

CHAPTER 1

INTRODUCTION

1.0 Importance of Education

A Nation's progress and development is well reflected through its education system. Educated human beings are the most important resource of any nation. A good system of education of a country always aims for producing citizens of intellectual and moral integrity. An educated person only has the wisdom and knowledge to work for the benefit and national interest of the country. Good educational institutions aim to inculcate the respect for spiritual and ethical values among students and also encourage them to work for human welfare. Also, they work as agencies for passing the culture of the nation to the younger generations. Good education system must convert a child into fully developed adult with enough wisdom and intellectual discipline. If students are intellectually and morally brought up through a good system of education, most of the troubles, the country faces would be at an end and lives of people and the country as a whole will progress.

Ancient India's education system – 'The Gurukul System' was praised by everyone, all across the world. While imparting knowledge by Gurus, skill developments also were taken into consideration by them. But with the advent of British, the education system of India had been converted as per the needs of the colonial powers. The traditional Indian schools were converted to create people who can be subordinates for the British as their prime motive was not the development of system of education in India, but to have Indian people who can help in their trading and profit making.

Though India woke up by breathing in the air of freedom from British rule in 1947, British colonial rule had left behind an education system which till date chained the minds of scholars and educators. Over these ages, academicians of the country were working relentlessly to raise an education system which can enhance the social and cultural identity of the country – a system which can fulfill the requirement of the time.

India's education system has undergone many reforms since 1947 till today. Much efforts have been made by different commissions and committees appointed by the government to improve the quality of education, appropriate to take care of the need of the generation, time to time. Despite of all the efforts, present education system is simply geared towards teaching and testing knowledge at every level. Knowledge is largely forgotten after the end of each exam. Students of the country are seen just focusing on cramming information. The best crammers are rewarded and this is one of the major flaws of Indian education system today. Focus should be on skill based and competency-based education, rather than content-based education, specifically in subject like mathematics. Here is the high time to re-define the objectives and purposes of the existing education system, also to re-structure the methodology of teaching – learning.

1.1 Mathematics as a Discipline

Mathematics is considered as an important subject in the school curriculum across the world. This is due to the significant role it plays in attaining the foundational numeracy skills required for life for every individual for their survival. In order to possess the mathematical competence for any individual, it is important to understand mathematics not just as a subject in the school curriculum but as a discipline.

Mathematics is both science and arts which deals with numbers, quantities, shapes, figures, patterns, measurements, notations, representations, how they are connected with one another and how they are applied to solve the problem situations in the real life. The word MATHEMATICS came from the Greek word 'mathema' meaning "science, knowledge or learning". Sometimes it is shortened to write 'maths' in some countries or 'math' in other few countries.

Ancient Indian mathematics and mathematicians have made valuable contributions in mathematics which were accepted world -wide. '0' was one of the important contributions made out of many by India. Important contributions were made by Indian scholars like Aryabhata, Brahmagupta, Bhaskara II, Varāhamihira, and Madhava.

Mathematics is broadly classified into two parts— Pure mathematics and Applied mathematics. Pure mathematics deals with direct mathematical concepts and theoretical frameworks rather than practical applications. Applied Mathematics is a discipline that focuses on using mathematical methods and techniques to help in solving problems in real life and also

in other fields which include science and technology, engineering, economics, business etc. Pure mathematics courses are proof based concepts and deal with theoretical possibilities. Applied mathematics uses mathematical tools to solve real life problems. In the academic year 2020-21, the Central Board of Secondary Education (CBSE) introduced Applied Mathematics as an elective subject at Senior Secondary level. CBSE Academic Guidelines (2023-24) state that “the syllabus of Mathematics in senior secondary grades meant for Science subjects may not be appropriate for the students who wish to pursue Commerce or Social Science-based subjects in university education. By keeping this in mind, one more elective course in the Mathematics syllabus is developed for Senior Secondary classes(for Classes XI & XII) with an aim to provide students relevant experience in Mathematics that can be used in fields other than Physical Sciences.”

Arithmetic, Geometry, Algebra, Statistics, Probability, Trigonometry and Calculus are the few common mathematics disciplines which are offered in the school curriculum, out of which Arithmetic, Geometry, Algebra are coming under pure mathematics whereas Statistics, Probability, Trigonometry and Calculus come under applied mathematics.

The below given figure well summarizes the important branches of mathematics.

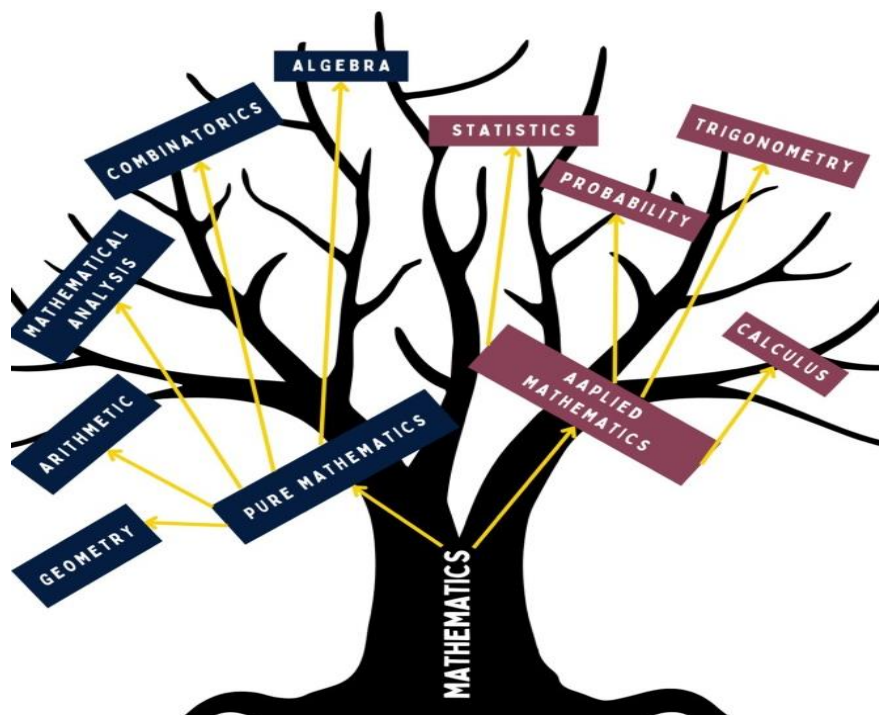


Figure 1.1 Branches of Mathematics

During early period of civilization, human beings used mathematics mainly for counting and for getting answer like “how many”, “how big”, “how much” etc. Symbols for numbers started from that period. Since then the academicians of the country had been trying to make the subject mathematics user friendly and relevant to real life situation in order to make it an interesting subject for learners.

The National Education Policy- 2020 emphasizes the importance of attaining the Foundational Numeracy skills for every single child of the country, by the age of 8 years. In the proposed education pattern of 5+3+3+4 by NEP-2020, the basic numeracy skills are expected to be gained by the end of the first 5 years of schooling. This focus of the policy itself talks about the important nature of mathematics in one’s life. In the foundational stage, students just begin to learn mathematics as numbers. Learners are expected to see mathematics as a discipline at this stage. Arithmetic as a discipline is introduced at this stage. At the preparatory stage, they start learning Geometry and basic Statistics through the topic- Data Handling. Then at the middle stage, Algebra is introduced. Secondary stage covers Trigonometry, Probability and the advance learning of all other branches which are already introduced to the learners at various stages.

Mathematics as a discipline is very important to learn in school education because it helps students to enhance a majority of skills required for their daily life. Mathematics can enhance the following skills in learners.

Cognitive development: Mathematics can improve memory, attention, and reasoning skills. These skills can positively impact academic performance across subjects.

Critical thinking: Critical thinking and problem-solving skills can be developed through mathematics learning.

Logical reasoning: Students develop logical reasoning skills and the ability to think abstractly.

Analytical thinking: Students develop analytical thinking skills.

Creativity: Students develop flexible thinking and creativity.

Career paths: Mathematics education opens up many different career paths.

Emotional health: Mathematics learning boosts emotional health.

Since mathematics connects and provides basic knowledge and foundational skills for other subjects of school curriculum like Science, Art, Economics etc., how to interlink mathematics with other subjects was to be addressed, which is now very well taken care by NEP-2020, by emphasizing on the interdisciplinary aspects of various subjects along with mathematics.

1.2 Nature of Mathematics as a Subject in School Education

Since last few decades, school mathematics education has made remarkable reforms by curriculum reformation, content modification in textbooks and reforms in teaching – learning process. The major reforms in curriculum for all stages of school education came after National Policy on Education (NPE, 1968). As per the report of ‘Kothari Commission’ (1964-66), basic mathematics or general mathematics was a compulsory subject up to class X and advance mathematics was included for class IX and X only at secondary level”. In general mathematics, Arithmetic, Geometry and simple Algebra were included. Advance Mathematics contains Integers, Quadratic Equation, Logarithm and Co-ordinate Geometry. But the system did not work much. Irrespective of all care for quality mathematics education at secondary level, a good number of students could not achieve the school final examination certificate. National Policy on Education (NPE,1986) again brought reformation in curriculum and textbooks, especially of Science and Mathematics. But in 1993, Yashpal Committee reported, “the curriculum overloaded; content not related to real life; teaching –learning mechanical; rote memorization without understanding the concept & mathematics teaching not related to real life”.

On the basis of Yashpal Committee report (1993), new curriculum was developed in 1998 by giving importance to Competency approach, Child centric approach, Joyful approach, Activity based approach. Competency approach in mathematics helps the learners to develop their ability to apply their theoretical and conceptual knowledge and skills in various real life situations. Child centric approach focuses on child’s needs, interest and views in the teaching- learning process. Joyful approach in teaching mathematics encourages the teachers to use various joyful activities to promote meaningful learning of mathematics such as games, story- telling, hands on activities and virtual learning activities. But to convert traditional fearful learning of mathematics to joyful learning in mathematics, teachers to be empowered with pedagogical challenges by reorientation on learners of learning, holistic approach in treatments of learner’s development

and learning, creating an inclusive environment in the classroom for all, engaging learners for construction of knowledge and fastening creativity, arranging active learning through activity and other assignments, upgrading up to date knowledge of concept and pedagogy, etc. (Das, 2012).

As per NCF (2005), a holistic composite curriculum for entire stage of school education was developed. NCERT new curriculum as per NCF 2005 for Primary, Middle, and Secondary Level consists of:

Sr. No.	Class 1 to V	Class VI to VIII	Class IX & X
1	Geometry (shapes and spatial understanding)	Number systems and playing with numbers	Number Systems
2	Number and operation	Algebra (introduction and expression)	Algebra
3	Mental Arithmetic	Ratio and proportions	Co-ordinate Geometry
4	Money	Geometry (basic ideas of 2D and 3D figures, shapes, symmetry and construction)	Geometry
5	Measurement	Mensuration	Mensuration
6	Data Handling	Data Handling – Introducing the graphs	Statistics and Probability
7	Pattern		Trigonometry

New sets of textbooks also were developed by NCERT with totally new approach.

NCERT(2006) published the ‘Position Paper’ by National Focus Group (NFG) on ‘Teaching of Mathematics’ which gave guidelines for the implementation of the NCF(2005) aspects related

to mathematics education and for improving the quality mathematics education at secondary level.

Hence remarkable changes had been brought in mathematics education at secondary level, time to time after independence of the country and especially in the last two decades, after the implementation of NCF(2005) in schools across the country and the schools abroad which followed CBSE curriculum and NCERT syllabus.

The latest policy on education declared by the government of the country which is the National Education Policy – 2020, recognized that “mathematics and mathematical thinking will be very important for India’s future and India’s leadership role in the numerous upcoming fields and professions that will involve artificial intelligence, machine learning, and data science, etc. Thus, mathematics and computational thinking will be given increased emphasis throughout the school years, starting with the foundational stage, through a variety of innovative methods, including the regular use of puzzles and games that make mathematical thinking more enjoyable and engaging. Activities involving coding will be introduced in Middle Stage” (NEP-2020, 4.25).

NEP-2020 has reduced the syllabus of mathematics drastically in school education with an aim to convert the teaching – learning process focus from ‘content based’ to ‘competency based’.

Though reforms are being made time to time to make mathematics education in schools more enjoyable through activity-based learning processes, research studies indicate that many students show specific learning difficulties in mathematics due to which the expected learning outcomes in the subject is still not becoming possible.

1.3 Importance of Mathematics Education at Secondary Level

Secondary education is the link between the primary and senior secondary education. In most of the State Education system and in CBSE, Class IX and Class X are considered under secondary level of education. It is the terminal point of formal education, which is the primary or elementary education. It is also the teenage years of the learners. The education and learning happening at this age has been recognized as very crucial for the development of their character, personality and for the development of job skills and other attributes which enhance the ability of children to act and function in the society as fully developed citizens.

Various Education Commissions appointed so far for the reformation of the system of our country had shown serious concerns about the secondary education. The University Education Commission (1948-49), under the chairmanship of Dr. S. Radhakrishnan had stated that “the standard of admission to university courses should correspond to that of the present intermediate examination”. NCF-2005 also states that secondary education prepares students for their higher education and also makes them skilled workforce ready to take global challenges. Keeping in mind the physical, mental status of learners at this age, and by understanding the need for reformation, NCF-2005 has made many radical proposals which include new pedagogic approach and change in the entire examination and evaluation system of secondary education. Learners at this level have intense vibrancy and energy. This is the period of physical changes and period of formation of learners’ identities. Curriculum planning and design of education at this level must enhance the skills of the transition happening at this age in learners and also secondary education must offer the required and adequate opportunities for learners to unfold their full potentials.

NCF (2005) states, “at the secondary stage, students begin to perceive the structure of Mathematics as a discipline. They become familiar with the characteristics of mathematical communication: carefully defined terms and concepts, the use of symbols to represent them, precisely stated propositions, and proofs justifying propositions. These aspects are developed particularly in the area of Geometry. Students develop their facility with Algebra, which is important not only in the application of Mathematics, but also within Mathematics in providing justifications and proofs. Mathematical modeling, data analysis and interpretation taught at this stage can consolidate a high level of mathematical literacy. Individual and group exploration of connections and patterns, visualization and generalization are important at this stage, and can be encouraged through the use of appropriate tools that include concrete models as Mathematics Laboratories and Computers”.

As secondary education prepares students for their higher education and also makes them as skilled workforce ready to take global challenges, it is necessary to strengthen this stage of students by providing quality mathematics education so that their mathematical abilities and logical thinking can be developed and can implement those skills in everyday life. Scholars have continuously emphasized the need of curriculum reforms and reforms in methodology of

teaching learning, result of which is the establishment of mathematics laboratory and ICT enabled mathematics education in schools, continuous in-service training programmes for teachers, skill development programmes and professional development programmes for teachers.

Actual learning happening at this age is the lifelong resource for many learners, along with the certificates they earn after the secondary schooling. In 2009, Government of India had initiated Rashtriya Madhyamik Shiksha Abhiyan (RMSA) with a focus “to make good quality secondary education, available, accessible and affordable to all young people irrespective of gender, socioeconomic condition, disability, geographical and other barriers”. Assuring the quality of teachers at this level is a necessity and providing opportunities for their professional development and growth is the key to maintain the quality secondary education.

The aim of secondary education must be to nurture the multiple abilities of learners. It is very important to nurture the logical – mathematical abilities in every child as it encourages and develops important ways of thinking necessary for their lives. Ensuring children to have a good grounding in mathematics will equip children for their future lives by developing the skills valued in industry and university (Ofsted, 2011). Mathematical skills are crucial for a wide array of analytical, technological, scientific security and economic applications (Emma, 2012). Mathematics is not only needed for the understanding of other sciences, understanding of a basic level of numeracy is required for all in order to function in an increasingly complex world (Burghes, 2011). The NEP (2020) strongly emphasizes the importance of secondary mathematics education for various skills development like critical thinking skill, problem solving skill etc. and also for the holistic development of students of this stage, equipping them with the 21st century skills.

It is evident from many research findings that secondary mathematics education is very crucial for learners because it helps students develop skills which are very essential for their higher education, making career choices and above all, for their lives.

1.4 Objectives of Teaching Mathematics at Secondary Level

The Gujarat State Education Board (GSEB) and the Central Board of Secondary Education (CBSE) have revised the curriculum and syllabus of mathematics at secondary level by considering the objectives of NCF (2005). Objectives of teaching mathematics at secondary level stated by CBSE are, “to help learners to consolidate the mathematical knowledge and skills acquired at the upper primary stage; Acquire knowledge and understanding, particularly by the way of motivation and visualization of basic concepts, terms, principles and symbols and underlying processes and skills; Develop mastery of basic algebraic skills; Develop drawing skills; Feel the flow of reason while proving a result or solving a problem; Apply the Mathematical knowledge and skills to solve real life problems by developing ability to think, analyze and articulate logically; Develop awareness of the need for national integration, protection of environment, observance of small family norms, removal of social barriers, elimination of gender biases; Develop necessary skills to work with modern technological devices such as calculators, computers, etc.; Develop interest in Mathematics as a problem-solving tool in various fields for its beautiful structures and patterns, etc. and Develop reverence and respect towards great Mathematicians for their contributions to the field of Mathematics”.

Rashtriya Madhyamik Shiksha Abhiyan (RMSA, 2009) also has stated the main objectives of teaching mathematics at secondary level as- “to develop the ability of students to conceptualize, inquire reason and communicate mathematically, to enable students to manipulate numbers, symbols and other mathematical objects, to develop the number sense, symbol sense, spatial sense and a sense of measurement as well as the capability in appreciating structures and patterns and to develop a positive attitude towards mathematics and the capability in appreciating the aesthetic nature and cultural aspect of mathematics”.

To achieve all the above objectives from a class of heterogeneous group of students – the students having diverse capabilities – the role of mathematics teacher of secondary level is more challenging.

1.5 Learning Difficulties in Mathematics

Learners of mathematics face various problems in their pursuit of the subject. Research findings reveal multiple reasons for the same such as personal problems, lack of interest and sheer negative attitude towards the subject. “Mathematics anxiety is the result of the students’ negative attitude or embarrassing experience with their mathematics teacher in previous years. Such an experience makes a student believing him or her deficient in mathematics ability and this mathematics anxiety results in poor performance in the subject.” (Ganal & Gujab, 2014).

A report of the CAGE committee (2005) on Universalisation of Secondary Education states, “there are views from many quarters that the most significant reason for ‘mass scale failure’ in the Class X board examination, is the common curriculum and the course offerings. Nearly 80% of the students who fail in board exam fail in Mathematics, English or Science, which makes an adverse impact on the ‘self- esteem’ of students”. As per National Policy on Education (1986), “the root cause of ‘mass scale failure’ is not the common curriculum but cause of failure lies in the framework in which subject is conceived, the manner in which knowledge is transacted and the evaluation parameters and the assessment procedures adopted to examine students. To study and succeed in basic mathematics and other subjects is a fundamental right of a child to have access to complete secondary education.”

‘10+2 pattern of school education’ was recommended by the Education Commission (1964-66). The commission advocated that “a minimum of 10 years of common curriculum is necessary to develop citizenship in a democracy”. In the 10 years common curriculum, mathematics is a compulsory subject. The present secondary curriculum offers the learners to learn a few other subjects along with mathematics. This approach of secondary education impacted a number of students negatively those who were with differential abilities and potentials in learning mathematics. Learners who do not have the mathematical abilities were unable to perform well and they were ridiculed on the basis of their low scores.

The ‘Position Paper’ on Teaching of Mathematics (NCERT-2006) by National Focus Group also talks about the development of mathematics programme that would ensure that everybody learns mathematics and does not fear it. But there is a strong teacher component in making any such programme more effective and successful.

Singha et al. (2012) gives the suggestive measures like exhibition of mathematical models, organizing mathematical quiz, student's seminar & regular refresher courses for mathematics teachers to make mathematics education more effective at secondary level.

By considering the learning difficulties in mathematics, NEP-2020 has made recommendations for Arts Integration, Sports Integration, Experiential learning, Game based learning, Story-telling approaches etc. in mathematics to make the subject more interesting for the learners. NEP-2020 recommends to reducing the content of the subject to focus more on competency development of learners, expecting a transformation in the system from content based learning to 'Competency Based Learning (CBL)'

1.6 Role of Mathematics Teachers

All students need concrete experience with mathematical objects and ideas before they get into abstraction. Getting them into the abstract thinking of mathematics is the responsibility of an efficient teacher. An efficient mathematics teacher only can develop the mathematical ability, mathematization of things, logical thinking etc. in learners, which are the main objectives of teaching mathematics. In fact, the potency of an educational system lies upon its teachers. Teachers are at the heart of effective mathematics teaching. They need to be well qualified and well trained and enthusiastic about mathematics. According to National Council for Mathematics Teachers (NCTM) of USA, "a mathematics teacher is someone who inspires to look beyond the pages of the textbook to make the learners problem solvers and critical thinkers". It is the role of each and every mathematics teacher of secondary level to ensure that students of their classrooms have knowledge and skills to face the challenges of day-to-day life. It is the teacher's responsibility to make each learner of the classroom to think critically, analyze and use the skills acquired in solving the problems.

A mathematics teacher of secondary level should be able to help learners in having a comprehensive understanding of the fundamental ideas of mathematics, able to transform a new condition or problem they face into a form that renders the relevance of mathematics, make the problem open to mathematical treatment, identify and use the relevant mathematical knowledge to solve the problem (Yeasmin, 2017).

NCERT (2022), in its published ‘Guidelines for 50 Hours of Continuous Professional Development for Teachers, Head Teachers and Teacher Educators, Based on *National Education Policy 2020*’ states, “A teacher in a school system is expected to perform a number of teaching and organisational functions. Some of the teaching functions include planning, designing and implementing teaching-learning activities, carrying out student assessment, organising different curricular, co-curricular activities, etc. Organisational functions include participation in school administration and management, school development, interaction with community, etc. The knowledge and skills required to perform different teaching and organizational functions are generally acquired by a teacher through structured initial teacher education programme. The teaching profession, like any other professional areas always evolves with new knowledge and skills generated through experience, research and development carried out in the field of education. A teacher in the school system needs to be updated with new knowledge and skills emerging out of research. At the same time, a teacher’s situated knowledge of their practice, the reflections on the practice and ideas about changing practices also need to be shared with other teachers and experts for wider learning, debate and discussion”. (CPD Guidelines based on NEP 2020, NCERT, 2022).

It is a real challenge for teachers to prepare their students for the 21st century’s higher educational demands of life and career. Learners should be equipped with not only the basic mathematics skills, but also with the skills which help them to face a continuously changing world. It becomes necessary for the teachers to update and rebuild themselves fit to meet the demands of the current century mathematics classrooms. They need to acquire the important characteristics to become good mathematics teachers.

Important Characteristics to Become a Good Mathematics Teacher

It is observed that the majority of the students of the classroom do not like the subject mathematics, but a good mathematics teacher has the power to change this attitude. “For students who are bored with numbers, a good mathematics teacher can bring new life into the subject. He / She should possess the following characteristics” (Zeiger, 2015).

- **“Knowledge of Mathematics:**

A successful mathematics teacher has an extensive knowledge of mathematics. This confidence boosts her credibility and helps students trust in her ability to teach them what they need to know.

- **Teaching Strategies:**

Students learn in different ways, and a good mathematics teacher understands that. She keeps up with the best practices in mathematics education and regularly incorporates them into her instruction to help all of her students learn.

- **Approach:**

In the classroom, a talented mathematics teacher does not take the “because I said so” approach or play the role of a know-it-all. Instead, she serves as a facilitator of learning, providing students with the knowledge and tools to solve problems and then encouraging students to solve them on their own.

- **Leadership:**

A skilled mathematics teacher is seen as a leader in her classroom and in the school. Her students respect her, not only for her knowledge of mathematics, but for her overall attitude and actions.

- **Care and Concern:**

A good mathematics teacher cares about her students. She recognizes when a student is having a bad day or needs some encouragement and addresses the problem to help the student refocus on the material.”

Qualification Framework

Mathematics teachers should also possess the minimum academic qualifications as per the norms laid by the concerned authorities. Now in the schools affiliated with CBSE, all the recruitments of teachers are to be made by adhering to the minimum qualifications norms notified by the National Council for Teacher Education (NCTE). So, as per NCTE & CBSE, a mathematics teacher of secondary school should possess the following academic qualifications.

- i) a) Graduation in / with the subject of Mathematics.
- b) A recognized degree / diploma in Education.

OR

- ii) BA. Ed. with Mathematics of the Regional College of Education.

The Private schools which are not funded by the government / the unaided schools may consider the CBSE conducted CTET scores or the scores of TET conducted by the State Government while appointing mathematics Teachers.

Apart from the basic academic qualifications and other characteristics for a Mathematics teacher, acquiring certain skills and applying those skills in teaching learning of mathematics are very important.

Skills required for Mathematics Teachers

NCF (2005) articulated “the need for connecting knowledge to life outside the school”. But in spite of having the wider spread acceptance of NCF(2005), the mathematics classrooms remained unchanged because of much of the teachers failed to understand and translate the ideas of NCF(2005) into real classroom practices.

As per NCTE and NCERT, the skills expected from a Mathematics Teacher, after the completion of his / her teacher education program are stated below.

“The course must enable the student teacher to - Develop insight into the meaning, nature, scope and objective of Mathematics education; Appreciate mathematics as a tool to engage the mind of every student; Appreciate mathematics to strengthen the student's resource; Appreciate the process of developing a concept; Appreciate the role of Mathematics in day-to-day life; Understand that Mathematics is more than formulae and mechanical procedures; Channelize, evaluate, explain and reconstruct students' thinking; See mathematics as something to talk about, to communicate through, to discuss among themselves, to work together on; Pose and solve meaningful problems; Appreciate the importance of Mathematics Laboratory in learning mathematics; Construct appropriate assessment tools for evaluating mathematics learning; Develop ability to use the concepts for life skills; Stimulate curiosity, creativity and inventiveness in Mathematics; Develop competencies for teaching-learning of Mathematics through various measures; Focus on understanding the nature of children's Mathematical thinking through direct observations of children's thinking and learning processes; Examine the language of mathematics, engaging with research on children's learning in specific areas; and

Visualize a Mathematics classroom where Mathematics will emerge as a subject of exploration and creation rather than an exercise of finding answers to old and complicated problems.

Teacher education institutes are making all the efforts in order to make the student teachers to acquire the above skills during their course of training. But still, after their pre-service programme and course completion when they enter in the profession, they find the methods of teaching, curricula and various other requirements in schools different from those advocated and implemented in teacher education institutes (NCTE, 2006). In 2014, National Council for Teacher Education brought reformation in the structure of teacher education programme in India. The B.Ed programme was made as a 2 years' course instead of earlier course of 1 year, by involving long internship duration for student teachers to expose in the actual school scenario, during the course of study. But in spite of all these efforts, academicians and educators of the country realize that there is a need of a systematic mechanism for the academic support for teachers and for their professional development. In this context, NEP -2020 also states (Para 5.15) that “Teachers will be given continuous opportunities for self-improvement and learning the latest innovations and advances in their professions.”

1.7 Present Status of Mathematics Teachers of Secondary Schools in India

India has made great emphasis on educating all its children since its independence. India, with its strong mathematical traditions, may be expected by the world to produce excellence in Mathematics (Ramanujam, 2012). But in reality, mathematics is often referred as the difficult subject and in India a large number of children fail or drop out before completing the schooling, because they are not able to cope with the demands of the curriculum (Rampal & Subramanian, 2012).

In many cases, Mathematics is taught by teachers who are not very confident of their mathematics. Even in cases where qualified teachers teach the subject, their conceptual understanding was seen inadequate (Dewan et al., 2012). Their understanding of the nature of mathematics and attitude to it and its learning are very different from what is underlined in the NCF (2005). The lack of ability of teachers in Mathematics is probably the result of their preparation at the school and college level. It may also be because of the inadequate efforts at

teachers' preparation or due to the lesser opportunities for teachers' professional development programmes.

At present in India, various mechanisms of building the capabilities and interests of Mathematics teachers are being evolved and many states started revising their D.Ed., B.Ed. curricula in accordance with the new framework (Rampal & Subramanian, 2012). Attempts are also being made to strengthen the in-service training programmes, to reach ideas to the teachers through ICT etc. But still there is a strong need for more such avenues and processes that would enable teachers to become more confident and to continue to engage in learning new things. By looking into these aspects, various committees and commissions appointed by the Government of India have made recommendations for bringing reforms in overall education system of the country and also to bring improvement in mathematics education by keeping teachers as its central position by recognizing the significant role they play in making education a quality one.

1.8 Recommendations of Various Commissions and Committees

It is only after independence, a more comprehensive system of education for all people in different regions came into existence. A department for education in each state and a Human Resource Development (HRD), at the center were formed in order to take care of all the aspects of education.

In that way, education system of the country has been changed a lot. In fact, the education system of India has been considered as one amongst the best in other countries. But academicians of the country, through various research and studies, are still trying to improve the system. Always the scope for improvement was felt and Govt. has taken initiative to appoint various committees and commissions for the reformation of education of the country, after independence.

After independence, making education available to all had become the main aim for the Government. In the subsequent years, several commissions and committees appointed by the Government for educational reformation had studied various problems of education system of the country and pointed out defects in the existing system and made many recommendations for

the improvement. The following given are some of the important commissions and their significant recommendations.

Secondary Education Commission (1952-53), also known as the Mudaliar Commission as it was under the Chairmanship of Dr. A. L. Swami Mudaliar. It was basically appointed to study the various problems of secondary education and to reform the pattern of secondary education. Commissions gave the following recommendations.

- The aim of secondary education must be to produce ideal citizens and also their character formation and development of personality.
- Some changes to make in the secondary school curriculum.
- Agriculture as compulsory subject for village students and Home Science for girls.
- Multipurpose schools according to the needs and interests of students with mother tongues as medium.
- Teachers and their preparation – important for a good system.

Though Secondary Education Commission in 1952 made valuable recommendations, the defects in the area of education persisted. To remove these defects, under the Chairmanship of Dr. D. S. Kothari, Government appointed an **Education Commission in 1964**, which is also known as **Kothari Commission (1964)**. The commission emphasized on education for national development. It stated in its report, “the destiny of India is now being shaped in her classrooms. In a world based on science and technology, it is education that determines the level of prosperity, welfare and security of the people.” It also emphasized that “Education must aim to relate to the life, needs and aspirations of people. It must address the problems of national development, contribute to social and national integration, modernize the society through knowledge and its applications, inculcate social, moral and spiritual values in the people and also it must focus on professional preparation of teachers which is very crucial.”

For the first time, a **National Policy on Education (NPE)** was formulated in **1968** for the essential development of our country. **NPE(1968)** recommended the programmes like free and compulsory education, equality of educational opportunities, protection of all Indian languages, identification of gifted children, education in Agriculture and Industries, Science education and

research, reform of examination system, part time education and correspondence curriculum, expansion of literacy and adult education and sports and games.

Again in 1986, a New Policy on Education- **NPE(1986)** was placed before the Indian Parliament for approval, with the objectives of: vocationalization of education; particularly at the secondary stage of education, the curriculum to make job-oriented, to awaken people about the various scientific and technological developments and to make the students at the various stages of education aware of the same in order that they may utilize them in their future life and also to encourage the governmental and non-governmental efforts for wiping out illiteracy and to emphasize the necessity of adult education, formal education and open schools. Along with many recommendations for the reformation of education system prevailed in the country, special mention was made about raising the standard of women and also of educators.

The National Policy on Education (1986) and its Programme of Action (POA) was reviewed and updated in 1992 by a Committee under the chairmanship of Sri Janardhan Reddy, known as **Janardhan Committee (1992)**. It was basically formed to look into the educational progress of scheduled castes and tribal people and to do the needful for bringing these people up to a desirable educational standard according to their inherent capacity and expressed desire. In the revised report also, the in-service education occupied the center stage (Yadav, 2012). The Committee emphasized the development of a common school system in order to provide all the needed facilities to the so far neglected backward class people. It also emphasized that Navodaya Vidyalaya school should be established in all the districts of each and every state of the country.

National Policy on Education (1986) recommended a common core component in the school curriculum throughout the country. The policy also entrusted NCERT with the responsibility of developing a National Curriculum Framework and reviewing the framework at frequent intervals. The **National Curriculum Framework (NCF-2005)** is one of the five National Curriculum Frameworks published in 1975, 1988, 2000, 2005 and 2023 by the National Council of Educational Research and Training (NCERT). The policies and recommendations in NCF-2005 were made on the basis of earlier government reports on education as “learning without burden” and also it has base on The National Policy on Education (1986).

The recommendations made in NCF-2005 are for the improvement of the entire educational system and with the purpose to make education a joyful experience for children. It provided the

framework for making syllabi, text books and teaching practices within the school education programmes in India. NCF-2005 largely focused to provide a curriculum which is not only limited to text books, but to go beyond books and classrooms. More emphasis was made on activity-based learning and for the holistic development of children. ICT based learning was also emphasized in NCF-2005. The objectives behind teaching various subjects were re-defined through NCF-2005. It recommended to bring significant changes in Mathematics education, Natural Sciences and Social Sciences. Overall, NCF-2005 was aimed to reduce stress, make education meaningful and relevant. NCF-2005 emphasized on connecting knowledge to life outside the school, making examination more flexible and non-threatening, using information technology to learn subjects. It also focused on systemic reforms like:

- Teacher education to focus on developing professional identity of the teacher.
- Examination reforms to reduce psychological stress particularly on children of Class X and XII.

NCF-2005 clearly states, quality teachers of any subject are the core of any education system and efforts to be made on preparation of teachers who can view knowledge not as just external reality embedded in text books, but as constructed in the shared context of teaching – learning. Realizing the importance of the role of teachers, NCERT organizes time to time training programmes for teacher educators and teachers. It plans for workshop in which the teachers are active participants and carry out research in the total process of education. The main focus of NCF-2005 being converting a child as an active learner and by considering the strong teacher component involved in it, recommendations are made on educating teachers through pre-service and in-service training programmes, in order to improve the quality of education.

Though, earlier policies were robust in conception and orientation, but it has not delivered the derived results in terms of acceptable outcomes in the education sector. Ministry of Human Resource and Development (MHRD) felt the need for another New Education Policy. After 39 years of the release of the National Policy on Education (1986), with an aim to prepare the youth of our country to meet the diverse global and national challenges of the present and future generations, the new **National Education Policy (NEP-2020)** was released under the Government of India's MHRD on 30th July, 2020. NEP -2020 has restructured the education pattern of schools from 10+2 pattern to 5+3+3+4, aiming the education for the age groups of 3 to 18 years. As mentioned in the policy draft, “the new National Education Policy (2020) defines

the purpose of the education system as to develop good human beings capable of rational thought and action, possessing compassion and empathy, courage and resilience, scientific temper and creative imagination, with sound ethical moorings and values. It aims to produce engaged, productive and contributing citizens to build an equitable, inclusive, and plural society as envisaged by our Constitution” (NEP, 2020). The aim is to bridge the gap between the current status of learning outcomes from learners and what is required for the future generation. As per the policy makers, it can be done only “through undertaking major reforms that bring the highest quality, equity, and integrity into the system, from early childhood care and education through higher education” (NEP, 2020). It is mentioned in the policy: “the aim must be for India to have an education system by 2040 that is second to none, with equitable access to the highest-quality education for all learners regardless of social or economic background” (NEP, 2020).

In this new policy also teacher preparation is given much importance. It states, “the teacher must be at the center of the fundamental reforms in the education system. The new education policy must help re-establish teachers, at all levels, as the most respected and essential members of our society, because they truly shape our next generation of citizens. It must do everything to empower teachers and help them to do their job as effectively as possible” (NEP, 2020).

The NEP 2020 also recommends (Para 5.15) that “Teachers will be given continuous opportunities for self-improvement and learning the latest innovations and advances in their professions. These will be offered in multiple modes, including local, regional, state, national, and international workshops as well as online teacher development modules. Platforms (especially online platforms) will be developed so that teachers may share ideas and best practices. Each teacher will be expected to participate in at least 50 hours of CPD opportunities every year for their own professional development, driven by their own interests. CPD opportunities will, in particular, systematically cover the latest pedagogies regarding foundational literacy and numeracy, formative and adaptive assessment of learning outcomes, competency based learning, and related pedagogies, such as experiential learning, arts-integrated, sports-integrated, and storytelling-based approaches, etc.” (MHRD, National Education Policy 2020, p. 22)

The major recommendations with respect to the teacher preparation and the professional development of teachers emphasized in the policy are:

- To ensure that outstanding students enter the teaching profession - especially from rural areas, a large number of merit-based scholarships shall be instituted across the country for studying quality 4- year integrated B.Ed. programmes
- Incentives will be provided for teachers to take up teaching jobs in rural areas, especially in areas that are currently facing acute shortage of quality teachers.
- The harmful practice of excessive teacher transfers will be halted, so that students have continuity in their role models and educational environments.
- Teacher Eligibility Tests (TETs) will be strengthened to inculcate better test material, both in terms of content and pedagogy
- A technology-based comprehensive teacher-requirement planning forecasting exercise will be conducted by each state to assess expected subject-wise teacher vacancies over the next two decades.
- Teachers will be given continuous opportunities for self-improvement and to learn the latest innovations and advances in their professions.

The policy, by looking into the strong teacher component in making the quality education, the following teacher preparation aspects are also mentioned..

- Independent mechanism for teacher recruitment – the recent TET (Teacher Eligibility Test) mechanism (with appropriate safeguards) will ensure good quality recruitment of teachers.
- Creation of an Autonomous Teacher Recruitment Board.
- Revamp of teacher education system and introduction of a four-year integrated B.Ed. Course or a two-year B.Ed. Course after graduation.
- Well thought out teacher preparation systems.

Apart from the recommendations for teacher preparation, the policy also talks about how education can be made fun and interesting for learners. It suggests to reduce the curriculum content to enhance essential learning and critical thinking, to make space for more holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning. Policy states: “the mandated content will focus on key concepts, ideas, applications, and problem solving. Teaching and learning will be conducted in a more interactive manner; questions will be encouraged, and classroom sessions will regularly contain more fun, creative, collaborative, and exploratory activities for students for deeper and more experiential learning. In all stages,

experiential learning will be adopted, including hands-on learning, arts-integrated and sports-integrated education, story-telling-based pedagogy, among others, as standard pedagogy within each subject, and with explorations of relations among different subjects. To close the gap in achievement of learning outcomes, classroom transactions will shift, towards competency-based learning and education. The assessment tools (including assessment “as”, “of”, and “for” learning) will also be aligned with the learning outcomes, capabilities, and dispositions as specified for each subject of a given class”. Policy recommends to having art integration for learning. It defines Art-integration as “a cross-curricular pedagogical approach that utilizes various aspects and forms of art and culture as the basis for learning of concepts across subjects. As a part of the thrust on experiential learning, art-integrated education will be embedded in classroom transactions not only for creating joyful classrooms, but also for imbibing the Indian ethos through integration of Indian art and culture in the teaching and learning process at every level. This art-integrated approach will strengthen the linkages between education and culture.” (NEP, 2020)

The academicians of the country are looking up to the NEP-2020, with an expectation to have the desired reform in the existing system of education- a paradigm shift.

The **National Curriculum Framework for School Education** (NCF-2023) provides goals, guidelines, elements to develop curricula, which syllabi and teaching- learning materials, assessment methods resources to be used etc. to the schools across India. It aims for the holistic transformation of the curricula to enable the positive learning experiences for the students. NCF-2023 also talks about the Teacher as the primary focus in education. NCF-2023 states that “the Teacher is at the heart of the practice of education. It is the Teacher who is ultimately the torchbearer for the changes we seek. As such, it is the perspective of the Teacher that must be carried by all, including syllabus and content developers, textbook writers, administrators, and others” (NCF- 2023, pg-12).

At present, the Central Board of Secondary Education (CBSE) is one of the most preferred boards in the country and the reasons are many. CBSE was formed officially in 1962 with the sole purpose to make a common standard and platform for every student in the country. It is a Board of Education for public and private schools, under the Union Government of India, MHRD as its Parent Organization. CBSE in all these years has set a good standard of education in India. Its effectiveness is reflected on the number of schools affiliating with it each year. With

its influential educational policies, CBSE has attempted to reform the education system of the country.

All India Board exams for Class X and XII were introduced by CBSE. It also has other interlinked objectives like prescribing conditions of examinations and conduct public examination at the end of Class X and XII, granting qualifying certificates to successful candidates of the affiliated schools, fulfilling the educational requirements of those students whose parents were employed in transferable jobs, prescribing and updating the course of instructions of examinations and affiliating institutions for the purpose of examination and uplifting of the academic standards of the country. The prime focus of the Board is on innovations in teaching-learning methodologies by devising students friendly and students centered paradigms, reforms in examinations and evaluation practices, skill learning of students by adding job-oriented and job-linked inputs, regularly updating the pedagogical skills of the teachers and administrators by conducting in-service training programs, workshops, etc.

The concrete pattern of education certainly involves a teacher, who is the heart of the system. But to have the growth and development of the teacher, one has to think about the variety of other sources and materials of education. One has to think of a curriculum or general frame works within which he / she works and one has to think about the text books. Also, there is a knowledge explosion through advancement in technology. According to the new changes, social needs and accordingly learners' needs have been changed. A teacher is expected to face the new changes in the system of education. One has to think about preparing the teachers to face all these changes, through continuous training and enrichment programs. Such needs are satisfied by NCERT – National Council of Educational Research and Training. Publishing program of the NCERT is a part of its total effort to improve the quality of school education. NCERT is an autonomous organization set up in 1961 by the Government of India to help State and the Central Governments on improving the quality of school education. Text books published by NCERT are used widely in schools affiliated with the CBSE, Kendriya Vidyalaya (KVS), Jawaharlal Navodaya Vidyalays and other several public schools.

The other functions of the NCERT are broadly related to:

- a) Research and development
- b) In-service and pre-service training.

All these are to achieve the main objectives of improving the quality of education.

NCERT has brought many developments in the overall system of education in India. It works for the academic wing of the Ministry of Education and Social Welfare and assists the Ministry in the formulation and implementation of its policies and programs in the field of school education.

The functions of NCERT are discharged on the following broad lines:

- a) To undertake studies, investigations and surveys relating to school education.
- b) To organize pre-service and in-service training mainly at an advanced level.
- c) To organize extension services.
- d) To disseminate improved educational techniques and good practices.
- e) To act as a clearing-house for ideas and information on all matters related to school education.

With a view to carrying out such functions effectively, the council works in close co-operation with the Education Department in the States and the Universities and generally with all organizations in the country for furthering the objectives of school education.

It is noted that all Commissions and Committees appointed by Government till date have reported and highly recommended the need to provide continuous opportunities for teachers for their professional growth. Also, teacher preparation –their training and professional development – is one strongly emphasized objective of both CBSE and NCERT.

1.8.1 Professional Development of Teachers in India: So Far After Independence

After independence of our country, several education commissions, committees, policies, and various other initiatives of the Government of India emphasised the importance of teachers' professional development as an important intervention for quality improvement in school education. The following section summarises the major initiatives of the government for the professional development of teachers so far in India, post- independence(Based on the Guidelines for 50 Hours of CPD for Teachers, Head Teachers and Teacher Educators, based on *National Education Policy 2020*' NCERT, 2022)

- As per the recommendation of the **Secondary Education Commission** (1952–53) the establishment of Extension Services Departments in about 100 Teacher Training Colleges was done.
- **Education Commission** (1964–66) recommended the establishment of 'school complexes' with a nodal school shouldering the responsibility for the professional development of all teachers working in the schools on the complex.

- The **NPE 1986** recommended the establishment of **District Institute for Education and Training (DIET)** in each district, and up-gradation of 250 colleges of education as Colleges of Teacher Education (CTEs), and strengthening 50 of them as Institutes of Advanced Studies in Education (IASEs) with an aim to provide in-service education for a duration of 2 weeks to 600 teachers in a year.
- The **Programme of Mass Orientation of School Teachers (PMOST)** was launched in 1987 to create awareness among teachers about the broad features of the **NPE 1986** for both primary and secondary teachers and then with an aim to provide the training on the content and pedagogy of school subject, the programme was replaced by another crash programme known as ‘**Special Orientation Programme for Primary Teachers’ (SOPT)** in the early 1990s.
- The implementation of the **District Primary Education Programme (DPEP)** in the mid-1990s was an important initiative for universalising elementary education. The programme had several components including the reorientation of content and pedagogy of primary school subjects, deployment of additional teachers and recurrent training of teachers.
- The **Sarva Shiksha Abhiyan (SSA)** - 2001 was implemented as India’s main programme for universalising elementary education. Under the **SSA**, in-service education of elementary teachers was aimed to provide 20 days training for a teacher every year, which is further split into two segments of 10 days each.
- The **Rashtriya Madhyamik Shiksha Abhiyan (RMSA)** scheme initiated in 2009, focus was laid on conducting in-service training programme for teachers of science, mathematics, languages and technology
- National Initiative for School Heads’ and Teachers’ Holistic Advancement (**NISHTHA**) at elementary stage under **Samagra Shiksha Abhiyan (2018)** is a flagship programme of MHRD to improve learning outcomes. The **NISHTHA** in face-to-face mode was launched on August 21, 2019. In total 19,520,337 certificates have been issued to teachers and head teachers for completing the online training for elementary level (**NISHTHA 1.0**). (Retrieved on February 24th, 2022).
- The new education policy announced by the government- the National Education Policy (NEP)- 2020 - highly recommends 50 hours of Continuous Professional Development

(CPD) for teachers in every academic year. CBSE, other state boards, NCERT and MHRD are now closely working on making its implementation possible, in order to achieve the targeted outcomes from this recommendation.

The above initiatives of the government are all aimed to make the teacher preparation very strong in the country so that teachers can produce the skilled work force who can contribute in the country's development. Because of the crucial role played by mathematics education in making a child competent, with all required skills for the life, the mathematics teachers must owe that cutting edge responsibility in making a child future ready. Though MHRD and other competent authorities are working very diligently on teacher preparation, the pre-service and in-service training of teachers and their professional development, opening more avenues for the professional development of mathematics teachers has become the nation's need.

1.9 Conceptual Framework of the Study

Educational institutions have to adapt all the needful mechanism to ensure the quality education happening through the existing system. Reformation in the education system is brought time to time by the concerned authorities of the country, in order to bring the desired competencies in teachers and to attain desired learning outcomes from the learners. Today's teachers are dealing with a generation who is too much exposed to the digital world. It is very much essential for the teachers of any subject to update themselves and equip with all skills and knowledge and to deliver not just as 'teacher' who just transacts the text book content but as the facilitator, who prepares the learners with necessary skills to deal with the present century life and its challenges. Having mathematical skills in every child is very important for the life. Due to this reason mathematics is considered as one of the major subjects in school curriculum. Secondary school education is meant to make the learners ready with the skills and knowledge for their higher education. There is a strong teacher component in making the learners fit for their further courses and life. So, teachers need time to time intervention and in-service developmental activities to understand and gain the skill and knowledge of the ever-evolving nature of mathematics.

1.9.1 Teaching as a Profession

A Profession is a vocation or what a person does for his living. Any profession requires the knowledge and educational qualification of that particular field of vocation. A professional is a person who has knowledge of his field of profession and also has commitment towards it with certain set of values associated with that profession. In ancient times only priesthood, law, medical and university teaching were considered as professions. As time progressed, many other fields of works like engineering, school teaching etc., also started considering as professions. Though the word meaning is something, it is well accepted by everyone that a profession or a person in a profession possesses the dignity and holds some values related to the profession. Same is the case, when it comes to teaching as a profession.

Over the ages, the profession – teaching has got high regards in the society due to the objectives involved in that profession. It creates all other professions. It is considered as one of the most highly esteemed professions. Content mastery (knowledge expertise), dedication to purpose and advocacy are considered as the strength or characteristics required for teaching profession. Teaching is more than just a job. It is a life choice and a commitment to society with extraordinary responsibility of holding young minds and hearts of society in hands.

There have been changes in the education system of the country. Due to the advance of technology and establishment of e-learning system, the perception of people for teaching as a profession has been changed. Teacher's role has been changed from a 'knowledge provider' to a 'knowledge facilitator'. Teachers in modern classrooms are no longer just teachers. They are expected to use and handle technological aspects effectively. It is not enough for them to be masters of their subjects, but also, they need to be equipped with pedagogic content knowledge, general pedagogic knowledge (e.g.: classroom management), curricular knowledge, contextual knowledge (i.e., expectations of society) and process knowledge (learning skills, observation skills, etc.). There is a need for their continuous professional development in order to make them fit for this present century teaching profession.

1.9.2 Professional Development Components and Approaches

A good professional development programme, though the receivers are teachers, ultimately helps children succeed and come out with good learning outcomes. Research studies on professional

development also relate its direct connection with students' achievement. On the basis of the several review of the related literature, Marzano (2003) concluded that the professional development activities experienced by teachers have impact on student achievement.

Kedzior & Fifield (2004) described effective professional development as a prolonged facet of classroom instruction that is integrated, logical and on-going and incorporates experiences that are consistent with teachers' goals; aligned with standards, assessments, other reform initiatives, and beset by the best research evidence.

National Curriculum Framework for Teachers Education (NCFTE, 2009) also puts forth several principles that need to govern the design of professional enrichment programs. These include,

- Designing programs with clarity about aims and strategies for achieving these aims.
- Allowing teachers to relate the content of the program to their experiences and also to find opportunities to reflect on their experiences.
- Need to respect the professional identity and knowledge of a teacher and to work with and from it.

According to Manichander (2016), the process of professional development should be based on sound educational practices such as contextual teaching. It should focus on

- Enriching teachers' knowledge of the subjects / topics being taught.
- Sharpening their teaching skills in the classrooms.
- Generating and contributing new knowledge to the profession.
- Increasing teachers' ability to monitor students' work in order to provide constructive feedback to students and hence to redirect teaching.

Depending on the particular instructional needs, teacher professional enrichment models / approaches can be divided into 3 categories (Manichander, 2016).

1) Standardized Teacher Professional Development:

- a) Cascade Model: This approach generally focuses on the exploration of new concepts and demonstration of and modeling of skills. A small group of teachers receive intensive training and then they provide training to their peers.

- b) Reflective Teaching Model (RTM): It recommends consistent, ongoing sessions of joint planning, teaching and reflection which help the teachers to reform their teaching strategies.
- c) Split Model: It consists 6 – 8 days training, the implementing the inputs in the actual classrooms, then follow-up training through reflective and open discussions.

2) Site-based Teacher Professional Development:

This includes intensive learning by groups of teachers in a school for long-term changes in instructional methods. It includes:

- a) Observation Model: Master trainer observes classroom and provide structured feedback.
- b) Open Lessons: Teachers develop lessons and ask colleagues to observe and get feedback focus on “teacher behavior”.
- c) Lesson Study: Teachers collaboratively plan, develop or improve a lesson, observe it, make changes for improvement and check the impact on student learning.
- d) Study Groups: Teachers collaborate as a single group to solve a common problem or create and implement a plan to attain a common goal.
- e) Inquiry/ Action Research: Teachers as team select an issue, investigate, research it, plan actions to remedy it, take action, reflect on outcomes.
- f) Mentoring: More experienced teachers / trainers guide novice teachers.

3) Self-directed Teacher Professional Development:

Teachers do independent learning, using available resources like computers, internet, etc. They initiate their own professional development.

By keeping in mind, the need or requirement of the subject / area, the programme developer has to decide the kind of programme suitable for the particular instructional needs and other generic needs.

1.9.3 Impact of Professional Development on Teachers’ Competencies

Every teacher should possess the essential competencies required in order to have effective teaching – learning happening in the classrooms. Encouraging teachers to continue developing

and extending their competencies is vital in this fast-changing world. (EC, Education and Training, 2013). Research studies related to Teacher Education emphasize in arranging provision of professional learning opportunities to help teachers in developing their competencies throughout their career.

The knowledge, skills and commitment of teachers are the most important factors in achieving high quality learning outcomes. They should have deep knowledge of subjects, necessary pedagogical skills, skill to make effective use of ICT and ultimately the skill of help students to acquire their competencies (EU, 2009). European Union (2009) states, no course of initial Teacher Education, however excellent can equip teachers with all the competencies they require during their career. Demands on the teaching profession are evolving rapidly, imposing the need for new approaches, to be fully effective in teaching and capable of adjusting to the needs of learners in a world of rapid social, cultural, economic and technological change. Teachers need to reflect themselves on their own learning requirement and to take responsibility of their own learning and developing their skills. These competencies can be improved only through continuous professional development programmes. The above observations of European Union have relevance and are correct in the Indian context too.

In order to achieve the competencies required and also to advance in the career, teachers should scale out professional development opportunities. **Teacher development has moved beyond simple in-service workshops and has expanded into more robust system of continuing education (Quattlebaum, 2012).** Craig, et al. (1998) in document ‘Teacher Development – Making an Impact’ revealed that teachers professional development programmes can make high impact on Teachers’ Competencies and hence in the learning outcomes of students. A report of ‘A Study of Professional Development for Public School Educators in West Virginia (2005)’ also provides framework for viewing the relationship between professional development, teacher quality and student achievement in Mathematics (Yeasmin, 2017).

Yadav (2012) in the report of the study, ‘The impact of in-service teacher training on classroom transaction’ (carried out by NCERT and funded by MHRD) states, “In-service Education of Teachers (INSET) and its related training transaction has an impact on teachers in terms of their achievements and perceptions”.

1.9.4 Need for Professional Enrichment Programmes for Mathematics Teachers

Professional development is a program designed to promote the development of teachers in terms of their content, pedagogical knowledge and skills, through enrichment training provided to teachers over a period of time. Success as a teacher requires a continuous process that extends from professional preparation to the end of one's professional life. Conceptually, it is divided into teacher preparation and teacher training. While the beneficiary of In-service Teacher Professional Development (ITPD) is the teacher, the ultimate beneficiary is the student (Manichander, 2016).

Today's students will have to live and work in the 21st century, an era dominated by Worldwide Technology, Worldwide Communication and by a Global economy. NCF (2005) states that at the secondary stage, students begin to perceive the structure of Mathematics as a discipline. So, it is very important to strengthen the learners of this stage by improving the quality of teaching in a significant way. There is a need to improve Mathematics Teacher's professional capabilities by providing opportunities for them to strengthen secondary school mathematics education.

Various Commissions and Policymakers have made recommendations on the need for teachers' professional development.

The National Curriculum Framework for Teacher Education (NCFTE, 2009) in its reports mentioned the aims of continuing Professional Development Programmes for teachers. It states that there is a need to address the professional development and qualification of teachers to meet the increasing demand for quality secondary education.

The Rashtriya Madhyamik Shiksha Abhiyan (RMSA, 2009) Framework states that in-service teachers and heads of schools will be trained for five days every year (Manichander, 2016).

National Education Policy- 2020 highly recommends 50 hours of Continuous Professional Development (CPD) for teachers in every academic year.

Mathematics teachers are now more open to the fact that their teaching approach needs to undergo fundamental changes, to attain the expected outcomes, as per the objectives laid down by the recent NEP (2020). It is widely acknowledged that to support change in classroom teaching, in terms of implementation of NCF (2005) and NEP-2020, there must be system improvement involving teachers. This scenario demands the need of designing the teacher professional enrichment programme to fulfill the vision of teaching and learning mentioned in the NCF (2005) (Kumar, et al., 2012).

The ‘Guidelines for 50 Hours of Continuous Professional Development for Teachers, Head Teachers and Teacher Educators, Based on *National Education Policy 2020*’, published by NCERT (2022) states, “The centrality of teachers in bringing reforms in education has long been recognized by various policy documents, as well as by the reports of various educational commissions and committees. While recognizing the need to restore respect for teachers in society, the recently promulgated National Education Policy 2020 asserts that the teacher has to be brought to the centre of fundamental reforms in education. Thus, teachers are seen as the heart of the learning process. In other words, teachers are not only seen as the most important ‘element’ that needs to be changed to improve the education system, but they are also recognized as significant agents of change for implementing educational reforms. As a consequence, an increased emphasis has been placed on the need of professional development of teachers” (CPD Guidelines based on NEP 2020, NCERT, 2022).

1.9.5 Principles of Programme Design

The effectiveness of any enrichment programme depends mostly on the ability of programme developer. All development and enrichment programmes are designed to make some difference and improvement in the existing system. If the participants involved show positive changes in their practices, then only the programme is said to have a broader impact in the system. To make that impact possible, there are certain principles to be followed while developing the programme. Anderson & McCormick (2005) suggest 10 principles that may help designers to construct pedagogically sound e-learning programme, and these 10 principles may help any designer to develop effective enrichment programme for teachers by designing teaching-learning materials and other resources and also by designing teaching learning activities. Those 10 principles are given below:

1. Match the Curriculum:

The pedagogy should be matched with and aligned to the appropriate curriculum through clear objectives, the relevance of content covered; the appropriateness of student activities; and the nature of the assessment.

2. Inclusion:

The pedagogy should support inclusive practice seen in terms of different types and range of achievement; physical disabilities that can be particularly supported by e-learning, different social and ethnic groups and gender.

3. Learning Engagement:

The pedagogy should engage and motivate learners. This engagement should be evident in an ethos of being both educational and motivating.

4. Innovative Approaches:

It should be evident why learning technologies are being used, rather than a non-technological approach which activities the same end as effectively. E-learning should be fit for purpose.

5. Effective learning:

This principle can be demonstrated in a variety of ways, for example by using a range of different approaches in the learning platforms that will allow the student to choose one that suits her, or that can be personalized to her, or by satisfying a number of the characteristics of good learning (learner agency; learner autonomy; enabling or encouraging collaboration)

6. Formative Assessment:

The pedagogy should provide formative assessment.

7. Summative Assessment:

The summative assessment must be valid and reliable; comprehensibly by teachers, learners and parents; able to deal with a range of achievements levels; and free from adverse emotional impact on the learner.

8. Coherence, Consistency & Transparency:

The pedagogy must be internally coherent and consistent in the way the objectives, content, student activity and assessment match to each other. It must be open and accessible in the design.

9. Ease of use:

Programme should be transparent in its ease of use.

10. Cost-Effectiveness:

Technology solutions need to be justified and affordable and the costs sustainable (Anderson & McCormick, 2005)

Researcher reviewed the ‘Guidelines for 50 Hours of Professional Development for Teachers, Head Teachers and Teacher Educators’, based on National Education Policy (2020), published by NCERT (2022). In the guidelines, it states, “The challenge of designing relevant CPD programmes involves developing them in such a manner that they remain useful to their local contexts as well as cater to the national level concerns” (CPD Guidelines based on NEP 2020, NCERT,2022).

By keeping in mind the important aspects of such guidelines, the programme principles and other factors, designers can develop Professional Enrichment Programme beneficial for teachers which in turn will provide improved learning experiences for learners. The review of such programme principles helped the researcher to understand the significance of few parameters to be involved in the present programme development. Along with such reviews, the close and vigilant observations by the researcher on the evolving nature of the mathematics curriculum and the present mathematics education, gave ways to draw a series of reasons and the rationale of the study.

1.10 Rationale of the Study

Many of the previous studies and reports explain why mathematics matters, why is it important that we should produce young people who are good at mathematics and why it has become increasingly urgent that we address problems related to quality mathematics education.

Studying mathematics stimulates curiosity, promotes creativity and gives children the skills they need for the life after school. NCF (2005) states that at the secondary stage only, students can perceive the structure of mathematics as a discipline and correlate the concepts learned in the primary stage. Focusing on high-quality teaching as the key prerequisite for high-quality education and training, the teacher must provide its learners with the competencies they need to adapt to the globalized complex environments which can be well attained only through quality mathematics education (Caena, 2011).

It is observed that the present mathematics teaching emphasizes mainly memorization and solving problems mechanically through rote learning of formulae and their application through traditional methods of teaching without giving importance to concept clarification and activities. This has lowered the standards of mathematics education (Gandhi, & Varma, 2007). CBSE Class X Board results of Mathematics subject also reveal that several students were not clear with the various concepts taught in the subject. According to many mathematics teachers, “in Board exam, students face difficulties to relate the concepts with the case-based questions and the problems related to the real-life situations.”

These all problems can be solved, and the standard of mathematics education can be improved only through quality mathematics teaching, and that quality can be brought only by raising the standards of mathematics teachers. To raise the level of the teachers, it is necessary to provide them with good professional enrichment programmes. Teachers need to be constantly encouraged to analyze themselves and also, they need to introspect about what are they presently doing, whether it is enough for the 21st-century learners, and whether it meets the expectations of recently released education policies and other recommendations made by various commissions time to time for improving mathematics education in India.

For anybody who wishes to have quality mathematics teaching, it is important to look carefully into the summary of the outcomes of mathematics education mentioned in the report published by NCERT- 2009 which are:

- Interactive mathematics classes were found superior in learning.
- The classroom behavior of the teachers with good command and confidence over the subject was found effective and satisfactory.

The researcher, being in the field of education for the last 21 years - as a mathematics teacher as well as the Principal of a Secondary School- could closely observe the lack of quality teaching taking place in the secondary stage of mathematics, in both generic and content-related aspects, resulting into the poor performance of students and hence students slowly losing interest in mathematics subject. Researcher understood the need of quality improvement of mathematics teachers, especially at secondary level.

Secondary mathematics education is considered as the most crucial one, as it serves as the foundation for the higher education and making the career choices of the learners. Mathematics

learned at this level paves as the strong base for studying other subjects like Physics, Chemistry, Biology, Accountancy, Economics etc. of Class XI & XII. The researcher also realized, if the secondary level mathematics education is not strengthened, we will be losing a fragile opportunity of building a generation who has proficiency in learning abstract mathematics which is very important in making the careers in many fields like various streams of engineering, architecture, aviation etc. So to strengthen this level mathematics education, there is a strong teacher component involved. Until and unless secondary mathematics teachers understand the significance of secondary mathematics education in learners' lives, the desired learning outcomes of mathematics education of this level is not possible. Teachers need to stand strong in all the aspects – content as well as generic- in making the quality mathematics education possible at this level, for which they need guidelines and professional development programmes time to time. Then only one can make the mathematics teachers understand about the very evolving nature of mathematics subject and the demands and expectations of this generation mathematics learners. In order to make this level mathematics education strong, there are urgent needs of developing the secondary level mathematics teachers by offering them with various professional enrichment programmes.

Through the review of related literature made by the researcher, it was clear that in most of the studies, researchers pointed out the need for teachers' training and professional development programmes at regular intervals. Reviewed research studies also revealed the important role of quality mathematics teachers in making quality mathematics education possible for the learners.

The NCERT report (NCERT, 2016) on “Evaluation of In-Service Training Programmes of NCERT”, clearly states in the findings that “in order to develop an in-depth understanding on a particular issue, offering of long duration programmes through distance/online modes needs consideration”. National Education Policy (NEP)-2020 also has made emphasis and now mandatory that teachers must undergo 50 hours of Continuous Professional Development (CPD) in an academic year.

Though many professional enrichment programmes and modules have been developed by scholars and academic reformers, mostly abroad and very few in India, the researcher observed that very few programmes are being developed by focusing the topics which are difficult to understand by the learners or for complex topics at the secondary level.

In this context, the researcher was interested in concentrating on the generic and content aspects and also of few systemic aspects of teaching mathematics, while developing the programme. The researcher was interested in developing a Professional Enrichment Programme with a strong desire to influence mathematics education at secondary stage which in turn may positively affect the students' learning outcomes. The researcher also had the desire to inculcate and develop the learners' interest in the subject of mathematics at secondary level through the programme which was aimed to develop for the secondary mathematics teachers.

Further, the present study and the developed professional enrichment programme by the researcher may contribute as the resource for secondary mathematics teachers for the coming decades, as the programme adds value to improve the present mathematics education of secondary section. The findings of the programme can be a data base for the future researchers and scholars who intend to contribute positively to secondary mathematics education. In the broader sense, the findings of the study can immensely and significantly contribute to have certain understandings on the present education system, when the requirement arises in future for another reform in the mathematics education and the need for another policy draft.

While developing the programme, the researcher focused on the following research questions.

1.11 Research Questions

- 1) How mathematics as a subject is being taught in Secondary Schools?
- 2) What are the major challenges of Mathematics Teachers?
- 3) What are the Professional development needs of mathematics teachers at Secondary School level?
- 4) How do Mathematics Teachers upgrade their Professional Competencies?
- 5) How will the Professional Enrichment Programme (PEP) develop the teaching skills in teachers?
- 6) What impact does the PEP make on Mathematics learning outcomes of students?

1.12 Objectives of the Study

On the basis of the research questions framed, the researcher had the following objectives for the present study.

- 1) To identify the Professional development needs of Secondary School Mathematics Teachers.
- 2) To develop a Professional Enrichment Programme (PEP) for Mathematics Teachers of Secondary Schools.
- 3) To study the effectiveness of the developed programme.

1.13 Chapterization

The details of Chapterization of this thesis are given below:

Chapter 1

This chapter comprises of introduction, importance of secondary education, especially mathematics education, role of mathematics teachers and the conceptual framework of the present study in terms of learning outcomes in mathematics education, importance of professional competencies, professional enrichment programmes and its development. In this chapter, the researcher also emphasized the significance of the present study.

Chapter 2

Chapter 2 provides the detailed information about the review of related literature.

Review of related literature is done with the purpose to explore the studies made as of now in terms of professional development of teachers of mathematics and of other subjects. The various programmes developed were also explored to understand the content and design, implementation and evaluation. The reviewed literature helped the researcher to understand the technicality and other aspects of the program designing and development.

Chapter 3

In the third chapter, titled Research Methodology, the Research design and Methodologies adopted at various stages of the study are mentioned in details.

Chapter 4

The fourth chapter provides the Data Analysis, Interpretation and Result presentation. It also provides a detailed discussion about the major findings and implication of the study.

Chapter 5

Summary, Suggestions and Conclusion is given in Chapter 5. Though the researcher could focus few aspects of secondary mathematics education for the present study, the suggestions for more such research and development of more programmes on various other topics and aspects are suggested in the Chapter.

1.14 Conclusion

In this chapter, researcher has expressed the reasons and need for developing professional enrichment programmes for the secondary mathematics teachers, by broadly looking into the present mathematics education status. A very close study of the reforms taken place as of now, in the Indian education system to improve the quality of secondary mathematics education, by understanding its significance in students' lives is very well carried out by the researcher and the researcher's view on it and the rationale for the present study is well presented in this chapter.

The researcher could make a strong foundation for the present study through the review of related literature. Developing professional enrichment programme for mathematics teachers demands such strong base. The reviewed research and other related literature helped the researcher to focus on the various aspects while developing the professional enrichment programme for mathematics teachers of secondary schools. Review of related literature also provided an understanding about the implementation and evaluation of the programme developed by the researcher. The details of the reviewed studies are presented in the next chapter.