. There are other means than directed experience to evolve students in inquiry and science.

The present curriculum does not allow students to bring in their own lived-world, to interpret or to share the curriculum. The knowledge they are studying has been "approved" as legitimate, unquestionable. Many activities they have to do carry little meaning for them. Many topics neglect or ignore students' own knowledge. It is right at the beginning of the program, the very first lesson, that students deny themselves as knowers. In its place the students are offered the "perfection" of instrument.

Throughout the program, the curriculum closely guides students, interpreting experience for them. Students are manipulated by particular interests and taught to accept uncritically values and beliefs.

Aoki (1978a) presents the students with a possibility to reflect upon the knowledge they study. If we apply his notion to the school science program, the students should learn to question the basis of their own scientific knowledge and become conscious of the underlying value or ideology that the society, the school, or even the science course holds. Students should be able to reflect and foresee the possible consequences of science and technology. They must be educated to have a holistic world view in order that they know how to appraise all knowledge not just scientific knowledge within a scientific framework.

Critical reflection demands the active involvement of both teachers and students in their ongoing social situation. Prescriptive intents serve little purpose in a classroom environment engaged in critically reflective activities. Rather, reflective activities themselves reveal to the participants the intent as the program progresses. Students and teachers must be willing to participate directly in the social world as it exists outside the classroom. Learning under such conditions thus becomes a sharing of ideas, knowledge and actions as they are considered in terms of their ideological background (Aoki, 1978).

Science curriculum taught in the context of human affairs should be built around the "real problem" that emphasizes the practical, cultural, and liberating values of science, and provides answers to students' questions, such as "Why am I learning this?" Students should be provided with a better portrait of science and technology, not bits of information. That is, it should include both the historical and social aspects of science and technology, an account of the interrelationship among science and society and a reflection on the nature of knowledge. Reflection on the nature of scientific knowledge will help the students become aware of the "true" limits of science.

Curriculum should present the history of science, not who discovered what and when, but how they discovered and what was the competing paradigm in scientific research at that time. Thus, the students will have a more realistic perception and expectation of science and technological function. History provides an opportunity to reflect on scientific knowledge.

In conclusion I would like to offer a more substantive example of how science can be brought into the curriculum from the students' everyday life. The first example involves my own experience as it relates to the topic presented in the text on the reproduction of fish. The particular fish discussed in the text is very popular among the young, especially in my hometown. Almost everybody knows it. These fishes were aggressive and would hold local competitions to see who could raise the best "fighter." Some of us would breed them at home, in the process becoming quite adept at observing and recognizing fish behavior. We not only knew how to differentiate between male and female, we would mate them to produce offspring with characteristics that we liked. That is, we in our own way, were doing some sophisticated science.

When the text takes this very same topic and transforms it into a step-by-step laboratory procedure that tells the student not only what stages of fish life to reproduce but also how to observe them, this lived experience is lost. The students no longer raise their own questions, no longer see the social or individual issues affecting the way science is done.

Another example stems from the southern part of Thailand where the countryside is renowned for its rubber tree cultivation. It has been said that when one approaches this agricultural area one can tell immediately that one is in South Thailand although one has never been there before. The rubber trees are everywhere. The rubber trees are part of a way of life. The students in these areas grew up with the rubber tree and possess numerous skills that can be utilized in a science classroom. The students should be encouraged to bring this knowledge into the class. This knowledge should be the basis of doing science on which perhaps a more academic orientation can be expanded.

The curriculum emphasizes in this topic the industrial use of rubber, providing a host of detail on how to extract and process rubber, and how to produce more, higher quality latex. This information is important. The rubber industry in Thailand has the second leading income. But teaching science in this format once again shows to the students that science is applied to rather than determined by social matrix.

Students should have an opportunity to bring in their lived world and as shown by the two examples above, they may contain some genuine science sources. Students should be encouraged to pose their own questions, raise their own issues, and obtain their own solutions in science. These questions, issues and solutions do not have to be invariably scientific but can reflect the broader social environment in which they are, after all, immersed. If the students are allowed to do their own presentation of science material and design their own experimental projects, they may gain an insight into a scientific activity that remains mostly esoteric in the current curriculum and above all they may realize that science depends on them, on the questions they ask.

There are many other similar examples in rural Thailand that can be clearly identified with the particular region where students live. These examples provide a unique opportunity for the curriculum to incorporate students' prior knowledge into the science activities. The examples indicate that a more regional perspective in science curriculum would probably better serve the needs of the people.

CHAPTER VI

SUMMARY, RECOMMENDATIONS & PERSONAL REFLECTION

Summary

The primary concern of this study was the junior high school science program in Thailand. The author felt that the school science curriculum currently presented in the Thai educational system did not reflect the needs and the character of the Thai students. The study focused on the historical background in the development of the curriculum and its current form and organization rather than what was actually taught. This study investigated the underlying world view and the hidden values present within to determine possible alternatives to the current approach, methods, and subject matter, so that a more complete perspective of science and its role in social environment could be presented.

The study began with the premise that evaluation of school science programs is a "sense-making" activity (Werner, 1979) in which the interpretor interprets educational programs from some perspective or as Aoki put it:

> No program can be evaluated in its entirety. But we can increase our vision of whatever we are viewing through the employment of as many perspectives as we can find appropriate and utilize for our purpose.[1]

(1978b, p. 2)

The frame of reference employed in this study was critical interpretation, which intends to probe, uncover, and make explicit the underlying foundations which may be implicit and hidden. The model of research was informed by an understanding of critical theory. The emphasis was placed on the work of Habermas and his "knowledge-constituted interest." The study adopted his critique of ideology in which he analyzed knowledge and human interests from the critical theory perspective. In his analysis he distinguishes the perspective of empirical scientific theory with respect to the relationship to the social phenomena. He describes theory as a way of looking at the social world that manifests cognitive interest in producing knowledge.

Habermas acknowledges three types of "knowledge-constituted interests." These are technical interest with control, practical interest with mutual understanding, and emancipatory interest with self-reflection. He provides us with examples as to how these conceptions of knowledge can be used to create tension between different world-views. This conflict has the potential to uncover new possibilities for probing deeper into our ways of knowing.

Aoki (1978a) has applied this orientation to various aspects of educational theory. The primary interest in this approach is to emancipate the individual from her or his taken-for-granted situation by self-reflection, to improve through an emancipated action the human condition. This critical orientation also includes a historical hermeneutics stance which emphasizes the understanding of meaning as attributed to situations by individuals. People are not viewed as separate from this world, but as influencing and being influenced by their surroundings.

In critical interpretation the evaluator must be self-reflective and aware of the fundamental beliefs which inform and dominate that which is taken-for-granted in programs. In order to reflect, the evaluator must broaden her or his perspective or world view. Critical theory and hermeneutic understanding, on which this study was based, suggest looking at the history and social context as well as distancing one self from the situation. As a result, this study brought in the history of scientific thought and the history of Thai education, in particular science education. The history provides the evaluator with an opportunity to grasp how the program originated and what influenced it. In this position the evaluator is in a positon to achieve better understandings of the junior high school science program.

The evaluator must further take note of the current social situation and cultural attitudes in Thailand. The social issues raised in an environment, as it is presently witnessed in Thailand today, have special character and demand special attention. They stem in part from the attempt to bridge the gap between the technological and economic growth of other industrial countries, compressing the development and the association of values and attitudes that took centuries to evolve elsewhere, to just few decades. The problems resulting in such a situation are numerous, since what is new is also foreign, in the sense that it is the product of a vastly different cultural system and the influx of such foreign values and commodities is becoming ever greater and faster.

Schooling in such a situation should not only be concerned with accomodating the needs of newly sprung industries, producing the skills, attitudes, and emotions required for such a technological orientation, but also for establishing and maintaining a national and regional consciousness that reflects continuity with the past. Schooling should not be dominated by external or foreign influences which are often prominent and tested against a broad range of social realities, for example, as is evidenced in the adoption of academic science courses into secondary education.

These are then the considerations that were taken into account when analysing the junior high school science program in Thailand. In analyzing the curriculum I asked how well these and other similar issues were incorporated into the classroom activities. I think the following comment by the Institute, "Any child who leaves school with a negative attitude toward science presents a potential barrier to the advancement of science and technology," captures the essence of the problem of Thai junior high school science curriculum as it exists today. It reveals, first of all, the narrow perspective within which science and technology was promoted. Students appear to be a necessary resource for, rather than a benefactor of, scientific development. Secondly, it acknowledges a challenge, especially in developing countries, to present science that does not alienate and obfuscate the real meaning of scientific activity in the lived moment.

The social meaning of school experience has been accepted as unproblematic by the curriculum developers. The emphasis on "technological control" as evidenced by their commitment to means-ends format has involved finding the one best set of means to reach pre-chosen educational ends, rather than a common ground on which to integrate both the social and scientific meanings. The Thai curriculum espoused "the scientific inquiry" as the means to reach its pre-chosen educational ends.

What did "scientific inquiry" mean to the Thai curriculum developers? As was stated by Sapienchai (1980, 1982), the inquiry approach was not only the method of science but it was also the method of studying science in school. However, scientific inquiry in the context of the Thai science program was not the approach that scientists employ to gain the natural knowledge. The whole notion of "inquiry" was reduced to "controlled scientific inquiry," and it became the only way to inquire about all knowledge. This notion disclosed itself in the way the curriculum was presented, as one of the objectives of school science was to "imitate" the methods of scientific inquiry and reasoning. The "imitation" consisted in directing students' experience in "approved" knowledge. Questions asked, experiments performed, classroom activities conducted were all part of a reconstruction of scientific logic.

The IPST has often stated that understanding the nature of science was a major objective for the Thai school science program. The curriculum developers assumed that if students understand science the way scientists know science it would not only be inherently interesting, but beneficial to their lives. The courses were then written as a set of separate disciplines (biology, chemistry, and physics) in the presentation of their structure and their modes of inquiry. Science was regarded as "important" and presented under such interpretations as "thinking like scientist" and "...love to think, loves to experiment and has enthusiasm (scientist)." These attitudes were thought to be essential in all scientific activities.

However, in this approach there frequently exists a considerable gap between the outcomes of the learning process as is sought by curriculum developers and those obtained in the typical science classroom. This problem is particularly relevant to developing countries where the differences between culture and scientific thinking must be bridged almost overnight. Special attention must be paid to the way culture and science correlate their values to make the transition to a culturally and scientifically integrated society meaningful for the student. This task is manifold and its success is not guaranteed under the best of conditions. When a country like Thailand, as was shown above, strictly adopts science curricula without any serious regard for the cultural aspect of the problem, its failure to bridge the gap is almost secured. For when a gap of this nature exists, there is a likelihood of students being alienated from and developing negative attitudes toward science and technology; which is contradictory to the initial intent of the curriculum.

In such a situation, together with the prevailing myth of a benevolent science and the high regard for proper scientific attitudes, a sense of elitism was promoted in the students' imitation of scientism. Courses designed in this way, especially in general science courses, select and separate the potential scientists from their fellow students. Those who succeeded could pride themselves on being members of an elite "intellectual" class which usually leads them to patronize the views and aspirations of others. An attitude which reveals an underlying commitment to an undemocratic situation.

Finally, the curriculum fails in what I consider to be the most important function of any curriculum. That is, to develop and help promote a critical stance toward everyday experience. If the curriculum emphasizes the scientific method, it might be because it cannot be denied or avoided as an important ingredient in science, as many educators believe. But the approach adopted tends to delimit the students' perception as well as their keen observation of the environment by asking them to imitate the method whose appropriateness is never questioned. In this Thai science course, science is seen as a method of disciplined curiosity. The curriculum emphasizes the adopting of the perspective of science within its narrow definition of method. Under this direction, attention is directed toward describing rather than understanding, towards adopting notions and methods from system theory rather then everyday reality.

Symons (1975) provided a thoughtful perspective on how science should be viewed within a cultural phenomena and within a social context. "Sci[illegible] is not just a set of laws but an activity which involves people, attitudes, and aims. Although the scientific laws may be universal, scientific practice is not. Science is very much a part of the cultural fabric of a country. A country's physical and biological characteristics present a set of unique needs that differ from others because of its unique constitution" (p. 94).

This view was supported in this study as an alternative to the technical approach adopted in the current curriculum. Science, it is proposed, should be taught through the lived-experience. In this way the students are encouraged to pose their own questions and pursue their own investigations in all aspects of life, not only science. Science is seen to be integrated with other social activities rather than apart as a discipline concerned with its own inherent joy and knowledge. Students should learn to question the basis of scientific knowledge and become conscious of the underlying values and ideology. They should be provided with a holistic view of the world.

The prespecified objectives and the content presented in the current curriculum did not allow students, or even the teacher, to bring their own lived experience into the classroom and give full meaning to the situation in which they found themselves. Everything was pre-determined, students had to study within the assigned frame of reference. Thus, the curriculum as presented could not fully claim to be relevant to the society and everyday life.

Jacknicke & Rowell suggested that, "...in order that students be able to give their meaning to the situation or to understand the situation they live in, they should be acquaintained with the history, the philosophy and the social study of science" (p. 14). This approach provides opportunities to reflect on scientific knowledge, promotes values, critical judgement and brings the immediate environment to the class. The history part of science will show how social and political climate can determine whether scientific activity is valued or ignored, and whether the results of research are well used.

The denial to the student of this type of participation in doing science, on the other hand, results in highly stratified knowledge and as is suggested by Young:

> If knowledge is highly stratified there will be a clear distinction between what is taken to count as knowledge, and what is not, on the basis of which process of selection and exclusion for curriculum will take place. (1971, p. 19)

This may indicate that any curriculum developer who imparts theory to students is creating for them a passive view of life. Manipulating them, for example, to remain within their own particular social class. That is to say that the separation of knowledge into theoretical and practical prevents an understanding by the student of the potential actions which may result in a transformation of her/his social situation (Bowles & Gintis, 1976). A passive student may become a passive citizen.

Introducing the S-T-S relation into the curriculum is not as radical as one may think. Canada, many states in the United States, England, and South East Asia have clearly acknowledged and adopted some of these issues as national policies. In Canada, a great deal of concern about the S-T-S interaction became a part of the national policy of science curriculum. Many Canadian science educators reflect a concern about the way the children in Canada learn about the accomplishments and the impact of science in other countries, such as Apollo or the flight of Sputnik, and at the same time know nothing about the impact of science in their own country.

In conclusion, the curriculum illustrates the need to make an overt decision about two crucial matters. Should the curriculum emphasize the abstract and basic subject matter or the section of the population for whom the course is intended? The question of priorities must be asked now. What is more important? To inculcate in students the thinking of a discipline so that perhaps there is a certain expediency in learning of what may be a useful "activity in life" or proceed more cautiously, more reflectively, perhaps at the expense of the expediency, towards a more holistic, integrated "way of life." I do not profess that I can answer this question for the Thai people. I would not be disappointed if a "happy" medium was found and implemented in the Thai general science course. However, what is important, and becoming more urgent with the passing of time, is that an awareness of such a need should be brought to the Thai people. It is the Thai students of today who must ultimately decide what Thailand will mean to the world and to them in the future, not science and its Western epistemology. Science must serve the Thai community and not, as it is now becoming more and more evident in the west, the community serving science.

Recommendations

This study regards critical theory as basic to all human rational endeavors. It views an informed praxis as an emancipatory activity and considers such an activity as essential for the classroom environment. Adopting this stance should be regarded as one of the priority goals to be included in the present curriculum. Adopting this attitude, however, requires a manifold effort at all levels of curriculum activities. The curriculum developers must take into account not only the subject matter they wish to present but an interaction of all participants who interact with the curriculum. For example, students and teachers, must have a contribution to what and how the curriculum presents material. This participation presents its own special unique problems that can be seen to differ from the conventional technical approach, means-ends relationship. My recommendations will be made along these lines.

First of all, critical theory demands that the educational system in Thailand be examined with respect to its traditional role in Thai society. As has been indicated earlier the educational system in Thailand has always held an authoritative position in providing an esoteric knowledge to students. This in part reflects Thai cultural traditions which legitimize a hierachial respect for seniority and status. Thus, a critical analysis has to reinterpret these roles and how these roles can be reconciled with the critical awareness mode of thinking.

The curriculum developers should try to encompass the entire social system and its determinants in an educational situation. Looking to other countries for educational standards avoids the broader issues of cultural variances that do exist and need to be taken into consideration when developing the Thai curriculum. The adopting of these programs retains both the learning theories and the cultural ethos pertaining to distinct cultural background, usually creating not only conflict of values but also a widening gap between authority and ignorance. This would seem to indicate that there is a need for re-interpreting knowledge, especially scientific knowledge and its application, in the Thai context and tradition. The re-interpretation has to be actualized at all levels of the educational system if this translation is to be effective.

The current societal conditions, that are in some respect caused by ignorance and the now pervading presence of science and technology, should be addressed fully in a curriculum that discusses science as a social activity. Technological consumerism promotes a naive view of science and a naive view of social responsibility and participation. The curriculum should accept the challenge of creating an active citizen in all aspects of social function, including scientific and technological decision-making. An active citizen should be aware of the consequences that can be produced by an interaction between Thai culture and science and technology. For example, she or he should be a well-informed citizen on the side-effects of pharmaceutical prescriptions, or the effects of the technical mode of thinking and the conflicts therein created within her or his own tradition.

To accomplish these ideals, the curriculum needs to be self-reflective, in the sense that its portrayal of subject matter should always encourage both the teacher and students to further reflect on the knowledge or activities presented.

As my analysis of the current Thai curriculum showed, special attention has to be given to the details of all classroom activities. The taken-for-granted perspective must be carefully weighed in light of knowledge presented and methods used. An ideological presentation of concepts, such as the use of instruments alluded to in the earlier part of the study, may lead to a false consciousness and misrepresentation of the actual scientific value. Thus, continuous reflection becomes an essential freeing element in the learning process.

This could also be facilitated by providing for the teachers and students supplementary reading and other information materials, possibly including official documents, scientific research papers, and journals as part of the classroom activities. These may require a certain compromise in the actual content being presented in the classroom situations, according to the level of sophistication of the students, but their value to the overall scientific perspective is important. The use of the historical and philosophical views of science will clarify to the students the role science plays in human thought.

Finally, it has to be determined what a general science course at the junior high school level should offer the Thai students. The Ministry of Education has expressed the need to raise the level of compulsory education in Thailand from grade 6 to grade 9. This raises some fundamental issues about the educational purpose, as this implies that the majority of students taking this course in the future will come from the rural area. The rural students, as indicated, have different expectations from their schooling compared to their metropolitan counterparts, and also different uses for scientific information.

The recommendations made above have been presented in an abstract form as I do not feel that I am in the position to make more concrete suggestions. The initial concrete strategies must be worked out by a concerted effort into the varied aspects of both Thai cultural and scientific phenomena. They must reflect the true nature and the true needs of a society that are, at present, almost entirely neglected in the IPST curriculum.

Personal Reflection

The motivation of this study has been primarily a reflection on my personal science education. I have a major in a strictly scientific oriented program that led to post-secondary education specializing in science education. High school in Thailand, at the time, offered to students science, arts, and general streams. The latter two were usually viewed as inferior. Students who chose these streams usually regarded themselves as unable to perform in the science subjects. The students who remained in the science stream had to adjust and function within a rigid curriculum. Everybody worked hard, attempting to absorb and digest every necessary detail to achieve the standards set by the qualification examination. These examinations played a key role in enabling students to access the highly esteemed professionally oriented areas of further study.

In this environment, there was little time for us to reflect on the type of knowledge we were taught, and to realize its implications in our everyday life. This knowledge was always presented and taught as esoteric to which students had very little contribution. The approach in school involved the regurgitation of assigned material and performing prescribed skills. A competitive atmosphere dominated all classroom activities that was also carried on to the university level. Science education provided an opportunity for an individual to prove herself or himself through her or his ability in meeting a set standard and, if successful, an individual could pride herself or himself in belonging to an elite intellectual class.

By coming here to the University of Alberta, enrolled as a graduate student in the Department of Secondary Education, I was exposed to a different, and in some sense a more encompassing, perspective about education in general. The programs offered presented [illegible] of alternatives to the conventional perspective in [illegible]land. It has had a strong influence on my current pe[illegible] attitude towards education and has turned out to be a [illegible] force behind my initiative in pursuing this study. T[illegible]rses offered at this University provided me wit[illegible] important insights on how to proceed and attain the pre[illegible] dialogue in the study. However, I must confess th[illegible] still hesitate to abandon a way of thinking that has u[illegible] now been a dominant part of my life. In this light I fou[illegible]tical theory to be a compromising, even a mitig[illegible] element in what I think is my radical transformation.

I now believe that th[illegible] a need to educate the young Thai people to have a bett[illegible] a better understanding of the situation they and the[illegible]ntry find themselves in; a [illegible]ation that is progress[illegible] becoming determined by the [illegible]eign western perspectiv[illegible] The Thai people must realize the inherent benefit and h[illegible]th respect to all social, env[illegible]mental and cultural [illegible]s that inevitably accompany any such adoption. I beli[illegible] that this type of awareness can [illegible] achieved and promoted t[illegible] an education grounded in a critical stance.

The science program I [illegible]ded in Thailand did very little to raise these ques[illegible]. The initial mode of teaching science has been [illegible]tempt to accomodate the void crisis in the specialized labor market demanded by the influx of new technology with its emphasis on the technical skills and versatility in employing them. As a result, the other aspects of technology were ignored. I place for myself the task of promoting a dialogue that will contribute to an awareness of these particular issues among not only the Thai educators, but also the average Thai citizen.

I have discussed my thoughts about education with friends who asked me on more than one occasion the type of course I intended to teach upon return to Thailand. They perceived this decision in terms of science or social science orientation. I have always responded by asking them, "What should be the purpose of science education after all?" That is I believe this question should always be open to further reinterpretation and not enframed within unnecessarily restrictive views of current pedagogy.

BIBLIOGRAPHY

BIBLIOGRAPHY

Agin, M. L. and Pella, M. O. Teaching interrelationships of science and society using a socio-historical approach. School Science and Mathematics, 1972, 72, 320-333.

Aikenhead, G. The measuremnts of high school students' knowledge about science and scientists. Science Education, 1973, 57, 539-549.

Aikenhead, G. Science in social issues implications for teaching. Ottawa: Science Council of Canada, 1980.

Aikenhead, G. The science/society interface A paper presented at the International Symposium, NSTA annual convention. Dallas, Texas, 1983.

Airola, P. Are you confuse? Phoenix, Arizona: Health Plus, 1971.

Adorno, W. T. The postivistic dispute in German sociology. New York: Harper & Row, 1972.

Aoki, T. T. Theoretic dimensions of curriculum: reflection from a micro-perspective. Canadian Journal of Education, 1977, 1, 49-58.

Aoki, T. T. Toward curriculum inquiry in a new key. Presentation on Art Education Research, No.2, Concordia University, Montreal, 1978a, 47-69.

Aoki, T. T. Toward new conceptions for evaluation in social studies: curriclum evaluation in a new key. Vancouver: Center for the Study of Curriculum and Instruction,, UBC, 1978b.

Aoki, T. T. A critical approach to program evaluation on the B.C. social studies curriculum.. A paper presented at AERA, Annual Conference, San Francisco, 1979.

Aoki, T. T. Toward a dialectical between the conceptual and the lived world: transcending instrumental in curriculum orientation. An invited paper for presentation at Teacher Education Seminar in Seoul, Korea, 1982.

Aoki, T. T. Address to the member of the Canadian Association for Curriculum Studies A speech given at the CACS/CSSE Conference in Montreal, May 25, 1985.

Apel, K. O. The a priori of communication and the foundation of humanities. Man and World, 1972, 1, 3-37.

Aphornratana, K. Competency-based training for science teacher. A paper presented at ROEAP, UNESCO, Bangkok, November 10-18, 1981.

Aphornratana, K. (ed.) Response to the comment appears in the book "Science: 200 years Ratanakosintr". IPST News, 1982, 1, 3-8.

Apple, M. Ideology and curriculum. London: Routledge & Kegan Paul Ltd., 1979.

Apple, M. W. The other side of the hidden curriculum: correspondence theories and the labor process. Interchange, 1980-1981, 3, 5-22.

Arato, A., and Gebhardt, E. (eds.) The essential Frankfurt School reader. New York: Contiuum, 1982.

Archewaumroong, P. The history of science education in Thailand up to 1982. pp. 66-98. In Science Society of Thailand. Science: 200 years Ratanakosintr. Bangkok, Thailand: Graphic Art Publication, 1982.

Aylward, G. H. How the university will react to the change of the science education program developed by IPST. IPST News, 1977, 1, 38-40.

Barnes, B. (a) Sociology of science. London: Penguin Books Ltd., 1972

Barnes, B. (b) On the reception of scientific belief. pp. 269-291. In S.B. Barnes (ed.) Sociology of Science. London: Penguin Books, Ltd. 1972.

Barnes, B. Scientific knowledge and sociological theory. London: Routledge & Keagan Paul, 1974.

Barnes, S. B. Interests and the growth of knowledge. London: Routledge & Keagan Paul, 1977.

Barrett, W. Illusion of technique: a search for meaning in a technological civilization. New York, 1979.

Bateson, G. Mind and nature. New York: Doulton, 1979.

Bellack, A. A., and Kliebard, H. M. Curriculum and evaluation. Berkeley: MaCutcheon Publishing Co., 1977.

Benson, G. Teachers' and students' understandings of biology. Unpublished Doctoral Dissertation, University of Alberta, 1984.

Berano, P. Technology and human freedom. Science for People, 1984, 6, 17-21.

Berger, P. Invitation to sociology: a humanistic perspective. New York: Doubleday & Company, Inc., 1963.

Berger, P. and Luckmann, T. The social construction of reality: treatise in the sociology of knowledge. New York: Doubleday & Company, Inc., 1967.

Bernal, J. D. The social function of science. New York: MacMillan, 1939.

Berstein, B. Class, codes and control. vol 3: Towards a theory of educational transmisssions. London: Routledge & Kegan Paul, 1975.

Berstein, R. The restructuring of social and political theory. Philadelphia: University of Pennsylvania Press, 1978.

Blake, R. M., Ducasse, C. Y., and Madden, E. H. Theories of the scientific method. Seattle: University of Washington Press, 1966.

Bleicher, J. Contemporary hermeneutics: hermeneutics as method, philosophy, and critique. London: Routledge & Kegan Paul, 1980.

Bodington, S. Science and social action. London: Allison & Busby, 1978.

Bourgeoise, P. Paul Ricoeur's hermeneutical phenomenology. Philosophy Today, 1972, 16, 20-27.

Bowles, S. and Gintiss, H. Schooling in Capitalist America. London: Routledge & Kegan Paul, 1976.

Branningan, A. The social basic of scientific discoveries. Cambridge: Cambridge University Press, 1981.

Bronowski, J. Science and human values. rev. ed. New York: Harper & Row Publishers, 1965.

Bruner, J. The process of education. New York: Vintage Book, 1963.

Bruner, J. S. The process of education revisiced. Phi Delta Kappan, 1971, 1, 18-21.

Burke, K. The philosophy of literary form. Baton Rouge: LSSU Press, 1941.

Bybee, W. R. The new transformation of science education. Science Education, 1977, 1, 85-97.

Capra, F. The turning point: science, society and dthe rising culture. Toronto: Bantum Books, 1983.

Callahan, R. E. Education and the cult of effeciency. Chicago: University of Chicago Press, 1962.

Carson, T. A hermeneutic investigation of the meaning of curriculum implementation for consultants and teachers. Unpublished Doctoral Dissertation, University of Alberta, 1984.

Chantawimol, M. Secondary school science and mathematics curriculum. IPST, Ministry of Education, Bangkok, Thailand.

Chuapanich, C. Related literature in secondary edcuation. Bangkok: Sukhothaithammathirat University, 1982.

Connelly, F. M., Whaleton, M. W., Feingold, M., and Elbaz, F. Enquiry teaching in science : A handbook for secondary school teachers. Toronto: The OISE, 1977.

Connerton, P. Critical sociology: Selected readings. Harmondsworth, Middlesex: Penguin Books, 1976.

Conant, J. B. Science and commonsense. New Heaven: York University Press, 1961.

Connerton, P. Tragedy of Enlightenment: an essay on the Frankfurt School. Cambridge: Cambridge University Press, 1977.

Cox, R. R. Schutz's theory of relevance: A phenomenological critique. The Hague: Martinus Nijhoff, 1978.

Crossland, J. P. The science of matter. Baltimore: Penguin, 1971.

Crowther, J. G. The social relations of science. London: The Cresset Press, 1967.

Dallmayr, F. R. Critical theory criticized: knowledge and human interests and its aftermath. Philosohy of Social Science, 1972, 2, 211-229.

Dallmayr, F. R. Reason and emancipation: notes on Habermas. Man and World, 1972, 5, 79-109.

Dampier, W.C. A history of science and its relations with philosophy and religion. Cambridge University Press, 1971.

Danto, A. C. Deep interpretation. Journal of Philosophy, 1981, 78, 73-85.

Dewey, J. Democracy and education. New York: The Free Press, 1966.

Dolby, R. G. A. The sociology of knowledge in natural science. Science Studies, 1971, 1, 309-330.

Downey, K. J. The scientific community: organic or mechanical. Sociology Quaterly, 1969, 4, 438-454.

Dumanoski, D. Acid rain. Sierra, 1980, May/June.

Durant, W. The story of philosophy. New York: Simon and Schuster, 1983.

Edward, A. D. and Furlong, V. A. Language in classroom interaction. Educational Research, 1977, 19, 122-128.

Eisner, E. The educational imagination. New York: MacMillan Publishing Co., 1979.

Eisner, E. W., and Vallence, E. (eds.) Conflicting conceptions of curriculum. Berkeley: MacCutcheon Publishing Co., 1974.

Elton, L. R. B. The assesment of students: a new approach. University Quaterly, 1978, 22, 291-301.

Engle, G. The need for a new medical model science: a challenge for biomedical. Science, 1977, 8.

Erikson, G. Students' belief about science concepts: a missing ingredient in the instructional process. Mimeograph, Univeristy of British Columbia, 1982.

Feibleman, J. K. Scientific method. The Hague: Martinus Nijhoff, 1972.

Feyerabend, P. Against method. London: NLB Humanities

Press, 1975.

Feyerabend, P. Science in a free society. veso ed. NLB Humanities Press, 1982.

Friere, P. Pedagogy of the oppressed. New York: Herder and Herder, 1972.

Gadamer, H. Truth and method. New York: The Seabury Press, 1975.

Gadamer, H. Philosophical hermeneutics. Berkeley: University of California Press, 1976.

Garfinkle, H. The anthropological foundation of a humane psychology. pp. 185-233. in J. R. Royce (ed.) Humanistic psychology. New York: Plenum Publishing Corporation, 1980.

Gasking, E. The rise of experimental biology. New York: Random House, 1970.

Gay, G. Conceptual models of the curriculum planning process. pp. 120-43. in A. W. Foshay (ed.) Considered action for curriculum improvement. Alexandria, Va.: ASCD, 1980.

Geuss, R. The idea of a critical theory: Habermas and the Frankfurt School. Cambridge: Cambridge University Press, 1981.

Girard, G. I. Impact of NSF science curriculum projects. School Science and Mathematics, 1979, 79, 3-6.

Giroux, H. A. (ed.) Curriculum and instruction: alternatives in education. Berkeley: McCutcheon Publishing, Inc., 1983.

Giroux, H. A. Theory and resistance in education: a pedagogy for the opposition. Massachusettes: Bergin & Garvey Publishing, Inc., 1983.

Greene, M. Curriculum and consciousness. pp. 237-53. In A. Bellack & H. Kliebard (eds.) Curriculum and evaluation. Berkeley: McCutcheon, 1977.

Greene, M. Landscape of learning. New York: Teacher College Press, 1978.

Habermas, J. Knowledge and human interests. Boston: Beacon Press, 1971a.

Habermas, J. Toward a rational society: a student protest, science and politics. London: Heinmann, 1971b.

Habermas, J. The analytic theory of science and dialectics. pp. 131-62. In T. Adorno (ed.) The positivistic dispute in German social science. New York: Harper & Row, 1976.

Habermas, J. Communication and the evolution of society. Boston: Beacon Press, 1979.

Hackings, I. Scientific revolutions. New York: Oxford University Press, 1981.

Harms, N., and Yager, R. (eds.) What research says to the science teacher. vol.3. Washington, D. C.: National Science Teacher Association, 1981.

Harmin, M., Kirchenbaum, H. and Simon, S. B. Teaching science with a focus on value. The Science Teacher, 1970, January, 16-20.

Harrison, B. E. Social worlds: British Columbia social studies curriculum unit "Developing Tropical World" as reflected ttrough the writing of George Herbert Mead and Alfred Schutz. Unpublished Doctoral Dissertation, The University of Alberta, 1984.

Harrison, G. The role of technology in science education. pp. 18-26. In C. P. MaFadden (ed.) World trends in science education. Halifax: Atlantic Institute of Education, 1980.

Held, D. Introduction to critical theory: Horkheimer to Habermas. London: Hutchinson, 1980.

Heller, A. Dialectical theory. Cultural Hermeneutics, 1974, 2, 167-209.

Heller, A. Society, nature, and critical theory. Cultural Hermeneutics, 1974, 4, 123-148.

Heller, A. Toward a sociology of knowledge of everyday life. Cultural Hermeneutics, 1975, 3, 7-18.

Hernadez, D. F. Development needs of science education in the Republic of Phillipines. (Doctoral Dissertation, Indiana University, 1960). Dissertation Abstracts International, 1959-60, 20, 2032.

Hesse, M. In defence of objectivity. Oxfords: The University Press, 1973.

Heyman, R. D. Analyzing the curriculum. International Review of Education, 1981, 27, 449-70.

Hirch, E. D. Validity in interpretation. London: Yale University Press, 1976.

Horkheimer, M., and Adorno, T. Dialectic of enlightenment. New York: Herder and Herder, 1972.

Horkheimer, M. Critique of instrumental reason: lecture and essays since the end of World War II. New York, Seabury Press, 1974.

Hoy, D. C. The Critical circle. Berkley: University of California Press, 1978.

Hoy, D. C. Hermeneutics. Social Research, 1980, 4, 649-671.

Hurd, P. Scientific enlightenment for an age of science. Science Teacher, 1970, 37, 13-15.

Hurd, P. Research in science education: planning for the future. Journal of Research in Science Teaching, 1971, 3, 243-249.

Hurd, P. Science, technology, and society: new goals for interdisciplinary science. Science Teacher, 1975, 42, 27-30.

Hurd, P. Perspective for the reform of science education. Science Teacher, 1986,

Husserl, E. The crisis of European science and the transcendental phenomenology. Evanston: Northewestern University Press, 1970.

Illich, I. Medical nemesis. New York: Bantum, 1977.

Ivany, J. W. G. Philosophy of science and the science curriculum. Journal of Research in Science Teaching, 1969, 6, 144-151.

IPST. The principle in developing science and mathematics curriculum according to the 6-3-3 system. IPST News, 1979, April-July, 6-11.

IPST. Report on analysis the content "environmental science" in school science pprogram at all level. 1982.

IPST. Twelve years of devvelopment of science and mathematics education in Thailand. Bangkok, Thailand: Chuanpim Publication, 1984.

Jacknicke, K. G., and Rowell, P. M. Reaching for possibilities in science education. Occasional paper no. 33, University of Alberta, 1984.

Jay, M. The dialectical imagination: a history of the Frankfurt School and the Institute of Social Science Research, 1923-1950. Boston: Little & Brown Co., 1973.

Jennings, A. and Ingle, R. (eds.) Science teachers for tomorrow's schools. London: The University of London Institute of Education, 1982.

Joergenson, J. The development of logical empiricism. Chicago: The University of Chicago Press, 1970.

Jungwirth, E., and Dreyfus, A. Secondary school biology student's reaction to logical fallacies in scientific as compared with everyday contexts. In W. P. Archenhold (ed.) Cognitive development research in science and mathematics. Leeds: The University of Leeds Printing Service, 1980.

Kaplan, A. The conduct of inquiry. Scranton: Chandler, 1964.

Kempa, R. Science education research: some thoughts and observation. Studies in Science Education, 1976, 3, 97-105.

Ketudhat, S. Science education reform in developing countries. Closing Address at the Sixth International Conference on Chemistry Education, University of Maryland at College Park, USA, August 9-14, 1981.

Ketudhat, S. Science and technology for all. IPST Nes, 1984, 4, 5-18.

Kessen, W. Statement of purposes and objectives of science education. Journal of Research in Science Teaching, 1964, 2, 3-6.

Kidd, R., and Kumar, K. Co-opting Friere: a critical analysis of Pseudo-Frierian adult education. Economic and Political Weekly, 1981, 1, 15-17.

Kimball, M. E. Understanding the nature of science: a comparison of scientists and science teacher. Journal of Reasearch in Science Teaching, 1968, 5, 110-20.

Kinneavy, J. L. A theory of discourse. Eaglewood Cliffs, N. J.: Prentice Hall, 1971.

Kilbourn, B. World view and curriculum. Interchange, 1980-1981, 11, 1-10.

Klopfler, L. E. Teaching physics for the 21st century: science and its culture context. School Science and Mathematics, 1975, 5

Kniker, C. R., and Naylor, N. A. Teaching for today and tomorrow. Columbus: Charles E. Merill, 1981.

Kuhn, T. S. The functions of dogma in scientific research. pp. 347-69. In A. C. Crombie (ed.) Scientific change. New York: Basic Books, 1963.

Kuhn, T. S. The structure of scientific revolution. 2nd ed. Chicago: The University of Chicago Press, 1970.

Kuhn, T. A paraphased in Chronicle of Higher Education, 1985, August 7, 7.

Laing, R. D. The voice of experience. New York: Pantheon, 1982.

Lakatos, I. and Musgrave, A. (eds.) Criticism and the growth of knowledge. Cambridge: Cambridge University Press, 1970.

Lawn, M. and Barton, L. Rethinking curriculum studies. New York: John Wiley & Son, Inc., 1981.

Lamaimas, S. and Savannathat, C. Attitudes of parents toward occupation and education. In A. Tapinkae (ed.) Education in Thailand: some Thai perspectives. Washington: US. Government Printing Office, 1973.

Lenk, H. Technology and scientism? remark concerning an ideological discussion. Man and World, 1972, 3, 253-271.

Lowery, L. F. Toward improving the science education research enterprise. Journal of Research in Science Teaching, 1980, 17, 275-281.

Lutterodt, S. The adaptation of science curricula: an explanatory analysis of some relevant questions.

pp.79-89. In C. P. McFadden (ed.) World trends in science education. Halifax: Atlantic Institute of Education, 1980.

McCarthy, T. The critical theory of Jurgen Habermas. Cambridge: MIT Press, 1978.

Macdonald, J. B. Curriculum and human interests. pp. 283-98. In Pinar, W. (ed.). Curriculum theorizing: the reconceptualists. Berkeley: McCutchan Publication Co., 1975.

MacDonald, J. B. Theory and practice and the hermeneutic circle. The Journal of Curriculum Theorizing, 1982, 1, 171-76.

Mackay, L. D. Development of understanding about the nature of science. Journal of Research in Science Teaching, 1971, 8, 57-66.

Magoon, A. Constructivist approaches in educational research. Review of Educational Research, 1977, 4, 651-693.

Major, J. R., and Puglisi, C. J. Two decades of curriculum projects. In M. R. Abraham (ed.) Science education/society: a guide to interaction and influence. Columbus: ERIC/SMEAC Information Reference Center, 1978.

Marx, W. Habermas' philosophical conception of history, Cultural Hermeneutics, 1976, 3, 335-347.

Mayer, W. Adaptation of BSCS biology throughout the world. The American Bilogy Teacher, 1974, 9, 543-545, 561.

McCutcheon, G. Educational criticism: reflection and reconstruction. The Journal of Curriculum Theorizing, 1982, 4, 171-176.

Mead, M. and Metraux, R. Image of the scientists among high school students. Science, 1957, 126, 384-389.

Medawar, P. B. Induction and intuition in scientific method. Philadelphia: American Philosophical Society, 1969.

Meja, V. The sociology of knowledge and the critique of ideology. Cultural Hermeneutics, 1975, 3, 51-58.

Mendelsohn, E. The social production of scientific knowledge. Dordrecht: D. Reidel Publishing Co., 1977.

Mendelsohn, E. Values and science: a critical reassessment. The Science Teacher, 1976, January, 21-23.

Mendelson, J. The Habermas-Gadamer debate. New German Crittique, 1979, 18, 44-73.

Merton, R. The sociology of science. Chicago: The Universsity of Chicago Press, 1965.

Molnar, A., and Zahorik, J. A. Curriculum theory. Washington, D.C.: ASCD, 1977.

Mulkay, M. Some aspects of cultural growth in the natural science. Social Research, 1969, 36, 22-52.

Mulkay, M. J. Science and the sociology of knowledge. London: George Allen & Unwin, 1979.

Nadar, R., and Abbotts, J. The menace of atomic energy. New York: Norton, 1977.

National Identity Office. Thailand in the 80s. Bangkok, THailand: Muang Boran Publication, 1984.

Nay, M. and Crocker, R. Science teaching and the affective attributes of scientists. Science Education, 1970, 1, 59-67.

Neurath, O. Unified science as encyclopedia integration. International Encyclopedia of Unified Science, 1, 1971.

Newton-Smith, W. H. The rationality of science. London: Routledge & Keagan Paul, 1981.

Nickles, T. Scientific discoveries: case studies. Dordreht: D. Reidel, 1980.

Okey, J. R. Effects of a modified mastery leaarning strategy on achievement, attitudes and on-task behavior of high school chemistry students. Journal of Research in Science Teaching, 1983, 3, 203-211.

Olson, J., and Russel, T. L. (eds.) Case studies in science teaching. Vol 3. Ottawa: Science Council of Canada, 1980.

Orpwood, G. Science education in Canada: the basis for a research study. Ottawa: Science Council of Canada, 1983.

Orpwood, G., and Alam, I. Statistical data base for Canadian science education. Vol. 2. Ottawa: Science Council of Canada, 1980.

Palmer, R. E. Hermeneutics. Evanston: Northwestern University Press, 1969.

Parson, J. and Beauchamp, L. The curriculum of student teacher evaluation. Unblished paper, Department of Secondary Education, University of Alberta, 1986.

Pella, M. O., O'Hearn, G. T. and Gale, G. W. Referents to scientific literacy. Journal of Reasearch in Science Teaching, 1966, 4, 199-208.

[illegible] W. F. (ed.) Curriculum theorizing: the [illegible]nceptualists. Berkeley: MaCutcheon Publishing [illegible]peration, 1975.

Pinar, W. Reply to my critics. Curriculum Inquiry, 1980, 2, 199-205.

Pinar, W, and Grumet. M. Theory and practice and the reconceptualisation of the curriculum studies. pp. 20-42 in M. Lawn and L. Barton (eds.) Rethinking curriculum studies: a radical approach. New York: John Wiley & Sons, 1981.

Polanyi, M. Personal knowledge: toward a post-critical philosophy. Chicago: The University of Chicago Press, 1958.

Polanyi, M. The unaccountable element in science. pp. 105-120. In Grene, M. (ed.) Knowing and being: essay by Michael Polanyi. London: Routledge & Kegan Paul, 1969.

Popper, K. Conjectures and refutations. New York: Basic Books, 1962.

Power, C. N. Competing paradigm in science education research. Journal of Research in Science Teaching, 1976, 13, 579-587.

Pratte, R. Metaphorical models and curriculum theory. Curriculum Inquiry, 1981, 11, 307-320.

Radhakrishna, S. (ed.) Science, technology and global problems: views from the developing world. New York: Pergamon Press, 1979.

Ricoeur, P. Ethics and culture: Habermas and Gadamer in dialogue. Philosophy Today, 1973a, 17, 153-165.

Ricoeur, P. The task of hermeneutics. Philosophy Today, 1973b, 17, 112-128.

Ricoeur, P. The conflict of interpretations. Evanston: Northwestern University Press, 1974.

Ricoeur, P. Interpretation theory: discourse and the surplus of meaning. Texas: Christian University Press, 1976.

Ricoeur, P. Hermeneutics and human science. Cambridge: Cambridge University Press, 1981.

Robinow, P., and Sullivan, W. (eds.) Interpretive social science: A reader. California: University of California Press, 1979.

Robinson, J. T. Philosophical and historical bases of science teaching. Review of Educational Research, 1969, 39, 459-471.

Romey, W. D. Inquiry techniques for teaching science. Englewood Cliffs, New Jersey: Prentice Hall Inc., 1968.

Rosenthal, D. B. Trends in science and society education: An analysis of the literature. The American Biology Teacher, 1983, 1, 18-22.

Rowell, P. M. Planning for implementation of the International Baccalaureate Program: a situational study. Unpublished Doctoral Dissertation, The University of Alberta, 1983.

Russel, B. The impact of science on society. Massachusettes: George Allen & Unwin, 1985.

Sangalang, L. E. Some aspects of science education for rural Phillipines and implications for the education of teachers for the community schools. (Doctoral Dissertation, Indiana University, 1961). Dissertation International, 1961-62, 22, 1093.

Santillana, G. de, and Zielsel, E. The development of rationalism and empiricism. Chicago: The University of Chicago Press, 1970.

Sapienchai, N. Philosophy and aim in teaching science. IPST News, 1977, 4, 1-5.

Sapienchai, N. (ed.) The nature of science. IPST News, 1980, 3-4, 2-8.

Sapienchai, N. The effect of the development of secondary school science on the higher education curriculum. IPST News, 1981, 3, 2-11.

Sapienchai, N. Some issues in science education in Thailand. A paper presented at the Regional Planning Workshop on Recam-German Corporation in Mathematics, Science and Technology Education, August 15-20, 1982.

Sapienchai, N. Science and technology for all. IPST News, 1984a, 2, 2-11.

Sapienchai, N. Science and technology for all. pp. 193-200. In IPST. Twelve years of development of science and mathematics education in Thailand. Bangkok: Chuanpim Publication, 1984b.

Schutz, A. Collected paper I: the problem of social reality. Natanson, M. (ed.). The Hague: Martinus Nijhoff, 1962.

Schutz, A. Reflections on the problem of relevance. London: Yale University Press, 1970.

Schutz, A. Problem of social reality. The Hague: Matinus Nijhoff, 1973.

Scwab, J. J. The teaching of science as enquiry. pp. 3-103. In J. J. Schwab and P. F. Brandwein. The teaching of science. Massachusettes: Harvard University Press, 1962.

Schwab, J. J. Structure of the disciplines: Meaning and significances. pp. 189-207. In G. W. Ford and L. Pungo. (eds.) The structure of knowledge and the curriculum. Chicago: Rand McNally & Company, 1964.

Science Council of Canada. Science for every student: educating Canadians for tomorrow's world. Ottawa, Science Council of Canada, 1984.

Science Society of Thailand. Science: 200 years Ratanakosintr. Bangkok, Thailand, Graphic Art Publication, 1982.

Scrouton, R. A shorter history of modern philosophy from Descartes to Wittengenstein. London: Ark, 1984.

Seigel, H. On the distortion of the history of science in science education. Science Education, 1979, 63, 111-18.

Setti, L. and Tapingkae, A. Education in Thailand: some Thai perspectives. Washington: US Government Printing Office, 1973.

Slayer, M., and Adey, P. Towards a science of science teaching. London: Heinemann, 1981.

Smathapun, S. Science and society. IPST News, 1984, 3, 18-20.

Sroydhurum, P. National science case study: Thailand. Bangkok: The Institute for the Promotion of Teaching Science and Technology, 1982.

Sroydhurum, P. The development of science and mathematics curriculum of IPST. pp. 1-22. In IPST. Twelve years of development of science and mathematics education in Thailand. Bangkok, Thailand: Chuanpim Publication, 1984.

Stanley, W. P. and Sawadi-panich, K. Education in Thailand: secondary education, manpower and educational planning. Thailand, Bangkok: Thai Watana Panich, 1966.

Steffensen, M. The various aims of science education. In R. Stake and J. Easley (eds.) Case studies in science education. Vol III. Washington, D. C.: U.S. Government Printing Office, 1978.

Swasdi-Panich, K. The diffusion of education innovations in the government secondary schools of Thailand. Michigan: Institute for International Studies, 1966.

Symons, T. H. B. To know ourselves. The Report of the Commision of Canadian Studies, Vol I. Association of Universities and College of Canada, Ottawa, Ontario, 1975.

Symposium. The Frankfurt School. Contiuum, 1970, 8, 3-133.

Tamthai, P. The development of the junior-high school science curriculum. pp. 84-91. In IPST Twelve years of development of science and mathematics education in Thailand. Bangkok, Thailand: Chuanpim Publication, 1984.

Tanner, D., and Tanner, L. Curriculum development. New York: MacMillan Publishing Co., 1975.

Thompson, J. B., and Held, D. (eds.) Habermas: critical debates. London: The Macmillan Press Ltd., 1982.

Thompson, J. B. Critical hermeneutics: a study in the thought of Paul Ricoeur and Jurgen Habermas. Cambridge: Cambridge University Press, 1981.

Taylor, P. Interpretation and the science of man. The Review of Metaphysics, 1971, 25, 3-34.

Taylor, R. Basic principles of curriculum and instruction. Chicago: University of Chicago Press, 1949.

Tipayatas, P. The direction of Thai science. Journal of the Graduate School Chulalongkorn University, 1983, September, 92-99.

Tyler, R. Forces redirecting science teaching in revolution in teaching new theory, technology and curriculum. New York: Bantum, 1962.

Vandervoort, F. S. What would John Dewey say about science teaching today?. The American Biology Teacher, 1983, 1, 39-41.

Veblen, T. The place of science in modern civilization. American Journal of Sociology, 1960, 2, 585-609.

Wade, N. Thomas S. Kuhn: revolutionary theorist of science. Science, 1977, 197, 143-145.

Walker, M. The nature of scientific thought. Englewood Cliffs: Prentice-Hall, Inc., 1963.

Wallace, W. A. The philosophical setting of Medieval science. in D. C. Lindberg (ed.). Science in the Middle Age. Chicago: The University of Chicago Press, 1978.

Waring, M. Social pressure and curriculum innovation. London: The University Printing House, 1979.

Watson, G. F. Science education for survival. pp. 6-9. In C.P. McFadden (ed.) World trends in science education. Halifax: Atlantic Institute of Education, 1980.

Weiss, J. The realities of curriculum work: the classroom level. pp. 176-95. In A. W. Foshay (ed.) Considered action for curriculum improvement. Alexandria. Va.: ASCD, 1980.

Welch, W. Curriculum evaluation. Review of Educational

Reserach, 1969, 4, 75-86.

Welch, W. Twenty years of science curriculum development: a look back. pp. 282-306. In D. Berlinger (ed.) Review of research in education. vol 7, American Educational Research Association, 1979.

Wellmer, A. Critical theory of society. New York: Herder & Herder, 1971.

Werner, W. H. Evaluation: sense-making of school program. Occasional paper no. 11, Department of Secondary Education, University of Alberta, 1979.

White, R. T. and Butte, W. L. Curriculum development in Thailand. The Australia Science Teachers Journal, 1975, 3, 42-52.

Wongthongleuang, S. Is science a private property? IPST News, 1981, 4, 8-16.

Woodman, J. The unhealthiest alliance. New Age, 1977, October.

Wronski, S. P. Secondary education, man power and education planning in Thailand. Michigan: Institute for International Studies, 1966.

Yager, E. R. In defense of defining science education on the social/society interface. Science Education, 1985, 2, 143-144.

Yager, E. R. What's wrong with school science curriculum? The Science Teacher, 1986, January, 145-147.

Young, M. F. D. Knowledge and control. London: Collier-Macmillan Publishers, 1971.

Young, M. F. D. Notes for a sociology of science education. Studies in Science Education, 1974, 1, 51-60.

Znaniecki, F. The sicial role of the man and science. New York: Columbia University Press, 1940.

APPENDIX A:

MATERIAL USED IN THE ANALYSIS OF THE SCHOOL SCIENCE CURRICULUM

Material Used in the Analysis of the Curriculum

1. Course Syllabus by IPST submitted to the Ministry of Education
2. IPST pamphlets
3. IPST, <u>Twelve years of development of science and mathematics education in Thailand</u>. Bangkok, IPST, Ministry of Education, 1984.
4. Junior-high School Science Textbooks:

    Science Textbook Book 1 Grade 7

    Science Textbook Book 2 Grade 7

    Science Textbook Book 3 Grade 8

    Science Textbook Book 4 Grade 8

    Science Textbook Book 5 Grade 9

    Science Textbook Book 6 Grade 9

5. Teachers' Guide

    Teachers' Guide Grade 7 (for Book 1&2)

    Teachers' Guide Grade 8 Book 3

    Teachers' Guide Grade 8 Book 4

    Teachers' Guide Grade 9 Book 5

    Teachers' Guide Grade 9 Book 6

6. IPST Publications and Reports
7. IPST News (Journal Published by IPST)

APPENDIX B: COURSE SYLLABUS

Course Syllabus

Lower Secondary Science Syllabus 1976

Objectives

1. To develop an understanding of the basic principles and theories of science.
2. To develop an understanding of the nature, scope, and and limitation of science.
3. To develop a scientific attitude.
4. To develop skills important for scientific investigations.
5. To develop an understanding of the consequences of science on man(and)his physical and biological environment.

Science Course Description

New science curriculum has been prepared for lower secondary school students. The course contains scientific principles and contents that are integration of various disciplines. The contents encompassing daily life and environment are interrelated. Experimentation is emphasized so that students will acquire science process skills which will be beneficial in further study and solving problems in day-to-day living.

The teaching of the six courses, Sc 101, Sc 102, Sc 203, Sc 204, Sc 305, Sc 306, require the integration of theories and lab work. Each course is worth 3 credits and requires 4 periods per week per semester. It is suggested that the courses be taken in the above sequential order.

Sc 101

Introducing science; How scientists work; Observation Experimentation; Proposing hypothesis; Observation requires sensory organs, i.e., eyes, ears. nose, tongue, and body; Senses are limited and are not always reliable Standard and units of measurement; SI system; Using tools to aid and extend the scope of senses; Thermometer; Medical thermometer; Handlens; Mass and density

Water; Its important; Its properties; States of water and the change of states; Melting point and boiling point; Latent heat of fusion and latent heat of vapourization; Water density; Ground water sources; Underground water sources; Man-made water sources; Dam; Reservoir; Other substances in water; Solutions and suspensions; Solubility and concentration of solutions; Saturated solution; Crystallization; Soft water and hard water; Temporary hard water and permanent hard water; Treatment of hard water; Distillation; Filtration; Precipitation; Pipe water;

Polluted water; Prevention and treatment of polluted water

Atmosphere around us; Properties of atmosphere; Atmospheric pressure; Units and measurement of atmospheric pressure; Barometer; Atmospheric pressure at the same and different levels; Composition of atmosphere; Causes of atmospheric changes; Atmospheric temperature at different areas and altitudes; Atmospheric layers; Relations between atmospheric pressure, density and temperature; Formation of wind and storm; Humidity in atmosphere; Hygrometer; Formation of clouds, fog, rain, and hail; Principles of artificial rain; Weather forecast; Importance of atmosphere to living things

Sc 102

Properties of substances; Classification of substances into homogeneous heterogeneous substances; Solution; Properties of solution; Separation of solution; Chromatography; Properties of pure substances; Heat energy; Changes of pure substances; Elements and compounds; Properties of elements; Classification of elements into metals and non-metals; Usefulness of elements; Formation of oxides; Application of properties of substances to daily life

Rocks and minerals; How the earth is formed; Rock classification: igneous rock, sedimentary rock, and metamorphic rock; Their characteristics and properties; Their sources in Thailand; Characteristics and properties of minerals; Mineral classification; Important mineral sources; Usefulness of mineral rocks and their conservation

Living things and environmental condition; Their relationship; Relationship between plants and animals; Photosynthesis requires carbondioxide gas, chlorophyll, light, and water; Food chain; Producer and consumer; Importance of food; Respiration of plants and animals; Circulation of carbondioxide gas; Ecosystem; Adaptation of living things to environmental condition; Man and environment

<u>Sc 203</u>

Energy and changes; Importance of energy; Forms of energy; Latent heat; Exothermic reaction and endothermic reaction; Indicator; Acid and base; Catalysis; Chemical reaction; Law of conservation of Mass; Law of constant proportion; Atom and molecule; Transformation of energy; Electrochemical cell; Electric current meter; Dynamo; Motor; Electric bell

Food and energy; Energy in living things; Food and groups of food; Testing food group; Composition of food; Importance of food; Minerals and vitamins; Importance of well-balanced diet; Energy from food; Measuring energy from food and its units; Food combustion in living things; Energy and living things; Utilization of energy in various activities

Transport in living things; Characteristics of plant and animal cells; Interrelationship between digestion and size of molecule; Enzymes and food digestion; Digestive tract of man; Diffusion and osmosis Transport in plants; Transport of water, minerals, food, and gas in plants; Transpiration of plants; Transport in animals; Transport through blood vessels; Receiving and discharging gas; Blood circulation; How heart works; Secretion through kidney and skin; Importance of transport system in living things

Sc 204

Energy utilization; Energy involved in daily living; Quantity of energy consumed in Thailand; Heat value of fuels; Simple apparatus measuring electric energy; Principles of use of ammeter and voltmeter; Ohm's law; Properties of resistent wire, conductor, insulator, and fuse; Series and parallel circuits; Energy storage; Lead storage cell; Transfer of energy; Conduction, convection, and radiation; Energy Saving

Changes of earth crust; Evidences of the changes; Causes of the changes; Weathering; Erosion; Transportation; Deposition; Formation of soil; Characteristics and properties of soil; Sub-soil and top-soil; Soil improvement for cultivation; Soil conservation

Into space; Study objects; Studying celestial objects; Principles of telescope; Problems of space journey; Magnitude and direction of attractional force of the earth; Velocity; Acceleration caused by gravitation; Overcoming the force of attraction; Action and reaction; Fuel propelling; Principles of launching spacecraft; Characteristics of spacecraft; Frictional force and motion in space; Inertia; Principles of launching orbital spacecraft; Fall of object; Orbital velocity; Escaping velocity; Life in space; Problems on pressure and temperature; Weightlessness and other environment; Journey to the moon and the return journey; Moon, Mars, and other planets expedition; Progress of space survey and benefits for Thailand

Sc 305

Growth and reproduction; Growth of plants; Elongation and change in size of cells; Matters affecting growth of plants; Growth of man; Growth of animals with stepwise changes; Reproduction of plants; Sexual and asextual reproduction; Pollination and fertilization; Plant propagation from its various parts; Importance of both types of reproduction; Reproduction of animals; Sexual reproduction of animals; External and internal fertilization; Reproductive system of man; Pregnancy and birth control; Asexual reproduction of animals; Artificial insemination of animals

Population and natural balance; Density of population; Population survey; Random sampling and popoluation census; Population increase ans its characteristics; Matters influencing population growth; Birth, death, and migration; Problems of population growth and their solutions

Agricultural product increase; Reasons for product increase; Important products; Factors affecting agricultural product increase Selection; Characteristics of soil and improvement; Improving structure of soil; Agricultural products of the regions of Thailand Fertilizer;

Utilization and testing; Crop rotation; Irrigation; Elimination of enemy of plants; Bara rubber product increase and propagation of aquatic animals

Sc 306

Industry involving agricultural products; Industry important to agriculture; Rice milling industry; Nutritional value of hand-milled rice and factory-milled rice; Nutritional quality improvement; Industry involving rice product; Rice fermentation and alcoholic drinks from rice; Bran oil product; Rice paper production; Rubber industry; Improving the quality of rubber; Synthetic rubber; Production problem and rubber exportation problem; Cane sugar industry; Artificial sugar; Aquatic animal industry; Food preservation industry

Transportation and communication; Importance of transportation development; Relationship between the shape of vehicle and motion; Reducing friction; Principles of vehicle safety; Monmentum; Inertia; Center of gravity of object; Safe distance of stopping cars; Principles of motor used in driving vehicles; External and internal combustion engine and steam engine; Gasoline engine; Diesel engine; Land, water, and air vehicles; Bouyancy; Communication; Development of communication; Electromagnetic apparatus for communication: telegraph, telephone, teletype, microphone, and radio; Usefulness of transportation and communication

Environmental condition; Effect of population growth on the environment; Environmental adjustment for the benefit of living; Causes of environmental dilapidation; Causes an prevention for polluted water and air; Garbage and disposal; Polluted soil; Effect of energy utilization on the environment; Prevention and control of sound level; Maintaining natural balance

APPENDIX C: EXAMPLE FROM TEACHERS' GUIDE

Teachers' Guide

Lesson 8

Food and Energy

Behavioral Objectives: After studying this unit, the students should be able to:

1. tell that plants and animals need different kinds of energy derived from a transformation process.
2. explain that the sources of energy come from food that is produced by plants or from food chain.
3. tell that food chain is a transfer of energy stored in food.
4. draw a diagram demonstrating the energy transfer and energy transformation in living things, from the beginning of food chain to the end.
5. tell that food is composed of protein, carbohydrate, fat, mineral, vitamin and water, and the usefulness of these materials and their sources.
6. do the testing of protein, starch, sugar, fat, and vitamin c in food.
7. tell the elements that make up protein, carbohydrate, and fat.
8. summarize from the experiment that calcium and phosphorous are the important elements for strengthening the bone structure.
9. explain the importance of consuming variety of food,

and in the right proportion.

10. perform the experiment to demonstrate that food stores energy, that can be measured in the form of heat.
11. tell that respiration is a food combustion at cellular level, and that this process uses oxygen and enzymes, and produces energy, carboondioxide, and water.
12. summarize that body consumes different amounts of energy for different activities, and to know how to calculate the amount of food intake to suit these different activities.
13. explain the relationship between photosynthesis and respiration.
14. set the hypothesis from the problem presented, design the experiment and do the experiment to verify the hypothesis.

Table of Class activities

providing information	discuss on experiment	discuss on obtain data	teacher demonstrate	Sequence of the concepts in the lesson	experimenation	Students' ativity: draw graph	obtainingdata	calculation	hypothesizing	examine sample tables & pictures
				Lesson 8: Food and Energy						
		2		Life needs energy for survival. Energy for living comes from food which is produced by green plants						1

provide information	discuss on experiment	discuss on obtained data	teacher demonstrate	Sequences of the Conceptsts in the lesson Lesson 8: Food and Energy	experiment	Students' activity: draw graph	obtain data	calculation	hypothesizing	examine sample table & picture
		2		Green plants are able to change light energy to chemical energy which is then stored in the food. This energy is transfered to a consumer.						1
2		1		Plants and animals change stored chemical energy to other forms before using it.						
2		1		There are many different kinds of food and there are many ways to categorize them. One common method is to categorize them according to chemical components.						
3	2			Testing method for sugar, starch, protein, and fat.	1					
2		1		Carbohydrate, protein, and fat are foods that provide energy.						
2		1		Protein is not only used to provide energy but also to remedy our body. Fat will help the body absorb energy.						3
4	2			Carbohydrate, protein and fat contain the same elements.These are carbon, hydrogen & oxygen.	1					3
3	2			Human body is also composed of different elements that come from food.						1
5	2	4		Do the experiment about the importance of phosphorous, that leads to the understanding of the importance of other elements in the human body.	1					3
4	2	3		Study the importance of an element to the growth of the plants.	1					

provide information	discuss on experiment	discuss on obtain data	teacher demonstrate	Sequences of the Concepts in the lesson Lesson 8: Food and Energy	experiment	Students' activity: draw graph	obtain data	calculation	hypothesis	examine sample table & pictures
4	2	3		Mineral, vitamin, and water are in the category of food that does not give energy, but keeps the body warm and healthy.						1
4	2	3		Test vitamin C in food	1					
3		2		Study the usefulness, the sources and the possible harm of lacking vitamin.						
4		2		The importance of including every kind of food and in the right proportion, in the food in-take.				3		1
5	2	4		Do the experiment to verify that food stores energy. This energy can be measured in the form of heat.	1			3		
4	2	3		Each kind of food contains different kinds and different amounts of energy. Each food contains different amounts of calories.			1			
4	2	3		Food combustion can occur at body temperature and release carbon dioxide, water and heat energy. This process is called respiration.	1					
2		1		In respiration, chemical energy will change to heat energy and other forms as well. This reaction need enzymes.						
5		4		Different activities consume different amounts of energy.		3		2		1
3		2		Study the relationship among energy, photosynthesis and respiration						1

Summary of the Important Concepts of the Lesson

The aim of this lesson is for the students to study about food. Food is the source of energy for every living organism. Green plants are able to produce their own food by changing solar energy to chemical energy, storing it in the form of food. Animals are not able to produce their own food and thus must depend on green plants directly or indirectly.

There are different kinds of food such as carbohydrate, protein, fat, vitamin, mineral and water. Each food has different uses. The first three foods give us energy, but not the last three which are necessary for growing and immunology. The study of food testing and the knowing of how to calculate the food calories, indicates that the food we eat must contain every kind of nutrient and in the right proportion. The lack of nutrient in the body causes disease. Students will also study the different forms of energy we consume for different activities. This includes learning that the process of food combustion needs enzymes, and can occur at body temperature. This process is called respiration. In respiratory system, the chemical energy will change to other forms of energy before it can be used. For example heat energy or kinetic energy. This energy is used for living.

Class time approximately 12 periods

Teacher introduces the lessson by discussing the different forms of energy and their transformation, corresponding to the previous lesson. Then, the teacher asks the students whether plants and animals need energy for their living. Where does this energy come from? Then the teacher leads to the topic 8.1.

Time suggested 30 minutes

Topic 8.1 What is the source of energy?

Teacher reviews the knowledge about photosynthesis and the transfer of energy in food chain, by using the picture and the questions posed in the students' text. The teacher then leads to the following conclusions:

1. The primary energy comes from solar energy through the photosynthesis.
2. The impotant source of energy is food that is produced by the green plants.
3. Food chain is a transfer of chemical energy from producer to consumer.
4. Chemical energy that is stored in food can be used only after it changes to other forms, for example, kinetic enegy or heat energy.

Time suggested 30 minutes

Topic 8.2 Food

Teacher asks the questions posed in the students' text. The purpose is for the students to be aware of the importance of food in providing energy and for growing. Then the teacher asks, "How many kinds of food are there? What is the usefulness of each kind? and leads to the sub-topic 8.2.1.

Sub-topic 8.2.1 Kinds of Food

Teacher discusses the criteria for categorizing the kinds of food, in the view of the detail given in the students' text. Then asks, how are we going to use chemical method to categorize the food type?

Experiment 8.1 Testing Nutrients in Food

The aim of this experiment is to teach the student how to test carbohydrates, fat and protein in foods.

Behavioral Objectives: After the experiment, student should be able to:

1. test for carbohydrates, protein and fat
2. tell which nutrient is contained in each food,
3. tell that sugar and starch are carbohydrates,
4. tell that carbohydrate, protein and fat are foods that provide energy, while water, vitamin and mineral are foods that do not.

Time Suggested	disussion before experiment	10 min.
	experiment	40 min.
	discussion after experiment	20 min.
	total	70 min.

Chemicals and apparatus

Items	amount/group (4 students)	total for 12 grs. (48 students)
1. starch	1 g	12 g
2. glucose	1 g	12 g
3. coconut oil	2 cm	24 cm
4. egg white	-	2 eggs
5. milk	2 cm	24 cm
6. distilled water	40 cm	480 cm
7. Iodine solution	5 cm	60 cm
8. Biuret solution	5 cm	60 cm
9. Benedict solution	5 cm	60 cm
10. mid-size test tube	3	36
12. white paper 4x10 cm	1	12
13. dropper	1	12
14. syringe 12 cm	1	12
15. beaker 100 cm	1	12

Preparation

1. Prepare iodine solution by using 2 grams of iodine, 4 grams of potassium iodide, and 100 ccs. of distilled water. Stir and keep it in the tighly closed bottle.
2. Preparation of benedict's solution
3. Preparation of biurate solution
4. Prepare uncooked egg white by using 2 egg whites, stiring them in water, and shaking them well.

Discussion before the experiment

1. Teacher explains and makes sure that students understand the steps in performing the experiment.

2. To record the results the students should do the following if the color of the solution does not change, put the mark "-" in the table. If the color does change, put the name

of the color in the table. Changing color means, that "color" has to change not just hue.

3. Remind the students not to add water in the egg white. They can do the experiment, with the egg white in this form.

4. Teacher should suggest to students to test the coconut oil last, as it is difficult to clean, wasting class time.

5. Food that reacts with benedict solution gives yellow, yellow-green, orange or brown hue. Students should record only these reactions in the table. If other changes occur ~~use the~~ mark "-."

Sample Results

Substance tested	Change Occured			
	Iodine sol.	Benedict sol.	Biuret sol.	paper test
Starch	dark blue	-	-	
Glucose	-	orange/orange brown	-	
Egg White	-	-	purple	-
Milk	-	orange/yellow brown	purple	-
coconut oil	-	-	-	translucent

Discussion after the experiment

Teacher gathers the results of every group on the blackboard and leads the class discussion in order to summarize that:

1. starch is a carbohydrate that reacts chemically with iodine, giving blue color to the reactants.

2. glucose, same as starch, is a carbohydrate. It does not react with the iodine solution, but it does react with the benedict solution giving an orange color to the reactants.

3. Egg white and milk are proteins, and react with biurate solution giving the reactants purple color.

4. Milk contains lactose. Lactose reacts with benedict solution giving the same result as glucose. Milk is also a protein, because it reacts with biurate solution giving purple color to the reactants, the same way as an egg white.

5. Coconut oil is a fat, which when rubbed on paper makes it translucent.

6. The testing of any kind of food, can be done by using iodine solution to test for starch, benedict solution to test for glucose, biurate to test for protein, and fat could be tested by rubbing it with paper.

Teacher lectures about the usefulness of different kinds of food, including malnutrition which is presented in the students' text.

Suggestions

1. In addition to protein and glucose, milk also contains fat. However, due to the small amount present, it cannot be detected (by these techniques).

2. Teacher should use fresh milk. But if it is not convenient, coconut milk can be used instead.

3. Another method to test protein is by adding Nitric acid to the solution that is being tested. If protein is present, the solution will change color to yellow.

4. The orange color occurs, because cupric (copper) reduces to cuprous oxide in the reaction between sugar and benedict solution.

$$Cu^{++} \dashrightarrow Cu^{+++}$$

5. Testing glucose with benedict solution, will sometimes produce yellow-green, yellow or orange hue, depending on the amount of sugar used. If a small amount of sugar is present, the solution will change to yellow-green or yellow. If a large amount is present, the color will change to orange or orange-brown. If it changes to other color, it means that there is no glucose. That is why the testing of an egg white with a benedict solution giving purple color, failed.

6. Testing protein with a solution that contains copper and sodium hydroxide will give purple or purple-pink hue. The purple substance is biurate. When benedict solution is added into the food containing protein, the same results will occur because benedict solution contains copper and base.

The other topics and experiments are based on similar structure.

APPENDIX D: EXAMPLE FROM STUDENTS' TEXT

Students' Text

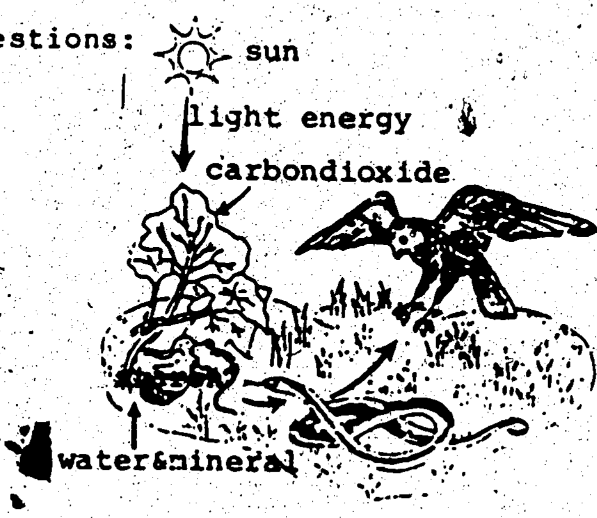
Lesson 8

Food and Energy

Students have learned that there are many forms of energy. Energy can change to from one form to another, such as the burning charcoal. Chemical energy stored in charcoal will change to light and heat when used in cooking. The transformation of energy has many uses. In our everyday life we interact with different forms of energy. For example, electric energy, sound energy, mechanical energy, and light energy. Every life needs energy, and transforms it according to its own use. For example, growing, moving and reproducing. Where does this energy come from?

8.1 Where does energy come from?

Students have learned that green plants are able to use solar energy for producing their own food, while animals and other life forms cannot. Examine the picture and answer the following questions:



pic 8.1 Photosynthesis and Food Chain

- What is photosynthesis? What is necessary for photosynthesis?
- What do producer and consumer mean? How do they differ?
- From the picture, what is the primary, secondary and last consumer?
- How is the photosynthesis important to life?

In photosynthesis plants will transform light energy into chemical enegy and store it in the form of food. The plants produce the following food: glucose, starch, protein, and fat. These compounds are stored in every part of the plant. For example it is stored in the leaves, trunk, roots and seeds. Plants will use them as a source of energy for their activities. Animals and other life forms that do not have chlolophyll, are not able to produce their own food and must depend directly or indirectly on plants. Plants are called producers. Animals that consume plants, directly or indirectly, are called comsumers. In the food-chain, this consuming process transforms the energy of food. The food that animals consume needs to be transformed into other forms of energy, before it can be used.

- For what purpose do animals use the food?
- Is there any energy transformation when animals eat food?
- Draw a picture showing the order of energy transformation in a food chain, starting from the light energy to the last consumer.

- What is the first energy of life? Where does it come from?

Human being is a consumer, and food is a necessary source of energy for his life. This can be compared to fuel that keeps the machine working. We will continue studying about food in what follows:

8.2 Food

Did you ever fast? How did you feel? What will happen to human beings or animals that experience food shortage, or plants that lack water or light? Why? Do you ever think about what is food? What is it composed of? How many different kinds of food are there? How they are useful? How we choose to consume food to obtain useful energy from it? Why is food a source of energy? The following lesson will enable students to gain a better understanding about food.

8.2.1 Kinds of Food

Food is anything that is consumable and provides benefit to the body. There are many kinds of food, as well as there are many methods to categorize them. For example, taste, type or usefulness. The most accepted method, that is often used is to categorized food components. From analysing different kinds of ~~food, it~~ is found that food is composed of many substances. Each substance has different uses. The following experiment is to teach the students how to test different kinds of food by simple chemical testing.

Experiment 8.1 Testing Different Kinds of Food

Directions: 1. Put 1 spoon (no.1) of starch in a mid-size test tube, which contains 6 cm of water. Shake well. Then divide the resulting solution into 3 equal portions, 2 cm each, pouring them into other 3 mid-size test tubes.

2. Add 2 drops of iodine solution into tes tube no.1, 10 drops of biurate solution into test tube no.2. Observe and record the changes that occur.

3. Add 5 drops of benedict solution into test tube no.3, then boil the test tube in 100 cm of boiling water for 5 minutes. Observe and record the changes that occur.

4. Use small amount of starch and rub it on white paper 5 or 6 times. Look into the light, and see if it is translucent or not.

5. Repeat step 1-4, but this time use glucose ~~egg~~ white, milk and coconut oil in that order. Don't add water into the last three foods, but use them directly. Record the results.

Table of Record of Experiment 8.1

FOOD	The Change Observed			
	Iodine sol.	Biuret sol.	Benedict sol.	Rub with paper
starch				
glucose				
egg white				
milk				
coconut oil				

- From the experiment, do starch and glucose have the same property? Give reasons.
- Starch and glucose are carbohydrates, but give different results. Can the student tell which solution should be used for testing starch, and which solution for glucose?
- What kind of food reacts with benedict solution, giving the same result as glucose?
- What is the result after dropping the coconut oil on paper? If you want to know whether food contains fat, what should the students do?
- Egg white and milk contain protein. If you want to know whether food contains protein, what should you do?
- From the experiment, what kind o[illegible]lk?

Student has tested three different kinds of food. Carbohydrates, protein, and fat. Carbohydrates can be categorized into 2 kinds: sugar and starch. There are many kinds of sugar, for example glucose, lactose and sucrose (white sugar). Glucose is used in the experiment, and reacts with benedict solution. Lactose is in the milk and produces the same reaction. However sucrose does not, except when boiled with benedict solution for some time. Sugar that comes in the urine of a diabetes patient, can be tested with the benedict solution.

What kind of sugar is contained in urine?

Carbohydrates, protein, and fat are important for life. They provide the energy that is used for warming our body and for working. Most energy comes from carbohydrates and fat. Protein not only gives us energy, but also repairs our organs. Fat not only gives us energy but makes up parts of our organs, for example nerve cells and brain cells. Body will store food in the form of fat and keep it under the skin. This will protect us from the cold weather and keep our body warm. Most importantly, fat helps dissolving of some of the vitamins that body absorbs.

If the body lacks protein, the growing process will be affected. A child that lacks protein, will not grow, will be weak, and will have low immunology. Some look very thin, but others look swollen. The skin becomes rough and it may cause mental retardation.