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ABSTRACT

The Asian Programme of Educational Innovation for Development (APEID) sponsored a meeting to: (1) critically examine the outcomes of past activities pertaining to science education and relate them to countries' on-going and projected activities; (2) analyze various new thrusts emerging in the Asian region in the field of secondary science education programs, particularly for developing competence and creativity; and (3) to examine the proposed work plan for the third cycle of APEID and suggest emphases for various activities, both at the regional and national levels. These areas are summarized in chapters 1-3 of this publication. Individual papers presented are highlighted/summarized in an appendix. Topics and issues discussed include: innovations and new thrusts in science education; role of practical experiences and laboratory experiments in developing competency and creativity in science students; evaluation of secondary science education in Indonesia; science education in Japan; linking science curriculum to the rural environment; science education for the year 2000, focusing on biological/physical sciences, curriculum development, teacher education, and others; designing and developing science curricula for new technological demands (Korea); Field Studies Centre Program in Sri Lanka; competency-based science teacher education in Thailand; and future strategies for science curriculum development for developing competence and creativity. (Author/JN)

Asian Programme of Educational Innovation for Development **APEID**

TOWARDS A BETTER SCIENCE EDUCATION

Report of a Study Group Meeting
on Science Curriculum and Instructional Materials Development
Bangkok, 10-18 November 1981

CONTENTS

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507

Opinions expressed in this publication represent the views of the participants of the Study Group Meeting, and do not necessarily coincide with the official position of Unesco. The designations employed and the presentation of the material herein do not imply the expression of any opinion whatsoever on the part of Unesco concerning the legal status of any country, or of its authorities, or concerning the delimitations of the frontiers of any country or territory.

INTRODUCTION

Background

In the work plan of the Asian Programme of Educational Innovation for Development (APEID), under the area of 'Science (including Mathematics) and Technology Education', a project had been included on 'Designing and Developing Innovative Science Curriculum and Instructional Materials'. A number of activities had been organized under this project during the second cycle of APEID which had their main focus on science as an integral part of the first level of school education and the concern was to link science education to real-life situations, rural environment and using the child's immediate environment and locally available materials for providing science experiences. To achieve this, a series of guidelines, strategies, and methodologies were co-operatively developed and these were exemplified through preparation of a variety of instructional materials for pupils and teacher training materials. In addition, some activities also looked into the teaching of different science disciplines at the secondary school level.

The Study Group Meeting was planned as the final activity under this project for the second cycle period with a view to examine critically all the outcomes of the various past activities and in the light of emerging developments and thrusts in the field of science education, suggest future actions and identify emphases for activities proposed in APEID's work plan for the third cycle.

The Study Group Meeting was organized by the Unesco Regional Office for Education in Asia and the Pacific (ROEAP) through its Asian Centre of Educational Innovation for Development (ACEID) and was held at Unesco ROEAP, Bangkok, from 10 to 18 November 1981.

Purpose of the Meeting

More specifically, the purposes of this Meeting were to:

i) critically examine the outcomes of the past activities and relate them to countries' on-going and projected activities with a view to incorporate the latest developments;

ii) analyse the various new thrusts emerging in the region in the field of secondary science education programmes, particularly for developing competence and creativity; and

iii) examine the proposed work plan for the third cycle of APEID and suggest emphases for various activities, both at the regional and national levels.

Participation

Nine participants, one each from Bangladesh, India, Indonesia, Japan, Nepal, Philippines, Republic of Korea, Sri Lnaka and Thailand, participated in the Meeting. In addition, one resource person participant and four staff members from Unesco ROEAP also participated in the Meeting. The list of participants is in Annex I.

Opening Session

The Meeting was inaugurated by Mr. Raja Roy Singh, Assistant Director-General, Unesco ROEAP. While welcoming the participants, he thanked them and their governments for having kindly accepted the invitation of Unesco and sparing their valuable time to attend this Meeting. He indicated that this Meeting had come at a very opportune time as APEID's second cycle is coming to a close and plans for future activities are being developed. He requested the participants to critically look at the past activities and suggest how new activities should be developed in the future. Under Unesco Programme for Co-operation with Member States, the activities under APEID are a reflection and contribution to what is being done in the countries. He also indicated that as Unesco's Medium-Term Plan covering the period 1984-89 is being developed and the Conference on Application of Science and Technology in Asia (CASTASIA II) will be held early next year, the deliberations of this Meeting would be of much help.

Referring to the development of science education during the 60's, he indicated that there was a great spur and worldwide movement, though essentially for selective groups and as support for the generation of knowledge. Though in 70's, the progress somewhat slowed down and became uneven and unspectacular, science education again is coming to the fore, particularly for what it can contribute to societal and personal development. He pointed out that in developing countries, we are struggling with many problems and have not been able to solve them. Unless we are able to change our economies and modernize, we cannot even ensure subsistence and survival. Hence, any science education programme has to be viewed in terms of development needs of participating countries. He concluded his remarks by indicating that great progress has been made in this region in science education because two or three decades ago about 60 per cent of the children had no access to science education but today almost all children had an access to science education of some form or the other as an integral part of general education. He wished the Meeting all success.

The Inaugural Session came to a close after an introduction of the participants.

Method of Work

Prior to the Meeting, each participant had been requested to prepare a discussion paper on a particular aspect of science education in which the country had insights and experiences to share. A summary of the discussion papers of the Meeting is in Annex II.

During the first plenary, the participants elected Dr. D.F. Hernandez (Philippines) as Chairperson, Mr. M.A. Jabbar (Bangladesh) as Vice-Chairperson, Dr. A.K. Jalaluddin (India) and Mr. W.S. Perera (Sri Lanka) as Rapporteurs. Dr. M.C. Pant, Specialist in Science Education, ACEID, assisted the Meeting as its Secretary. The Meeting then adopted the agenda and schedule of work.

Throughout its deliberations, the Meeting met in plenaries. In two plenaries, it reviewed the past APEID activities, examined the outcomes and made suggestions with a view to relate them to participating countries' on-going and projected activities as well as for making improvements in future activities. In the next eight plenaries, participants presented their discussion papers on certain identified aspects of science education. These were followed by general discussion for identifying problems, issues and emerging thrusts, particularly for developing competence and creativity. In the next two plenary sessions, the Meeting examined the work plan for APEID's third cycle and identified emphases which should be reflected in various activities.

In the concluding session, the Meeting considered its draft report and adopted it with modifications.

Chapter One

REVIEW OF THE OUTCOMES OF THE PAST APEID ACTIVITIES ON SCIENCE EDUCATION

The Meeting examined the past activities of APEID pertaining to science education in relation to the on-going and projected activities of the countries represented. The secretariat had placed before the Meeting a detailed review of the past APEID activities in relation to science education.

It was noted with satisfaction that the rate of expansion of science education during the period under review was well ahead of the rate of expansion of the total enrolments. It was also noted that without exception all the countries of the region had chosen the curriculum as the focal point of their programmes for the upgrading of science education. Institutional capabilities for science curriculum development had also been strengthened in the seventies. APEID's role in encouraging national initiatives to tilt science education towards real-life concerns was also recognized.

A feature of the progress of science education in the period under review was the emergence of programmes, even on a small scale, to link science education with work-experience and with available environmental and community resources. It was encouraging to note that the beginnings of a shift towards a recognition of first-hand experiences as learning inputs and towards the 'processes' of science as being more important than the 'products' had already taken place. Further, there was the recognition that science education should also directly serve as a means of improvement of the health and nutrition of the community at large.

APEID had played a valuable role in the encouragement and consolidation of national initiatives in the provision of support services to science education such as the development of instructional materials, textbooks and course guides and low cost and improvised science equipment.

It was noted that the pre-service teacher education system had not responded to the changes in the curriculum and the shifts in emphases, to the extent expected. Although pre-service teacher education was a concern during the period under review the changes at the classroom level had not been adequately taken into account by the teacher colleges. The teacher preparation for the implementation of curricular reforms therefore had been borne by in-service teacher education programmes organized by institutions other than the teacher training colleges. Utilization of in-service education on a programme-oriented basis which was in most cases an innovation had become institutionalized as a parallel teacher education system during the period. The emergence of a sensitive and quickly responding teacher in-service education system, it was noted, could lead to further isolation of the pre-service education system from the mainstream of curriculum innovation and renewal. This trend, which could only lead the pre-service education towards obsolencency, has to be arrested and necessary action to bring pre-service education into the main stream of curriculum innovation and renewal has to be urgently taken.

The particular mechanisms adopted and developed by APEID in identifying topical concerns and obtaining a regional consensus have greatly contributed to the success of APEID. The particular concerns chosen by APEID although they were primarily national concerns impelled the concentration of national efforts on these concerns. APEID was able, through the various modes developed, to keep these concerns in focus and at the same time induce the development of skills and attitudes required for the tackling of these concerns. Further, APEID's role as catalyst and sustainer of innovations could be well documented.

Yet in reviewing the programme of science education during the first two cycles of APEID, the following were seen as the major shortcomings requiring sufficient attention of science educators.

1. <u>The lack of involvement of the majority of educational personnel in the process of curriculum renewal</u>

Curriculum changes and shifts in emphases in teaching of concepts and skills had taken place without the active participation of the majority of the educational personnel in the process of change. Changes had been attempted without the educational personnel and the public being adequately prepared for accepting the rationale of the changes. The lack of success could be attributed to this lack of commitment and conviction on the part of the educational personnel at the delivery end of the changes. The particular modes utilized in preparation of sub-regional workshops, seminars by APEID could be adopted as a means of reaching the grass roots level personnel. Here reference is made to the national workshops and seminars which were organized as pre-requisites to the participation at the sub-regional level. At national level workshops, national experiences were synthesized. In doing so a larger number of national level personnel had to be involved in the particular mode of APEID. If this process could have been taken one or more steps further down to sub-national and institutional level preparatory workshops and seminars, the reach of APEID would be considerably widened. Similarly a mode such as follow-up workshops and seminars following a sub-regional workshop or seminar could facilitate the reverse flow of ideas. The development of mechanisms for the wider dissemination of the deliberations at the regional workshops and seminars would also have facilitated the required information flow.

2. Competencies required for the curriculum changes

Adequate steps had not been taken to specify the teacher competencies required for teaching new content and new emphases. If teacher competencies in relation to curricular changes had been specified, teacher preparation could have been undertaken on a more rational basis. The teacher college lecturers being generalists could not respond to the specific competency needs of the teachers in relation to the particular content changes. Hence any reform at the teacher college level should take this factor also into account. The demand for integration, multidisciplinary approach and linkages with the outside world required competencies which had not been considered necessary for the teaching of the traditional curricula. This calls for more activities in the area of teacher training.

3. Non-utilization of the knowledge made available by researches in educational psychology

In many countries the learning experiences had not been planned on the basis of developmental psychology of the learner. The age of transition from concrete operations to formal operations was not given heed in the preparing of the learning packages, which had a large component of concept learning in the formal way. Concept learning had become abstract learning without enabling the pupils to cross the concrete operational level. It has to be recognized that the transition from concrete to formal is not achieved at the same time for all types of learning experiences. For some learning experiences the concrete operational stage is prolonged in the developmental span of a child. In this connection, a taxonomy of curriculum design was also proposed. More concern in this regard will have to be shown in the third cycle activities.

4. Overload of content and lack of integration

Curriculum updating had in many instances become content addition without assimilating new content into a rational scheme. It has to be recognized that the response to the 'knowledge explosion' should not be in the form of a 'content explosion' in the curriculum. A way of responding to the knowledge explosion could be by means of developing new ways of presenting the content and by adopting strategies that would encourage acquisition of new knowledge without new content being specifically included in the curriculum. The trend towards integration and multidisciplinary approach could have been better utilized to cope with the knowledge explosion without resorting to an overloading of content.

5. Neglect of the affective domain

Science could be uniquely utilized to help develop a coherent perception and a view of the world. Our responses to the world are determined by a combination of cognitive and affective learning. Although the objectives of science teaching include those depending on the affective components of learning, yet they remain neglected. Science teaching in most cases appears to stop at the threshold where affective learning should take place.

6. Assessment procedures being out of step with changes in curricular design

Assessment procedures are still based on the notion that learning is 'rote learning'. They continue to reinforce rote learning while not encouraging the new trends in teaching-learning. Even though use of real-life situations for curriculum development was emphasized in many APEID activities, they are tested mainly on those based on contrived situations. Further there is little attempt to give credit to the learner for what he has already learned when assessments are done.

7. Neglect of a systems approach to curriculum development

The concept of the curriculum as a sum total of teaching and learning experiences and processes, systematically organized with some definite goals and objectives in view are at present not adequately appreciated by most of the personnel associated with school education. The major components of a curriculum, such as the syllabus, instructional materials, equipment, teaching aids and technology, teaching/learning strategies, methodologies and evaluation are generally developed in isolation. As a result, the package of materials and activities proposed and developed under a curriculum loses internal coherence and internal consistency and their effectiveness at the grass roots level is greatly reduced. By its very nature, teaching and learning of science demand an open and flexible approach to the curriculum and a certain degree of freedom to the teacher to improvise. However, in most cases in the real school situation, a science curriculum is virtually reduced to a rigidly defined syllabus or textbook, and the teaching and learning procedures are designed to suit the demands of the terminal examinations. An innovation in any area of a science curriculum cannot therefore succeed unless changes in consonance with this innovation are also brought about in the other components of the curriculum and the role of the delivery system accordingly redefined.

8. <u>Neglect of the research/data base</u>

It had not been possible to build up a reasonably effective research base at regional and national levels during the period under review. The time span covered by the first two cycles of APEID had been a very fertile one as regards development of ideas and methodologies in the educational field. Yet the research and data base pertaining to monitoring, evaluating and validating in support of the educational development enterprise has not been developed. Even the data and information gathered, had not been sufficiently organized to facilitate their practical utilization. This should become a major activity during the third cycle of APEID.

Chapter Two

SYNTHESIS OF EXPERIENCES, PROBLEMS AND ISSUES

In the developing countries there has been a remarkable change in the last few decades in their perception of science and of education.

It is realized that science has led to the growth and diffusion of culture to an extent never possible before. It has not only radically altered man's capacity to interact with his environment but, what is of still deeper significance, it has provided new tools of thought and has extended man's mental horizon. It has thus influenced even the basic values of life and given to civilization a new vitality and a new dynamism. No wonder the developing countries urgently want to utilize this potential for the development of their productive and human resources.

The concern of education as a whole has undergone tremendous change. Philosophies of education which would lay exclusive stress on the nurture of the intellect and the growth of the individual have yielded place to those which recognize that the individual functions in a social milieu and therefore even to optimize his own potential, education should extend its concern to social, and economic development. The ivory tower concept with its attendant limitations to the book, the teacher, the terminal examination and ultimately the cultivation of a narrow sector of the cognitive domain, has largely been replaced with concern for a wide spectrum of intellectual, affective, and social and psychomotor skills. The learning continuum now tends to touch upon real-life situations and problems. It visualizes interaction of the school with the environment and the community. Consequently, it operates in an expanded time and space domain giving rise to concepts of school and out-of-school education, education of the common man, and continuing life long education. Only by accepting such a philosophy and model, it is realized that the developing countries can satisfy their aspirations of optimizing human and social benefits for their people.

Science education combines the potentials of these two powerful aspects of human endeavour and has rightly been dentified as the pressing need of the developing countries. But in order to play its expected role it must incorporate the vital features of, (a) promotion of all round scientific and technological competence and creativity, (b) fostering of scientific method, attitudes or temperament and (c) dissemination of scientific knowledge and attitude, and awareness of its social role and significance amongst the public. Stereotyped scientific knowledge passed from teacher to pupil in the classroom is likely not to realize the potential of science in development either of the individual or of the society, and also may not be cost effective.

On the other hand a qualitatively new approach is both possible and necessary. However while it would make a telling contribution to the pace of human and social development in our countries, it would involve a series of new creative activities in curriculum development, materials development, teacher education and resource management. It would also involve that education be funded in accordance with its important role in expediting development and providing adequate human resource backup for it. Thus the implementation of a proper educational design will be an investment in the future of our countries, which will bring returns both in terms of economic development and the quality of life of our people.

The papers presented by the members of the Study Group covered a very wide range of topics in science education. The authors in their personal capacity as experts very frankly and constructively reviewed the present status of science education in their respective countries. It is interesting to note that all members of the group showed a common perception of the fundamental conceptual and operational problems in the field of science education in the countries of the region and shared common concern for the urgent need to initiate appropriate projects and programmes with a long term perspective in view. The need to develop a research and data base as a prerequisite for a more scientific formulation of policy on science education and development of curriculum, teaching student learning and evaluation was strongly felt by the Group.

While deliberating on the specific problems in science education, the members felt that many of the major issues referred to by them were closely related to the general problems of improvement of school education. This relationship was viewed in more than one way. The process of socialization of the school is facilitated when the school comes into more intimate contact with the social and natural environment in which it is located, and the teaching and learning of science is promoted through practical interaction of the teachers and students with the environment. This, in turn, makes science more relevant to the learner and the society both temporally and spatially. Similarly, the intellectual growth of the student is facilitated when his competencies and creativity are enhanced through a systematic process of education. Here again, a well planned and all rounded curriculum in science may lead the student to uncover, understand and practice the process and method of science and to think independently which happen to be the ultimate goals of education.

While the need to introduce science as an important component of general education is widely recognized, the distinctive attributes of this component as "science for all" are not always clearly spelt out. In some countries of the region students are given the option to choose courses in science at different difficulty levels even at those stages where science is taught as a part of general education. The differentiation of science courses at this early stage is by and large a reflection of the unevenness in the levels of competence and creativity among the student population and also of the existing imbalances in the availability of the physical and human resources required for teaching science in different categories of high schools.

It was strongly felt that the present policy of financing school education in the countries of the region should be commensurate with the new role science is expected to play and the special needs of science education. Appropriate allocation of resources for teaching of science in the primary, middle and secondary schools, and also for the professional development of the science teacher and for providing the school with a technical support service would go a long way in accelerating the rate of economic development and in spreading a scientific temper and culture. The spread of scientific knowledge and awareness through science education was also visualized by the members as a significant step for promotion of social development, conservation of nature, health and family life, and responsible parenthood. Propagation of science education as a part of general education in the countries of the region will also provide the most favourable climate for promotion of international understanding and co-operation.

The present trend of introducing increasingly new and difficult concepts in science courses at the general education stages as a process of renewal of curriculum and the inability of the students to cope with such development happened to be a central topic of discussion in the meeting. The experiences of the countries from the other regions of the world were also taken into account by the Group. The members strongly felt that such an anomalous situation, as obtained in most of the countries was the result of a lack of appropriate channels of communication and collaboration among the university scientists, the science curriculum workers at the national level, teacher educators and science teachers. Non availability of sufficient and reliable data on the cognitive development of representative samples of student population and the widespread practice of introducing new instructional materials without adequate and systematic formative and summative research were considered as other major factors responsible for the above development.

The Group devoted much time to analyse the implications of some recent research findings based on the administration of science reasoning classroom tasks to large groups of secondary students. These researches showed that while about 80% of the scientific concepts prescribed in the textbooks required formal operational competency of the students, it was only about 20% of the student population that could acquire such competency. While the Group expressed the urgent need to conduct more socio-cultural group-specific surveys and researches of the above type in the countries of the region, they felt that the observed inability of the majority of the students to operate at the formal operational level in a contrived situation might not reveal their innate abilities. Some members cited instances where children from the remote and rural areas could handle multivariate situations and concepts rather confidently where the tasks were designed keeping their familiar experiences in view. These experiences highlighted the importance of developing appropriate teaching-learning and teacher education strategies with a view to handling the task of accelerating the cognitive and affective development of that section of secondary student population whose competencies remain confined to the concrete operational level.

Some members mentioned research projects under implementation in their countries and the steps taken by the national curriculum development centres to introduce an inbuilt component of testing and evaluation into all curriculum development activities. However, some members felt that in spite of the best efforts of the curriculum workers in providing a scientific basis for the development of school science curriculum, the school authorities generally took the syllabi of the science courses as the only basis for teaching science, which again was planned to prepare the students for the public examinations. As the existing methods of testing learning achievements is essentially and wrongly confined to the evaluation of the cognitive-memory or recall of information, these tests can hardly be considered as indicators of competencies and creativity of the bulk of the student population. As a result, the originality, spirit of inquiry and experimentation, and initiative of the student get no encouragement.

It was observed that the social attributes and social skills of a student were significantly correlated with the success in life of the student. Development of the life skills, and social and affective skills of the student were therefore considered to be desirable and practical goals of science education.

In this context, the problems of cognitive and affective development of the first generation and slow learners and disadvantaged groups were discussed. It was felt that as at present the practical life experiences and the language abilities of the students, their reading preparednes and other innate competencies are not adequately exploited for development and implementation of science curriculum, the above groups are affected most adversely under the present method of curriculum renewal. References were made to some research findings in the Philippines, Singapore, the Republic of Korea and India which corroborated the above observations.

The importance of evolving a flexible and multifaceted teaching and learning of science through introduction of open-ended practical activities, projects, field visits, work experience, etc. was strongly stressed by the Group. One of the positive ways of incorporating these activities in the instructional materials and practical activities could be the introduction of technology and activity-oriented ideas and tasks interfacing the basic scientific concepts. As the frontiers of science were by and large related to technological innovations and high-level refinements of the basic concepts rather than in the fundamentals, a gradual introduction of science technology interface materials in the science curriculum stressing the understanding of these fundamentals would make the process of curriculum renewal much easier and practical.

It was felt that introduction of elements of technology in school science would bring the social studies and industrial arts closer to the sciences. Similarly, many of the mathematical operations which are at present taught in isolation could be made more purposeful to the students by interfacing them with their application in the relevant science topics. Both the empirical and deductive methods of teaching science can facilitate the process of mathematization and consequently the understanding of the logic of generalization and abstraction by the students.

The members of the Group unanimously expressed the view that the present verification type or fixed-result oriented laboratory experiments, wherever they are prescribed as a part of science syllabi at the general education level, have very little impact in terms of improving the student's understanding of the subject. The widespread use of practical 'cookbooks' by the students and the casual interest shown by the school to practical and field activities make the results of these experiences less reliable even in terms of acquisition of the appropriate manipulative skills and positive scientific attitudes by the students. Introduction of simple modular worksheets for student activities in Indonesia and India on an experimental basis and field projects in Japan and Sri Lanka were cited as important innovations in this area.

At this stage the Group stressed the need to have a judicious and balanced approach to the development of teaching, learning and supplementary materials, ideas and activities from the point of view of promoting simultaneously convergent and divergent thinking, and deductive and inductive competencies. A scientific grading and organization of these materials and activities on the basis of the student competencies required for mastering them was also considered essential for the development of the cognitive-memory and evaluative thinking which according to the present practices happened to be two important objectives of teaching and evaluation. The contention was that an improvement in the teaching procedure even under the present curricular constraints was likely to improve significantly the performance of the average and below average students. It was urged that the achievement tests should take an all round view of the development of the student and also the qualitative aspects of his performance in practical activities.

Several view points were expressed in the Meeting regarding the expected terminal behaviour of the students in relation to teaching and learning of science, particularly at the secondary stage of school education. A point of view was that any categorization of the mental ability of a student according to the Piagetian stages or classification of the learning outcomes according to the Bloom Taxonomy was likely to be mechanically interpreted and used by an average science teacher, who might not ordinarily be in a position to translate the proficiency of a student in a science subject into the above behavioural or developmental goals. Another view was that if an all-round growth of the personality of a child was taken seriously as the goal of general school education and the teacher was required to nurture such growth while teaching science to a mixed-ability group of students in a class, he should be provided with the know-how to handle the situation as far as practicable. A basic understanding of the structure of knowledge, the process of learning, and the development of the students' mind was considered very important for effective teaching of science. The growing apprehension in the mind of an average student about his ability to learn science, particularly the physical sciences was an indication of the increasing mismatch between the cognitive demand of these subjects and the ability of the average student. The Group felt that the above points of view were not mutually exclusive and, in fact, they emphasized the urgency to focus attention on the need to reorient and develop the science teacher and to technically support him on a continuing basis for the improvement of the quality of science education.

After a detailed analysis of the past experiences, the Group unanimously arrived at the conclusion that the science teacher occupied the crucial position for improvement of science education at the grassroots level. It was also felt that an appropriate re-orientation of the science teacher very much depended on the attitude of the school principals and school administrators towards the new requirements and trends of science teaching. Their orientation was also equally important.

The existing limitations of the teacher training institutions in performing the above tasks in the absence of any other supportive networks was highlighted by all members of the Group. They also reviewed the innovations in this field in the countries of the region, some of which are mentioned below as illustration.

The Law for the Promotion of Science Education promulgated in Japan in 1953 aims at substantial development of equipment and facilities for science and mathematics education and it assigns the financial responsibilities of national and local governments for the promotion of science education. The Science Education Centre in each prefecture in Japan conducts in-service training, research, consultation, information services and other activities for school teachers. Radio and television are now being widely used in the Republic of Korea for creating a climate for curriculum renewal and in-service training of teachers. In January 1980, the Directorate of Secondary General Education of Indonesia began an in-service and on-service[1] teacher training programme, with emphasis on content and test item analysis, preparation of innovative lesson plans or modified unit lessons for one semester science programme. In Thailand, the content-oriented training of science teachers is being replaced by a Competency-Based Teacher Education (CBTE). CBTE emphasizes the performance of the teacher trainees on the basis of their ability to promote desirable learning and behavioural outcomes of their students. In the Philippines, curriculum development has been decentralized in one or two regions with the aim of encouraging science teachers to prepare some modules specific to regional and community needs. Sri Lanka has expanded the Field Study Centres programme by the addition of three more centres in 1981 and now has six such centres to expose pupils and teachers to environmental studies on a first-hand basis. Establishment of trade schools in Nepal in the recent years was considered to be an important step towards vocationalization of secondary education for accelerated rural development. As a means of popularizing science, Bangladesh has initiated a science club and science fair movement. One specialist science instructor has been appointed in each of the 48 Government Primary Teachers Training Institutes (PTI) in Bangladesh recently for the first time for pre-service training of primary school teachers in science. Development of institutional linkages between high schools and the neighbouring colleges for the improvement of school education and in-service training of teachers in the name of "school-college complex", establishment of about 70 Continuing Education Centres for continuing training of science teachers and organization of science fairs at the school, district, state and national levels, have been mentioned as some recent developments in India.

In the context of the involvement of the colleges imparting higher education and training to the potential teachers, it was felt that school-college interactions might create an appropriate reorientation of the college teachers and teacher educators and enable them to appreciate the problems of implementation and evaluation of a

1/ This is a programme to train teachers while they are actually working in their own schools as against the in-service training where they are called to a central place.

curriculum at the classroom level and in cross-cultural settings. Such interactions, it was felt, would go a long way in creating a demand for curricular and teaching reforms at the college level as well in terms of establishing organic linkages between the content, method and evaluation.

It was also felt that the effectiveness of a training exercise depended largely on how the practical teaching-learning techniques and skills were transferred by the teacher educator to the teacher-trainee and in turn by the teacher to the student. The need to study systematically the present teaching procedures and teacher behaviours were also stressed in the Meeting.

It was felt that as the present classroom behaviour of the teachers by and large reflected the methods through which they were themselves taught and trained, a qualitative improvement in school education was strongly linked with the quality of education at the college and teacher training levels. It would be wiser to launch simultaneously programmes for improvement of teaching science in the colleges also.

The Group suggested that desired changes in curriculum (in contrast to a syllabus) should be introduced through a process of successive approximations with the involvement of science teachers, taking the existing situation as the starting point.

The teachers' role as a moderator of student discussions, co-ordinator of student activities and a motivator and co-learner was also mentioned as areas of teacher-educators' immediate concern.

This brought the discussion to a point where the present limitations of the present science textbooks became rather obvious. The openness of a science curriculum demanded not only use of different kinds of printed and audio-visual materials for transfer of knowledge and skills but it also visualized generation of knowledge locally through interesting, environment-based and socially useful activities as an integral part of science education. Participation of science teachers and students in this form of local-level curriculum development under the overall nationally designed curricular outlines was considered to be a method as well as an important goal of science education.

Following the discussion centred around the papers presented, the participants divided themselves into groups for further identification of the problems and issues as they affect the following areas of science education:

Curriculum Design and Development

It was noted that the curriculum was chosen as the focal point of the programmes for the renovation of science education, by all the participating countries of APEID during the first two cycles. It was also in this sphere that significant progress was made in the building up of expertise and institutional capability. It will be therefore expedient to utilize this field as the spearhead of the thrust for initiating action for correcting the shortcomings of the present educational systems with a view to make science education a truly effective means of social and economic development.

The general consensus was that a broader view of the purposes of education has to be taken if the curriculum has to be more effective. The emphasis on cognitive elements and the confining of evaluation to the cognitive sphere even in a still narrower way was considered to be the major shortcoming of the obtaining curricula. It was thought that a curriculum design which could take into account elements illustratively listed below could be a means of bringing about the changes desired.

Competencies, attitudes and skills to be developed

Knowledge acquired, memory short term/long term, application - recall for particular purpose, speed of learning, speed of grasp, analytical, curiosity, tendency to experiment/enquiry oriented, presentation of ideas/(synthesizing of knowledge), discussion skills (using feedback), experimental skills; Eagerness to acquire knowledge, disciplined, orderly and hard working, initiative (readiness to think and implement), responsibility, energetic, capacity for team work/co-operation ability, leadership, organization, imagination/foresight, open minded, autonomous/self reliance/self confidence, originality/ innovativeness, social awareness - oriented towards social justice/ fair play, lack of prejudices, tolerance, aesthetic awareness, tenacity/persistance.

Since several of these could be classified as being both cognitive and affective, no attempt has been made to indicate the particular category. Further, this should be considered as only an illustrative list.

It was recognized that a major overhaul of the curriculum design would be necessary if the above-mentioned competencies are to be developed. Particular elements of these will have to be emphasized in curricula designed to foster open competence and creativity.

Towards a better science education

The Group recommended that the innovative programmes in the design and development of science curricula should focus specifically on:

1. the spread of scientific knowledge;
2. the use of scientific method(s) of inquiry and experimentation;
3. the development of cognitive, affective and psycho-motor skills;
4. providing a favourable climate for removing the barriers to cognitive and affective development of the first generation learners and disadvantaged groups;
5. linking science education with real-life experiences of the learners;
6. bringing the different disciplines of science closer together so as to ensure a multidisciplinary approach to teaching-learning in science;
7. incorporating open-ended practical activities, projects, work-experience, field-work, community surveys and problem-solving situations;
8. encouraging co-curricular activities related to science and technology education such as science clubs, science fairs;
9. the greater use of the psychology of learning in science education;
10. giving greater attention to language aspects.

The Group further recommended that the APEID should, with particular reference to science education:

1. strengthen national initiative and efforts for curricular innovations in the area of science education including the design, development and implementation and preparation of instructional material, training material/modules for teacher training and also newer instruments for measuring student achievement;
2. strengthen and stimulate national institutions and groups engaged in the design, development and implementation of the curricula;
3. strengthen national capabilities through exchange of experiences and co-operative efforts in curricular renewal including teacher education curricula, and techniques of evaluation; and

4. strengthen national capabilities for research and studies relevant to science curriculum and school practices in science teaching.

. Open-competence

We are in an age of rapid changes in the natural sciences and social situations. In order to adapt to the rapidly changing and progressing age and to contribute to the socio-economic progress it is important for all the students to acquire certain competencies and attitudes to solve problems, processing appropriately fast expanding information and to think creatively. For education to assist in this, school science education programmes will have to provide for teaching-learning experiences through a variety of methods which will help develop concepts and skills which are flexible and applicable to a wide variety of situations rather than limited in scope.

Following is an illustrative list of 'Open-competences' which science teaching-learning can help develop. The list should be considered as being tenative and could be further refined and enlarged:

Process skills (scientific methods): Observation; Measurement; Recording; Infering; Designing and conducting of experiments; Data interpretation; Making assumptions; Formulating hypotheses and testing; Controlling variables and isolating; Formulating models; and Communication skills (including use of symbols, graphs, etc.)

Knowledge:

Understanding and using of: Concepts; Laws or principles, formulas, symbols and signs; Knowledge of methodology; and Mathematical skills.

Way of thinking: Deductive; Inductive; Analytical; Synthetical; Divergent; Convergent; Intuitive; Imaginative and Creative; dreaming, playing, initiating, creating.

Attitudes: Self-reliance; Positive self-confidence or self-concept on his/her judgement of ideas (or creations) with respect to science and science learning; Respect for others' judgement and ideas; Patience or tolerance for differences and disagreements from others (or listening to others); Courage and willingness for taking the responsibility for his or her judgement and ideas; Sensitivity to changes and new problems; Awareness of social and national development; and Love for nature as well as human beings.

Values: Seeing science as an important part of our culture; Seeing science as an approach to solve human and social problems; Seeing science as a process as well as a product; Understanding or recognizing science as the creation of co-operative work; Seeing science as a critical factor for the improvement of human welfare as well as the technical development; and Judging on the basis of sound evidence.

In order to foster the above elements of open-competence the skills and modes listed below need be taken into account:

1. Science equipment:

   - designing and developing equipment and facilities required by new science programmes;
   - utilizing used-materials; cans, bottles, batteries;
   - designing low-cost equipment;

2. Utilization of out-of-school facilities:

   - using homes, farms, natural resources such as forests, science museums, factories, etc.;
   - field trips;
   - outdoor surveys;
   - raising plants and animals; and

3. Use of audio-visual (AV) aids and materials;

   - operating AV aids: slide projector, OH projector, 16 mm film projector, etc.;
   - designing and developing models; skeleton of human body and animals, sedimentory topography, etc.; and
   - collecting and preparing specimens: minerals, rocks, fossils, etc.

Evaluation

Evaluation was considered to be a critical area in utilization of science education for development of human resources. The traditional examinations have tended to thwart the thrusts of new innovations in science education. In fact, the delay in reforming the examination system had been the single most important factor which has negated the reforms affected in the field of curriculum development. Some of the new trends in evaluation by their over-concern for 'objectivity' in its narrower sense had discouraged the creativity of both the teachers and students. Evaluation of the cognitive elements concerning their lower aspects is comparatively easy to develop and administer. This may be one of the reasons for the neglect of the higher aspects of the cognitive domain and the affective domain in evaluation. Although good psychomotor tests are available and are used in craft-training programmes, they are little used in science education on account of their being time consuming and costly.

Paper and pencil tests alone will not be adequate to evaluate the attainment of the desired objectives. Evaluation through observation and other informal evaluation procedures will need to be planned and administered in order to get information about a student's progress especially in the affective and psychomotor domains. Further, evaluation procedures have to be comprehensively laid down for teacher use to prevent use of tests in an arbitrary way.

Evaluation therefore has to be seen in the total context of the purposes of science education and not as an end in itself. It has to be compatible with fostering of open competence and creativity as well as those pertaining to the other desirable affective elements. Evaluation has to be further seen as an integral part of the teaching learning process. The open competences described earlier would require a different type of evaluation. In addition, if field activities, community oriented activities and project work have to be the important learning modes, suitable evaluation techniques have to be designed and utilized. In this context the issues and problems pertaining to evaluation have to be further examined and development of more valid and flexible procedures, processes and instruments have to be initiated on an urgent basis.

Training of personnel including professional support services

Teacher training methodology should accurately reflect the new and wide learning experiences being stipulated for the child. For instance, if the experimental method is stipulated for a package of learning experiences for the child, the teacher preparation methodology should also include learning by experimenting. In the same way the development of open competence in the pupils has to be fostered by a teacher preparation methodology which actually develops in the teacher knowledge, skills and attitudes associated with open competence. In addition the teacher preparation activities should include field activities reflecting those which are to be included at school level. If we intend using project-type learning experiences and utilization of environment and community resources for teaching-learning, teacher preparation should reflect the particular methodologies and competencies required for this. To foster such activities, the teacher must be made to perceive his role as a facilitator of learning and as a co-learner with the child.

Therefore, we need to identify competencies required for teaching a particular curriculum before teacher preparation for the implementation of the curriculum is undertaken.

Preparation of teachers should take into account the central role content plays in making a teacher competent. The content-base of teacher preparation has to be re-emphasized. Since content teaching at school level is becoming increasingly integrated and multi-disciplinary, teacher preparation pertaining to content should take this into account. The implications of this for undergraduate courses where undergraduate education is separate from teacher education have also to be considered.

Exposure to the problems and issues pertaining to evaluation including self evaluation both on the part of the teacher and of the student, should be a part of the teacher education courses. Training in evaluation techniques compatible with the major purposes of science education, including the fostering of open competence and creativity, has to be seen as a major component of teacher preparation.

Teacher education should foster favourable attitudes towards change. Teachers must be able to welcome change by regarding change as an opportunity for developing their competencies and skills. Because active engagement in innovative projects would give teachers the self-confidence to face boldly curriculum innovations during their professional careers, more opportunities have to be provided for teachers to engage themselves in innovative projects as part of professional training.

Professional support services to teacher education should be in the form of team-support with teams comprising content specialists, psychologists, science educators, practical teachers, community agency personnel and educational technologists. Materials required to support teacher education will include professional journals, curriculum and evaluative materials, applicable research monographs and equipment. Organizational support for teacher education could include teacher resource centres, field study centres and experimental schools. The methodologies which have been proved to be effective in in-service teacher education could be adapted for pre-service education. Teacher education will be greatly facilitated by the availability of institutional mechanisms for attachments of teachers individually and in groups to resource centres, field study centres and curriculum development centres. Another means of fostering the last aspect will be by actively employing teachers in research projects.

Implementation, Resource Management and Building a Research Base

The educational system is a time-honoured and change-resistant system. In spite of considerable concern of the Member States, and a good deal of advance thinking by international, regional and national agencies regarding new courses, programmes and structures, implementation has been weak and the system has not responded adequately to the needs of the people. It is therefore coming under increasing stress which sometimes tends to spill over to other spheres of our societies.

A multipronged approach for inducing and sustaining change is, therefore, required; (i) the formal or the school system should be supplied by alternative curricular programmes, delivery methods, teacher training, and above all, materials which can operationalize the various recommendations made by the Study Group; (ii) institutions which want to use the existing and self developed materials on a substantial scale should be provided not only the freedom but also the incentives to do so; (iii) in institutions where teachers want to use the materials for a whole course, they should also be given the freedom and assistance to do so; (iv) a sustained and major effort should be made to present the new ideas, their potential for development at large and proper nurture of the children, as also the shortcomings of the present system as reflected in research studies to the four crucial groups; parents, the public, the academics and the policy makers.

Institutions devoted to curriculum renewal on a continued basis is a relatively new development in the educational sphere. These institutions have grown and taken over a variety of responsibilities in the past two decades. Some of these institutions also undertake operational and action research activities. The management aspects of these institutions from the perspective of their objectives, resource needs and responsibilities require attention. These institutions require to have linkages with universities, research institutions, teacher-education institutions, public and private agencies. The resource management aspects of these institutions too have certain peculiarities. Some of the resources such as teachers belong to the school system. The curriculum renewal institutions have had to develop special administrative procedures to manage such resources. Therefore, it is timely to think of training of managers of curriculum development, curriculum innovation, action research and project evaluation.

The building of a sound research base and providing ready access to research findings will have a far reaching impact on the entire education system. The types of research will include, basic research in areas such as cognition, action or operational research pertaining to use of curriculum material, school practices, development of teacher resources etc., and research into institutional management. Basic research which would require a high level of competencies could be undertaken by universities. The operational type of research could be undertaken by the curriculum development and research agencies of the general education system. Interpretation of data in a form which will lend itself to utilization in school situations is also an area which needs special attention.

To bring about a climate of regard for research, it is necessary to get more and more educational personnel involved in research work. If research, especially of the operational type, could be farmed out to teacher colleges and schools, larger numbers could be employed in research activities, thereby creating a climate for reliance on research. The education system has an abundance of trained human resources. If a large number of topics for research could be identified, these could be farmed out to the large number of other concerned institutions. Such an undertaking would require the building of national capabilities for organization, co-ordination, documentation of research and dissemination of research findings to the grass roots level.

Research findings have to be presented in a variety of ways if a wider clientele is to be reached. The clientele or target groups could be identified as professionals, policy makers, classroom teachers and the general public. The type of problem discussed and the presentation should take into account the particular target group intended. The modes of dissemination have also to be evidenced to include journals, monographs, cumulative indexes of research works, newsletters, articles in newspapers, radio and TV discussions and public lectures.

Chapter Three

EMPHASIS FOR VARIOUS SCIENCE AND TECHNOLOGY EDUCATION ACTIVITIES IN APEID'S THIRD CYCLE

The Meeting examined the work plan of the programme area 'Education for Promotion of Scientific and Technological Competence and Creativity' as developed by the Seventh Regional Consultation Meeting on APEID in June 1981 and also the work plan presented to UNDP by Unesco, ROEAP. The Meeting endorsed the draft work plan of APEID third programming cycle, while making suggestions for greater concentration on some selected population groups and aspects of science education.

Recognizing that the education systems are basically conservative and resistant to change, and that the systems have in the past thwarted serious attempts to alter them, the Meeting identified the elements needing concentrated attention in the education systems which could be used as levers for transformation.

Within the scope of APEID, and in collaboration with other Unesco programmes, measures should be taken to promote co-operative action and exchanges on school's out-of-school activities and their role in out-of-school youth programmes, for example field activity programmes, science fairs, science clubs.

More and more efforts should be made to involve the out-of-school youth population in school science programmes even if they are of a formal nature, as schools can provide a major resource for the popularization of science and technology, their applications and implications.

Another area to be given attention is the further development of complete learning packages for the non-traditional curriculum elements being freshly brought into the curriculum.

Another area which should receive priority during the third cycle of APEID should be a number of studies and researches on concerns expressed in the earlier Chapters. In this context the need was felt for forthright presentation of the results of such studies and research to focus attention where the system fails to come up to expectations.

Evaluation techniques to access the pupil performance, particularly if out-of-school activities and field and project work are to be used as teaching/learning strategy for science, will have to be further examined and developed. New and compatible evaluation techniques, teacher preparation methodologies, etc., could be built into field and project work and non-traditional curriculum elements as complete learning packages. These packages and their handling could then be used as curriculum development and process exemplars in the training of teachers and other educational personnel. Such a strategy would thereby serve as an effective means of transforming the larger system.

As teachers shall continue to have a crucial role in any programme of science teaching and changes in the system can be brought through teachers, the various activities planned for the third cycle should have a 'training element' as one of the important components. Another area which needs attention, and for which it may be even necessary to organize some specific activities, is examinations and evaluation in science. If we are looking for competence and creativity then new types of instruments and tools for evaluation will have to be developed with focus on practical tests carried over a long period of time.

Another activity that could be considered for the third cycle could be a multidisciplinary seminar on creativity.

The Meeting noted with satisfaction that the mode of preceeding a regional or sub-regional activity by a national level activity has yielded high dividends and recommended that this practice should be continued and even extended to provide opportunities at the national level to have sub-national or district level activities. This would also help extend APEID activities to grassroots level.

The Meeting agreed on the need for the general transformation of the education systems in order to make them serve as vehicles of economic and social development. The particular emphases on out-of-school youth, modes such as field activities, development of evaluation techniques, teacher preparation and strengthening of research capabilities is based on the realization that with the limited resources and time only critical areas of the education system could be taken in hand. This strategy is in keeping with the catalytic role of APEID which it has continued to play in the educational development of the region.

Annex I

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SUMMARY OF DISCUSSION PAPERS PRESENTED BY PARTICIPANTS

'Innovations and new thrusts in science education'
by
M.A. Jabbar, Bangladesh

Science in Madrasah Education System

In Bangladesh there is an indigenous system of education, called Madrasah Education, which is somewhat parallel to the general system but heavily tilted towards religious (Islamic) studies. With effect from 1975 general science has been included in the curriculum of primary level of the Madrasah system and since 1976 the general science course for the secondary school stage of the general system (grades: 9-10) has been adopted for the Madrasah classes 11-12. In addition, an elective science group of secondary school certificate standard has been introduced in a limited number of Madrasahs since 1976 and Higher Secondary Certificate Level (grades: 11-12) Courses are being offered in the Fazil Madrasahs (classes: 13-14) from the same year.

New Science Curricula

The new science curricula prepared by the National Curriculum and Syllabus Committee were introduced at the primary stage in 1978 and at the first year of the junior secondary stage in 1980. Efforts have been made in the new science curricula to correlate science and technology education to the learners' environment so as to make it a tool to be used by them for solving their real-life problems and at the same time to avoid undue emphasis on the facts of science and rote learning. In redesigning the courses attempts have been made to incorporate curricular content linked with the real-life situations and include learning experiences and activities around the learners' environment aimed at developing productive skills, particularly the use of local resources available in the neighbourhood of the school and the community. The use of 'environment as the laboratory' is envisaged as an alternative to the formal laboratory at the first level of education and complementing and supplementing the laboratory at the second level by drawing upon the environmental resources and improvising low-cost but workable apparatus/equipment using 'waste and cheap' materials found locally. The new curricula provide for adequate flexibility allowing schools to incorporate in the curriculum learning experiences and activities obtaining in the locality and the region, local resources and expertise. Some of the objectives of the new science curriculum are to:

- i) develop interest and curiosity about natural phenomena and objects;
- ii) develop the skill of observation through the study of environment;
- iii) develop ability for using scientific methods of work;
- iv) develop ability to think logically;
- v) provide scientific knowledge and skills as tools to solve problems.

In the new curriculum for the primary stage science has been treated as a part of 'environmental studies' which is interdisciplinary in nature and includes information, concepts and principles basic to both natural and social sciences. Such an approach with the study of environment is envisaged to help the learner to know his environment and its problems intimately so that he is prepared with appropriate attitudes, skills and competencies to solve problems scientifically, i.e. by using the tools, techniques and process of science. In the lower secondary stage integrated science courses have been designed. For the secondary stage (classes 9-10) the National Curriculum and Syllabus Committee has recommended that in place of the present diversified courses in science, agriculture, industrial arts, etc., a unified curriculum providing "Science for all" should be introduced. When implemented in 1983, the proposed curriculum will do away with the elective and general science courses now obtaining.

Co-curricular activities in science

Under the auspices of the Science and Technology Ministry, science clubs and science weeks are encouraged when annual science fairs both at the national and regional levels are organized by the students of the secondary schools and colleges with their teachers acting as advisers. These activities help students to be creative and to acquire competencies in many areas of science education. The projects so far undertaken by the club members may be divided into the following categories among others: (a) experimental proof of established laws and principles; (b) improvising/preparing apparatus/equipment; (c) survey and mapping; (d) observations and recording; (e) collection of information/data through hand-made instruments; (f) production oriented activities; (g) inventions; (h) innovations, etc.

New Institutional Arrangements

Recently a National Curriculum Development Centre has been set up with responsibility for updating and modernizing curricula including those for science education from the primary to the pre-university stages of the general stream and technical and vocational education as well as teacher education for primary school teachers.

A specialist science instructor has been appointed in each of the 47 Primary Teacher Training Institutes.

'Practical experiences for development of competence and creativity - Open-ended experiments and projects'
by
A.K. Jalaluddin, India

Introduction

A discussion on the role of practical experiences and laboratory experiments in developing competency and creativity of the school children gains added significance when it is initiated keeping in view the overall progress in science education and the constraints under which a school organization has to operate. The existing research data have been indicating a shift in emphasis from development of innovative science curricula and laboratory experiments to more fundamental issues involving the cognitive development of the child.

Administration of Piagetian classroom tasks to thousands of school children in collaboration with science teachers in some countries, in contrast to the administration of paper-pencil psychometric tests by specialists to a limited number of children, has recently brought to light the bitter truth that between 70 to 90 per cent of the children in the mixed ability secondary classes in some developed countries are not in a position to satisfy the prescribed curriculum demand due to their innate mental and intellectual inability to operate at the formal operational level as defined by Piaget.

As the developmental level strongly depends on the gender and socio-cultural background of the child, teaching of science becomes still more problematic in cross-cultural settings and in the developing societies.

Towards a better science education

When viewed in the context of the growing concern in the countries of the region to incorporate science curriculum as an important constitutent of general education at the secondary or lower secondary stage, the existing mismatch between the curriculum demand and the level of mental development of the students becomes a question of crucial importance in developing curriculum and instructional materials for the secondary school population. The contents and methods of teaching science to satisfy the demand of "Science for all" are yet to be defined in terms of new curriculum and instructional materials.

It is now widely believed that a teaching strategy designed to improve the power of logical thinking and scientific reasoning of the pupil with a view to accelerating their transition from the concrete to the formal operational level need not necessarily take place at the expense of the small minority of pupils in a class who are already capable of learning at the formal operational level. Practical experiences of the pupils, whether at home or in the school, may provide the appropriate ground for such transition. However, as the school achievement tests by and large ignore the mental activity and emotional factors of the child, the traditional science curricula and examinations make the majority of the pupils feel incompetent. Consequently they are pushed to rote learning, even in the case of laboratory experiments.

While the process of developing new secondary science curricula and laboratory experiments in the recent years in India has created an awareness among the curriculum workers, teacher educators and science teachers of the new trends in science teaching, their impact in terms of reducing the mismatch between the growing curricular demand and the power of understanding of the pupil is yet to be felt. The idea of incorporating open-ended experiments and practical projects in science in the secondary and higher secondary levels are generally met with an air of apathy and at times resistance not only from the school principals and science teachers but also from the pupils and their parents on the ground of their irrelevance to the traditional institutional incentives and achievement tests. The success of any innovation in the intrinsic aspects of science education, therefore, seems to be organically linked with the problems of institutionalization of the innovative practices, on which the very rationale of introducing science teaching in the school system is based.

New Curricula of the Sixties

The idea of concept-formation dominated the objectives of the well known curricula developed in the United Kingdom and the United States of America in the sixties. These curricula required the active participation of students in laboratory work in the secondary classes. Five major functions of the laboratory identified in the literature in this period are:

manipulative skills; process of science; knowledge of the subject matter; attitude and interests; and values. However, some recent studies have shown that while the laboratory enhanced manipulative skills and attitudes, it was not particularly effective in increasing students' knowledge. It has also been reported that laboratory experiences made no differences for either delayed retention or transfer of knowledge. In the background of growing concern about the cognitive development of the pupil, the project approach to teaching and learning science was initiated in a number of senior high schools in the United States. However, very soon it was found that the project method could be used with much success essentially with the intellectually gifted and highly interested students. As the students join the secondary level of education with low and high entry competencies, the appeal of investigatory or open-ended practical assignments or research projects varied considerably not only among the students but also among the teachers. The majority of them felt comfortable when a question had one answer or a problem had one solution. When told that there may be no 'right' answers to a question posed, or that there are alternative solutions to a problem, or when asked to 'think creatively' about material rather than simply to organize and reproduce it, students so trained become bewildered, anxious or angry

Much of the gap between the 'desirable' and 'achievable' in the classroom situation in science education has in the ultimate analysis been found to be due to socio-cultural determinants of the school organization and the developmental constraints of the student. It is now widely known that 'substantive changes in school organization or in classroom life cannot be made by following a master formula that is not adapted to the particular school society'. Similarly, reliable evidence is now available which show a massive mismatch in secondary schools between the expectation of institutionalized courses, textbooks and examination, and the ability of the children to assimilate the experiences they are given .

The renewed interest in Piaget in the seventies has brought to light several implications of the Piagetian theory of structure of knowledge in not only exposing the present day problems in science education but also in scientifically attacking these problems. The Piagetian model enables one to construct instruments for the determination of the level of development of pupils' mental schemes and, interestingly enough, also of cognitive complexity of curriculum material. By using both these means on the basis of the same set of postulates it has been possible to determine the upper limit of the level of science curriculum materials that can be handled by each pupil or group of pupils. When science teachers are involved in developing and using the Piagetian tasks, they themselves undergo a process of unlearning and relearning which is so vital for the creation of a climate for change in the school organization.

Recent Developments

While reorganizing the secondary science curriculum in 1975-77 in India, the researchers in the field had to face serious constraints most of which did not have any scientific basis. For example, some teachers, students, educational administrators and parents had been seriously analysing the load of science curriculum in terms of the number of pages a science book contained.

Under the present emphasis on the lecture method of teaching, the principals and science teachers, in spite of their best intentions, find it very difficult to provide logistical and academic support for orchestrating the necessary co-ordination between class-room lectures and practical activities in science. As a result, there exists a gap between the preferred role of organized practical activities in secondary science curriculum and the actual practices in the schools. In those states where laboratory experiments by the students is an examinable subject in the general education level, i.e., at the end of class 10, a cursory glance at the practical examination results will show a uniformly high level of student achievement in contradistinction to the achievement scores of the same group of students in the corresponding subject papers where 50% or more students fail to secure the pass marks. This could be due to excessive emphasis on assessment of cognitive memory in the theory examination and adoption of the cookbook approach towards laboratory activities.

In the above circumstances, the science curriculum workers had to check the temptation of suggesting any hasty or ready-made solutions to the problem. While endorsing the existing practices as a transitory phase, they had to concentrate more on fundamental issues like redefining the aims of science education and the successive subordinate tasks to approximate these aims. In the process of formulating these details it was realized that the aims of science education could not be clearly defined or redefined without analysing the philosophy of education and the theories of learning on the one hand and the existing socio-cultural perspectives of the school organization on the other. The concern of some educational institutions to raise the level of general secondary education through provision of well equipped laboratories on the one hand and the lack of adequate physical and human means to effect such changes throughout the country on the other, raises more sharply the question of priorities. The more powerful sections of 'public' and urban schools have been urging for two streams in science education even at the lower secondary level where the principal of 'science for all' has been adopted as a policy. In fact, some of the Boards of Secondary Education had gone ahead with the creation of two science curricula for classes 9 & 10 with the implication that those schools which are not in a position to provide laboratory facilities may offer a less ambitious science course.

The immediate effect of this change was the re-introduction of a process of differentiation of courses at the end of class 8 which was sought to be avoided in view of the undesirability of asking a child to opt for specialization while entering the secondary stage at a comparatively early age. It is quite possible that in the near future only those students who opt for the so called higher level or 'disciplinewise' science courses may get preference with regard to admission into the science stream in the higher secondary level, although till now there has been no discrimination on this ground.

The moot point in mentioning this development is in no way to undermine the importance of upgrading the quality of science education. What is argued here is that whatever be the considera-tion in designing secondary science courses, the psychological and research bases of these courses should be so developed that the purposes for which these courses are developed are well served. It is quite possible that the majority of the secondary students fol-lowing either of the alternative courses may take recourse to rote learning due to their difficulties in internalizing most of the formal concepts. In the circumstances, mere bifurcation of the science courses or laboratory exercises may not pave the way for solution of the fundamental problems in science education.

The problem of replication

These developments acted as good lessons for the science curriculum workers and some of them came to the conclusion that they should be able to check the temptation of suggesting any drastic change of curriculum or instructional materials without actually preparing a scientific basis for curriculum renewal and its instituionalization. As the linking of institutionalization with research and development is vital for replication of any edu-cational innovation, a certain kind of innovation also from within the school organization was found to be a pre-requisite for the replication of any innovative material or practice. Such institu-tional innovations are facilitated through granting of more free-dom to the teachers and school principals. The logic behind the approach is that a change in the behaviour of the principal or science teacher, which is crucial for institutionalization of a scientific approach to the issues of renewal, cannot be brought about without actually making them enjoy a certain amount of funct-ional freedom in relation to the prescribed curriculum. While it is quite possible that many of the principals and teachers may not demonstrate serious departure from their usual behaviour, they are likely to be more motivated to accpet new ideas. Their response is likely to be more intense and genuine when these new ideas hap-pen to deal with the problems they face in improving the level of understanding and mental operation of the majority of their students. Here the freedom given to the teachers in reality may prepare them to recognize the necessity to unlearn and relearn.

Thus one arrives at a situation when the question of development of competence and creativity of the science student is found to be interwoven with the development of competence and creativity of the teacher at a higher plane. Again, it is through the participation of an appropriate number of science teachers in a systematic analysis of the existing curricular and lesson objectives and assessment of the mental abilities of their students in terms of the achievement of these objectives, that they would be in a position to understand the degree of mismatch between the two. The involvement of science teachers, maybe the more motivated among them, in the initial stages of a curriculum development project would enable them to acquire the skills of analysing curriculum, instructional materials, and cognitive abilities of the students. They may subsequently develop the skills to prepare tasks, workbooks, activities and assignments for the accelerated growth of those students who are otherwise unable to operate at the formal operational level, which happens to be the terminal behaviour set under the traditional 'academic' science curriculum.

Ordering of experience

It is interesting to note that most of the reasoning tasks draw the attention of the respondent to a series of activities and events. In this sense, the development of scientific reasoning is synonymous to the learning of a process of widening the area of understanding. Again, it may be noted in the above example that the reasoning tasks take advantage of life experience of the child and interpose with it some organized practical or experimental experiences, and the understanding of the child develops as a result of ordering these experiences as the concrete basis for their understanding of an abstract reality. One of the main limitations of the traditional 'academic' courses lies in the fact that they by and large do not take the real life experience of the child as a resource to be mined and exploited for developing their reasoning abilities and creativity. The same is the case with respect to the utilization of the varied and rich experience of the able and experienced teachers who can make slow learners acquire the required competencies through questioning and individualized instruction.

The first step towards matching the present curriculum demand with the level of cognitive development of the students would be to offer suitable learning experiences based on their common personal experience in the specific, prescribed areas of concept formation. This would enable the students to analyse and order their experience and to get a qualitative feeling of the area of interest before actually handling the quantitative treatments and abstractions.

When viewed in this perspective, practical teacher demonstrations, simulations, field visits, student laboratory tasks and teacher-student discussion before and after undertaking specific tasks, etc., reduce the role of practical activities, big or small, into a mode of instruction and inquiry rather than isolated items in a set curriculum. As all these activities are likely to improve the performance and self-initiative of the students, their introduction in the existing curricular framework is likely to be welcomed rather than resisted by the principals, teachers, students, and parents. Such steps can go hand in hand with the development of open-ended experiments and research projects for the more motivated and able students.

Illustrations of open-ended experiments and projects as introduced by the Central Board of Secondary Education have been published in their syllabi.

Several journals and brochures have also been published highlighting the activities of the school science clubs and science fairs activities in India.

Feedback on laboratory practices

On an analysis of the experience of implementation of the new science curricula, including practical experiments at the secondary and higher secondary levels adopted by several Boards during the last three years, one may arrive at several broad observations. Similarly, a close examination of the experiences of holding science fairs at the national and other levels during the last decade or more enables one to draw several conclusions. Some developments relating to the recent reorganization of the science curriculum have been mentioned earlier. The following are some observations relating to the laboratory practices:

1. Most rural schools have not been able to provide any space or equipment for pupil experiments at the secondary level;

2. About one third of the secondary schools have not yet been able to recruit teachers with an adequate science background to conduct science classes;

3. Teachers having a background in physical sciences find it difficult to teach life sciences and vice-versa at the secondary level;

4. Where 'science practical' is part of an examinable course at the end of class 10, the concerned school authorities by and large tend to offer the laboratory experiences to the students towards the end of the two-year secondary science course, instead of interweaving them with the regular classroom instructions throughout the two-year period;

5. Science teachers and students avoid doing open-ended, design and test-oriented experiments when such experiments are prescribed as alternatives to usual verification type of experiments in the syllabuses;

6. The idea of introducing research-oriented projects at the higher secondary level by a few Boards of Examination have unfortunately met with the traditional problems of failure. This is because of the fact that those projects which were cited as illustrations in the syllabii for the orientation and training of the teachers and students ultimately turned out to be the only projects available with the schools for the successive years. The details of the procedure to be followed in these projects were published in several 'cookbooks' which appeared on the market soon after they were recommended by NCERT. A teachers' guide on the subject has been recently published by NCERT; and

7. The activities suggested in the workbooks under the Secondary Science Project (NCERT) produced mixed response; those items which required the students to write their observations on the basis of practical experience were found to enhance their curiosity in the exercise. These workbooks are scheduled to be revised after the try-out.

Science fairs

Student and teacher motivation for participation in annual school science fairs have been found to depend on the interest of the school administration shown in such activities. Organization of science fairs at the district, state and national levels under grants from the NCERT, Jawaharlal Nehru Memorial Fund and some other agencies have, in turn, been found to create a healthy competition between the school organizations of different states. It is interesting to note that it is not always the best achievers who constitute the majority of those who take initiative in the science fairs. In most cases, it is the more motivated and enthusiastic students who take the lead. These experiences are yet to be replicated through the existing network of schools, institutions of higher education and research, agricultural and industrial training and extension centres.

National Talent Search

The NCERT has been conducting annually a National Science Talent Search (recently renamed as National Talent Search) to identify talented students before they pass out of the higher secondary stage. The Council also conducted scientific creativity tests with the purpose of predicting achievement in science in the Delhi Higher Secondary (Science) Examination (1974) of a group of students who also took the NSTS tests the same year. The study showed that higher scientific creativity scores generally, and high scientific creativity plus high IQ particularly, go with talent in the field of science. However, a recent research study showed that the Higher Secondary examination results in science did not happen to be a good predictor of the performance of the students in higher education in technology courses. While these studies may be of some use in a remote sense to science teachers, they might find simple tools for promotion and measurement of divergent thinking and creativity in the classroom situation more useful and interesting.

Perspectives for Future

The recent trends have shown how difficult it is to introduce innovative instructional materials, equipment or test items in the school organization. Even if such materials and ideas are incorporated in the organization, they are either likely to be inadequately utilized or utilized in a distorted or counter-productive manner unless the classroom behaviour of the science teacher and the teaching procedures also simultaneously undergo change. It has also been found that the existing teacher training institutes do not always provide the appropriate climate and leadership in the area due to lack of any significant scientific research base in these institutes and also due to their isolation from the process of educational, scientific, technological, and socio-economic development. In this context, the establishment of about 70 centres of continuing education by NCERT in the last three years for in-service training of science teachers in the States and promotion of the idea of institutional linkages between the schools, colleges and universities located in close proximity, popularly known as "school complex", happen to be two important institutional innovations in teacher development. The involvement of college and university teachers in the continuing education of school teachers and setting up of science education resource centres would enable the former, who wield much influence in determining the school science curriculum, to understand the problems of teaching science to mixed-ability student groups and to reorient themselves to the problems of science education.

'Evaluation of secondary school science education'
by
Benny Karyadi, Indonesia

Introduction

In describing an evaluation on science education in Indonesia it is necessary to obtain an overall view of what the educational system is, because the science programme in schools is only a part of the total educational programme.

A centralized curriculum has been used in our educational system. The current curriculum, the so-called 1975 curriculum, has been implemented gradually since 1976. This goal oriented curriculum is designed in such a way so as to give a clear direction for educational quality. The main objective of this curriculum is to improve the quality of student learning by focusing attention upon the teaching-learning processes and the evaluation procedures.

Objectives of the Science Programme

An important process in planning and developing Science Curriculum is identifying its purposes. These aims or purposes become the guidelines for the teacher to choose the teaching procedure, to devise the means and procedure for evaluating the learning outcomes or the effectiveness of the teaching process, and to define the responsibilities of the learners.

Clearly-defined objectives can maximize the teacher's efforts in the teaching process.

A teacher armed with the knowledge of behavioural objectives gains in several ways. Once the teacher has developed objectives for the concept or the unit, she can select content/topics and arrange or rearrange them into instructional sequences which can maximize learning. But sometimes a teacher may feel that knowing a certain concept, such as knowing a concept of chemical equilibrium, is important, then she should focus on this concept, spend sufficient time developing the concept, and derive appropriate behavioural objectives. It should be borne in mind that if the student cannot achieve the objectives after completing the instruction the teacher may not have done a satisfactory job of stating the objectives and/or utilizing appropriate learning procedures.

Many science educators recognize that unmeasurable objectives are little more than rhetoric, but a well stated and measurable objective will be very useful for selecting the teaching-learning and evaluation procedure. The objective should also be realistic.

It means that the teacher feels that she can and will do something in her science class. In terms of the science content, we must avoid objectives which we feel are too high-flown to be achieved by the students.

Main problem with objectives

1. Some science educators feel that specific science instructional objectives would prevent the creative teachers from following a genuine teaching learning process which has been used for several years. As specific instructional objectives have to be derived from a general instructional objective, they doubt if teachers are able to elaborate the general instructional objective exhaustively.

2. Too specific objectives cause problems in making objective type test items. Only one or two test items can be made for measuring the attainment of an objective. For example, given the ionic equilibrium constant of acids, students will be able to determine which one of those acids is the strongest acid.

Teaching-learning Strategy

An important part of a teacher's job is to create a good or effective and efficient learning atmosphere.

A teacher who teaches science as simply purveying large quantities of factual information will not be successful in guiding students to acquire the goal of science education. Science is more than content. Science is an organized body of knowledge consisting of processes, content or products and values. Teaching which does not include all three dimensions of science fails to place science properly.

Some teaching strategies are more effective than others but there is no single strategy which can be stated as the best strategy or the most effective for all the students and for all subject matters. Considering the variety of teaching strategies, it is necessary to select the best strategy for a particular student behaviour.

Research in learning science has repeatedly reported that learning science in secondary school as well as in primary school will be effective only when the student is actively involved in learning.

Problems in science teaching-learning strategies

Almost all science teachers realize that science should be taught both as process and product. Scientific values should also be inherently built in the teaching learning process. But, in practice there are a number of problems which hinder the teachers when selecting and organizing the desired teaching/learning process.

The main problems are:

1. Most teachers complain of an overloaded science curriculum.
2. Most of the senior secondary school science teachers have a university entrance test-oriented way of thinking in presenting their science courses. They do not pay much attention to the process implied in the teaching of science.

Evaluation of student learning in science classrooms

The science teacher needs to perceive evaluation in the broadest context. The teacher should see evaluation as a continuous and an integral part of the whole teaching-learning process - not merely as a method of distinguishing potential scientists or bright students from dull students, but as an effective technique for helping her to improve her teaching and enhance the learning of all students.

a) Steps to be taken to evaluate student progress

1. Identifying the specific behavioural objectives of a particular unit of the science course. The process of evaluation should be directly concerned with the establishment of the objectives.
2. Selecting situations and instruments which are most appropriate for observing and evaluating the extent to which the student has achieved one or more of these behavioural objectives.
3. Determining the achievement of objectives.
4. Recording, analysing and interpreting the test results.

b) Teaching-learning and evaluation

Good science teaching requires a strong evaluative base. A strong evaluative base demands well stated behavioural objectives from which to devise science item tests. Paper and pencil tests alone are not adequate to evaluate all the important results of science instruction. Evaluation through observation on of what and how the science activities should be planned and put into practice. By doing so, student progress in the affective and psychomotor domain can be followed by the teacher.

A good evaluation programme is an evaluation programme by which teacher can determine if the students are developing the skills.

Current activities/Projects in secondary science education in Indonesia

a) Textbook writing project

The aim of the project is to produce textbooks as well as teachers' manuals for Primary School and Secondary School in support of the implementation of the 1975 Curriculum.

b) In-service and On-service Teacher Training Programme for the Improvement of Science and Mathematics Teaching in General Secondary Schools

The in-service teacher training programme provides the opportunities for teachers to make lesson plans or modified unit lessons for the one semester science programme. Then, as a follow-up of the inservice teacher training programme, the participants use the lesson plans in their classrooms. The project instructors then visit the teachers in schools, to help them in solving classroom problems and to audio-tape teachers' lessons for later analysis. The instructors together with the science teachers prepare for the weekly meeting to discuss all kinds of problems and constraints in science classrooms and in laboratories.

c) The Development of Science Materials for the Development School Pilot Project

The Development School Pilot Project is a long term project which is designed to develop a new educational system in Indonesia. The educational system is expected to educate people to be creative, logical in thinking, critical in thinking, intelligent, skilful and other personal traits. The Modular Instructional System as a teaching-learning strategy has been adopted since 1974.

d) Science Education in Elementary School Projects

It is worth noting that there are 3 projects concerned with the improvement of Science Education in Elementary School. These are:

1) Development of Science Equipment Prototype.

A multi purpose Elementary Science Kit has been produced and it is now being distributed to schools.

2) Teaching Science Development Project.

   Emphasis is given on the development of process skills in the science instruction.

3) Cianjin Project.

   This project emphasizes on the improvement of the quality and the mechanism of supervision.

Efforts are being made to link the activities of these projects.

'Developing Open Competence Through Science Education'
by
Hiroshi Shimono, Japan

Main changes in science education which took place in Japan after the Second World War

a) Science education aimed at developing abilities to manage life reasonably (1947-1950). This was done by helping students to:

   1) acquire the abilities to observe, think and treat things scientifically;

   2) obtain knowledge about the scientific principles and their applications;

   3) acquire the attitudes to find out the truth and to create things positively.

b) Science education based on problem-solving methods (1951-1957) The general instructional objectives of science education were to:

   1) develop attitudes for solving positively the problems found in natural phenomena;

   2) improve one's life by managing efficiently family and social life;

   3) make children understand (to a certain degree) the contribution and the role of natural sciences towards modern life so as to understand the necessity of reinforcement of production.

c) From life-centred science to descipline based science (1958-1967). The instructional objectives of science education at elementary school were formulated to:

   1) develop attitudes to be familiar with nature and to learn directly from nature;

   2) develop attitudes and acquire skills to think reasonably and devise and manage on the basis of facts;

   3) understand facts and basic principles of natural science and to develop attitudes to rationalize one's life;

   4) understand the relationship between nature and human life and to develop attitudes to preserve nature;

d) Emphasis on the method and the logic of scientific recognition (1968-1979):

   1) for elementary science the emphasis of science education was on the intellectual behaviour to know nature. The learning contents were categorized into "Living Things and Their Environments"; "Substance and Energy"; and "The Earth and Universe".

   2) for the lower secondary science the focus was on learning scientific method through the process of inquiry and to understand the fundamental concepts of science.

e) The new curriculum (1980) adopted a flexible curriculum development approach.

   The guidelines for improving science education emphasized the development of competence and attitudes to investigate nature; and formulation of basic and fundamental concepts.

In elementary school, emphasis is placed on the direct experiences of natural objects and phenomena and the development of a rich mind to love nature. In lower secondary school, the emphasis is to make pupils understand basically the natural environment and to have a deeper recognition of the relationship between the human being and nature. In the upper secondary school, the emphases are on the development of comprehensive understanding of nature and of attitudes to respect nature.

Present State of Science Education in Japan

a) Learning programme of science

   1) Elementary school: Science education starts in the first grade. Children in grades 3 to 6 study 'Living Things and Their Environment', 'Substance and Energy' and 'The Earth and Universe' systematically. Approximately half of the periods for science at the lower grades in

elementary school and about one third of them at the upper grades in elementary school through lower secondary school are used for practical work and experiments.

2) Lower secondary school: Pupils study the following two areas systematically: 'Matter and phenomena related to substances and energy'; 'Living things and natural objects and phenomena'.

3) Upper secondary school: 'Science I' is required for all students of the first grade. The subject-areas such as 'Science II', 'Physics', 'Chemistry', 'Biology' and 'Earth science' are optional for students.

b) Course of study and textbooks

Several textbooks are published on the basis of the 'Course of Study' and instructional activities are organized in line with these textbooks.

c) Equipment and facilities for science education

The Law for the Promotion of Science Education formulated in 1953 aims at substantial development of equipment and facilities for science and mathematics education and further improvement of science education as a whole. Measures to strengthen in-service training programmes for teachers are included. The Law refers to the financial responsibilities of national and local governments for the promotion of science education.

d) In-service Training at Education Centres

At the Science Education Centre in each prefecture, programmes of in-service training, research, consultation, information services and other activities for school teachers are conducted.

e) Newly-established 'Science I' course for Upper Secondary School

The enrolment ratio in the upper secondary schools has reached 94.0% and the upper secondary school education is regarded more or less as universal education for all the youths aged fifteen to eighteen years, and not restricted to a selected few. Hence the need was felt to develop a science course suitable for all students.

The 'Science I' course aims to provide basic education regarding the natural sciences and to develop a balanced view of nature through the following:

1) Acquisition of basic and fundamental contents;

2) Promotion and development of a comprehensive view of nature;

3) Understanding of the natural environment.

The contents include: (1) Force and Energy; (2) Preparation of Substances and the changes they undergo; (3) Evolution; (4) Balance of the nature; and (5) Nature and Human Beings.

Developing Open Competence through Science Education - Development of Competence and Attitude to Investigate Nature

The 'Course of Study' points out the importance of learning science directly from nature right from the elementary to upper secondary stage. The objectives of lower secondary school science are as follows:

"To make pupils have the competence and attitude to investigate nature through observation and experiments; to make them have deeper understanding of natural objects and phenomena; and to make them recognize the relationship between nature and human beings".

The present is an age of rapid changes in the natural sciences and social situations. In order to adapt to the rapidly changing and progressing age and to contribute to social progress, it is important to acquire competences and attitudes to solve problems, processing appropriately ever increasing information, and to think creatively. These competences and attitudes are considered to be much concerned with 'Open Competence'.

Although these competences and attitudes would be promoted by all educational activities, science education particularly aims at promoting them through investigating activities related to natural objects and phenomena. 'Investigating nature' means to find out problems related to natural objects and phenomena; to find out laws in nature and to have deeper recognition of nature through collection and processing of relevant information. The process of investigation will be different according to the characteristic of object and objectives of investigations. For example, a series of activities to find out problems, to collect information, to process the information, and to draw conclusions will be organized in different order and with varying emphasis, and it is very important in any investigation of nature to develop adequately the order and ways of investigation.

Another aspect involved is 'method and ways' of thinking in the process of investigating nature. This is called 'Method of Science' and often used. It includes observation, experimentation, measurement, recording, data processing, estimation, assumption, reasoning, hypothesis, formation of models, etc. It is most effective to use the method of science when students face its need in the process of investigation. It can be expected that by its frequent use in the process of study, students will develop a deeper understanding and positive attitude for the scientific method. The competences and attitudes can be enhanced by asking students to go through the process of investigation at every possible opportunity in science teaching.

For development of creative competences and attitudes, it is very important to provide opportunities during the study of science for students to devise equipment and their own methods of experiment; to find out new relations among various natural objects and phenomena; and to make a creative solution.

Similarly for the development of proper value judgement, it is necessary to make students have deeper understanding and sensitivity with regards to the significance of nature investigation and implications of development or use of nature for the life of human beings or nature itself.

'Linking Science Curriculum to Rural Environment'

by

B.K. Shrestha, Nepal

Before the advent of the New Education System Plan, the traditional curriculum treated science education basically as a body of knowledge, a vast collection of facts recorded through the years, organized concepts and generalizations and theories. The New Education System, however, conceptualized science education as the basic fundamental of life and work and gave it due place in the school curriculum.

The New Plan, among its other objectives, highlights the broad national goal as: "to produce a cadre of able workers required for every development work of the country through the promotion, preservation, expansion and dissemination of knowledge, science, technical know-how and skills which are necessary for the economic development of the country." The educational objectives designed at the beginning of this Plan focus attention on the importance of inculcating the following qualities among the pupils:

- good moral character
- perseverance
- self-reliance
- creativity

- scientific way of thinking
- the habit of appreciation of the good ideas and feelings of others
- sense of cosmopolitanism.

The present science curriculum therefore takes a much broader view of the process of science education instead of making it merely the key to a professional career or qualification. It emphasizes the broad concepts and generalizations that are relevant to the students' environment and society. As education should be functional and life-oriented, it would not be an exaggeration to say that the new concepts of education and the goals of the National Education System can be effectively materialized through the incorporation of a meaningful component of science education. Hence the science education curriculum in Nepal is aimed at promoting an attitude i.e. a way of looking at the natural and physical environment. Science is as much a way of working as an approach to solving problems. Therefore, the emphasis in science education has been shifted from teacher-centred curriculum where the teacher dominates the whole scene of the teaching/learning processes to the student-centred one where the students carry out most of the activities themselves under the active supervision and guidance of the teacher concerned. To achieve these objectives the science curriculum should be flexible. The present science curriculum in Nepal has been conceived keeping these aspects in view. The curriculum does not remain confined only to the laboratory or classroom, but it also draws the attention of the teachers and students towards their immediate environment so that they could carry out experiments, observe the natural phenomena and find out facts. In order to implement this curriculum, short term training programmes for the teachers, supervisors and specialists concerned have been organized. The major thrusts of these programmes were to enable the educational personnel to link science with environment and the other activities associated with rural development.

'Science Education for the Year 2000'

by

D.F. Hernandez, Philippines

Introduction

It has become fashionable to take the year 2000 as the landmark year for thinking about the future, just as some years ago it was (and still is) usual to think in terms of decades about the trends in a certain field or subject area; thus, we tend to neatly categorize developments in the decades of the 1960's, the 1970's, the 1980's and, so on. This paper is another attempt to look at science education within the time frame of two decades, 1980 to 2000. It is by no means a forecast; rather it attempts to bring out the trends and the issues which may shape the developments of science education in the not so distant future. In many instances the direction it may take will depend very much on political decisions made by the leaders of a country and to some extent by the expressed will of the people. Yet decisions need to be based on knowledge of what is current and the probabilities of what may yet develop. Hence, looking at what science education may be like in the year 2000 could prove useful for the practitioners, the decision makers and others who in some way care about what direction it takes.

Science education interacts with and is influenced by many forces; any discussion of what it will be like in the future would need to consider these various interacting factors. The shape of the future as mentioned earlier will be determined largely by decisions governments take which in turn are dependent on the values of society and hence in some measure on the context and process of education.

The first part of this paper considers factors which impinge on science education and may thus influence the directions it may take. The second part deals more specifically with issues and some general considerations rather than outright predictions about science education. These should give us a peep into science education in the year 2000. Science education here refers to education at the pre-university levels and to teacher education for the corresponding levels.

Scenarios for Science Education in the Year 2000

Before considering science education two decades from now, we need to have a reality framework for the science education developments of the year 2000. We need to know the factors that in some way will affect these developments. The context is Southeast Asia rather than worldwide. The factors to be considered are those that now exist and from which new areas/developments are emerging. The assumption is that developments that may take place, two decades from now are generally already here, if not in Southeast Asia, in other parts of the world. However, the future will see better or more extensive use of some of these developments, greater understanding of others, more applications of still other ideas and so on.

Biological Sciences and Education

Many of the issues of the present and the near future are related to biology: food shortages, nutrition, environmental sanitation, health, environmental degradation, pollution, population control, resource management, conservation; in brief, the direction is in the use of knowledge for the advancement of society, for the benefit it brings to the quality of life. In biology, this approach centers on the realities of human life, the realities of society and alternatives for the future of humankind.

From 1978 to the present, the International Union of Biological Sciences, Commission of Biological Education has concentrated on biological education for community development. Three differences have been identified in this current move compared to conventional biology teaching: (1) biological topics that have implications for the community have greater priority for the school curriculum. Such topics would presumably include health, environment (ecology), nutrition, population genetics, behaviour and biological technologies such as those of agriculture, fisheries and medicine; (2) greater emphasis on human biology; (3) greater emphasis on what might be called issues studies as differentiated from knowledge studies. The former emphasizes problem solving, decision making, while the latter emphasizes understanding. For example, Mendelian inheritance would be a knowledge topic, genetic engineering an issue topic.

An APEID Meeting of biology educators identified aspects of biology education which are crucial for the secondary school curriculum: environmental aspects of biology education, genetic aspects and health, nutrition and agricultural aspects. For each of these major areas, the pertinent specific concepts/principles, practical experiences for students, teaching learning strategies, intellectual skills and values were identified. The result of this meeting provides the interested biology educator and curriculum developer with a specific handbook about topics and strategies that Asian educators believe are urgently needed in the education of the secondary school level adolescent now and in the near future.

On a more general and worldwide level, Dr. Paul DeHart Hurd suggested a context for the teaching of biology in the future. Because it bears upon the subject of this paper, the objectives are briefly summarized below: biology (we can substitute the word 'science' and the following will still apply) as part of a liberal education in the future should:

1. be taught in a social and human context;
2. include values and ethics as goals recognizing that there are moral and aesthetic as well as scientific answers to human problems;
3. have courses organized more according to biosocial events and problems rather than on logic of biological discipline;
4. consist of subject matter that can serve real life and practical ends;

5. be taught from a holistic and integrative point of view;
6. ensure that laboratory investigations include individual and laboratory based problems, issues, policies;
7. encourage development of skills such as decision making, valuing, ecological thinking, (self-reliance, social responsibility, use of indigenous and appropriate technology)*;
8. orient teaching towards the future giving students opportunities to consider alternatives;
9. use more individualized and personalized teaching to accommodate learning systems of different students; and
10. recognize the role of the biology teacher as an interpreter of biology concepts, an intermediary between scientist and the public.

In the area of ecology and the environment there is concern among ecologists for holistic thinking and approach, for more relevant perceptions of ecology which relate it to nationalism and development. Ignacy Sachs of UNEP has provided a concept of eco-development which is very pertinent to current thoughts on this subject among third world countries. Ecodevelopment,he says, is a style of development particularly suited to rural regions of the Third World. It calls for specific solutions to particular problems in the light of cultural, ecological data and long term as well as immediate needs.

Our peep into the future should provide some insights on what some Asian countries, the Philippines included, would like to have realized — an agro-bio-industrial society. This perception calls for a return to the land — but at the same time it does not reject modern technology. The trend in this type of technology is towards miniaturization, more efficient utilization of materials and energy, recycling and use of "cleaner" technologies. Agro-bio industry is an integrated system of production of goods and services which tightly links primary production from agriculture, fishery and forestry with the conversion of the raw materials into complex and more useful products. A few examples of the applications of microbiology are: production of power alcohol; syntheses of antibiotics for medical and agricultural use; syntheses of hormones for medical purposes; the transfer of nitrogen fixing genes to new organisms which associate with non-leguminous plants.

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* Items in parenthesis added by the writer.

The extent to which some of the foregoing developments in the biological sciences will prevail generally in Asian countries will determine to a large extent the inputs that should go into science education assuming the political will is for the schools to serve the same ends as those of the nation.

The Physical Sciences and Education

In the near future we will see a more rational and systematic understanding of the origin and distribution of chemical elements as a result of studies on nuclear reactions that occur naturally or are induced by accelerators. Because of the explorations in space, there will be a better understanding of extraterrestrial conditions which led to the creation of our universe and the elements that comprise it. Many new elements and isotopes will be synthesized. Another area that will likely be advanced is how elements differ and how they can be identified in the presence of each other — analyses may extend to the detection and scaling of single atoms! The future promises to fill in the blanks that exist in our understanding of the origin and reactions of molecules and atoms. Accordingly, it is expected that many conventional positions in chemistry will be revised.

Appraisal studies suggest that in the near future (10 years hence) the main feedstock for petrochemicals and source of energy will still be oil and natural gas. The major nonpetroleum sources for which hoped-for technological developments may break through include coal, shell oil, tar sands, solar energy in the form of biomass; direct heating, photovoltaic technology or hydrogen generation. Nuclear energy is technologically developed, whether or not it is actually used will depend on political decisions and acceptance by the public. The chemical industry will continue to supply essential needs of food, housing, clothing, transportation, drugs, health, recreation and so on — it will become part of many aspects of modern life. The computer will play an important part in analysis of experimental data, technical calculations associated with many aspects of chemical industry. It will become a major research tool, it will run complex chemical processes and produce better products with fewer problems. Environmental concerns will continue to be the focus of the public in relation to the operation of chemical industries.

Chemistry, physics, biology will overlap and interwine increasingly. Biochemists will continue the probe into the chemistry of life. Space explorations may clarify and deepen understanding of space and physical laws.

The rate of change in chemical education is slow — this may not be a bad thing — if education were to reflect all the changes immediately we may end up with an erratic curriculum which shows no direction. However, there is a need for restructuring curricula because pre-professional students are not receiving optional education to prepare them for work in the existing field. Examination of books in chemistry show a preponderance of materials far removed from what the chemists are now doing in research and development.

Chemists, more than any other scientist, are more likely to work in industry. Implications of this trend for curriculum include: increased emphasis on the technical and practical in the curriculum of a chemistry major, incorporation of some chemical engineering courses, more polymer chemistry, statistics, marketing, economics, communication.

Science, Society and Culture

In his article on the cultural impediments to scientific thinking (in Southeast Asia) S.H. Alatas identifies a type of mentality which he calls bebalisma which has the following characteristics: authoritarian, non-reflective, non-experimental, no power of anticipation, non-rational, unenquiring, no love for order in thinking, no capacity for sustained contextual appraisal, credulous beyond limit, lack of refinement, non-cummulative in the succession of thought and no maintenance mentality. These characterize an attitude of the mind that obstructs the development of the scientific and technological spirit necessary to motivate industrialization and effective agricultural planning. Since the third world is suffering from a lack of science and technology and it is the will of most countries to move towards a more scientific society, there is then a need to develop scientific mentality in order to improve the situation.

Another viewpoint stresses that industrialization is itself a cultural concept. "Technology produces goals and demands as well as provides the ways and means (far beyond the 'technical' ones) to attend to them, and prescribes the modes of approach and conduct."

What are some of the changes in values and behaviour patterns that are brought about by industrialization? (1) work attitudes and relationships. Industrialization implies segregation of economic activities from the traditional family community setting; (2) changing patterns of community life. Urbanization is accelerated which in turn affects the life styles of the population and their human interaction patterns. (3) family systems and family relations e.g., widening generation gap between parents and children (4) counter values and popular culture. Industrial technology and innovations usually brings external values, fashions, lifestyles. Loss of culture does not necessarily follow from introduction of industrialization. Changes undergone in Asian countries as a result of the impact of industrialization may fall into four categories according to Alatas: (1) eliminative changes; (2) additive changes; (3) supportive changes; and (4) synthetic changes. It is only the first category of changes that results in loss of culture. The rest enrich the indigenous culture.

For countries with many languages, the importance of language as a medium of instruction is a problem that keeps being raised. Because no books are available in the local language which are of the same quality as internationally accepted textbooks on the same subject, science subjects are taught in English in universities. In the Philippines this is also true at the secondary and elementary levels.

Response of educators to government thrusts for national development has been in the main, in terms of science education projects that address the problems of rural development and disadvantaged areas of the country. Rural development is interpreted as a strategy designed to improve the economic and social life of the masses. Types of learning units prepared by the Science Education Centre, University of the Philippines, in response to national development goals include: those which are occupation oriented, those that improve on indigenuous technology, those that relate to conservation and recycling, those on health, nutrition, sanitation. Even industrialized countries have concerned themselves with making science education more relevant to the real life situation of the students, more practical. This was the theme of a seminar held in 1980 in Malvern, United Kingdom on the theme, Science, Education and Society.

The students

A very important element of educational enterprise are the students in Asian schools. In the Philippines we have 8.2 million elementary school pupils, 2.7 million secondary school students. About 79% of elementary pupils finish grade IV; 66% finish grade VI; 54% reach first year high school and 34% complete secondary level of education (fourth year high school). At tertiary level, 17% enter first year college and 13% complete 4 years of college education. India has about 60 million primary school children and about 50% either drop out or do not proceed beyond the first level of education. The problems related to school enrolment may vary in degree, but more or less most Asian countries would have the problem of accommodating (physically and in terms of the curriculum) a larger number of students for two reasons: the large number of school children already born (population growth rates have decreased but not sufficiently to make a difference in actual school needs), and democratization of admissions at all levels of education.

Broadening the base of admissions (including entry of more women in the three levels of education) will change the nature of the school population. Lessening of the demarcation lines between formal and non-formal education (e.g. the use of equivalency test to enable a student who has dropped out of school to re-enter the formal system at the grade level he qualifies) will further contribute to the heterogeneity of educational needs.

Some of the studies on students have focused on cognitive development, particularly at the first level of education. Similar studies have been conducted on students at the other two levels of education, and even with teachers. Most of the studies at the primary stage of education tend to confirm the findings of Piaget with respect to the sequence but not in terms of the time or age at which a given stage is manifested. Results of studies on the secondary and college levels in the Philippines show that students are mostly concrete thinkers. This has serious implications for the curriculum and instructional methods.

The age structure of the school population may not change much but there will be more school children from the disadvantaged areas and deprived families. Instructional materials and methodologies more appropriate to this group have to be utilized at least during the early years of schooling of this expanded school population. Characteristics of the student population would tend to change depending on the rate of change in the environment, physical, social and psychological.

Future perspectives

Some ideas about science education in the future are dealt with in this section in the context of Southeast Asia, more specifically of the Philippines. As stated earlier these are not predictions but issues and possible developments about which decisions should be made in the future. Science education will not develop by itself; people in decision making positions will have to decide on questions such as those raised in the following paragraphs.

Curriculum development

How much stress should be placed on society's development needs, and the concerns of society in the science curriculum? The first is already a trend at least in some Asian countries. Science topics of the "science and society" type have appeared in modular form. It is not unlikely that new books will incorporate some such topics.

Science taught with humanistic dimensions might be one way of meeting the interests of the large group of non-science oriented students. The teaching of values or a system of beliefs which permeate the entire curriculum (including science) may be a policy decision. Already some countries have incorporated moral education in their school curricula. The question arises, how much or to what extent can science education contribute to this aspect of the curriculum?

Should the science curriculum be developed locally or nationally? Should it be centralized or decentralized? In a small way decentralized curriculum development has been done in one or two regions of the Philippines via preparation of some modules specific to regional needs/interests. This type of grass roots curriculum development enables the teacher to introduce local or community concerns into science education. The community becomes a learning situation or laboratory; learning hopefully becomes more interesting because of the reality of the learning experiences. A national textbook/syllabus is still used however; the community topics are introduced at relevant points. This is just one way of attending to this issue; several others may be developed and tried out.

Should the science curriculum attend to the development of both cognitive and affective dimensions? Much discussion and some research on teaching the logical core and the affective dimensions of concepts have been done, but science curricula have not yet reflected these in the formal curriculum itself. This issue is concommitant with the preceeding one. Including community oriented topics and local problems would increase the perceptual awareness about things around us and correspondingly, the "public" or scientific meanings of concepts as well as their "private" or idiosyncratic meanings will enter into the learning situation.

Should school science education closely reflect what the discipline is all about and what scientists are doing? To teach science according to the structure of the discipline was an important objective of curriculum projects of the 1960's. It may still be considered as an objective but not as a primary objective particularly for students who will not go on to science as a career.

Should science education at the school level be integrated? To what degree should integration be introduced? Will such integration include the social sciences? humanities? other subjects? which ones? In Philippine schools for example, apart from the elementary school science curricula, integrated science is taught at only one level, the first year high school level.

Towards a better science education

What does scientific literacy mean? Could this be defined in terms of competencies for each level of education? If this is done the curriculum could be examined to determine whether or not it provides at each grade level experiences for development of scientific literacy.

Is the curriculum future-oriented? Does it provide for: the development of decision making skills, consideration of alternatives for the future course of human affairs, diversified needs of students?

Does the curriculum reflect what is known about how learning takes place? Is there a match between the cognitive demands of the curriculum and the cognitive levels of the students?

Does the curriculum meet the requirements of the college-bound students as well as the non-science or terminal student?

Does the curriculum include some work on computers? This device will be much used in various if not all fields of science. It is important that students become familiar with computers, if not all students at least special groups of students e.g., those in science high schools should be offered computer courses.

What do we know about factors which contribute to the attitudes adopted by students in helping them learn science, in helping them cross the secondary/tertiary interface, in helping the teachers create an environment for better learning? Results of research on this aspect of learning should feed directly to curriculum developers, teacher educators and classroom teachers so they can be used to improve learning situations.

Teacher Education

The stress on humanism and values will demand use of techniques of teaching which have not been conventionally used in science teaching. For example, in helping students think about the future some techniques have been used successfully but are as yet not commonly known among science teachers: the Delphi technique which involves an intuitive method of organizing and shaping expert forecasts about the future, use of the cross-impact matrix in which students assess the impact of several factors on each other; decision-making techniques like the decision tree which involve the student in analysing alternatives from a sequence of decisions, and so on.

More use of educational technology may become necessary in teacher education. In most teacher education programmes, although hardware like video tape recorders are known or heard about, very few teacher training institutions actually use them. Their use may become necessary as more children enter the schools but at the same time less students opt to go into teaching careers. Other ways of using VTR than for microteaching need to be tried.

Teacher education programmes need more innovation to keep them abreast of requirements of science programmes the teachers are expected to implement.

Improving the quality of teacher preparation by various means has been suggested many times in different international settings. Some of those suggested by Cheong, S.Y. (1980) include: more inquiry oriented learning, more interaction between trainees and tutors, trainees and materials and among trainees themselves; use of training methods that utilize small group instruction and to a lesser extent, individualized instruction, e.g., microteaching, mini courses, audiotutorials. Small group discussions, seminars, direct observation are used to complement laboratory based activities. Several types of teacher education materials have also been produced; but most of these are for the formal system. Software for learning informally and on their own has yet to make an impact on teacher education. However, in Asia, projects for distance learning (via radio and TV) are now ongoing or being initiated.

A review of teacher education developments would be incomplete without mention of one of the best known projects in this field - the Science Teacher Education Project (STEP). In this programme teaching practice becomes a time for inquiring into the job at the same time as it is a time for practising. STEP draws away from a programmed blueprint type of teacher education and relies mainly on a bank of good ideas offering the teacher what is possible at a given time. In doing so, it mirrors the real situation in which teachers teach for it is claimed they rarely manage the ideal planned programme but work on opportunities they have.

In teacher education as in pre-university education there is a cry for a "return to the basics." In this case the basics mean content. There are three positions regarding teaching of content. Some would stress professional education and methodology almost to complete exclusion of content. Others call for content course and the doing away of educational philosophy, psychology, sociology. Still others argue for integration of subject and professional training.

The education of teachers needs to incorporate several experiences which are demanded of teachers once they are in the field. And, their training should be such that they can more easily adapt to changing needs in the field, make decisions about what is suitable for their own situation and accordingly undertake the necessary planning and implementation. There are however some experiences that are too significant to be left out of teacher training programmes altogether. For example, for some years now, science educators have been concerned with rural life and environment. Most of our teachers end up teaching in rural schools. Are they being educated for such environments? Most teacher training institutions are in urban areas; just providing practice teaching in rural schools would hardly meet this need. How could science teachers for example, use the rural environment more in everyday teaching? Another experience teachers need is the integration of various areas of knowledge. This ability is expected of the practising teacher. How much (or how little) of the prospective teacher's courses are integrated so that the teacher really gets a feel of what an integrated course is?

In science and mathematics education it seems particularly necessary that there be constant interaction between practising scientists and practising teachers; or between those in the forefront of knowledge and discoveries and those involved in disseminating knowledge; and university collaboration is necessary in curriculum development (such relationships help keep much trivia out of the books, it assists in developing a sense of inquiry). It is felt that such programmes could best be fashioned and implemented by greater school-university co-operation, i.e., among the schools, Ministry/Department of Education and the University in a given province or region. Teacher education must also be concerned with strategies for acquiring new knowledge, the aim should be not the production of polished practitioners but preparation of beginning professionals who have the capabilities and attitudes for lifelong learnings.

Science Education and the Public

Great progress in science and technology and the great strides made in electronics, computer, astronomy, communication and other areas, make it imperative to find better ways of bridging the gap between science and the marketplace. Too much misinformation and lack of understanding of these advances make decisions a risky process at both the everyday life level and the policy making level.

Projects like England's "Science and Society" which is developed in readable short modules, intended for the formal school system could well be used by adults and youth who are out of school. A more common way of reaching the public is via mass media: newspapers and the television. In some Asian countries the latter is already being used for this purpose. But science programmes, as in the Philippines, are imported and of rather a high level for the masses of the people. It will be necessary to prepare materials for national broadcast choosing topics and level of delivery more appropriate to the present level of the masses of our people. This does not imply that the imported programmes should be stopped — they have an audience which could grow over the years as the people become more familiar with advances in science.

Whose is the responsibility for educating the public in science and mathematics? In some countries like the Philippines there is a government agency given charge of non-formal education. Extension programmes of industries, government and non-government agencies, institutions of higher learning, also contribute to this goal of educating the public. Science education/or teaching centres, science museums, have several advantages which can be put to good use for serving the public. Many of the science modules they prepare can be used for public education purposes. Most have facilities for producing multi-media materials which can be aimed at reaching the masses of the people. Our public education efforts however, have not undergone systematic evaluation apart from subjective statements from participants attesting to the usefulness and enjoyment derived from the programmes.

The Ministry charged with public information may eventually have to assume the task of educating the public on scientific issues which affect everyday life and have implications for society. Issues on land management, fishery rights, displacement of people and entire communities due to building of roads, dams, bridges and atomic energy plants need to be publicly aired, the necessary scientific information needs to be presented, so people can form their own opinions based on accurate information.

In brief, every institution engaged in science education shares to some extent the responsibility for public education through their extension or service programmes or ad hoc activities offered for public consumption. But there seems to be a need for a more systematic way of educating the public particularly on issues that affect everyday life and the society as a whole.

Concluding remarks

What was attempted in this paper was to present a review of current development in science education, some related issues and questions, and some alternatives. From many of the current developments and issues may arise the shape of science education in the year 2000. No attempt was made at comprehensiveness; all that was intended at the outset was to present a paper which could stimulate discussion that could bring out more contributions about what the shape and future of science education will be like two decades from now.

'Designing and Developing Science Curriculum
for New Technological Demands'
by
Jong-Ha Han, Rep. of Korea

Science Curriculum

In the Republic of Korea, primary school provides six years of compulsory education to children between the ages of 6 and 11. Upon completion of elementary education, students aged from 12 to 14 attend middle school, which offers three years of lower secondary education. The high school offers 3 years of upper secondary education to students aged from 15 to 17.

The high schools are generally divided into two streams, academic and vocational. Students entering academic high schools generally pursue higher education after graduation, whereas, those who enter vocational high schools would seek employment.

Since 1968 there has been a rapid increase in the number of middle school students. After the abolishing of middle school entrance examination in 1968, the number of students has doubled in 10 years (1969-1978) and the rate of elementary school students entering middle schools has increased from 58.4% in 1969 to 95.7% in 1980. The same trend of increase is seen in high schools. In 1980, nearly 83% of the middle school graduates entered high school.

Science is taught in primary and middle school as an integrated subject. In high school, science is separated into four fields; physics, chemistry, biology and earth science, out of which two fields may be selected. Three to four hours per week are allotted for science education in primary and middle schools. In high school, each field is allotted two hours per week throughout the year. For students who wish to major in science, all of the four fields of science are the requirement.

The current science curricula were revised in 1973. During the "national reconstration era" (1945-1962), science curriculum was an adjusted version of colonial era curriculum. The first major curriculum revision took place in the decade of 1963-1972. Based on the educational philosophy of life experience initiated by John Dewey, the educational contents were selected and organized according to students' interests and demands. Hence, the curriculum content happened to emphasize rote memorization of facts, rather than developing creativity or scientific thinking.

After the completion of the first revision, the second revision followed during 1973-1974.

The principal guideline for the revision was to steer away from Dewey's life-centred curriculum to a discipline-centred one, which focuses on the structure of scientific knowledge and process skills or enquiry. The movement towards a discipline-centred curriculum also attempted to introduce into the classroom what and how the scientists worked.

The guidelines for the 1973-1974 science curriculum revision stipulated that basic concepts should be emphasized and organized in the form of their interrelationships; science learning should be designed in terms of enquiry processes to help a meaningful understanding of the fundamental structure of science; five conceptual schemes, namely, matter, energy, interaction, change and life be used as content selection criteria. As a result, in the second revision, not much emphasis was placed on the application and effects of science.

Problems and Issues

The eight years of implementation of the 1973-1974 revised science curriculum has brought to focus some problems and challenges.

Firstly, by emphasizing the basic concepts or theories, the science curriculum deals very little with applied fields and topics of practical utility. As a result, the curriculum fails to arouse student interest in science. The critics of curriculum point out that opportunity for understanding the basic concepts by exposure to practical and applied science and thus chances for creative thinking are very limited. In other words, although the students may have understood the basic concepts of science, opportunity to enhance their creative problem-solving ability is very limited, as very little is provided for students to apply their science learning to real life situations and technological advances.

Science teaching which provides the understanding of technology, or its relationship to science, as a goal is yet to find its proper place in the elementary and secondary school curriculum. Many teachers, curriculum designers, teacher educators and evaluators have been feeling that the present system of science education is rather inadequate for preparing students for a fast-growing technological environment and development. They feel that in order to reflect the increasing importance and relevance of technology in our society, there is a need for reappraisal of our educational objectives and educational structures.

With the rapid changes taking place in the Republic of Korea this is not a small problem. The social change in the Republic of Korea for the last 30 years is tremendous. In the 1950's the Republic of Korea was an agricultural-based society with small-size industries largely dependant on manual labour. In the decade of 1960's the Republic of Korea developed into a labour-intensive light industrial nation. From 1970 onward, much effort has gone into developing a framework for highly industrialized society by shifting from the light to heavy and chemical industry. Therefore, in order to facilitate this change, there is a felt need for highly developed scientific technology.

In view of the present development trends, the Republic of Korea is expected to develop into a highly industrialized society by the 1990s. It is predicted that the demand for scientific and technological manpower will reach 5.6 million in 1991, accounting for 1.1% of the total population. This figure includes 500,800 who are college graduates and above, of which high level manpower (holders of the master's degree and degrees above that level) will constitute 10% (50,000). This represents the minimum requirement for manpower at this level to realize the goal of a highly industrialized society.

In such a process of industrialization and rapid economic development, there arises an urgent need to prepare suitably qualified and skilled manpower. The employers want men with the capability to deal with modern technology, an enquiring and creative mind, a good basic understanding of science, and the ability to make decisions. But they are not getting what they want under the current curriculum. Science education has therefore to so orient itself as to contribute considerably towards the current national technological manpower demand. Science teaching should also consider that many of the young boys and girls who are educated now will be the future leaders in the government and the industry. These leaders, whether administrators or managers, must possess sufficient technological-related knowledge and judgement besides the normally necessary personal qualities. Scientific literacy and technology appreciation are essential for them to make wise decisions on matters which require some scientific and technological information. They should be taught to realize both the potential and the limitation of science and technology in its wider social and moral context.

The current curriculum of science unfortunatley overlooks the various problems of social and environmental impact of high industrialized society. Problems resulting from rapid industrialization such as environmental deterioration, pollution of various kinds, destruction of ecology, shortage of natural resources are not much incorporated in the science curriculum. As a result the students are not provided with active involvement in science learning to develop problem-solving skills in such areas.

The current curriculum also fails to give insights into problems inherent in an industrialized society such as dehumanization, or change of traditional ethics and values.

There are also many external constraints of the current curriculum. One of the major ones is the quality of science teachers. The majority of them lack teaching skills to promote and develop a problem-solving ability, creativity and an enquiring mind in the students, even if they have a lot of knowledge. The pre-service programmes for teachers do not, in most cases, offer an opportunity for them to develop such teaching skills. This, in fact, is one of the major factors contributing to the ineffectiveness of the teaching-learning process even after a curriculum revision.

Another impeding factor is insufficient and inadequate laboratory facilities and equipment. In principle the science curriculum is constructed in such a way as to incorporate experiments and practices to master a basic concept. However, the current teaching methods are very much dependent upon teacher's lectures.

Lastly, student evaluation methods being used are not suitable. Since evaluation is dependent only on paper and pencil tests, rote memorization of facts, not problem solving, neither scientific thinking nor creativity is evaluated. In order to improve student learning, developing new evaluation methods and tools is very much needed.

The college entrance examination has a mal-influence upon high school science learning. The examination is a paper and pencil test, and the competitiveness of the examination forces high school students to memorize factual knowledge rather than understand, practice, and apply their science learning. High school students finish school almost without a single experimentation, the main reason may be that weightage given to science subjects is relatively small, compared with other subjects. This uneven reflection of subjects in the college entrance examination tends to influence students not to study science subjects such as physics, or chemistry.

What is more, the majority of students feel that science subjects are too difficult for them to understand. The main reason for this is that the teaching of science is still essentially academically oriented and too abstract in nature. Emphasis is placed on pure science, particularly for the secondary students, with the result that many students have left school lacking an awareness of technology and real understanding of science. More often than not, the students are drilled in memorizing important principles, formulae and facts in a textbook in order to reproduce them like a parrot in the examination. The content and approach are so formal that even good students find science too demanding and difficult to follow.

Among students, science courses have a bad reputation for being difficult. Among the natural science subjects, physics is by far the most unpopular and has a bad image in high schools. Many students at high school avoid taking physics if at all possible.

Moreover, the majority of the students who take physics, chemistry and earth science feel that the subjects are irrelevant to their real life needs. They are not able to relate what they learn in the science classroom with many things they come into contact with in their daily lives. The teachers get so immersed in the fundamentals of science that they lose track of the practical applications. No wonder the students feel that science is remote and coldly theoretical. As a result, science classes lose students' interests and cannot attract even the bright students' attention.

An examination of the curriculum reveals that the physics course is organized for future physicists and the chemistry course for future chemists. However, the majority of the students do not aspire to be either a physicist or a chemist. Their future career may be of wide variety and range from businessmen, politician, writer, artist, historian, social worker...all the way to philosophers.

To this majority physical science's influence upon society, relationship between physics and modern technology, and everyday application of physics concepts are far more important and interesting than pure physics. Whether they become an artist or a politician, knowledge of physics must be helpful to all students. In short, in developing scientific thinking and making philosophical and scientific judgement, major amendments need to be made in the current science curriculum.

Innovative Activities for Science Curriculum Development

By identifying and analysing the problems of the 1973-1974 revised science curriculum, the Korean Educational Development Institute (KEDI) has proposed the following guidelines for curriculum revision.

Guiding Principles of Science Curriculum Revision

1. Select the sequence and scope of the content based on learners' interests and needs.

The earlier practice was that the selection was done purely based on theoretical structure, linkages and internal validity of the discipline. Therefore, the content was not compatible with the interests and ability of the learners. Added to this was the excessive amount of topics covered in a given period. The coupled effect results in reduction of time for experimental work and thus promoting rote memorization.

2. The content of science should be related to real life situations and applied science fields. It also should introduce as many examples of application of basic concepts of science in everyday life as possible.

3. It should strongly emphasize, the need for the conservation of nature, alternative energy exploration search, worldwide food shortage and other problems with which industrialized nations as well as developing ones are confronted today. Up until now these problems were only mentioned in passing. In the future, not only an introduction to the problem but also some guidance as to how to tackle and solve such problems utilizing the multi-disciplinary approach should be incorporated into science curriculum.

4. Consideration must be taken of the sequence and continuity in the science curriculum in terms of the learner's intellectual development from primary and middle to high school levels. In the current curriculum, however, same instances or same topics are taught in different fields and at different school levels without added meaning. For example, the ecology, and its concepts are taught at the same level in the primary and middle school.

5. For the primary and middle school level, science should be presented as an integrated subject matter. There exists a close link and interdependence between science and applied sciences. The interrelationship of physics and chemistry, physics and biology, etc., should be considered while developing primary and middle school curricula. In fact the integration of content by topics or problems would provide a multi-disciplinary approach of physics, chemistry and biology to tackle a problem.

6. For the high school, the science curriculum should consist of four science fields, namely, physics, chemistry, biology and earth science. Each field would be specified at two levels; general or ordinary and advanced. In general or ordinary courses, basic knowledge, history of science, relationship between science and technological development will constitute the major portion. On the other hand advanced courses will concentrate on theoretical aspects and advanced topics.

Elementary Science Curriculum Development

The focus of science curriculum for the primary schools is on arousing childrens interest to promote active pursuit of science learning, and developing positive attitudes and self-confidence. The science curriculum would provide learning activities to enable children to create their own ideas and enjoy themselves in science learning.

Middle School Science Curriculum

More topics related to technology and real life problems are added to basic concepts and laws or principles.

Towards a better science education

There has been a criticism that the discipline-centred curriculum is too dry and too abstract for students. This results in students losing their interest in science. To correct this, applied science and real life problems, such as environmental pollution, conservation of nature, alternative energy resources, have been incorporated in the revised science curriculum for the middle school. The multi-disciplinary approach has also been introduced to solve these problems. In addition, the number of learning units have been reduced to ease the student's work load, which was rather heavy and incompatible with allotted time in the current curriculum.

High School Science Curriculum

For the high schools, science is divided into four fields of physics, chemistry, biology and earth science. As previously mentioned, each field is specified at two levels, general or ordinary and advanced. In general or ordinary courses, curriculum content comprises of basic knowledge, historical development of science, interaction of science and technology development. This course is meant for students who may study humanities or other than science in colleges.

Advanced courses emphasize more theoretical science and advanced topics than ordinary ones. These will be offered to would-be science majors in colleges. Each course contains some problems, including various pollutions caused by technology, energy crisis, nature preservation, etc. Additionally, in the 1981 revision, much emphasis has been placed on the science teaching of vocational high schools. Three or more fields of science will be offered as a requirement, in the revised curriculum, while one or two more science courses will be offered as an elective in current curriculum.

Concluding Remarks

Some major problems which still need attention are:

First of all, the major stumbling block is that many specialists from colleges and universities still insist upon including a body of abstract knowledge in school science curricula and show little or no interest in the applied fields and technology.

As a matter of fact, incorporating technology into the basic science course implies introducing a flavour of creative technology in a school. It means allowing students to get themselves involved in technological activities and projects which include the process of creative problem-solving, decision-making, and finally the actual implementation or construction. In recent years, project work has been increasingly considered by many curriculum specialists to be a very essential and integral part of a school physics or chemistry and technology programme. It is growing in popularity and spreading quickly in schools, especially in the highly industrialized countries. Experience so far has shown that project work can help the students identify and foster many abilities which are normally ignored or not possible in the traditional textbook-centred learning. The everyday technological environment provides a wealth of interesting practical problems for students to tackle. In the process of active participation and investigation, they can acquire invaluable real-life experiences such as identifying a problem, making a decision, designing a solution, applying his knowledge purposefully, and learning new skills, which go a long way to develop competence and creativity.

But such project method does not attract the attention of science curriculum specialists from colleges. Some of them, who are familiar with this method, hesitate to introduce such methods, because there is a dearth of qualified teachers to teach and use them well.

Secondly, the goal of integrated science for primary and middle schools proposed by KEDI was not achieved as much as was expected. Some specialists have negative attitudes toward integration of science because of the current system of pre-service teacher education. That is, teachers have been trained to be physics, chemistry or biology teacher instead of integrated science teachers.

Thirdly, there is a lack of facilities and proper laboratories. Also, crowded classrooms do not allow students to have space enough to conduct laboratory work.

Due to insufficient and inadequate facilities and equipment, only a few schools can provide students with laboratory work and practical tasks suggested by the curriculum. Actually, experiments are not practiced in middle and high schools. Therefore, many teachers even express their dislike towards incorporating many experiments into the curriculum.

These are the most urgent problems to be solved in the country. These problems prevent KEDI from introducing new topics such as project methods in science curriculum revision.

'Using the Environment for Practical Science Experiences - Project Work and Field Centres'

by

W.S. Perera, Sri Lanka

Introduction

The matters presented for discussion in this paper are based on first-hand experiences in formulating and directing the Field Studies Centre Programme from 1979. In this programme students studying science in the senior secondary grades (grades 11 and 12) attend a study camp utilizing the environment for various study projects.

The Field Study Centre Programme

Sri Lanka has already six Field Study Centres under the Field Study Centre programme. This is a field activity programme with the broad objective of exposing pupils and teachers to environmental studies on a first-hand basis. The programme as such was not launched with a neatly defined conceptual basis to achieve well defined objectives. It was thought that a programme such as this, operating in widely different environments and depending on the initiatives of groups of local teachers, should only have a broadly defined conceptual basis for the achievement of some broad objectives. These objectives and the activities through which they are to be achieved are indicated below. It is believed that such a framework will allow the Field Studies Centre Programme to grow and develop without being stifled at birth by a strait-jacket of objectives, specific objectives and other minutia.

Programme Development and Implementation

The conceptual basis of the programme was actually derived inductively. The programme which obtains today is derived historically from two different projects. One was the Field Work Centre project at Thondaimannar, in the Northern Province of Sri Lanka. This was evolved out of a Hydro-Biological Survey concerning the Jaffna lagoon, when a band of young science teachers who participated in the survey decided to continue their association on a permanent basis. The Thondaimannar Field Work Centre grew out of this fortuitious banding of science teachers and it grew up to become a well equipped centre in the late sixties owing to the determined and visionary efforts of this group of teachers. The second influence was the community and productive work-oriented project work programme which was introduced into the senior secondary curriculum in 1976. Under this programme pupils undertook a variety of projects ranging from community health to solar-energy utilization.

The main guidelines for the undertaking of the projects were that they should be:

a) community oriented or have a practical benefit;

b) done by a group of pupils;

c) done over a two year span.

The utilization of the small State Forest reserve in Kegalle, by the Kegalle Secondary school as a science teaching resource was one of the projects. This 25 acre reserve called 'Kurulukelle' (Bird Jungle) is situated right next to the school.

The little work which was done at Kurulukelle indicated the potential an organized adoption of an environmental reserve afforded for an effective science teaching programme. Also when the setting up an environmental science teaching programme utilizing such natural resources began to be considered, the insights obtained by analysing the reasons for the success of the Thondaimanner Field Work Centre became very useful. The particular insight gained concerned how a programme can develop and flourish without much central support. Based on such an analysis the requirements for a Field Studies Centre were decided to be:

a) an interesting natural resource such as a forest, a lagoon or a river bank - to provide the environmental base. The resource should be complex and big enough, to be challenging as well to continue to be a fertile source for a number of studies;

b) a physical resource base with reasonably equipped science laboratories, and residential facilities;

c) an organizational base which can bring together on a permanent basis science teachers and professional scientists.

The last two requirements can be usually met by utilizing a large secondary school with senior secondary laboratory facilities. To meet the first condition the school has to be sited close to the environmental base as was the case of the Kurulukelle Field Studies Centre. With these as the broad framework and the objectives given below the Field Studies Centre Programme was initiated in July 1979, with Kegalle Kurulukelle Centre and the already developed Thondaimanner Field Workd Centre as the first two centres. The programme is directed and financed by the Educational Planning and Research Branch of the Ministry of Education.

Objectives

The broad objectives of the programme are:

a) to provide facilities for the study of the environment on a first-hand basis;

b) to provide opportunities to pupils to work with scientists and experts;

c) to foster wholesome attitudes towards the environment;

d) to provide assistance to specialized agencies such as the National Science Council in the documentation of Sri Lanka's fauna and flora;

e) to provide opportunities for the youth to take a leadership rôle in the conservation of the natural environment and for its utilization as a learning resource.

Performance and Achievements

The network now has the following Centres:

a) The Kurulukele forest reserve Field Study Centre at Kegalle, 80 km from Colombo in operation from August 1979

The 25 acré forest reserve is the environmental base while the physical plant and organizational base is Kegalu Vidyalaya, a large secondary school. A two storeyed laboratory/science museum/ residential block has been obtained already for the centre.

b) The Kaluganga River Field Study Centre at Horana, 40 km from Colombo in operation from September 1979

A Kaluganga River Bank site at Naragala is the environmental base while the organizational base is at Taxila Central College with Sri Palee Central College Horana, functioning as an associate centre. A large room which serves as the laboratory/science museum has been obtained for this centre at Texila Central College.

c) The Ratnapura Peak Wilderness Reserve Field Study Centre

This began operations in 1981 and has the organizational base at Sri Pada Secondary School, Palabaddala, 125 km from Colombo. The Peak Wilderness Reserve is an extensive forest reserve ranging in elevation from 400 to 2000 meters.

d) Ratnapura, Karawita Field Study Centre

This has a forest reserve close to the organization base - Karawita Central College, 125 km from Colombo. Sri Lanka's largest virgin forest reserve, Sinharaja is close to this Centre.

e) The Thondaimanner - Field Work Centre

This centre which has been in existence from 1969 joined the Field Study Centre network in 1979. It is situated in the Jaffna Peninsula 400 km from Colombo and has its environmental resource, the large Thondaimanner lagoon. The centre already has several buildings, including a two-storeyed auditorium-cum-residential block.

f) The Ruhunu - Field Studies Centre

This is situated in the Southern region of Sri Lanka 260 km from Colombo. The organizational base is Deberawewa Senior Secondary School and the environmental base is the bird sanctuary around the irrigation lake at Wirawila and several other irrigation lakes in the vicinity of the school. The Yala National Park is also close to this centre. Work was initiated at this centre on 1 October 1981 with a special camp devoted to the study of solar-energy. At this camp pupils were introduced to several solar energy utilization devices including solar cells. One of the tasks was to find the feasibility of utilizing solar cells to power small reading lamps. (Only 10% of Sri Lanka's homes have electric power and out of the 60 pupils who attended this camp only one came from a home wired for electricity. The incidence of solar energy on 2 October 1981 was 7.4 Kilowatt-hours per square meter as measured by the pupils and they were able to light the classrooms and power a TV set with the power collected during the day).

A laboratory building to be built up as a science museum has been obtained for this centre already.

Trails and study stations have already been developed at the Kurulukelle Forest Reserve, Field Study Centre. Development of Science Museums are already under way at all these centres. The Thondaimanner Centre already has these facilities well developed. These centres have already had some of their activities documented at the Sub-regional Workshop on Innovative Science Curriculum in 1979, under the Asian Programme of Educational Innovation for Development at Unesco, Bangkok. At the national workshops these centres were able to bring together national experts from Universities and research institutions to help curriculum developers and teachers, develop activities for school use. These centres also serve as the pioneering organizations for propagation of the utilization of resource-economic sources of energy such as solar energy, wind energy and bio-mass energy. These centres will also be used as the resource centres for the co-curricular conservation/energy project clubs which will be formed in all the 1500 schools with senior secondary classes in 1982.

'Competency-based Training for Science Teachers'
by
K. Aphornratana, Thailand

The training planned for science teachers in Thailand used to be content-oriented until the establishment of the Institute for the Promotion of Teaching Science and Technology (IPST) by the Ministry of Education in 1968. IPST was authorized to develop mathematics and science curricula for primary and secondary schools. The new curricula were expected to be implemented in 1976, after the trial period.

Since then the subject contents, the teaching and learning techniques, the curriculum materials as well as evaluation methods have been improved and changed. Consequently, it is necessary to conduct in-service training of teachers of all science subjects in order to enable them to teach the new curricula efficiently. Therefore the IPST planned teacher training programmes in parallel with the production of various educational materials.

The teaching technique that is heavily emphasized in the IPST science textbooks is inquiry methods through several activities, i.e., experiments, charts, problem solving, questioning etc. It was decided then that the experiments and demonstrations should be integrated all through the book so that the teachers may be able to conduct the experiments with more confidence, safely and efficiently and use questions properly, in addition to knowing the content well.

Thus IPST's in-service training programme for science teachers emphasizes not only the subject matter but also science process skills and other essential skills as well. The programme provides facilities for the teacher to do experiments and discuss the results in a scientific manner. Accordingly, there is enough evidence to claim that the training is more or less competency-based to a certain extent.

In 1977, another project concerning competency-based training for science teachers was launched. It was aimed at students in teacher training colleges and universities.

The Ministry of University Affairs appointed a group of representatives from faculties of Science and Education of all Universities and from the Teacher Training Department. The project is referred to as the Thai Science Teacher Education Project and its objectives are:

1. carry out research and development in Science and Mathematics Curricula including teaching techniques;
2. identify science and mathematics teachers' competencies;
3. investigate ways and means in order to develop teachers' competencies; and
4. investigate and produce documents and materials for developing science and mathematics teachers' competencies.

In order to achieve the objectives, four working groups of 15 persons each, have been assigned responsibilities for specific areas.

The first group is engaged in research to obtain data for the preparation of science teaching curricula.

The second group is working on science teaching and material production. It is also responsible for the production of printed materials as well as experimental kits and audio-visual aids for developing skills and competencies of science teachers throughout the country.

The third and fourth groups have the same objectives as the first and second group respectively, but their assignment relates to mathematics instead of science.

The second group has already produced fifteen units of instructional packages. Each package consists of instructor's guide, background reading materials, exercises and answers, test items and answers. The packages are:

Nature of Science

Science Concept Formation

Solving Problems by Scientific Method

Questioning Techniques

Behavioural Objectives

Introducing a Lesson

Teaching Science by Inquiry Approach

Lesson Planning

Safety in Laboratories

Science Process Skills

Laboratory Skills

Motivation and Reinforcement in Classrooms

Laboratory Management

Science Equipment Maintenances

Measurement and Evaluation in Science

Out of these, eight package units have been tried in all the Universities. The remaining six package units are in the process of trial and modification. Besides these instructional packages, the second group also produced supplementary reading materials on three topics: Science Curriculum Development, Scientific Attitude Development and Psychology for Teaching and Learning Science.

The fourth group has prepared the following eleven package units:

Mathematics Process Skills

Writing Behavioural Objectives

Evaluation in Mathematics

Mathematics Teaching Methods

Question Asking Skill

Motivation Techniques

Introducing a Lesson

Selecting and Using Mathematics Teaching Aids

Sequencing Instruction

Preparing Instructional Packages

Instructional Planning

After a close study of these projects it was revealed that there might have been a difference in the level of competencies achieved i.e., in the performance. However, the development of competencies for science teachers by IPST style is satisfactory for the present situation. As the assignments are offered to the in-service teachers with several years of teaching experience, their performance evaluation is not included in the projects.

Future Strategies for Science Curriculum Development for Developing Competence and Creativity

by

Rais Ahmed, India

Future strategies can best be discussed when the scope of the task has been defined. Hence the existing as well as the desirable objectives of science education at the secondary level* have to be amplified and a specific meaning attributed to the words 'competence' and 'creativity'.

Role of Secondary Education

It is obvious that secondary education plays a crucial role in the economic and social development of any country. As terminal education for the vast majority of a country's population it has to serve the purpose of preparing people for a great multitude of primary jobs in trade and commerce, agriculture and industry, services and administration, education,culture and research. As a feeder for tertiary and higher levels of professional education it has to meet rigorously high standards implicit in the high developmental ambitions of our people. In societies intent upon self-reliant growth in conditions where science and technology is, and will increasingly be, a compulsive element in all human activity, science education must be one of the essential features of secondary education. Furthermore, the potential of science education in moulding the perception of social and natural forces which shape our destiny, and in encouraging creative work of far reaching significance cannot be denied. In modern times the educational system, in the interests of raising the very quality of education must participate - not only indirectly by supply of manpower, but directly through students and teachers in the developmental activities going on in the society, and in this field science education can and must play a leading role.

In this format it is proposed to take a more detailed look at the problems of structure, content and methodology, as well as defining competence and creativity.

Course Structure and Content

The problem of structure is complicated by the fact that the terminal and feeder functions of secondary education cannot be separated. In some countries there are alternative channels at the secondary level which might seem like a neat way of resolving the issues, but experience tells us that those who opt for the channel which leads to termination of studies at the secondary stage in fact opt for lower grades of employment for the rest of their lives.

* Since that is the level with which we are concerned here.

The issue is partly that students are required to make such a hard choice when they are too young (about 14+), and it is more importantly that by this device society creates an invisible barrier in the path of those who happen to belong to the lower strata of society or who live in rural areas or are first generation learners. In other countries the four or five years of secondary education are divided into two - the secondary followed by a couple of years of higher secondary. Secondary education in this case is common for all and therefore it represents a level which the country considers desirable of achievement by a large number of its citizens. It must then assume the character of general education in which science is a component at par with social science, mathematics and the necessary languages, fine arts and physical education etc. It is widely considered expedient to have either an integrated science course in such cases - or to have an admixture of discipline oriented and interdisciplinary units. Since the purpose of the science courses is not necessarily to lay the foundation of further studies, rather it is to give a well rounded education for intelligent living, it seems that efforts will have to be made continuously for avoiding premature specialized discipline oriented learning.

Where the secondary is common, the structure of higher secondary has to serve a number of purposes - for example as feeder for professional agricultural, medical, or engineering education; again as feeder for undergraduate and postgraduate science education; and as a facility for supporting vocational education which would be terminal. Institutional separation for each category would be not only uneconomical but largely unpractical since students at this stage may choose any stream in their minds but ultimate or actual selection usually comes at the end of higher secondary education. Thus, once again, it is necessary to have a number of science disciplines as part of the curriculum, and each has to be of wide interest and utility. For example it is generally required that the four subjects of physics, chemistry, biology and mathematics be learnt by all who are in the science and associated streams. Since a few other subjects are to be handled, the share of time for each science subject may be about 20% - with the requirement of a broad coverage.

This poses a variety of problems for the course designers: the courses cannot be entirely problem oriented or application oriented since creating a conceptual foundation alone would ensure application of knowledge at later stages of professional education; the courses cannot be entirely in accordance with the conceptual framework needed for a systematic study of each subject which would come after the higher secondary stage since those for whom each subject is merely supportive of a general understanding of science required for the eventual profession will lose interest and such a self-contained framework is not even feasible; the courses cannot be so wide as to take in modern developments of which now every citizen becomes aware through radio, television or newspapers, yet they cannot expect a student to be oblivious of current knowledge and merely concentrate on basics. There has been some movement for interdisciplinary or even integrated courses at this level - but the question is still open and all alternatives, from integration to various kinds of interlinking of units and even separate broad disciplines ought to be discussed so that each country may make a choice according to the perceived needs of its people.

Curriculum and the Present Interpretation

Beyond the interplay of structure and content lie the real complexities of the curriculum, some arising from the dynamic relation between the components of the curriculum and the other from our roots in our tradition and culture in relation to education.

One can, perhaps without much disagreement, describe five components of a science curriculum as:

- content or syllabus (theory)
- experimental work
- methods of interaction
- appropriate evaluation
- total learning environment

If a variety of educational objectives such as cognitive, affective and skill development are to be achieved then it is obvious that the five components must mutually reinforce or harmonise in the pursuit of these objectives although some particular objective may be served more effectively by some particular component of the curriculum. In the system which we have put in operation, firstly we have, almost completely, left out the affective domain - perhaps because character, attitudes, moral and value judgements etc. were wrongly seen to be associated exclusively with religious education. Secondly, cognitive development was equated with transmission of knowledge to the student, which in turn became 'pouring' of information in the 'empty vessels' which symbolized students. The natural method is then the lecture, accompanied by the book - the competence to be primarily encouraged became memory, tested by a terminal examination. Similarly skill development was reduced from its scope of a wide variety of personal and social skills to the competence of performing set manual tasks* in contrived situations.

* the word 'experiments' has been avoided because it connotes a certain openness with regard to outcomes.

This may appear to be too harsh a judgement regarding the prevalent system - and there certainly are exceptions as well as numerous efforts in which new ground is being broken. But if change or innovation is to be encouraged, the starting point must be a truthful description of what is, by and large, the reality. However, this reality has its historical roots since we are not far removed from the period of abysmal popular ignorance capped by 'education' of a select few, and education starting as religious instruction resulting in memorization of our very holy books.

Curriculum and Future Perspective

In the case of science education the chasm between the postulated objectives and processes and the practiced aims and techniques is wider because science is not merely knowledge, it is an outlook as well as a method, by which an individual may guide his action and create new knowledge. The central problem of science education is, therefore, to move away from the mere 'mastery of facts' to the broader horizons of intellectual development accompanied by personality traits and skills conducive to the optimization of individuals who would be creative by themselves and constructive towards social change. This may sound like a tall order, but it is perfectly feasible in a good programme of school education. In fact, even in preindustrial society, the elite got almost this kind of education.

Let us first examine the question of knowledge as a part of cognitive development. At the higher secondary stage, knowledge of basic facts and theories such as is required to understand the framework and scope of the discipline has to be provided. Here the 'broader horizons' would mean: (a) the ramification of the discipline with other disciplines which are included in the course, and beyond that (b) the implications of the subject matter of this discipline to socio-economic and/or cultural problems and development. In the narrow sense one may interpret (b) as applications of the discipline - but what is meant here is more than that, it is the role of the discipline in solving our problems of today and also our long range problems - which includes some discussion of how scientific solutions are sometimes available, but other circumstances and restraints prevent taking full advantage of existing scientific knowledge. Two common questions - namely how rigorous our treatement of the discipline should be, and how far can we be up-to-date - are quite simply answered in the broader horizons description. Rigorousness should be attempted, but not at the cost of a view that emphasises significance of knowledge to human and social development; rigorousness is inward looking - where the concern is with the logic and concepts of a subject - what is suggested here is an outward look which contributes more to the cognition of reality. Similarly, rigorousness may lead to stress on well-established concepts of the subject, leaving aside the frontier areas where knowledge is less sure nevertheless it has far reaching significance, is a subject of ongoing debate, and contributes to the making of scientific and technological choices which may affect the future of society. Discussions on energy, or environment, or new sources of food, or nuclear and chemical weapons etc. are simple examples. In other words we cannot afford to ignore what is going on now in the various disciplines to the extent that it already makes news and is taken notice of by even the proverbial common man.

Acquiring Knowledge

A second point which is extremely important is that the school must provide the student an opportunity to gather knowledge - in a realistic manner, that is in a manner in which knowledge is actually gathered in life. Thus a lecture by the teacher should not be presumed to be the only source of knowledge - and giving knowledge should be far less important than allowing a student, through foresight and good planning, opportunities to learn for himself. The programme of 'teaching' each subject should be so designed that a student is required to learn, at least some part of what he is supposed to learn, through direct access to books and magazines - and some through his own experimentation/exploration or observation. What is being suggested is emphasis on what may be called prelimaries of research through projects, data collection or any other kind of field work etc. Furthermore, the programme must also be designed to provide two other sources of knowledge, namely opportunities of discussion with fellow students and teachers and of reflection - which may lead to synthesis and creative presentation of a student's own ideas.

Scientific Method

Science education is in a position to make a unique contribution to education by making it possible for students to imbibe the scientific methods, which would enable them to effectively tackle numerous social and personal problems, and which would create in them a sense of optimism and high aspiration. In other words science education is capable of making an impact on the affective domain such as hardly anything else can, and this potential should be utilized to the full.

Firstly, facts and theories could be presented in a social and historical context so as to bring out the fact that scientific methods of enquiry are a potent means of acquiring knowledge that human problems can be understood and solved in terms of new knowledge, and that at any time such knowledge is the closest approximation to truth at that time. It could be brought out that the spirit of enquiry and acceptance of the right to question are central to the entire achievement of science. A habit not to take things for granted, no matter from what source they come, unless they can be explained and understood has led science to scatter ignorance from wide areas, and to cut across much of superstition and obscurantism. Science education could also strongly establish the notion that change is the law of life, therefore on the one side it could lead to openness and flexibility - as opposed to dogmatism and rigidity, and on the other side to a motivation for change and therefore the cultivation of an individual who could effectively participate in designing or planning and bringing about social change. If scientific method promotes a rational and an objective outlook by the same measure it could lead to lack of prejudice, tolerance of difference - racial, cultural or religious, and appreciation and enjoyment of cultures other than ones own. Hence it could promote national integration, as well as egalitarian, secular and democratic values.

In the affective domain, just as making the scientific method a habit of thought (or acquiring a 'scientific temper') encourages positive personality features, it also helps develop those personality traits which are identified to be significant in human creativity. These are for example independent thinking, self reliance and hence boldness to take the consequences of ones actions, and lack of inhibition in breaking from the traditional and popularly accepted ideas or beliefs or even modes of conduct. Flexibility in thought and action, fluency of ideas and expression, and a feeling of high aspiration provide a person with the right personality ingredients to be creative.

It is seen that broader intellectual development, or cultivation of positive personality elements are not always - and perhaps not so much, a matter of the content of a course as it is of the processes of implementation*. It is the same thing with the

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* The point that broader intellectual development, awareness of social implications of science and cultivation of a scientific attitude of mind need not always be brought about through introducing separate topics in the content has been made repeatedly. The teacher should have the ability to handle some of this through his interactions in lectures or seminars etc. For example, in the course of teaching electromagnetic induction (whose importance in social transformation through generation of power, communications etc. should in any case be underlined) it would be noted that a series of discoveries in this connection were made around 1820-1830 - the question can be raised as to why all the persons named are Europeans, what was happening in, say, India, why we were unaware of such great discoveries which were likely to change society - around that time we were insisting on translation of books in Persian, Arabic or Sanskrit, and then came Macaulay's minute for English as the medium of instruction - what were the effects, and so on. Numerous topics - say on nuclear energy and weapons - the debates and dangers - could be dealt with so as to bring about broader benefits.

cultivation of broader skills, particularly social skills of democratic operation; ability to organise and take work from others and to co-operate in teamwork, to be able to suppress ones own private interests for that which is good for all, and above all to take criticism and criticise others in a spirit of reform and redress. The various kinds of tutorials and forums of discussion, as well as the informality of guiding field work - particularly work in the community could be designed to lead to interactions between teachers and students which bring 'personally creative and socially constructive' ideas into focus - and take a student much beyond the book or the lecture in forming his personality through his own endeavour.

Learning Environment

The importance of total learning environment may be seen from the fact that well-known studies have shown the school to be a minor contributor in student learning. In fact IEA* studies gave a very low and sometimes insignificant correlation between student achievement and purely pedagogical variables such as teacher competence, number of hours at school, amount of homework etc., but consistently higher correlations with socio-economic background of students - which implies a contribution to learning made by the home and societal factors. It is possible to conjecture that this kind of result is natural when the school concentrates too narrowly on the knowledge-memory factor and leaves out broad, mutually reinforcing cognitive and affective areas to be taken care of by the environment in which a student functions. It is also possible, in fact more likely, that the purely economic factor is not so important as the related cultural factors - the interest of parents in books, the supervision of a child's study by parents, the quality of conversation in the circle of friends, the psychological reward (by family esteem) of any significant success, the expressional opportunities provided in the home etc. Thus, raising the cultural level of the school (in which we may include the quality of thought required in performance of prescribed assignments, stimulation of extra-curricular activities particularly creative activities, fostering of high regards for scholarship and social service etc.) and that of the community should be a direct concern of the school. Fortunately, student participation in activities directed towards cultural and even socio-economic development of the community could serve a dual purpose - a service to the community by those who can help in a variety of ways, and a gain for the quality of education. A point not to be lost sight of is that higher secondary students are in a very sensitive stage of their emotional and ideational development. Sixteen to eighteen

* International Association for Evaluation of Educational Achievement (IEA) has conducted studies in various subjects spanning over a number of countries. The result quoted here is well known and supported by the evidence of success of students from well off families in many countries

year olds are coming to the threshold of a distinct personality of which world-outlook (or ambitions and ideals) are an integral part. They know a lot of separate things from study, experience and perception and they are usually groping to tie the loose ends in a consistent philosophy of life. Therefore exposure to open discussions regarding socio-scientific problems, as well as exposure to first hand experience in connection with field work, cultural and developmental activities in the community would provide just the right kind of atmosphere for a student to frame his own philosophy of life - which would not be an indoctrinated philosophy (because the entire scientific approach teaches independence of judgement), but a self generated (and therefore more likely to be practiced) system of thought as a guide to action.

Competence, Creativity, Evaluation

The elements of a science education programme at the higher secondary level have been sketched and although the task of implementing such a programme is complex, it is shown to be quite practicable. The complexity is due to the very fact that education is required to bring about wide ranging change in human capability and behaviour. If we narrow down the aims to simply enable a person to know the inner world of a few disciplines, we are likely to have a simpler dispensation but both man and society will gain only a fraction of what is possible, and it might even increase our problems.

In the design which is being suggested, there would be some difficulty in listing the components of competence because this word is traditionally applied in situations where limited cognitive development is aimed at. The present definition is also related to evaluation because there is a tendency to leave out or underplay that which cannot be examined in a traditional manner. Therefore while we single out a spectrum of capabilities which the system should strive to cultivate in the students, we should also accept the fact that a wide-ranging modification in the system of evaluation is implicit. This should involve not just paper and pencil tests during the sessional but other forms of evaluation appropriate to the objectives being pursued. Broader awareness, for example, would involve on the one hand wider reading (for which library facilities should be provided and more than that, books should be prepared on suitable topics in the language of instruction) and participation in tutorials, seminars, and school debates etc., and on the other grading of student product in an objective manner. The ability to acquire knowledge on his own can be both developed and assessed through a variety of tasks which involve small projects, field work, library assignments etc. culminating in suitable reports. Initiative, imagination, flexibility, organizing and planning ability of experimental or theoretical work are elements of creativity which again are cultivated by performance of tasks and evaluated through teacher observation and end-product grading. On the affective side too the growth and development of a student can be graded by well known techniques.

Future Strategies

If the tasks crucial for implementing a reformed science education are to be listed, they are:

1) A discussion of the scope, purpose and structure of secondary education including exchange of experience between countries.

2) A series of national and international discussions and seminars on the nature of science education at the secondary stage (If a change is to be made, thought must be given and opinion ~~allowed to~~ gather force).

3) In the framework of 1 and 2 above - or coming after some clarity is achieved and opinion mobilized, workshops on curriculum design to achieve the broad objectives. In this connection some groups may be assisted in drawing up details of how each subject may be handled from the point of view of content and methodology.

4) Seminars on evaluation in the new system which would pose numerous problems of validity, and public acceptance.

5) Seminars on the development of materials - books, audio visual aids (which could be very useful to serve the broader purposes if they are not just technical films and the like) and techniques of conducting tutorials, field studies, open-ended experimental procedures, seminars etc., as main means of implementing the ideas.

6) Seminars on management of the new programmes of science education, including management of community oriented activities with the help of government machinery, public participation and voluntary organizations.

7) Workshops on preparation of materials aimed at cultivating a scientific attitude in the public at large (these are also not just technical or information materials - but largely materials reflecting the application of the method and outlook of science to a number of social and cultural problems). In this connection too assistance may be provided to groups willing to and capable of producing various kinds of software.

8) Seminars on the overall school design with such innovative systems - so that some schools may experiment with such an approach to science education.

9) A new kind of teacher training programme has to be evolved through workshops, and instructional materials produced.