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RECENT TRENDS IN SCIENCE CURRICULUM DEVELOPMENT

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In reviewing the recent trends in science curriculum development around the world one cannot but wonder at the rapid changes that are taking place. It is surprising how quickly the science curricula change to reflect the social, economic, and technological problems that are of concern to most communities today. Indeed one is left with the feeling that some of these changes are occurring too rapidly in school curriculum, and sometimes before specialists have identified and understood the underlying causes or fully determined the extent and significance of the social crisis that gives rise to the changes the new curricula are designed to reflect.

Let us look at the nature of science curriculum developments over the past 10 to 15 years. At the beginning of the 1960's far reaching major curriculum development programmes in the sciences were launched on both sides of the Atlantic. These projects, unprecedented in their size in the history of school science, recruited large numbers of scientists, college educators and teachers to work together to produce new modern science curricula. Modern techniques of eduational technology were employed and many subsidiary and supporting materials were produced to supplement the students books and teachers guides. These million dollar projects produced the Biological Sciences Curriculum Studies (BSCS) biology texts, the Physical Science Study Committee (PSSC) physics, Chem Studies, Nuffield Chemistry, Physics, and Biology.

A glance at the forewords in the publications of these projects in chemistry quickly establishes the nature of the products of these curriculum development projects:–

> Chem Studies describes itself as "Chemistry–an experimental science" presenting chemistry as it is today. Unifying principles grow out of observations students make in laboratory.
>
> Nuffield describes chemistry as a dynamic interplay between observation. which is steadily increasing in scope and accuracy, *and* speculation. Change is therefore inseparable from the development of the subject.

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PSSC was the first of the new science curricula to be published and it is obvious how it has influenced the chemistry and biology curricula. PSSC in 1960 was a revolutionary approach to teaching physics. In conventional teaching, physics knowledge is presented as facts. "Atoms *do* exist and look like this or that." Demonstrations and student experiments are made, but students generally understand these to be illustrations of facts, and not the very basis from which physics knowledge has been built up. In the modern physics course, the approach is quite different. The physicist is seen as one who systematizes his observation of how Nature behaves. This is the basic theme of the whole course. Physical knowledge is based on experiments and has the same limitations in accuracy that experiments have. The most important concept in this presentation of physics is the *physical model* (or *theory)*, and this has a central position in the whole course. The starting point is the experiment from which you construct a model which in turn suggests new experiments. These lead to refinement or rejection of the model and so on. The students are led to realize that we never arrive at the "Truth". What we reach is a closer and closer approximation of how nature behaves. The model is never "right" and never "wrong"; it can only be said to be "good" or "bad" In February 1966 a reviewer of PSSC (2nd edition) wrote "Although this treatment is unique, there is a consistent motif behind it all. It can withstand the sharpest criticism of the scientific world". Is this statement valid today? Certainly PSSC has not been found wanting as a career-oriented course, although it has been clearly established as a course for the higher ability science-oriented students.

The Biological Sciences Curriculum Studies (BSCS) states:– "Of all the disciplines science is most relevant to the continuation of life on Planet Earth. And of all the sciences biology is the most relevant to our daily lives." The new biology curricula exploit this unique role in examining many aspects of people. The traditional divisions of botany, zoology, physiology, genetics, etc. have been broken up and integrated into a meaningful whole of life science relevant to man in present day society. The study of botany and zoology as parcels of organized knowledge was appropriate when the main activities in the discipline were concerned with structure and classification but these divisions are not appropriate today. Cellular biology, for instance, studies plant cells and animal cells together, since the major aspects of their structure and function are in common. Also an area such as modern genetics involves the study of the molecular structure of genes, the physiology of how genes direct reactions, the way genes are organized in populations of organisms, and the way they change in evolution. We cannot properly study genetics without studying physiology, ecology and development. Nor can we study ecology, physiology and development without studying genetics. The new biology is people oriented and learner centred. It is concerned with our evolutionary history, structure, function, development and behaviour, in relationship to our environment. It is unifying the science of life as never before.

In all the branches of science the 1960–65 curricula had a number of important common features. They attempted to involve the students as doers of science. They guided the students to the principles and generalizations of the disciplines through the observations they made in the school laboratory or on field trip. They attempted to paint a valid picture of how scientific advances begin and develop, of the great power of the scientific methods and their limitations. They train students to make observations, weigh facts, and frame valid conclusions. They aim to inculcate in the student a habit of questioning and of seeking understanding rather than being satisfied with blind acceptance of dogmatic assertions.

I have dwelt at some length on these "career-oriented courses" as they have been labelled; for, inspite of their critics, these courses are very valid, vital programmes today that are evolving all the time through continuous renewal and development. The MS 4/5 (grade 11/12) physics, chemistry, biology curricula developed by the Institute for the Promotion of Teaching Science and Technology (IPST), are strongly influenced by these curricula and they might be seen also as evolving from them.

Criticisms have been and are still being voiced at regular intervals by second and third generation science educators. The major criticisms come from countries where these courses were used as the only science course for the 10 - 12 graders and where the school system catered for a very high percentage of the total age group population. Some critics see the courses as too professional, too intellectually demanding for all but a minority. They claim that undue concern at the school level with the needs of the profession may have led to a neglect of the contribution that the discipline can make to the general education of all children.

Other criticisms stem from various factors in some developed societies which have created an anti-scientific trend among many young people. Science seems to be advancing, but the quality of life vis a vis war, poverty, pollution, malnutrition and alienation seems to be deteriorating. These critics are concerned that these courses with their motivation relying on a highly committed science orientation in the student are not attractive to the students influenced by the anti-science trends. Now there is some justification for these criticisms. The original developers thought that because the courses were good modern science they would have an appeal far beyond the science-oriented. Science was riding high in society when these texts were appearing in the mid-sixties. It was not predicted in 1965 that within 10 years people of influence in governments, education and in society would be challenging the use of funds for the continuing development of the sciences on all frontiers.

However these courses are continually being revised by their users — they have been improved and expanded in the sections on applications of science and they are evolving to give a broader appeal but they retain a reasonable level of intellectual challenge. Most countries have now developed or are developing alternative courses for the non-science-oriented. All but a few countries retain and continue to develop their professional science courses at the upper secondary school for the science-oriented students. Even a small country can afford its own international airway company (and some can afford two) and so it can also afford a modern physics, chemistry and biology course to orient its science-minded students towards science and technological professions, as well as a general education course in science for the non-science students.

Let me move quickly through the major curriculum developments, as I see them, that have followed in the wake of the professionally oriented courses. Around 1970 the Harvard Project Physics began publishing its multi-media approach to physics teaching. Relating physics much more closely to the experiences and interests of the students. Many parts of the course are self-paced but the materials, equipment and expendables are very expensive.

From the middle sixties to the present day interest has grown in the integration of the science disciplines—usually in the grades 7 to 9 or 7 to 10. These integrated science courses have often taken the place of the old style general science courses which were never too successful. We have a lot of problems with the double meanings of words in science and this word "integrated" is a difficult one. One proponent describes integrated science as follows: "Integrated science is non-disintegrated science. It is seeing nature in the unity with which it sees itself". But if this makes the meaning of "integrated" clearer, when one looks through these courses the meaning of "science" in "integrated science" becomes more diffuse. Its use in these courses is frequently ambiguous, sometimes incompatible and occasionally contradictory. It seems that it encompasses social science, behavioural science, home science, applied science, technology and environmental science and occasionally economics and political science. However these courses attempt to present, in an interesting and enjoyable way, science relevant to the student and to his society. They depart from the earlier courses in science which were written with the sole objective of preparing the student for the upper secondary sciences.

The modular interdisciplinary course were introduced in the early 1970's for grade 11 and 12 students to continue the approach and aims of the integrated science programmes that were gaining popularity in grades 7 to 10. (The Interdisciplinary Approach to chemistry is one of the most successful examples of a grade 11 and 12 modular course.) These courses are structured in separate units or modules. The modules are interchangeable and as these courses are developed more modules are produced to add to the individual student's choice. Outmoded modules can be easily replaced without having to discard a whole book as would be the case in a one book course. By introducing a range of modules individual student interests and to some extent different student abilities can be catered for. The interdisciplinary courses were introduced to provide alternative science for the non-science majors in grades 11 and 12, but in the U.S.A. they are continuing to increase in popularity with science majors also. The modules are based on motivational topics of real and current interest to the average general student. This can be judged from the titles of modules such as Body Chemistry, Photography, Air, Water, Noise, Energy Pollution, Population Control, Psychedelic Drugs, National and World Energy Resources.

The modular courses are here to stay. The use of modular units is entirely in keeping with modern trends in learning and teaching. They offer maximum ease and simplicity in revising to keep the curriculum up to date. The programmes are structured for change, for teacher development, for tomorrow.

In 1972-73 the first publications of Nuffield A (Advanced) Level discipline sciences appeared. These courses are concept-centred experimentally-based courses equivalent to the first year college course in U.S.A., first year university courses in Australia and New Zealand, and about first year university level in Thailand. They are an extension of the spirit of the 1963 O (Ordinary) level courses into the final stages of English Grammar School.

From 1973 to the present, increasing emphasis has been placed in universities, colleges and secondary schools on "Environmental Studies/Sciences". These developments arise from current social concern about environmental matters. They are in more evidence in highly industrialized countries where a genuine fear is growing of the possibility in the foreseeable future of man destroying his livelihood by consuming his natural resources and poisoning his environment with his wastes. In some universities, departments of environmental studies have been set up within social studies schools, and in others departments of environmental sciences have been established by science faculties. Universities in the U.K. are offering honours degrees in environmental science. These courses usually comprise the application of physics, chemistry, biology and mathematics to the study of the environment. Other universities have founded interdisciplinary boards or institutes of environmental studies where biologists, chemists, physicists, mathematicians, social and political scientists and government and economics specialists provide a full study of the scientific, social, economic and political implications of conservation and environmental management on a regional and global front.

Such interdisciplinary studies are laying the foundations for economic, technologically and ecologically sound principles for developing national and global resources. However the environmental courses developed for secondary schools have tended in general to be designed for students of average or less than average ability in science as alternatives to the basic science courses. Most of the approaches are confined to local or regional problems of environmental contamination and, important as these developments are, they do not relate to the deeper and more long term disharmonies of man's relationship with his environment which are the fundamental causes of the problems. Environmental pollution is the symptom of the malaise and not the malady itself. It is the last stage of a process which has taken a raw material, processed it, used it, and then thrown away the unwanted substances. However we can expect to see more complete treatments of environmental management introduced into schools through curriculum development processes assisted by the graduates and staff of the university environmental studies departments.

There is a growing promotion by some science educators of "technology" courses as additional options in modular courses or as an expansion of ideas and themes in the integrated courses for 7th to 12th grades and even for science programmes at elementary school. I do not see why so much effort should go into promoting technology themes as something so different from science courses at the school level, but the technology educators believe that it is important for teachers to appreciate the difference between science and technology so that they can introduce the processes described as "technological" into their courses.

Let me briefly describe these differences between science and technology as one prominent promoter[1] of technology in science courses describes them. "Science", he says, "is associated with man's natural desire to know, to understand, to explain, to predict. Technology is the result of man's equally natural desire to find ever new and better ways of satisfying these needs, of achieving his goals of doing the job". The figure below contrasts the motive force, the process and the products of science and technology. Science is a desire to "know". Technology is a desire to "do".

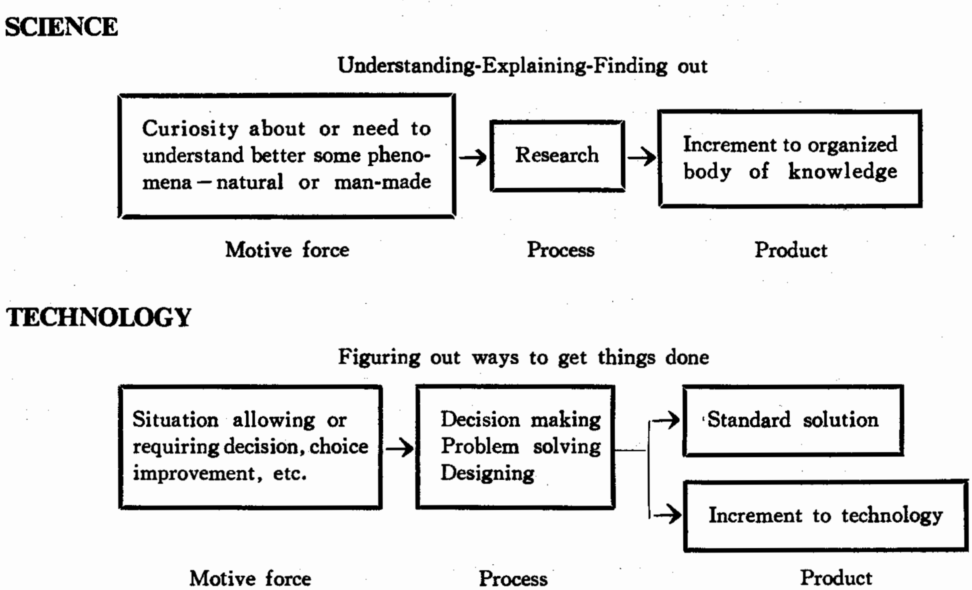

Fig. 1

Most courses in the separate sciences, in integrated science, and in environmental science contain elements of problem solving and create decision making situations for students. I add this distinction of what I consider two closely related and interwoven processes that should be contained in all good science courses, not to promote the distinction between science and technology, but to ensure a place for the "desire to do" processes in science curriculum development.

Likewise for completeness I refer to the introduction this year in the U.K. of a General Certificate of Education A level syllabus in *Social Biology*. This may reflect the previous unbalance in conventional biology curricula which was not satisfactorily corrected by the Nuffield courses but is well catered for in the BSCS courses. While this new course may do much to make social biology an acceptable subject in secondary schools, it would be unfortunate if biological education were to polarize to the extent of a socially oriented biology for people, on the one hand, and a biology for biologists on the other.

The courses that have been developed since the mid-sixties are referred to by science educators as "second generation curricula", presumably they infer that the mid-sixty courses are the "first generation curricula" and again by inference, a generation in science curriculum spans about 5 to 6 years. I believe at least 5 to 6 years of concerted effort is required if a new course is to gain a foothold in a school system; new generations of science curricula are born before the previous generations are weaned. Be that as it may, six charateristics of second generation curricula are identifiable. In second generation curricula:–

(i) the traditional disciplines are integrated;
(ii) activities are learner-centred;
(iii) identification and study of socially oriented problems are featured;
(iv) interpreting data and making decisions are encouraged;
(v) interests and values are emphasized;
(vi) adaptations to individual and group differences are possible.

At the present time, in an increasing number of countries, courses that meet these charactistics are presented as alternatives to discipline-oriented senior courses taken prior to career selection. They are more generally introduced in the junior high school in grades 7 to 10 and they are finding their way into elementary schools in many countries.

In conclusion I would like to classify the new science courses of the Institute for the Promotion of Teaching Science and Technology in terms of the trends in science curricula presented above. The IPST courses and the years of implementation into the schools of the Kingdom are given below:

Implementation of IPST science courses

1976	Professional-oriented courses		
	MS 4 Two semester course	–	Physics (6 period)
			Chemistry (4 period)
			Biology (4 period)
	Non-professional		
	MS 4 Two semester course	–	Modular physical science (4 period)
	MS 1 Two semester course	–	General science (4 period)
1977	Professional-oriented courses		
	MS 5 Two semester courses	–	Physics (6 period)
			Chemistry (4 period)
			Biology (4 period)
	Non-professional		
	MS 5 Two semester course	–	Modular physical science (4 period)
	MS 2 Two semester course	–	General science (4 period)
1978	Non-Professional course		
	MS 3 Two semester course	–	General science (4 period)

Note IPST also has developed mathematics courses from grade 1 through 12. Implementation begins in 1977.

As I mentioned earlier the upper secondary MS 4 and MS 5 courses in physics, chemistry and biology (grade 11 and 12) have evolved from the professional oriented courses introduced in the mid sixties. These courses however take account of changing times and they attempt to include applications of science principles to problem solving and decision making on matters of current concern to the students and Thailand. Nevertheless these courses are deliberately designed to interest science-oriented students. They are set at a depth that should be intellectually stimulating without being difficult for the student of slightly above average ability. They remain basically discipline and conceptually oriented. They are essential ingredients of an 11th and 12th grade education programme for future scientists and technologists. Characteristics (ii), (iii), (iv) of second generation curricula are true of these courses.

Running parallel with these courses is the IPST interdisciplinary course in "physical science". The course materials are presented in modular from, each rated at 1 semester credit; twelve modules are planned at the present. This course will be offered as an alternative to the discipline sciences for grade 11 and 12 students, although in the future some modules may be suitable for students who take only a portion of the total discipline-oriented courses offered. The modules are topic-centred providing a broad coverage of science of relevance to the educated citizen. The first five characteristics of a second generation course are met to some degree by the physical science course. Later some modules centred on basic concepts needed for solving problems may be developed to give greater challenge to the students of higher ability, but at the present stage of educational development in Thailand it is not feasible to implement on a large scale materials tailored for individual students.

The MS 1 to 3 (grade 8 to 10) general science course is an integrated science programme divided into six semesters. The first two semesters are concerned with the science of the world around us, the next two take energy concept as the integrating theme and the last two focus on the environment of Thailand, attempting to point to the need to balance agricultural, industrial and population growth with the sensible carrying capacity of the nation's natural resources and environment. These courses are interest-motivated, and involve students in doing science, in identifying problems and looking for methods of solving them. The first five characteristics of the second generation curricula aptly describe the new general science course.

The IPST believes that its science courses when fully functional in the nation's schools will provide students, particularly at the upper secondary level, with adequate choice in curricula to satisfy their interests, aspirations and abilities.

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Reference

1. Foecke, H.A. (1974) in *New Trends in Integrated Science: Some Basic Questions on Science Teaching* (Richmond, P.E., ed.), vol. III, p. 1, UNESCO Press.