CHAPTER - II

IMPORTANCE OF MATHEMATICS

AND

IMPORTANCE OF TEACHER

SECTION I : Secondary Education in India and the Central Schools

SECTION II : Nature of Mathematics and Aims of Mathematics Teaching

SECTION III : Correlation of School Mathematics with Other Subjects

SECTION IV : Educational values of Mathematics

SECTION V : Importance of the Teacher
1.1 IMPORTANCE OF SECONDARY EDUCATION

Since independence, the expansion of secondary education in India has been remarkable as is evident from the enormously increase in the number of schools and the enrolment of pupils. Attention is being paid to the qualitative improvement of secondary education.

This stage of education has a particularly vital role to play in the far-reaching social, cultural and economic revolution which is taking place in India. It is the most crucial stage of education. On the quality of secondary education depends the quality of education as a whole.

1.2 AIMS OF SECONDARY EDUCATION

The aim of education is to make available to posterity, the wisdom of the past and present so that the youth may be equipped to solve the problems of the future. The chief purpose of higher education is to form an elite not for its own sake but for the society. But after independence the aims of secondary education have been modified. It is viewed primarily as a stage complete in itself with its own ends and special purposes. On passing out of the secondary school, such students who do not propose to join the college or technical institutions should be able to enter the various walks of life and fill the role of what may be called leadership at the intermediate level.

1.3 STRUCTURE AND DURATION

Education is a State subject in India and each of the 25 States are free to decide about their own structure of education and the
duration of the school courses. As a result, every State had adapted its own system and there was lack of uniformity. However, with the introduction of the 10 + 2 + 3 pattern of education, uniformity of structure all over the India is evident, secondary education consists of Class VIII to Class X. Classes XI and XII constitute the Higher Secondary Classes. High school stage consists of Classes VIII, IX and X.

1.4 CURRICULUM

The outline of the secondary school curriculum is as follows:

1. Three Languages: In non-Hindi speaking areas, these languages will normally be (i) the mother-tongue or the regional language (ii) Hindi at a higher or lower level (iii) English at a higher or lower level. In Hindi speaking areas, they will normally be (i) the mother tongue or the regional language (ii) English (or Hindi, if English has already been taken as the mother tongue) and (iii) a modern Indian language other than Hindi.

(Note: A classical language may be studied in addition to the above three languages on an optional basis).

2. Mathematics

3. Science

4. History, Geography and Civics
5. Art

6. Work Experience (also known as Socially Useful Productive Work)

7. Physical Education

8. Education in Moral and Spiritual Values

The study was conducted mainly on a sample of teachers and students drawn from the Central Schools which are secondary schools of the Government of India.

1.5 THE CENTRAL SCHOOLS

The scheme for the establishment of Central Schools was approved by the Government of India in 1962. Its implementation was started by the Ministry of Education in 1963, when 20 of the Regimental Schools run by the Ministry of Defence, were taken over and converted into Central Schools. Delhi Education code was initially followed for administering the Central Schools.

Later the Kendriya Vidyalaya Sangathan, an autonomous body, was set up by the Ministry of Education, and was registered as a society in December 1965. It actually assumed charge of these Kendriya Vidyalayas with effect from 1.4.1966. Since then various executive orders, instructions and directions had been issued both by the Ministry of Education and the Kendriya Vidyalaya Sangathan with regard to the
functioning of Kendriya Vidyalayas, both in the academic and administrative fields.

There was a network of 362 Kendriya Vidyalayas spread all over the country by 1970. By 1992 their number had increased. This phenomenal growth was mainly due to the popularity of Kendriya Vidyalayas, which have brought a good deal of relief and satisfaction to the Central Government employees liable to frequent transfers. With common syllabus and medium of instruction in Kendriya Vidyalayas, the education of the children of such employees does not get disrupted when they move from place to place.

During the period of their existence for about two decades, additional dimensions have developed in the areas of administration, academics and accounts. To mention a few - introduction of 10 + 2 scheme of studies, opening of Kendriya Vidyalayas in public sector undertakings, modification of admission policy, frequent pay revisions etc.

The idea of encouraging the growth of secondary schools with a common syllabus and medium of instruction for the benefit of the children of Central Government employees liable to frequent transfers was first mooted by the Second Central Pay Commission which recommended provision of this facility by the Government for its employees.

In the course of a few years, the Kendriya Vidyalayas have not only grown in number, but have also made rapid strides in all the
key areas of present day educational reforms and have come to be recognised as pivotal institutions striving to raise the quality of education at school level.

The main objectives of the Central Schools are:

(i) To meet the educational needs of the children of transferable Central Government employees, including defence personnel, by providing a common programme of education.

(ii) To develop them as model schools in the context of the national goals of Indian education.

(iii) To initiate and promote experimentation in education in collaboration with other bodies like CBSE and NCERT etc; and to promote national integration.

1.5.1 **MAIN FEATURES OF THE SCHEME**

The main features of the scheme are:

1) The schools are established at places having sizeable concentration of transferable Central Government employees including defence personnel. The schools in the defence sector are established on the recommendation of the Ministry of Defence where as those in the civil sector are established on the recommendation of the various Ministries of the Government of India or the concerned State Governments. Kendriya Vidyalayas are also opened
in the campuses of Public Sector Undertakings only when these agencies agree to provide physical facilities in terms of plant and equipment as per the norms prescribed for Kendriya Vidyalayas and to bear all the recurring and non-recurring expenditure.

ii) The schools give priority in admission to the children of transferable Central Government employees including defence personnel. In case of project schools, children of employees of these agencies get the first preference.

iii) The quality of teaching is kept reasonably high by an appropriate teacher-pupil ratio and provision of suitable teachers with high academic qualifications.

iv) Instruction is imparted through the media of Hindi and English, the ultimate object being to enable the pupils to achieve proficiency in both the languages.

v) The same syllabus and text books are followed in all the Kendriya Vidyalayas.

vi) The Kendriya Vidyalayas prepare students for the All India Secondary Schools Certificate at the end of Class X; and All India Senior School Certificate Examination at the end of Class XII. These examinations are conducted by the Central Board of Secondary Education, New Delhi.
vii) These vidyalayas are intended to be partly residential in character. Hostel facilities have been provided in a few Kendriya Vidyalayas in different parts of the country for the benefit of students, particularly those whose parents are transferred in the middle of the school session to stations which do not have a Kendriya Vidyalaya.

viii) Education upto Class VIII is free in Kendriya Vidyalayas. Tuition fee at varying rates based on the income of the parents are chargeable from students of Classes IX, X, XI and XII.

1.5.2 ADMINISTRATION OF CENTRAL SCHOOLS

The Minister or Minister of State or Deputy Minister in the Ministry of Education in-charge of the Kendriya Vidyalaya Scheme is the Chairman of the Sangathan. The Vice-Chairman is an officer of the Ministry of Education appointed by the Government of India. The other members are appointed by the Government of India from amongst senior officers of the Ministries of Finance, Defence, Works and Housing and Department of Personnel as well as distinguished educationists including representatives of the C.B.S.E. and N.C.E.R.T. and State Government. The Board of Governors is charged with the responsibility of carrying out the objectives of the Sangathan. It is responsible for the management of all affairs and has authority to exercise all the powers of the Sangathan. The Chairman of Sangathan is also the Chairman of its Board of Governors.

Commissioner is the Executive Head of the Sangathan and the Chief
Administrator of the Central Schools Organisation (also known as the Kendriya Vidyalaya Sangathan). Deputy Commissioners are the Principal Officers, who assist the Commissioner. For proper administration, supervision, inspection and control of Vidyalayas, the country has been divided into regions. Each region is under the charge of an Assistant Commissioner.

The Financial Adviser - cum - Chief Accounts Officer renders advice on financial matters and assists in the supervision of accounts and internal audit.

The Administrative Officers assist the Deputy Commissioners in all matters concerning administration of the Head Office and look after the house-keeping duties. There is a Vigilance Officer whose chief functions are:

i) To advise the Commissioner/D.C. in all disciplinary and vigilance matters.

ii) To advise the Appellate Authorities

iii) To assist the D.C. in legal matters

iv) To supervise the work of the Internal Work Study Unit

1.5.3 In each academic year the Vidyalayas hold the following tests and examinations:
a) Periodical / Unit Tests - It shall be conducted in each subject in the class / period itself as many times as necessary. A minimum of six such tests of pupils' progress spread uniformly throughout the year are to be conducted each year.

b) The Mid-Year Test comprises of the entire syllabus covered upto that period. The duration of this test will not ordinarily exceed two teaching periods and this will be held before the end of the Second Term which ends in December.

c) Session ending Examination is the only formal examination which is held during the last ten days of April. The duration of each paper shall not exceed $2\frac{1}{2}$ hours for Class IX, $1\frac{1}{2}$ hours for classes VI to VIII and 1 hour for class V for each subject. The entire course prescribed for the year is to be tested in the examination.

The aim of these tests and examination is to assess how far instructional objectives have been realised. The results of these tests are used by the teachers to improve their instructions by organising special instruction wherever individual weaknesses have been identified.

These tests need not necessarily be always written tests. They may be programmed to include oral test skills and assessment of a project to test application. These tests may also include open-book examinations.
The Principal maintains a Register of Examination Results in which the consolidated results of all the tests / examination held are recorded, class-wise and the subject-wise together with a description of the measures taken to remedy the weaknesses disclosed. The question papers, mark sheets and answerbooks of the session ending examination are preserved for one year for reference.

The results of promotion / retention are declared by the Principal in the first week of May.

The final assessment of a pupil in Classes V to IX and XI at the end of the year is based on the total achievement in all tests and in the examination as well as his class/homework during the year.

The final assessment is based on a maximum of 100 marks in each subject distributed as under:

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Marks</th>
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<tr>
<td>i)</td>
<td>Classwork, homework, projects</td>
<td>20</td>
</tr>
<tr>
<td>ii)</td>
<td>Periodical / Unit tests</td>
<td>20</td>
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<tr>
<td>iii)</td>
<td>Mid-Session examination</td>
<td>20</td>
</tr>
<tr>
<td>iv)</td>
<td>Session ending examination</td>
<td>40</td>
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Total: 100

Subjects involving practical work in Classes VI to IX and record books are allotted one-third weightage.
A candidate must obtain not less than 35% marks in each of the academic subjects to get promoted to the next class.

In classes IX and XI, a pupil should obtain not less than 35% in each academic subject and an aggregate of 40% for promotion.

In Classes V to VIII, a candidate failing in one or two subjects may be granted promotion provided he has secured at least 30% marks in each of the subjects he has failed but maintained the aggregate of 35%.

In class IX, a candidate securing an aggregate of 40% but failing in one or two subjects by not more than 5 marks (i.e. getting not less than 30% in each of these subjects) would be eligible to take a supplementary examination in these subjects. The examination is generally held in the last week of June. The students are promoted to the next higher class only if they secure at least 35% marks in each of the academic subjects in the supplementary examination.

1.5.4 POLITICAL PRESSURE IN CENTRAL SCHOOLS

Veteran educationist Amrik Singh has highlighted the political pressure on Central Schools:

"Almost every Minister for Education for the last quarter century has got several new schools established. A couple of them are invariably in his constituency or in his State. In one case a school was set up in Delhi more or less to satisfy the exclusive claim of MPs. Those who would have asked inconvenient questions were bought over and now there is no one to protest."
Meanwhile there have been reports in the press that during the last few months more than 6,000 students have been admitted on an out-of-turn basis. As per norms, a section has to consist of 30 students. Those admitted out-of-turn are over and above that. In practice therefore the strength of the section was closer to 35 than 30. With this spate of admissions, in some of the Delhi schools, the strength of the section in certain cases is as high as 60 or more. What kind of instruction can be imparted in these conditions?

For quite a few years the number of such cases was small. Before long MPs discovered that this was a source of patronage and even of income. They started pressuring the Minister to give out-of-turn admissions. He had no right to do so but evidently no Chairman of the KVS could refuse. When the matter got out of hand, the situation was sought to be resolved by discontinuing the system altogether.
SECTION II

NATURE OF MATHEMATICS

AND

AIMS OF MATHEMATICS TEACHING
Mathematics is a basic survival skill. Qualification - crude or sophisticated, is essential in various walks of life. A person devoid of numeracy is greatly handicapped in the struggle for survival. Mathematics holds a central position in the field of knowledge and enriches every branch of knowledge by its sophisticated techniques and approaches towards accurate qualification.

Jean-Claude Martin, Rector of the Academy of Bordeaux in France, has proposed a general reorientation of Mathematics, "which is a useful tool for the majority of students". According to him, teaching of Mathematics should not be designed to produce future mathematicians. Very few students reach the university. A Mathematics teacher is sure to fail in his endeavours if he concentrates only on the brighter students and prods them to become specialists in Mathematics. This age old orientation causes, "avoidable, system-related failures in Mathematical learning and often results in a strong aversion to Mathematics". Here we can divine the seminal causes of the ineffectiveness of teachers. The attitude and orientation of mathematics teachers is a great contributing factor to their success or failure. Effectiveness of mathematics teachers can ultimately be traced to their attitude towards teaching of mathematics. The effectiveness of mathematics teaching depends upon solving multi-disciplinary problems by using modelling methods, restoring student interest, making the students realise its utility, in enriching their knowledge of related subjects, encouraging logical reasoning and allowing access to a higher level of mathematics for such of the students who have the ability and the aptitude.

Education was for the classes and was never meant for the masses up to
the 19th Century. Today mass education is imperative in the developing countries. The real effectiveness of the mathematics teaching depends on their capability, "... to embed mathematical education into the specific cultural contexts of these countries." \(^4\)

Vien Vened F Nebres has highlighted the existing mismatch between mathematical education and the needs of the majority of the people. He states that, "There is a tremendous need for researchers in mathematics education in developing countries to look at the actual life of the urban workers, rural farmers and merchants; and to identify the mathematics in daily life that is needed and used by the people. Then it is necessary to compare this needed mathematics with what is provided in the curriculum and to search for a better fit between the two." \(^5\) Nebres has correctly diagnosed the reasons for the effectiveness or otherwise of mathematics teachers, especially in the developing countries.

Afzal Ahmed, a member of the Cockeroff Committee, has examined the relevance of this Report and States that,

"A suitable mathematics curriculum for the majority assumes greater importance as societies in the world become more technological and sophisticated. But at the same time, the evidence of failure at learning and applying mathematics by a large proportion of the population is also growing." \(^6\)

The mathematics teacher is caught between the charbydis of sophistication and Scylla of simplification. He is not sure what to do and his is a divided mind. A person who is not sure of his goals can hardly be effective.
According to Lingard:

"Mathematics is more than a body of knowledge, a bundle of facts and techniques. A lot has rightly been said and written in recent years about mathematizing and about humanising mathematics. Mathematics is an activity. It deals with skills and processes and ideas. It is something experienced and developed by each individual."

Hans Freudenthal has highlighted the importance of cognitive domain in Mathematics and remarked, "the best paradigm of cognitive education is mathematics."

Mathematics is nothing but the totality of skills, processes and ideas involved in solving the problems of mankind. Mathematics is a highly intellectual process.

According to Isaac Newton:

"Mathematics is virtually a product of pure thought. Even though it draws its starting point from the world of experience, it refines them into concepts well beyond the scope of that world, and then, by purely logical processes of combination, inference and construction builds the most elaborate thought scheme."

Mathematics is a logical systematic thought process. It is something abstract drawn from the real life experience. It is highly conceptualised.

Wilder has succinctly described the gradual evolution of mathematical concepts:
In the beginning, it derived its concepts, such as number, directly from the external world. But as mathematics evolved, a higher order abstraction was achieved, in which concepts began to be applied to concepts.¹⁰

U.G. Chitriv has tried to delineate the different facets of Mathematics. He states:

1. Mathematics is a product of pure thought.
2. Mathematics is a highly conceptualized construction.
3. Mathematics is a regular structure of closely related concepts.
4. Elementary concepts of mathematics can be acquired by direct experience from the physical world.
5. Higher order abstract concepts in mathematics can be arrived at by the process of pure thought and logic or intuition.¹¹

Thus, the term 'mathematics' has been interpreted and explained in various ways. It is the numerical and calculation part of man's life and knowledge. It facilitates exact interpretation. It is also called the science of logical reasoning as it develops reasoning power of mind.

Some more definitions of mathematics by eminent mathematicians highlight the nature of Mathematics.

(i) Mathematics in its widest significance is the development of all types of formal deductive reasoning - Alfred North Whitehead

(ii) Pure mathematics is the class of all propositions of the form 'P' implies 'q' where ('P' and 'q' are propositions containing one or more variables, the same in two propositions and neither 'p' nor 'q' contains any constants except logical constants - Bertrand Russell
(iii) Mathematics is the science which draws necessary conclusions - Charless S. Pierce

(iv) Mathematics is general, is fundamentally the science of self-evident things - Kelin

(v) Mathematicians do not study objects but the relations between them. Matter does not engage their attention. They are interested in form alone" - Poincare

Whitehend, Russel, Pierce, Kelvin, Poincare and other eminent mathematicians have highlighted the high philosophy of Mathematics as an intellectual discipline. Martin, Damerow, Nebres and Ahmed and other educationists concerned with mathematics have emphasised the pitfalls and dangers of a highly abstract-ivory-tower approach to mathematics.

The Mathematics Teacher must understand the true nature of mathematics and must be capable enough to graduate the gradients of the difficult concepts of this subject to needs of all categories of people in the world. Mathematics can ill-afford to be an esoteric and mystic ritual practised band confined to a few master-minds. Ultimately, the effectiveness of the mathematics teacher depends upon the universality of its reach.
AIMS OF MATHEMATICS TEACHING
Every subject including Mathematics has either explicit or implicit objectives. When the objectives are explicit, the teacher's task is comparatively simpler. He has to strive to achieve the stated objectives. In most of the advanced countries, test books contain explicit graduated objectives. However, in the Indian context, this is not always true. Imitating the programmed text of the West, some objectives are stated in a somewhat haphazard manner. Spelling out the objectives in specific terms and delineating the conceptual flow chart is a tough task which has not been attempted with rigour in India.

Smith, Stanley and Shores have succinctly stated the role of objectives and subject matter:

"The objectives stressed will be those that reflect the controlling ideas and sentiments contained in the universals. The subject matter will tend to be that which is believed to embrace the most significant ideas and most generally used knowledge and skills." 13

The objectives of mathematics change with the changing times and needs of the society. Consequently, the subject matter included (or excluded) undergoes changes.

Right from the inception of the first English School of Orissa in 1835 at Puri, Arithmetic had been included in the curriculum. Arithmetic continued to occupy the most dominant place in the secondary school curriculum upto 1854. In 1854, Algebra and Geometry were included. By 1881, Euclidean Geometry, mensuration and Algebra were taught along with Arithmetic. By 1901, Geometry was included at the middle school level. This status-quo was maintained till 1952.
As per the recommendations of the Secondary Education Commission (1952) drastic changes were affected in the mathematics curriculum. The National Council of Educational Research and Training, the apex body overseeing the qualitative improvement of school education in India, has consistently been trying to update the mathematics curriculum of India in consonance with the latest developments in the advanced countries. The changes in the mathematics curriculum of India have come about due to the changes in the field of mathematics as well as changed perceptions as regards the importance of Mathematics in the total curriculum.

Indian Education, which mainly catered to the needs of the classes is now constrained to subserve the needs of the masses. The clientele of the secondary schools is bulging and it no longer continues to cater only to the needs of the middle classes. The heterogenous student population entering the secondary school curriculum including that of mathematics. Bringing the schools closer to life has been the recurrent strain of modern education. Mathematics, too, is made relevant through necessary curricular changes. Teachers must understand the content of modern mathematics and the context in which they are operating, to be able to internalise the basic objectives of teaching mathematics.

According to Andrew J.C. Begg:

"In mathematics education, the three most common aims are summed up as:

Personal - to help students solve the everyday problems of adult life;

Vocational - to give a foundation upon which a range of specialised skills can be built;

Humanistic - to show mathematics as part of our cultural heritage" 15
He views the mathematics programme as part of a total educational package. The general aims of mathematics teaching would include the development of self-respect concern for others and urge to enquire. It purports to develop the skills of communication, responsibility, criticism and cooperation.

The classical objective of teaching of mathematics has been for the sake of mathematics itself. "But the training of mathematician can interest only a minute portion of students." 16

This age old objective is of very little use in the present day context. The alternative suggested objectives are to utilise mathematics as a tool or utilise mathematical models to solve the day to day problems of life. Teachers subscribe to both the classical objective and the modern objective. So mathematics teaching through goals with a differentiated progression has adopted. "This would imply avoiding a dropping in standard through an evaluative process based on objectives that clearly marked out the development of curriculum, the chronology of which would be subject to modification and would permit the most gifted students to advance more quickly and those in difficulty to follow at a different pace." 17

The society and its schools are changing. Swift scientific changes are coming about. Many social demands are emerging. Educationists are finding ways of changing the contents and conditions of general education. New mathematics is an outcome of this worldwide movement.
The Cockcroft Report has outlined the objectives of mathematics education as to include opportunities for:

"--- exposition by the teacher;
--- discussion between teacher and pupils and between pupils themselves;
--- appropriate practical work;
--- consolidated and practice of fundamental skills and routines;
--- problem solving including the application of mathematics to everyday situation;
--- investigational work."

The Cockcroft Report has reinforced the findings of Newsome Report of 1963. It had stated:

"Our aim in the teaching of mathematics to all pupils, to those with average and below average ability no less than to those with marked academic talent, should be to bring them to an interest in the content of mathematics itself at however modest a level (paragraph 459).

Few, if any, of our pupils are ever likely to become mathematicians, but some may well come to find satisfaction in mathematical work if its purpose has first been clearly seen and confidence established through the successful use of mathematics as a tool (paragraph 422)."

In the early 1950s, the National Council on Teaching of Mathematics commission on post-war plans recommended that schools "should guarantee functional competence to all who can possibly achieve it."

The direction of school mathematics in the 1960s was geared to "the structure of mathematics, the discovery of patterns, and the fundamental
ideas underlying the familiar practices and procedures of arithmetic. Emphasis on computational skills was definitely not a feature that received much attention as a core subject ——21

This alleged neglect of computational skills created public uproar. The National Advisory Committee on Mathematics Education in 1975 —— The NACOME Report stated that teachers "sought improved skill performance through deeper student understanding of the structures computational methods. Though the goal of increased computational competence has not been reached on any massive national level, this failure does not invalidate the 'understanding leads to skill' hypothesis"22

To meet the public criticism, the mathematics text books of 1970s explicitly stated the emphasis on basic skills, a real world applications and simple problem solving as the objectives. New mathematics was coming under severe criticism and, 'Back-to-Basics' movement gain momentum. The NCTM had suggested the following objectives for school mathematics during the 1980s. They are:

"1. Problem solving should be the focus of school mathematics in the 1980s.
2. Basic skills in mathematics should be defined to encompass more than computational facility.
3. Mathematics programme should take full advantage of the power of calculators and computers at all grade levels."23

The teaching task would gain direction and specificity through a set of clearly stated objectives. Their lack is likely to leave many a practising
teacher in wilderness. Due to lack of direction they are likely to just drift through teaching. But spelling out the objectives in specific terms is a highly technical task.

Gronlund aptly commented that:

"Stating objectives in terms of learning outcomes rather than the learning process admittedly is easier said than done"24

In 'New Trends in Mathematics Teaching' volume II published by UNESCO Hans Freudenthal had aptly summed up the prevailing situation of mathematics teaching throughout the world and which is most appropriately applicable to the Indian situation. He stated:

"In reality, there was never anything startlingly abrupt in the development of mathematics and the lack of continuity in only noticeable in school curricula. Whereas higher education has always followed - often, however with a certain delay. The progress of research, the programme and methods of other branches of teaching have remained more or less unchanged for long periods. When reform became inevitable, it seemed therefore as if a total break with the past was being made"25

School mathematics in general has remained unchanged over long periods and this is partly due to a lack of understanding of the objectives of teaching the subject.

Dubisch Roy stated the teaching should be so conducted that the objectives became transparent and "the students can see the value of a thoughtful approach to the subject"26

Objectives are to be borne in mind by the teachers. They are not
The shifts in the objectives of the teaching mathematics in U.S.A. indicates that the teaching community is sensitive to the criticisms of the public and the developments in the content area in India. Educational public opinion is yet to emerge and the sensitivity of the teachers to the challenges of the time is not commensurate with the needs.

Objectives of School Mathematics in India

(i) Secondary Education Commission, 1952

Secondary Education Commission of India of 1952-53 did not attempt to analyse the objectives of different school subjects. It stressed the vocationalization of education and thus indirectly provided a fillip to the teaching of mathematics.

(ii) Indian Education Commission, 1966

The Indian Education Commission of 1964-66, which was headed by Dr. D.S.Kothari, provided one of the best analytical studies relating to Indian Education with cogent suggestions for improvement. It outlined the general approach to school mathematics. It stated:

"Set language may be used in defining the basic terms in geometry and operations with numbers. It is only through the use of set language that a proper integration of arithmetic algebra and geometry is possible. The use of the school Mathematics Study Group notations for line, segment, ray and so on, which provide for more precision in language, may be adopted."

The Commission further said in describing the methods of teaching:
"Emphasis should be more on the understanding of basic principles than on the mechanical teaching of mathematical computations"

From the above statements, it can be derived that the objectives of teaching mathematics at the secondary school stage should be to develop:

i) Knowledge of basic terms and notations;
ii) Ability in operations with numbers;
iii) Ability to integrate different branches of mathematics in solving problems;
iv) Habit of precision
v) Understanding of basic principles;
vi) Ability in mathematical computations"

(iii) The Review Committee on Education, 1977

The Government of India, Ministry of Education & Social Welfare, appointed a Review Committee under the Chairmanship of Sri Iswar Bhai Patel an eminent educationist of India and then Vice-Chancellor of the Gujarat University. This Committee was specifically asked to spell out, in detail, the curriculum for the Ten Year School. The erstwhile Eleven Year School system was substituted by this Ten Year School system. Necessarily, many adjustments had to be effected in the curricular process. It included mathematics as a compulsory subject right across the school curriculum. Minimum learning continuum relating to mathematics was considered as indispensable and integral to school education.

(iv) Challenge of Education, 1985

The Government of India published a benchmark study relating to the state of education in India in 1985. It was known as Challenge of Education.
It stated:

"Since competence in mathematics and science is likely to be crucial to everyone in the coming decades, this aspect of the teaching-learning process assumes as much importance as the enforcement of discipline."

(v) National Policy on Education, 1986

In May 1986, the Government of India announced the National Policy on Education. It was based on the data provided in the benchmark survey of challenge of Education of 1985 and the emerging needs of the Nation.

The National Policy on Education, though extremely short and succinct devoted two paragraphs to mathematics teaching. It stated:

"Mathematics should be visualised as the vehicle to train a child to think, reason, analyse and to articulate logically. Apart from being a specific subject, it should be treated as a concomitant to any subject involving analysis and reasoning. With the recent introduction of computers in schools, educational computing and the emergence of learning through the understanding of cause-effect relationships and the interplay of variables, the teaching of mathematics will be suitably redesigned to bring it in line with modern technological devices."

The Policy was based on a frame work in which objectives of teaching mathematics were enumerated:

"At the secondary stage, the learner should acquire knowledge and understanding of concepts, symbols and processes related to algebra, geometry, elementary trigonometry and statistics. He should develop the ability to solve problems through algebraic method and apply his knowledge of trigonometry and statistics to solve/interpret simple problems. He should also acquire knowledge and understanding of such concepts as are required to study mathematics as discipline. He should further develop facility with the use of ready reckoners, tables and calculators etc."
vi) National Council of Educational Research & Training, India.

The National Council of Educational Research & Training (NCERT) is the apex body at the Central level of India. It is entrusted with the work to advise Central as well as the State Governments in the matters relating to school education, undertaking research activities, training of teachers, extending expert opinion and advice to the State Department of Education and finally devising basic principles and guidelines for framing the syllabi.

The objectives accepted by the NCERT at the national level in teaching mathematics were:

"The students should be able to:

i) understand and use number system;

ii) acquire necessary computational skills including use of logarithms;

iii) understand mathematical concepts in use in trade and commerce and be able to apply them;

iv) become acquainted with spatial forms and develop ability to apply the knowledge to measure areas and volumes;

v) develop deductive reasoning;

vi) understand quantitative data and use elementary statistics to represent them in different forms and be able to interpret the data for better understanding of situations and for application in life."

The effectiveness of teaching any subject including mathematics depends upon objectives spelt out in a clear cut manner. The 'purpose served by' mathematics depends upon its objectives. Effectiveness of teaching is very
often confined to the efficacy of selected teaching methods. Effectiveness of mathematics teachers can never be assessed solely through comparative studies pertaining to the results obtained through the adoption of different methodologies.

Teaching effectiveness is a wholistic concept related to the total system of teaching and learning. The foregoing detailed discussion had tried to highlight the changing perceptions relating to the objectives of teaching mathematics. This would clarify the present situation vis-a-vis the objectives of mathematics education; and thus contribute to a proper understanding of the effectiveness of mathematics teachers on the basis of their conception or misconception of objectives.
SECTION - III

CORRELATION OF SCHOOL MATHEMATICS

WITH OTHER SUBJECTS
According to Comte, Mathematics is an indispensable subject of study. He said:

"All Scientific Education which does not commence with mathematics is, of necessity, defective at its foundation"32

A teacher of Mathematics who wants to be effective must generate a love for mathematics among his students. Love for mathematics can be created once the students understand its utility. Almost all science subjects bear some relation with mathematics. A good grounding in Mathematics is a sine qua non for understanding other sciences properly. The scope of mathematics encompasses highlighting the role of mathematics in all walks of life, generating mathematical consciousness amongst all and stressing its utility for the study of various subjects.

Mathematics Across the Curriculum

1. Mathematics and Physics

Perhaps no other science is as close to Mathematics as Physics is. For higher education in physics, good qualification in Mathematics is essential. Jagat Narayan Kapur opines:

"Most of our contemporary mathematics was generated in a physical context. It was created in the solving of problems of physics. Consequently physics provides the greatest stock of examples to illustrate and to motivate mathematical concepts"33

Every rule and every law of physics is expressed in form of a mathematical equation. The units of measurement are employed to substances in physics as frequently as in mathematics.
Einstein's law is explained with the equation $E = mc^2$. The law of gravitation is given in the form of equation:

$$F = \frac{G m_1 m_2}{r^2}$$

Similarly resultant velocity is given by the formula:

$$R = \sqrt{u^2 + v^2 + 2uv \cos \theta}$$

What Oxygen is to life, mathematics is to physics. Physics can neither survive nor flourish without the aid of advanced mathematical techniques.

2. Mathematics and Chemistry

All chemical combinations and their equations are governed by certain mathematical laws. Formation of chemical compounds is governed by mathematical calculations.

Water is a compound. Hydrogen and Oxygen form its constituents and they are present in the ratio 2 : 1

Atomic weights are nothing but numbers and molecular weights are calculated with the help of these numbers:

"In this atomic age, atom ceases to be the smallest indivisible particle of matter. The atom is a composite of many smaller particles like neutrons, protons and electrons. A slight disturbance in their balance produces tremendous energy. Harnessing this energy requires quantitative interpretation of change of form of energy. These equations and interpretations are provided by mathematics"
Every student of chemistry must have a fairly good working knowledge of mathematics. The sophisticated methods of measurement and quantification are as much a need in the chemistry laboratory as they are in Physics laboratory.

3. Mathematics and Biology

"The old fallacy - that there is no meaningful interaction between mathematics and biology - has been completely exploded now that agriculture, biological and medical scientists are employing mathematics, statistics and computers on a large scale and since mathematicians, statisticians and engineers need to possess a good knowledge of biology to be able to contribute to genetics to population dynamics, biofluid dynamics, agricultural statistics, biomedical engineering etc."

Mathematical processes and calculations are being increasingly employed in advanced studies relating to heredity, nutrition, growth, maturation, fatigue and many other branches of Biology and Physiology.

4. Mathematics and Engineering

Mathematics is the foundation of engineering and technology. Therefore, a good qualification in Mathematics is necessary for admission into engineering course. Almost each and every process of engineering requires the careful application of mathematical rules and precision. The technological race of advanced nations is greatly dependent upon the requisite advances in mathematics.

5. Mathematics and Agriculture

Agricultural Management is in high demand. Measurement of land estimating investment or expenditure, production per unit area, cost of labour, time and work, seed rate, manure rate etc are some of the aspects of agriculture in which mathematics is applied.
6. Mathematics and Geography

"Geographical map-making is essentially a mathematical problem, though it sometimes involves college-level mathematics. Secondary school students can be taken as far as possible in the principles of geographical map making, and can be motivated to learn higher mathematics to achieve particular projections. We can have maps which show distances accurately or angles accurately or areas accurately. These may be called geometrical maps. We can also have population maps or economic resources maps."36

It requires a great Mathematical ingenuity to construct the maps showing per capita income of a country in comparison to other countries.

7. Mathematics and Language Arts, Crafts and Sports

Here are given a few prominent views on the relationship between mathematics and fine arts. Leibnitz, the great mathematician, stated, "Music is a hidden exercise in arithmetic of a mind unconscious of dealing with numbers."37

Bertrand Russel has tried to portray the inherent subtle, aesthetic sense of mathematics. He said:

"Mathematics, rightly viewed, possesses not only truth but supreme beauty - a beauty cold and austere, like that of sculpture without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show."38

Beauty of a piece of art depends upon the symmetry and harmony, which in turn depend greatly on the subconscious understanding of proportions. The effective approach of Architecture, sculpture or painting can be heightened through a proper understanding of the mathematical principles behind the design.
8. Mathematics and Ethics

George David Birkhoff in his article 'A Mathematical Approach to Ethics', has opined that for certain purposes, philosophic thought may be treated separately in its logical, aesthetic and ethical aspects concerned respectively with the true, the beautiful and the good. According to him,

"More specifically, social customs and systems of law and of religion contain a vast mass of ethical data, embodying the accepted ethical solutions of innumerable practical problems of analytic ethics, and inductive method can generally be applied to treat new problems when they arise. In so far as these solutions are not purely empirical, they could be codified by means of the ethical formula. Such a codification would list and classify the very extensive variety of ethical intuition (postulates) in part the cause of, and in the part result of, specific social interactions. There is little doubt of the basic role which the sentiments of love, goodwill, loyalty, and other feelings of sensuous', aesthetic or intellectual type play in such intuitions. These provide a substratum of absolute elements, of which the specific manifestation demands on the particular culture and period concerned"39

9. Mathematics and Amusement

Mathematical quizzes, competitions, designing with the aid of geometrical patterns provide adequate avenues for recreation and engaging oneself in creative activities:

"Games and Puzzles are the subject of a considerable mathematical literature, much of which is both difficult and tedious. The writing on magic squares alone suffice to make a fair sized library. Nothing more dismal can be imagined. It is not inevitable that the mathematical treatment of games should work a blight. Games are among the most interesting creations of the human mind and the analysis of their structure is full of adventure and surprises. Unfortunately there is never a lack of mathematicians for the job of transforming detectable ingredients into a dish that tastes like a damp blanket"40
10. Mathematics and Social Sciences

Social sciences, in general, were highly theoretical and philosophical. Most of them lacked exactitude and precision. To a very great extent, amorphous and nebulous. Almost all the Social Sciences are trying to attain exactitude. In the process all of them are employing sophisticated mathematical formulae and statistical process to analyse the data and arrive at appropriate conclusions.

Alfred Marshall, the doyen of modern Economics, had already forcing the importance of mathematical analysis in this field. He averred, "The direct application of mathematical reasoning to the discovery of economic truths has recently rendered great services in the hands of master mathematicians". Econometrics with its strong and inextricable linkage to mathematics is fast displacing economics.

Measurement has entered in a big way and 'metry' is the in-thing. Sociometry and anthropometry are emerging as distinct fields of study.

Political behaviour, voting pattern, political choices, political predictions are increasingly being computerised and mathematically analysed. Today the computers are playing a critical role in arriving at a variety of political decisions including the selection of the right candidate for a particular constituency.

Today good management is considered to be, "....... the key to the well being of our present day society". Accounting, auditing, appraisal etc necessitate a high degree of mathematical knowledge. High level mathematics and computer literacy are essential for every minute.
History and Mathematics are generally viewed to be antipodes of each other. But modern Historiography is heavily relying on mathematics to attain greater accuracy and authenticity. Chronological tables and many types of historical data need careful mathematical processing.

The process of 'development' is a highly complicated process which is being actualised by peeling knowledge from variety of disciplines. It is sophisticated social engineering. Here again advanced mathematical knowledge is an unavoidable pre-requisite. A riched data base and accurate projections are essential for proper planning of development.

Even in language teaching, mathematical approaches and mathematical models are being increasingly used. Initial Teaching Alphabet of James Pitman and John Downing very heavily realised on Madison project materials. Intrinsic motivation which is basic to mathematical logic had been applied in developing ITA. Chomsky had worked on the theory of generative and alternative grammars closely based on mathematical models.

Mathematical problems of the traditional text books are exciting and interesting. They are like purely formal puzzles but the application of mathematics with the needs of Social Sciences are grossly neglected. James G.March has diagnosed the reasons behind this phenomenon. According to him, behavioural and social sciences suffer from three major disabilities.

1. Virtually nothing from those disciplines is taught in the first twelve years of school.
2. The skills required for them are far more unique to them.
3. The social norm press towards social tends to be antianalytical. The behavioural sciences are associated (quite appropriately) with human beings and social problems. As a result they are associated (quite appropriately) with a rejection of things, quantities, abstractions. They tend (except for economic and political science) to be relatively feminine.\(^{44}\)

IVO.W. Molenaar has beautifully summarised March's stand as one that is designed, "..... to develop the artistry of thinking analytically about social sciences."\(^{45}\)

J.F. Ling has tried to examine the mathematical foundations of geography. He states:

"Generally speaking what characterises the newer approaches to geography is a concern with spatial arrangements which recur in one form or another all over the globe and can be abstracted from particular context. The understanding of such spatial arrangements can be advanced. So it is held by quantitative methods of analysis and/or the building of theoretical models. Examples of such spatial arrangements (usually called 'spatial distributions' by geographers, a term with statistical overtones) are transportation networks (arrangements of links connecting places); settlement patterns (arrangements of points in a region) land use patterns (arrangements of regions)."\(^{46}\)

Knowledge is an organic unity. The totality of human experience is knowledge. Different subjects are the different facets of this human experience; and are inter-related. Positive interaction in between the different subjects of the school would surely enhance the effectiveness of all subjects. Sometimes, the specialists adopt an isolationistic approach. However, this is not a healthy academic approach. Mathematics should be viewed as a contributing factor to the enrichment of experience in different fields. Hence the discussion in this section.
SECTION - IV

EDUCATIONAL VALUES OF MATHEMATICS
EDUCATIONAL VALUES OF MATHEMATICS

Manfred Kilka stated in 'Mathematics for All' that:

"Mathematics is the unique art and science that enables us to cope with the complexity with economic, social and technical problems in a rational, quantitative way. The education and training of students in this field is an international concern" 47

No other subject than mathematics bears such great importance. It is the subject that has attracted the attention of many eminent educationists throughout the world. Many conferences and committees have been set up in order to arrive at solutions to various problems confronted in the field of teaching and learning mathematics and to chalk out better strategies of instruction in this field. Eminent mathematicians and experts in mathematics education have pooled to gather their expertise to bring about revolutionary changes in mathematics instruction.

Numeracy is a basic survival skill and knowledge of Mathematics is essential for survival and progress in the present age of science and technology. This subject which is often described as the "Queen of Sciences" has been studied for initiating the following major values:

i) Practical or utilitarian
ii) Disciplinary
iii) Cultural
(i) Practical Value

The application utilization of the fundamental processes of mathematics permeate daily life. The lowest and the highest utilize the techniques of quantification in one form or the other. It cuts across a broad spectrum of occupational fields like accountancy, banking, business, engineering, technology, taxation, insurance etc. The different mathematical processes like counting, notation, addition, subtraction, multiplication, division, weighing, measuring etc are the simple and fundamental processes of mathematics which have immense practical value.

It is a helpful tool for the study of various sciences. Sherry Fraser remarked:

"Mathematics has been called the queen of sciences. She could also be called the gatekeeper to the job market. Too often students who might find job satisfaction in a scientific or technical field are unable to enter that field because of inadequate preparation in Mathematics."48

Ignorance of mathematics in the masses is a formidable obstacle in the way of a country's progress. Individual resources add up to form national resources.

Nepoleon Bonaparte had also reiterated its importance:

"The progress and the improvement of mathematics are linked to the prosperity of the State"49

Mathematics has played a crucial role in the efflorescence of the modern technological civilization by assisting all sciences to attain greater precision. Mathematics is an effective indispensable tool employed by all sciences like physics, chemistry, biology, medicine and engineering. Roger
Bacon had emphasized the importance of Mathematics in these words:

"Mathematics is the gate and key of the sciences...Neglect of mathematics works injury to all knowledge. Since he who is ignorant of it cannot know the other sciences or the things of the world. And, what is worse, men who are thus ignorant are unable to perceive their own ignorance and so do not seek a remedy."50

In the coming millennium the super computer and satellites are likely to usher in a super-technological civilization with mathematics occupying the centre-stage of all activities.

(ii) Disciplinary Value

According to Locke, "Mathematics is a way to settle in the mind a habit of reasoning."51

Mathematics helps the mind to become steady and balanced. Rigorous mathematical reasoning can free a person from bewilderment and mental unrest. Exactitude, precision and accuracy are the goals of mathematics education. These qualities nurture a disciplined intellectual orientation.

The learner has to assess the correctness and incorrectness of a statement; and thus arrive at the right conclusion. The higher mental processes develop through graduated exercises of mathematics. The students are able to collate and coordinate facts and perceive the logical relationship embedded in the mathematical problem. The emerging methodologies of mathematics instruction are changing the school climate. Watson opines:

"But even more from the way the teacher works in the classroom - forms the increasing emphasis on individual methods, on creativity rather than remembering, on new pattern of assessment and examination and on the use of a wide variety of project methods."
Such changes have certainly transformed the life of many classrooms and made school a different place for teachers and their students.52

Development of mathematics has provided a new orientation to the classroom, a new approach to the students and teachers with the major thrust on problem solving and practical application. Mathematics possesses such characteristics as accuracy, certainty, originality, rationality and veracity etc which greatly assist mankind in its struggle for existence and constant endeavour to forge ahead towards a better life. Courant and Robbins have highlighted the values of mathematics. They state:

"Mathematics an expression of the human mind, reflects the active will, the contemplative reason and the desire for aesthetic perfection. Its basic elements are logic and intuition, an analysis and construction, generality and individuality. Though different tradition may emphasize different aspects, it is only the interplay of these aesthetic forces and the struggle for their synthesis that constitute the life, usefulness and supreme value of mathematical science."53

Mathematics helps in developing intellectual capabilities of the learner. It generates the latent powers of thinking, reasoning, discovery and judgement of the individual.

J.P. Wickesham says, "No means are known whereby the faculties of the mind can be developed but by exercising them. By the potent spell of the magic word 'exercise', is evoked all human power."54

(iii) Cultural Value

Mathematics has played a very important role in building up modern civilisation by perfecting all sciences. Even though, people have only a
vague idea that all progress made by mass is the result of scientific progress they are strongly in favour of scientific and industrial education. But mathematics is basic to all these sciences.

Indian culture is firmly rooted in mathematics. Without mathematical knowledge building huge monuments like Qutbminar, Char Minar, Tajmahal or Konark would have been impossible. Building dams, roads, railways, industrial plants, power plants are nothing but the products of science in which mathematics is an integral part. In recognition of the crucial role of mathematics, it has aptly been remarked, "Mathematics is the science of all sciences and art of all arts".

The major advances of modern civilization can be attributed to the progress of various occupations such as agriculture, engineering, surveying, medicine, industry, navigation, rail-road building etc. The occupational network contributes to the efflorescence of culture. Mathematics contributes and has contributed in a variety of ways to the growth of a variety of occupations. Mathematics is steadily and silently shaping culture. The modern materialistic attitude is partly traceable to the effect of mathematics on life and culture.

Mathematics has deeply influenced even the fine arts like drawing, painting, sculpture, music etc. Mathematics has quickened the development of many an ancient civilization like the Indus valley civilization or Egyptian civilization. In recognition of the great impact of mathematics on culture, it has been rightly said, "Mathematics is the mirror of civilization".
Mathematics is highly essential for enriching and sharpening human thought. The ancient Indian mathematician Brahmagupta had highlighted the utility of Mathematics. He stated:

"As the sun eclipses the stars by his brilliancy, so the man of knowledge will eclipse the fame of others in the assemblies of the people if he proposes algebraic problems and still more if he solves them."
SECTION - V

IMPORTANCE OF THE TEACHER
Teaching is one of the oldest professions. Teachers have continued to occupy an important position. The teacher is an important fixture of the social scenario. Without teaching and teachers, there would be no civilization, no culture and no progress. Teaching and learning are the indispensable processes of human progress. Throughout the ages, the teacher has been accorded a place of honour and respect in the society. Scriptures and literatures abound in a variety of adulatory references to teachers.

In ancient India, the teacher was viewed as the creator (Lord Brahma), the caretaker (Lord Vishnu), the destroyer (Lord Shiva). Thus, teachers were treated as living embodiments of divinity.

Henry Von Dyke, with deep reverence to the teachers, had this to say of them:

"Great generals win campaigns, but it is the unknown soldier who wins the war. Famous educators plan new systems of pedagogy but it is the unknown teacher who directs and guides the young. He lives in obscurity and contends with hardship. For him, no trumpets blare, no chariots wait, no golden decorations are decreed. He keeps the watch along the borders of darkness and makes the attack on the trenches of ignorance and folly. Patient in his duty, he strives to conquer the evil powers which are the enemies of young. He awakens the indolent, encourages the eager, and steadies the unstable. He communicates his own joy at learning and shares with boys and girls the best treasures of his mind. He lights many candles which in later years will shine back to cheer him. This is his reward. Knowledge may be gained from books, but the love for knowledge is transmitted only by personal contact. No one has ever deserved better of republic than the unknown teacher. No one is more worthy to be enrolled in a democratic aristocracy, "king of himself and servant of mankind"."57

The progress of mankind has become possible, only due to the strivings of the teachers. The advances of civilization have a close and corresponding
relationship with the quality of teaching. The influence of the great teacher extends through many generations. The fate and fame of eminent teachers like Panini, Jesus, Shankaracharya, Gandhiji reverberate through centuries. The centrality of the teacher in any scheme of education needs no elucidation.

As yet the substitute has been found for the impact of mind upon mind, personality upon personality. The teacher continues to be the most influential factor in high school education. Curriculum, organisation, equipment, important as they are, count for little or nothing except as they are vitalised by the living personality of the teacher. It is he (and very often she) who translates the grand objectives of the intended curriculum into operational realities of the classroom. Dr.C.H. Jud has emphasized the importance of the teachers in the school system and stated:

"The teaching staff of any educational institution is its most essential item of equipment. Providing suitable teachers for American High Schools is a task so colossal that our civilization is staggered at its effort to meet the demand. Our ability or inability to provide competent teachers will determine the success or failure of the American experiment of universal secondary education."

Quality of education depends on quality of teachers at school level. The strength of an educational system largely depends upon the quality of its teachers. However enlightened the aims, however up to date and generous the equipment, however efficient the administration, the evaluation of children is determined by the teachers. Eventually the progress of a society depends on the quality of its teachers. A teacher is not only a communicator but also a mobiliser, a motivator and coordinator.
There exists a correlation between national development and quality of teachers. Chaurasia (1967) emphasized the relationship thus:

"It is universally accepted that the quality of Nation depends upon the quality of its citizens. The quality of its citizens depends in the critical measure upon the quality of their education. The quality of education depends upon several factors—time, inherited traits and attitude of parents, financial support, building, books and equipment in the school curriculum and methods of instruction. But the most significant factor is the quality of the teacher."

It is the teachers who are the acknowledged architects of the destiny of a Nation. While opening the Eleventh Conference of the Indian Association of Teacher Education (IATE 1968) the then Governor of Gujarat, Shri Shriram Narayan reiterated and stated:

"Teachers are the real architects of a Nation. The greatness of a country does not depend on lofty buildings, gigantic projects and large armies. The ultimate test of a Nation's greatness is the quality of her citizens. If a Nation possesses young men of sterling character and unimpeachable patriotism, She is bound to make rapid progress on all fronts. Young men are entrusted to the care of the teaching profession and it is, therefore, the sacred duty of the teacher to impart the right type of education to students in order to make them right type of citizens. Teachers can play a very vital role in shaping the future of India by paying attention to the young men entrusted to their care."
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