CHAPTER I

INTRODUCTION

Educational and National Objectives

Educational aims have been analysed in the last century and earlier, largely around universal, and to a great extent abstract concepts like character, personality, harmonious development, individuality, citizenship and the like. National objectives with a lot of focus upon the political, economic and social aspects have loomed large in discussions on educational planning and projects in the present century, especially during the second half. The two world wars have contributed much to the national consciousness, not only from the point of view of protecting the nation from assaults from without, but also from that of releasing and harnessing the internal potentials.

But national traditions and sentiments have to meet the challenge posed by modernity and international
relations. This calls for an all-out effort to tap the economic and human resources and potential of the nation, articulate the social relations among the different social groups within the nation, particularly in the wake of the increased geographical mobility, including even forced displacements, and efficient and ever-improving communication system, which has served to transport, inform and awaken.

The problem is even more crucial for nations which have newly become independent, which have been dismembered from a larger whole, which have been formed through newer mergers. India emerged as a free nation by about the close of the first half of the twentieth century and became a sovereign republic in the middle of the century. Attaining freedom is not merely a question of changing the horses which pull the chariot, or even changing the driver. The external conditions of being allowed to manage one's own affairs implies the development of internal conditions under which such management could be done in an enlightened, participant, just manner. In a country under foreign yoke for over a century, and under internal exploitative forces such as feudalism, discriminant caste etc., much longer, the task of nation-building is an
educational task which has to continue side by side with 
independent political governance.

Side by side with negative and exploitative forces, 
there have been positive and progressive factors both in 
traditional culture and in modern times which have spelt 
the hope that these problems are solvable largely with 
endogenous resources. But the reconstructive tasks 
facing the nation are gigantic. The best of traditional 
culture has to be preserved, sometimes revived and re-
constructed with a futuristic vision. The divisive, 
exploitative and reactionary forces have to be identified 
and controlled largely through a process of re-education 
(It is the residuum which cannot be thus handled educatively 
that has to be tackled politically and in the last resort, 
by force. In the democratic process, these forces them-
selves will play an important role in shaping both the 
educational and political mechanisms developed to handle 
them). The sections which have been exploited, suppressed 
and denied an education need to be given compensatory as 
well as forward-looking education. At the same time 
adaptations need to be made with reference to the challenge 
posed up modernization and the accompanying fast changes 
on a global plane.
Since independence (and over a period preceding it) these problems have been dealt with on the political, economic, social and educational fronts. This investigation is concerned primarily with the educational aspect, though the concept of modernisation built into the area of study would necessitate at least an elementary analysis of the other aspects. Among the major Educational Reports which have been produced after Independence, viz., The University Commission Report (1948), The Secondary Education Commission Report (1955), The Education Commission Report (1964-'66) and the New Education Policy Document (1986), the present investigation has been conducted largely under the ethos of the Education Commission Report. But the later document (1986) has not invalidated the analysis and framework on the basis of which the study is conducted, though some differential emphasis has been placed in NEP on aspects like Model School and culminating emphasis placed on Human Resource Development and Distance education.

Along with analysing some problems relating to national development such as economic growth and full employment, social and national integration, political
development, and social, moral and spiritual values, the Education Commission\(^1\) identifies education as the main instrument of change and highlights the importance of the development of human resources. It illustrates the point with apt examples:

There can be no hope of making the country self-sufficient in food unless the farmer himself is moved out of his age-long conservatism through a science-based education, becomes interested in experimentation and is ready to adopt techniques that increase yields ... The skilled man power needed for the relevant research and its systematic applications in agriculture, industry and other sections of life can only come from a development of scientific and technological education. Similarly, economic growth is not merely a matter of physical resources or of training skilled workers; it needs the education of the whole population in new ways of life, thought, and work.

This direct link between education, national development and prosperity emphasised by the Commission leads to the vision of an educational revolution. Education has to be related to the life, needs and aspirations of the people. One major thrust in the Education Commission Report is the close relation between education and productivity.

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This link is expected to be forged through the following high priority programmes:

Science as a basic component of education and culture;
Work experience as an integral part of general education;
Vocationalization of education, especially at the secondary school level, to meet the needs of industry, agriculture and trade; and
Improvement of scientific and technological education and research at the University stage with special emphasis on agriculture and allied sciences. ¹

The further elaboration of the culture of science and its relation to the quality of science teaching is significant:

The quality of science teaching has also to be raised considerably so as to achieve its proper objectives and purposes, namely, to promote an ever-deepening understanding of basic principles, to develop problem-solving, analytical skills and the ability to apply them to problems of the material environment and living and to promote the spirit of enquiry and experimentation. Only then can a scientific outlook become part of our way of life and culture. ²

It is interesting that within the last twenty years scientific culture has come in centrally in a discussion of Education and National objectives, instead of merely being treated as a means.

¹. Ibid., p. 6.
². Ibid., p. 7.
Education and Modernization

The linking of education with modernization is also one of the key themes in the Commission's discussion on education and national objectives. It is taken up for discussion here under a separate head since 'modernization' is one of the crucial terms in the topic under study. It is very difficult to carry on a discussion of modernization without 'Science' entering it at every turn.

Modernity is defined by Smith¹ in the following words:

"To be modern, ... it means to live in the environment that one's society has deliberately chosen to construct ... and this is what science makes available, the power and knowledge to be effectual, to determine results, to control change. The knowledge of what is possible ... and the technique of implementing these, this is modernity."

The Education Commission says that "the most distinctive feature of a modern society, in contrast with a traditional one, is in its adoption of a science-based technology."² Modernization extends its impact on educational reconstruction in several ways.

In a modern society the stock of knowledge is far greater and the pace of its growth is infinitely greater than in a traditional society. In this situation the concept of knowledge as something to be received passively and to be learnt 'by heart' and retained will not be appropriate. Such a 'storing' concept of knowledge would be meaningless when the store-house itself is continuously changing, a view indicated in the popular phrase 'explosion of knowledge'. Only the concept of knowledge as something to be actively discovered and a corresponding orientation of methods of learning and teaching would be consistent with modernity.

Social change takes place today at a quick, almost breath-taking rate. A static and conservative educational system in this situation can be harmful and even disastrous. "An educational system which does not continually renovate itself becomes out of date and hampers progress because it tends to create a lag between its operative purposes and standards and the new imperatives of development, both in quality and in quantity."¹ The aim of education itself now changes - from that of imparting of knowledge or the preparation of finished product to that of "the awakening of curiosity, the

¹. Ibid., p.18.
development of proper interests, attitudes and values and the building up of such essential skills as independent study and the capacity to think and judge for oneself without which it is not possible to become a responsible member of a democratic society." ¹

The changes associated with the modernization process disturb the traditional equilibrium maintained for centuries. Attempts to create a new social order trigger off a host of unexpected problems - social, economic, cultural and political. But tinkering with the problems with faltering steps, in a half-hearted manner, without faith, conviction and commitment can lead to a new situation which is worse than the old. "The only solution to these transitional problems is to move rapidly forward and create a new equilibrium, based on the full implications of the process of modernization." ²

Modernization and educational progress are closely related. The surest way to modernize quickly is to spread a type of education which would help people to respond appropriately to the new challenges of national reconstruction, to increase the base of education, to ensure that the intelligentsia are drawn from all strata

1. Ibid., p.19.
2. Ibid., p.18.
of the population. "To achieve this, greater emphasis must be placed ... on vocational subjects, science education and research."\(^1\)

But the Commission makes it clear that modernization does not negate moral and spiritual values or self-discipline. Modernization could create an economy of plenty which could offer to every individual "a larger way of life and a wider variety of choices."\(^2\) A well-conceived system of value education is all the more needed in such a situation.

The Nature of Science

The importance of science in relation to modernization and in relation to the national objectives has been brought out already. It would be of interest to analyse in brief the nature of modern science.

"Science", according to Einstein,\(^3\) "is the attempt to make the chaotic diversity of our sense-experience

\(^1\) Ibid., p.19.
\(^2\) Ibid., p.19.
correspond to a logically uniform system of thought ... the resulting co-ordination is unique and convincing."

Dampier\(^1\) defines science as "ordered knowledge of natural phenomena and the rational study of relations between the concepts in which these phenomena are expressed."

Science is defined in the Science Manpower Project as a "cumulative and endless series of empirical observations which result in the formation of concepts and theories, with both concepts and theories being subject to modification in the light of further empirical observation. Thus science is both a body of knowledge and the process of acquiring and refining knowledge, and one of its principal characteristics is its dynamic nature."\(^2\)

Wigner\(^3\) defines 'our science' as 'our store of knowledge of natural phenomena ... science is an edifice, not a pile of bricks, valuable as such a pile might be.'

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Science has a human side also: "Science is a human enterprise including the ongoing process of seeking explanations and understandings of the natural world, and also includes that which the process produces - man's store house of knowledge and one of its principal characteristics is its dynamic nature."  

Bronowsky² says, "Science is not a mechanism but a human progress."

Bridgman,³ the reputed Nobel Prize Winner in Physics says, "Science is nothing more than doing one's damndest with one's mind, no holds barred". In short, "Science is what scientist do, and there are as many scientific methods as there are individual scientists."  

Science is becoming more and more abstract. Modern physics and mathematics make altogether novel demands on abstraction and conceptualization of nature. Speaking about recent developments in theoretical physics, Dirac⁴ says:

Her (Nature's) fundamental laws do not govern the world as it appears in our mental picture in a direct way, but instead they control a substratum of which we cannot form a mental picture without introducing irrelevancies... This state of affairs is very satisfactory from a philosophical point of view, as implying an increasing recognition of the part played by the observer in himself introducing the regulations that appear in his observations, and a lack arbitrariness in the ways of nature, but it makes things less easy for the learner of physics. Like the fundamental concepts (e.g., proximity, identity) which every one must learn on his arrival into the world, the newer concepts of physics can be mastered only by long familiarity with their properties and uses.

The Nature of Science Education

The citation from Dirac on the highly abstract and conceptual nature of modern science and the necessity for picking these concepts naturally through 'long familiarity' implies "the need from the earliest stage of science education for a proper understanding of the basic principles and the process of scientific abstraction and creative thinking."¹

This has created a revolutionary change in the nature of science education. The old concepts of science teaching have become completely outdated and an entirely new ethos and approach to science in schools has come into existence.

¹. Ibid., p.397.
Writing about the spirit of modern science, Anderson \(^1\) says, "Science is more than content; Science is a neatly interwoven scheme consisting of content, process and values. Teaching which does not emphasize all three dimensions of science fails to place it in its proper perspective and fails to represent science honestly."

Rogers \(^2\) analyses the task of modern science education in a multifaceted context:

Science is the intellectual nursery for the next generation of scientist and technologist. Technology like the mule is strong and clever, but cannot breed its own generation ... Therefore all through, for non-scientists, scientists, technicians and technologist, our duty in school days is to teach science for understanding ... We need technical people with scientific training so that we can live in the scientific age. School is responsible for the good name of science ... and so it should provide a well understood preparation, a basis of knowledge and attitude.

While on the one hand science is becoming increasingly abstract and conceptual, it is also becoming increasingly democratic, humanistic and is becoming a powerful social force.


Science is today on a plane of high significance and importance. It is no longer, if indeed it ever was, a mysterious and occult hocus pocus to be known only to a few. It touches, influences and moulds the lives of everything. Science teachers have a great opportunity and responsibility to make a large contribution to the welfare and advancement of humanity. The intellectual aspects of this responsibility are at least coequal in importance with the material. Science is a great social force as well as a method of investigation. The understanding and acceptance of facts and this point of view and their implementation in practice will more than anything else, make science teaching what it can and should be. 1

To match the democratic perspective of science indicated above, there developed in the 1960s a kind of accessibility to the children of all citizens of abstract and conceptual science, in a form which they could understand, or at least a realization of the possibility. The Soviet Sputnik 'illumined the intellectual sky' of America and showed that the ordinary Soviet pupil could learn in ten years a level of Science and Mathematics which was reserved only for the 'gifted' minority in American and British schools — in twelve years. Psychologists and science educators like Bruner and Schwab could not reconcile themselves to the view that the average American should be inferior in educational potentiality or attainment to the average Soviet child. But they did not stop with merely smarting on

losing the curricular race to the Soviets. The Woods Hole Conference was held (September 1959) in which some thirty-five scientists, scholars and educators met to examine anew the nature of teaching methods and curricula in schools and to explore new approaches. While reserving a detailed summary of the results to the next chapter, it would be appropriate at this stage to present one or two statements of the chief spokesman of the group, Jerome Bruner. The optimum conditions of 'learning to learn', rekindling of the interest of the psychologists in curricular problems relating to complex knowledge, the centrality in learning of the structure of a subject (rather than the facts and techniques), and the importance of intuitive as well as analytical thinking in school were some of key issues explored in the conference.1

Bruner's famous credos that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development,"2 that "intellectual activity is anywhere the same, whether at the frontier of knowledge or in a third grade classroom,"3 that "it is possible to present the fundamental structure of a discipline

2. Ibid., p.33.
in such a way as to preserve some of the exciting sequences that lead a student to discover for himself,"\(^1\) that "the curriculum of a subject should be determined by the most fundamental understanding that can be achieved of the underlying principles that give structure to that subject,"\(^2\) have provided the base for many groups which have developed innovative and discovery approaches in school science education. Many others have also given similar leads in science education. The Nuffield teams in the U.K. using Piagetian approaches have several features in common with Brunerian approaches. Other exponents like Ausubel and Novak take positions different from the Brunerians and Piagetians. But in spite of the differences in point of view among different experts there has emerged certain common features in science education presenting abstract conceptual materials at the school stage. The differences are largely in the relative importance of verbal and discovery learning, the type of sequences, teaching styles etc.\(^3\)

\(^1\) Ibid., p.20.
\(^2\) Ibid., p.31.
The Education Commission, headed by the eminent Scientist Dr. D.S. Kothari exhibited a high sensitivity to science education in Indian schools and colleges. It says:

During the last few decades, the conceptual framework of physics has undergone a drastic change and this should be reflected in the high school physics curriculum. Similarly in Chemistry, the stress hitherto laid on memorisation of facts, formulae, processes and compounds should give place to an emphasis on the unifying concepts in the subject. It is necessary to highlight the application of chemistry in industry and daily life and its growing importance in our developing economy.¹

The Education Commission has emphasized environmental approaches at the lower primary education, but at the higher primary stage it recommends that “the emphasis may shift to the acquisition of knowledge together with the ability to think logically, to draw conclusions and to make decisions at a higher level. Science should now be taught as physics, chemistry, biology, geology and astronomy.”² The allocation of subjects among the classes V to VII suggested by the Commission was probably influenced by the Soviet practice, (whereas the earlier discussions seem to be based on the Western reaction to the sputnik stimulus).

2. Ibid., p.198.
Class V: Physics, Geology, Biology
Class VI: Physics, Chemistry, Biology
Class VII: Physics, Biology, Chemistry, Astronomy

The Commission declares:

The general science approach to the teaching of science which has been widely adopted at the elementary stage during the last ten years has not proved successful as it tends to make science appear somewhat formless and without structure and runs counter to its methodology. A disciplinary approach to science learning would, it is felt, be more effective in providing the necessary scientific base to young people. The introduction of astronomy is specially commended, as it plays an important part in imparting good science education and in developing a rational outlook.¹

While the general theory of science education presented in the Education Commission Report appears as ambitious in terms of subject discipline as the Soviet syllabi, the Commission recommends that at the Secondary stage the courses should build on the introductory courses at the earlier stage and "cover wider areas and go deeper into the content than before."²

Under Methods of Teaching Science and Mathematics, the Commission has underlined the importance of skill

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1. Ibid., p.198.
2. Ibid., p.198.
required for analysing and solving problems on the basis of scientific principles and data, the spirit of scientific inquiry, the preparation of textual and instructional material which emphasize the investigatory approach from the very beginning, close connection between science and agriculture and industry the use of 'home technology' in teaching.¹ A lot of work was conducted, particularly in the mid 1960s on the auspices of both UGC and NCERT. If the activities conducted in Summer Institutes and in the curricular teams of this period had diffused widely in the country, a genuine science education ethos should have developed in the country.

The Nature of Chemistry and Chemistry Education

In a system where general science or integrated science prevails in the school curriculum, the general science education theory should provide sufficient guidance for policy and practice. But since a disciplinary approach had been recommended by the Commission a certain amount specific theory of chemistry education could also be of value, though an intelligent practitioner or policy maker could still do a good job with a high and relevant 'g' factor alone.

¹. Ibid., p.200.
Campbell\(^1\) has given an interesting and insightful analysis of chemistry education:

Chemistry is the science of molecular behaviour. Chemists specialize in interpreting observations on large amounts of material in terms of the properties and interactions of individual molecules, and atoms. We trace our origins from the early atomic theories of the Indian Vedas and the Greek philosophers, through the alchemists' efforts at transmutations, Lavoisier's discovery of the conservation of matter, Dalton's and Avagadro's brilliant leaps from rather poor data to excellent insights, Maxwell and Boltzmann's Kinetic theory, Mendeleev's and Mayer's ordering of the chemical elements, to the discovery of radioactivity, the atomic nucleus, isotopes and the still-increasing set of sub-atomic particles. Then we retrace to atoms, the building blocks on which chemists concentrate while fully aware of the complexity of atomic composition. And, most recently, chemists have moved toward measurements based on the number and/or energy of photons and/or electrons (quantized particles) in addition to the bulk properties of mass and volume used previously.

Hence chemistry education involves a highly analytical and imaginative exercise moving from concrete macro experiences to highly micro components, from facts to daring guesses and back to facts, from ordinary deductive and inductive logic to probabilistic statistics. All this has to take place in the school stage itself and much of it is already taking place with highly investigatory approaches in the Nuffield and other progressive schemes.

Need and Significance of the Study

India being a developing nation should try to improve its system of education and particularly its science education component in order to catch up and keep pace with developed nations. Many developed countries have very progressive systems of education and they bring about curricular changes as often as needed so that the children in schools are not only aware of the latest progress in science and technology, but also acquire the analytical, investigatory and independent learning skills needed to cope with a fast changing world. Unless, we in India try to adopt a progressive system of education we will be lagging behind other nations.

The need for adopting the school to meet the challenge posed by technological changes, has been emphasised in several recent documents. The Education Commission Report (1964-66) has dealt with science education in depth, dealing with the quality of science education, major steps and programmes in strengthening science education and research, regional imbalance in science education, curriculum reform, Summer Science Institutes, books in science, scientific terminology etc. "If science is poorly taught and badly learnt, it is little
more than burdening the mind with dead information, and it could degenerate even into a new superstition. What we desperately need is improvement in standard and quality of science education at all levels in the country."¹ Hence the science curricula should be revised on modern lines periodically and the implementation of curricular and other reforms should be reviewed to ensure that there is a positive relation to what is planned and what takes place.

The Education Commission Report² has also made some very insightful remarks on the relation between science and culture:

If science is to be pursued with full vigour and zest and is to become a mighty force in Indian renaissance, it must derive its 'nourishment' from our cultural and spiritual heritage and not bypass it. Science must become an integral part of our cultural fabric. It is possible that when science takes root in the native soil, and is no longer an exotic plant, its growth pattern may be visibly influenced by those features which have been characteristic of Indian philosophic thought and civilization.

When modern science in its abstract, conceptual and new syntactical forms is brought to millions of pupils through school science and particularly through the mother-tongue, new interfaces between science and culture get revealed.

² Ibid., p.396.
If the potentialities of these new inputs and their interactions with the old could be clearly visualized and analysed, a true renaissance can be expected. If not, cultural dissonances, conflicts and anxieties could be expected when new scientific culture is exposed to the conscious and unconscious bearers of an ancient culture. At its best a true synthesis of modern science with the positive aspects of Indian tradition such as the spirit of inquiry and several valuable products of investigation, analysis and synthesis could take place. At the worst, even modern science could be degraded into a bundle of facts and terminologies and transmitted through traditional rote methods. Hence the interface of modern science education with traditional culture is an aspect which needs to be investigated.

The interest taken from about the close of the sixth decade of this century by various agencies such as the National Science Foundation, the Soviet Academy of Sciences, the French Institut Pedagogique National (later l'Institut National Pour la Recherche et la Documentation Pedagogique) and agencies like the Nuffield Foundation, in the problem of upgrading and modernising science education has been well documented: The Education Commission's emphasis on: "the need from the earliest stage of science
education for a proper understanding of the basic principles and the process of scientific abstraction and creative thinking" and its concern for the spirit of scientific inquiry and investigatory approach from the beginning etc., have been documented earlier. In its concern with improvement of standards in science, it has emphasized the 'disciplinary' approach from the upper primary stage, with chemistry being taught as a separate subject from Class VI, and with the curriculum being taken to deeper and deeper levels in the high school stage.

On the investigatory side, some stimulus from NCERT was given for encouraging projects through which pupils' scientific talent could be found out. This did improve the scientific ethos in the superior schools and created a climate in which the more innovative and sensitive among the ordinary schools could also train a select and 'gifted' few for revealing their scientific talents. But for the mass of pupils, the chief means of communicating the new message was through improved textbooks. In a way the models developed in U.S.A. were replicated in India also with committees consisting of top scientists, science educators (a few in this tribe were available)
and teachers. For the south zone Fr (Dr) Yeddanappalli chaired the chemistry team which included two other university teachers of high calibre, a few teachers of chemistry and even a representative of the South Indian Teachers Union Council of Educational Research. At the National level, the expertise included a chemistry educator of the calibre of C.N.R. Rao. But the investigatory field teams comparable to the Nuffield teams in the U.K. and the Brunerian and Schwabian groups in the U.S.A. did not emerge in India. The Indian teams operated as committees and as working groups and produced a lot of impressive materials. The Regionally produced materials were synthesized and edited centrally, and finally one central book was produced for each of the classes starting from Class VI.

With all the imagination exercised by leaders like Dr. Kothari in initiating such broad-based committees, and with all the excellent work done by these groups, the central tool for upgrading the chemistry syllabi was the textbooks—the textbooks produced by the NCERT in chemistry as a discipline, from about the mid 60s and the adaptive text books closely following NCERT by the agencies preparing pupils for centralized Boards of Examination and after a lapse of a few years by the state systems. When a model
text-book is the chief method of sponsoring an innovation, there is always the danger that even if investigatory modes were used in the preparation of the book, they need not necessarily be understood or adopted by the textbook users. The principle enunciated by Marx\(^1\) that while labour is intellectual and productive, "the process of labour disappears in the product", permitting appropriation of the product by others and alienation of the labour and even of the labourer, applies even to intellectual labour. In this case the working group members were prestige persons and their services were duly acknowledged in the early editions of the book and hence 'alienation of the labourer' did not take place. (Such alienation did take place when NCERT's science and other wings got stabilized, when the pioneering workers and modes of work tended to be alienated and even forgotten, and also in later 'workshops' with strong 'superordination-subordination' stance in which much of the creative work was done by competent teachers and other educational workers, who were paid Travelling and Daily Allowances, and the experts took the credit, and sometimes surrendered it to bigger experts).

But the educationally important thing is that 'the process of labour disappeared in the product' except in very superior institutions. Though 'the process' itself in this case was not comparable to the Nuffieldian, Brunerian or Schwabian process, it was something, and could have served as the first positive step towards modern science education. But in the mass of the schools the verbal products tended to be transmitted bypassing the process (an aspect which Dewey\(^1\) has sensed even more than Marx). Here it is not so much a question of exploiting the labourer, but that of the user skipping the educative or process aspect and clinging on to the verbal product as an apparently easy route. So with these discipline-based chemistry textbooks starting from Class VI, there was the danger of the 'discipline' degenerating into formal subject matter, into verbal and other symbols.

Perhaps this inbuilt danger in premature 'discipline-oriented' teaching also began to be corrected in the central school system and in certain other centrally oriented systems. They recruited teachers with relatively high qualifications and developed a system of inservice training and orientation for teachers. Where such orientation or training was

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was successful there was a chance of the process also featuring in chemistry education, and under the best conditions the participants could enjoy the process and realize that in the long run, this was the most economic and efficient method of acquiring and retaining even the product. But there also grew up a large number of 'result-oriented' schools, particularly the private ones, affiliated to Central Boards which focussed on the product and public examination results, and even take pride in the fact that they could skip science and education - and once such pace was set, it could even become the norm.

But the transformations in the state-level adaptations of NCERT's discipline-oriented textbooks were more hazardous. In this process the main skill needed was that of translating the 'Central Chemistry' books from English or Hindi to the languages of the different states. The minimal transformation was of course from that of 'Delhi Hindi' to 'Uttar Pradesh Hindi' or 'Madhya Pradesh Hindi'. But in many other cases the transformation was much more complex. An exponent of the language of science has pointed out that translation of scientific matter from English into a regional language usually takes place through Sanskrit. Thus new metalanguage tends to be
introduced and the focus falls on the Sanskritized scientific terminology. It has been even alleged that "the science textbooks in certain regional languages are designed to teach bad Sanskrit rather than good science." Since Kerala also is a state where the tendency of translating from English through Sanskrit into Malayalam is a common tendency, the danger of language, the medium of communication, becoming a clouding or obstructing factor cannot be discounted, and this aspect needs to be investigated.

The adaptation of modernized, upgraded and discipline-oriented chemistry to the Kerala context was a much more difficult task than elsewhere. Kerala also reflected certain unique factors making it receptive - even to the point of over-enthusiasm - to the upgrading of science and mathematics in schools - an overenthusiasm which could be seen as a blessing and also as a bane, at least in transition. The structure of schooling in the mid-1960s also entered as one of the actors in this educational scene. Following the Recommendations of the Secondary Education Commission, the 'Central System of Education' in the Kendriya Vidyalayas etc. and many state systems followed a eleven-year higher secondary education pattern,
i.e., an 11+3 system leading to the degree. Two or three states (like Tamil Nadu) had a 11+1+3 system to reach the equivalent degree. Kerala also followed a similar long route to the degree following a 10+2+3 system, and as it often happens, had to pay a heavy price, on various counts, for adopting a system, before it was announced as an innovation in the national system (In this case in the Education Commission Report, 1964-66). Thus Kerala had a ten-year schooling leading to S.S.L.C. followed by a two-year pre-degree course and a three-year degree course (To this day this pattern remains, and according to one kind of interpretation, Kerala remains as one of the states which has not implemented the 10+2+3 system, since '+2' remains yet in collegiate education).

How the structure of schooling can interact with the problem of curricular upgradation can perhaps be depicted best through the upgradation of science syllabi in Kerala in the early 1970s. The 'model' which Kerala had was the master textbooks of the NCERT leading up to 11-year Higher Secondary Examination. By this time the initial momentum given to Indian science education by the initiating teams (small though it was, as compared to Nuffield and the progressive and 'impatient' American teams) had spent itself.
The Department of Education in Science and Mathematics in NCERT had taken full control of the situation. The textbooks had become stabilized (some progressivists would say "become frozen").

When the upgraded national syllabus had become 'stabilized' it was a relatively simple problem to adopt or translate it into the state systems, particularly when 'product to product' transformation was the objective. But in Kerala there was also a problem of adapting an 11-year model to the 10-year school. At this time there was a young, energetic (and even impatient) Director of the Kerala State Institute of Education. He decided that the 11-year matter of Delhi can be compressed into the 10-year school of Kerala. Teams of college and school teachers of chemistry were formed and they put in matter even beyond the 11-year matter of Delhi into the 10-year Kerala schools. The exercise resulted in the former pre-degree matter in symbolic chemistry introduced for the first time into the upper primary school and B.Sc. material like highly abstract particulate and physical chemistry and periodic table as 'advance organizers' into high school chemistry. This was definitely a case of structure of chemistry and its discipline being introduced into the ordinary school to the ordinary pupils, taught by the ordinary teacher - but not in 'the honest form' which Bruner would insist upon.
Though a number of distortions, anxieties and traumas were obviously visible in this first and perhaps unique experience of upgradation of school chemistry, it does reflect the high sensitivity of the young Director of the State Institute of Education to the Education Commission Recommendations about upgradation, increasing abstraction, discipline-orientation of school chemistry.

If the Education Commission's recommendations on Teacher Education had been impregnated with its own recommendations on Science Education, it could have directed the harnessing of teacher education to the cause of modern science education. While giving several valuable suggestions of a theoretical nature, it also reflected some prejudice against the M.Ed. course as compared to (a possibly more dysfunctional) M.A. (Education) course.¹ The intention to develop education as a discipline comparable to the other social sciences is laudable and even "appointing professors in different disciplines as part-time professors in the schools of education to explain (sic.) new developments in their fields and the manner in which they will affect education

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¹. Ibid., p. 76, 69.
at the school stage" could have been fruitful if really
eminent professors could have been inducted to react on
equal terms with educationists. As it is, this
recommendation enabled an inferior Masters' Degree
holder in economics, politics or sociology (with of
course a second class degree) to 'explain' to educationists
about the applications of their discipline to school
education of which they were innocent. A sentence in the
next paragraph has dangerous overtones: "As education
can be studied without any commitment to being a teacher
and in combination with other subjects, many talented
students will study it and if their interest is aroused
sufficiently, some of them may join the profession."¹
The suggestion that 'talent' can be drawn into education,
only through 'non-commitment to being a teacher' has
probably done more to develop snobishness on the part of
'discipline-oriented' M.A. towards the 'task-oriented'
B.Ed./M.Ed., than anything else. The intention was
apparently to attract a Galbraith or Moyniheen into
education while allowing them to retain their interest
in economics or politics. ² In India also it did happen

1. Ibid., p.69.
2. Personal discussions with of the supervising teacher
   with Prof. M.V. Mathur, Member, Education Commission.
outside the portals of M.A. (Education). Eminent men like Malcolm Adiseshiah and K.N. Raj are acknowledged to be educationists while retaining their identity as developmental economists. But this has nothing to do with the recommendation of the Education Commission. Men of distinction have emerged in education through the M.Ed. channel as well as through M.A./M.Sc. in various subjects but it is doubtful whether this has revolutionized M.A. (Education) in the way expected. The chief market for this commonwealth of different streams is of course NCERT. It may be noted that educationists of non-eminence were also drawn from M.A. and M.Ed. streams!

The Education Commission's main concern was with removing the three isolations of teacher education - isolation from University life, isolation from schools and isolation from one another. ¹ These are elaborated in detail, but not in the same wavelength as the Commission's own treatment of science education. It is also not sufficiently appreciative of the integrated courses of general and professional education conducted in the Regional Colleges of Education with attached

¹ Ibid., p.68.
model schools where high calibre scientists were in fact interacting with high calibre educationists and psychologists: "We feel that it would be wrong to place an undue emphasis on such marginal experiments and that, from the point of view of raising standards in teacher education, it would be better to concentrate on improving the professional one year course following the three year course"\(^1\) (through, of course, the help of 'talented' people from other social sciences "without any commitment to being a teacher"!) It must be noted that in the Regional College, Mysore, the then Head of the Physics Department, Dr. Raja Madhava Rao interacted with Professor Devadasan and Dr. P.N. Dave of the Education Department and produced several teaching-learning materials including the adaptation of the P.S.S.C. materials to Indian conditions and fabrication of low-cost apparatus. But under the judgement of 'marginal experiments' pronounced in the Teacher Education Chapter of the Education Commission, it is no wonder that his ill contribution was unrecognized and rewarded.

The Regional Colleges of Education also conducted a number of Summer Institutes as envisaged by Dr. Kothari

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1. Ibid., p. 72.
bringing the newer experiments in science education to the teachers. If this 'process-experiment' had been linked to actual work in Indian schools we would have had functional models of modernized science education even in the 60's. But the Commission Report chose to isolate its Teacher Education chapter from its own chapters on Science Education and School Curriculum, it also felt that the problem could be solved by adding content course in the training colleges occupying about 20 per cent of the time. Thus a combination of education as a 'discipline' in the Anti-Deweyan sense in the training colleges and education department of Universities, and 'discipline' as 'subject-matter' from Class VI onwards was supposed to work the miracle.

Consequently the syllabi prepared for the training colleges and University Departments of Education immediately following the release of the Education Commission Report did not reflect the modern revolution in science education and the type of psychology needed to support it. It was this type of B.Ed. and M.Ed. syllabi which was introduced in the University of Kerala also in 1966.
Hence the highly upgraded and abstract syllabi in chemistry introduced in the Kerala schools from the early 70s* was done without the adequate pedagogical support either from the State Institute of Education, Science Education or from the training/education branches of the University. Chemically illiterate teachers were teaching the subject. The State Department's inservice programme had a time sequence, which might have taken them well over a decade to make the teachers literate enough to read and understand the books, but it did not have an analysis of the gap between teacher scholarship level and curricular expectations.

When, in 1974, the upgraded material came up to the high school, it was the last straw. The students went on a strike protesting against the gap between the level of their teachers' knowledge and the level of science and mathematics which they were expected to teach. The demands included the giving of inservice course on a crash basis to the teachers (or alternately withdrawal of the syllabus), provision of better textbooks and other learning conditions. In this sense this strike may be called an educational and

*It was about this time that the World Trend was turning away from 'discipline-oriented' theoretical chemistry for all at the school stage and various forms of combined/integrated science becoming increasingly popular (vide Discussion in Chapter II based on D.,J.,Waddington (ed.), Teaching School Chemistry, Sterling/Unesco, 1984, pp.64-77.
even progressive strike. The enthusiastic State Institute Director who initiated the reform meanwhile had been promoted as Director of Public Instruction and later shifted from that post. The new Director called a series of conferences and the issues were sorted out through consensus and through majority view (among those invited) rather than through pedagogical or scientific analysis. Thus organic chemistry was reduced from a very heavy load to nil. Symbolic chemistry was removed from upper primary classes, but all the formulae and equations were lumped together as one chapter at the end of Class VII. Occasionally scars left by the wounds sustained in the battle between curricular upgradation and downgradation could be traced. For example, Dalton's atomic theory was originally included and then deleted. But then Avagadro's hypotheses was retained and in discussing it Dalton was recalled.

Though the Kerala University Department of Education got its 1966 syllabi from the Teacher Education impulse of the Education Commission Report, by 1970 it became sensitive to the progressive science education recommendations in the same Report. Soon gap analysis between curricular expectations and teacher knowledge in chemistry, and models of filling up the gap were taken up. It was
in this context of expectation, promise, fulfilment and disappointment, isolations and attempts to break them, incidentally creating further isolations, that this study was taken up.

**Statement of the Problem**

For the reasons stated above the investigator decided to conduct a doctoral study on: "FACILITATIONS AND HINDRANCES FOR THE MODERNIZATION OF CHEMISTRY TEACHING IN THE SCHOOLS OF KERALA".

**Scope of the Study**

The study extended over a much longer period than originally envisaged. Meanwhile one more curricular revision took place in the early 80s (representing the world trends of the 70s) and the books were released between 1983 to 1985. The new chemistry books seemed to reflect modernity both in content and in pedagogic rhythms. It also adopted the General Science approach upto Class VIII, and the discipline of chemistry in its modern form was taken up only in the last two classes. Hence it was proposed to go back in time and try to get a view of what existed in the early 60s. Hence one aspect of the study was a textbook analysis conducted over three periods of time - early 60s, middle 70s and early 80s. This analysis is expected to give an idea of the quantum of curricular upgradation and the quality
of the conceptual processing as revealed in the textbooks during the different phases. Incidentally it is also expected to yield the concept of modernization of chemistry in schools as envisaged by the curriculum makers and textbook writers.

The conceptual and attitudinal aspects of modernization constitute another aspect of the study. Modernization has been analysed both in the models used by educational sociologists and also in the sense popularised by science curriculum reformers in the post-sputnik era. Innovation-Diffusion literature relating to science curricular reforms such as those of Miles also give some ideas of modernization. The investigator conducted her own analysis of modernization as a starting basis for the study. In one of the tools, the concepts which respondents have of modernization of science curricula were also analysed, because these pictures themselves could indicate facilitations or hindrances.

Attitudinal facilitations or hindrances were proposed to be measured through agreement-disagreement responses to progressive as well as regressive statements regarding modernization.

In addition to generalized analysis of the conceptual and attitudinal aspects of modernization, the rating of specific aspects of the upgraded chemistry curriculum was also taken up. This is naturally a task in which the judgement of those who can understand the nature of the topic and who can willingly spend some time for it has to be obtained.

The actual position with reference to certain factors identified as facilitations and hindrances - physical, administrative, attitudinal was also taken up for study. Qualifications of teachers, workload, steps taken to close the gap between teacher competency and curricular expectations, the effect of the inservice courses, teachers' job attachment, commitment and satisfaction, sensitivity to and use of environmental resources, laboratory facilities, cocurricular activities, reference materials, administrative facilities etc. were taken up for coverage in a survey.

The survey tools, such as rating scales, schedules, questionnaires etc. were cooperatively prepared with Anandan Nair, an investigator working on a parallel study in physics. But after the pilot study phase some tools took a slightly different shape. In the curricular item
rating scale, only the categories of judgement were common. The items in physics and chemistry obviously were different. The samples were also different. The analysis of textbooks taken in three different time segments was an aspect taken up by this investigator alone. In the matter of interpretation of survey findings, Anandan Nair used more quantitative elaborations, whereas the present investigator placed more emphasis on qualitative insights.

Limitations

1. The concept of modernisation is understood in different ways in different educational contexts. In some tools the pictures of modernisation held by different people were surveyed. In some tools such as attitude scales and textbook analysis, a point of view had to be taken by the investigator as an interpretative base. The investigator took a position close to that of Bruner rather than Ausubel or the early essentialists. An Ausubelian or a Novakean could interpret the data differently. Every point of view can have its vantage points and disadvantages. The investigator holds that in a verbalistically oriented context like India, an Ausubelian advance organizer position could lead more easily to distortions than a Brunerian position.
2. The sample size for the survey tool is relatively small. But the closeness of the results obtained in this study with those of Anandan Nair working with a much larger sample compensate for this to some extent.

3. Because of the high practical importance and applied nature of the topic and owing to the dearth of research studies in India in such areas, a broad-based and multifaceted approach was taken by the investigator. Hence a neatly established precision design over a narrow area was not opted for in this study.