CHAPTER 5
SUMMARY, DISCUSSION AND CONCLUSION

5.0 Introduction

The system of education of any country plays a vital role in transforming the students into fully equipped and developed individuals. Over the years, attempts have been made by the academicians and educationists of the country to develop an education system which expresses and promotes the social and cultural identity of the country, a system which serves the purpose of education and fulfill the requirements of the hour. Research studies in the education sector are continuously going on for bringing the desired changes and improvement in the existing system and to develop a system which equips the current century learners with the skills necessary for them to face the challenges of this technological era and the current century's learning and life.

Secondary Education is a bridge between the Primary and Higher Education systems and quality improvement in Secondary Education has a very significant role in equipping the learners with the required competency. Rashtriya Madhyamik Shiksha Abhiyan (RMSA), an initiative by Govt. of India in 2009, had focused much on assuring "good quality secondary education available, accessible and affordable to all young persons, irrespective of gender, socio-economic condition, disability, geographical and other barriers".

National Education Policy (NEP)- 2020 and its implementation in its real sense in the secondary education system is expected to bring a paradigm shift. To achieve the objectives laid down by the policy and policymakers, teachers play a vital role. So, empowering them with all skills- generic and content-based is very much essential.

5.1 Importance of Mathematics Education at Secondary Level

Mathematics as a compulsory subject has been taught in school education since ancient times. Mathematical skills are crucial for a wide array of analytical, technological, scientific security and economic applications (Emma, 2012). "Training students to become adept users of mathematics and to appreciate its usefulness is of paramount importance for the future. Mathematics is not only needed for the understanding of the other sciences, an understanding of

a basic level of numeracy is required for all, to function in an increasingly complex world" (Burghes, 2011).

Several efforts have been made through commissions and committees to improve the quality of education in general, and mathematics education in specific. National Curriculum Framework - NCF (2005) states that "at the secondary stage, students begin to perceive the structure of mathematics as a discipline. They will become familiar with the characteristics of mathematical communication: carefully defined terms and concepts, the use of symbols to represent them, precisely formulated statements, and the evidence that justifies them. These skills are developed particularly in the area of geometry. Students develop their algebraic skills also at this stage. This is important not only in the application of mathematics but also in providing reasons and proofs within mathematics".

About the secondary mathematics education, it is mentioned in NCF(2005) , "learners attain a high level of mathematical literacy through Statistics- the mathematical modelling, data analysis, and interpretation- taught at this stage. Individual and group exploration of connections and patterns, visualization, and generalization are important at this stage and can be encouraged using appropriate tools that include concrete models such as Mathematics Laboratories and Computers".

Now NATIONAL EDUCATION POLICY (NEP)-2020 is also emphasizing Competency Based Education of Mathematics and bringing so much of changes in its Assessment Pattern in the secondary level, which is expected to bring desirable changes in Secondary Mathematcs Education.

As secondary education prepares students for their higher education and makes them skilled workers ready to take on 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 implemented in those skills in everyday life. Scholars have continuously emphasized the need for curriculum reforms and reforms in the methodology of teaching-learning, the result of which is the establishment of mathematics laboratories and ICT-enabled mathematics education in schools, continuous in-service training programs for teachers, skill

development programs, and professional development programs for teachers. But the effectiveness of all these, on the performances of students has always been a topic of investigation for academicians.

Continuous research studies and curriculum reforms in mathematics education show that academicians are never satisfied with the existing methodology of teaching or something is lacking in the expected outcomes of students learning the subject mathematics. Schools are required to undergo reform to keep pace with the phenomenal changes in society both technologically and socially. The reform is possible only by improving teachers' content knowledge and pedagogical knowledge which can be brought only through effective Professional Enrichment Programmes for teachers.

In the past and in recent times, many commissions appointed by foreign countries and India to make reforms in the education system have given good recommendations to improve Mathematics education and its existing status.

The National Council of Teachers of Mathematics (NCTM-2009), USA outlined the essential components of a high-quality Mathematics Program for schools. It talks about the need of well-prepared mathematics teachers and equally supporting administrators. It is a guide for focused and sustained efforts to improve student's school Mathematics. It aims to do the following:

- Establish comprehensive and consistent learning objectives.
- Serve as a resource for teachers.
- Guide the development.
- Stimulate ideas and ongoing conversations.

Though NCTM and its suggestions and recommendations are applicable to USA education system, the researcher felt the principles mentioned by NCTM relevant in Indian Context also.

Below given are the six Principles given by NCTM:

"Equity**:** Excellence in Mathematics education requires equity – high expectations and strong support for all students.

Curriculum: A curriculum is more than a collection of activities; it must be coherent, focused on important Mathematics, and well-articulated across the grades.

Teaching: Effective Mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well.

Learning**:** Students must learn Mathematics with understanding, actively building new knowledge from experience and previous knowledge.

Assessment**:** Assessment should support the learning of important Mathematics and furnish useful information to both teachers and students.

Technology**:** Technology is essential in teaching and learning Mathematics; it influences the mathematics that is taught and enhances students learning."

NCTM has also recommended Content and Process Standards for school mathematics Education and recommended enhanced preparation of teachers and increased opportunities for professional development.

National Curriculum Framework (2005) for School Education, India has highlighted the major challenges of teaching mathematics in India. They are: "Most children have feelings of fear and failure when it comes to math. Therefore, they give up or abandon serious mathematics learning, The curriculum is disappointing not only to this non-participating majority but also to the talented minority by offering them no challenge, Problems, exercises, and methods of evaluation are mechanical and repetitive with too much emphasis on computation, Areas of mathematics spatial thinking are not developed enough in the curriculum and Teachers lack confidence, preparation, and support" (NCF-2005). Based on the above problems, the following recommendations are being made by NCF (2005) in connection to secondary mathematics education**:**

- To shift the focus of mathematics education from achieving narrow goals to higher goals.
- To engage every student with a sense of success, while at the same time offering the conceptual challenges to the emerging Mathematicians.
- To change modes of assessment to examine student's mathematization abilities rather than procedural knowledge.
- To enrich teachers with a variety of mathematical resources.

Though recommendations and reformations are being made from time to time for the change in the system to make mathematics education more enjoyable through activity-based learning processes, research studies show that several students show specific Mathematics Learning

Difficulties, due to which teachers struggle to achieve the Expected Learning Outcomes (ELO) in subject Mathematics. Due to the same reason, now NEP-2020 also is emphasizing doing away with Rote Learning (RL) and promoting Competency-Based Learning (CBL).

5.2 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 student's negative attitude or embarrassing experience with their mathematics teacher in previous years. Such an experience makes a student believe he or her deficient in mathematics ability and this mathematics anxiety results in poor performance in the subject (Ganal & Gujab, 2014).

Studies conducted in India also reveal that students and teachers face various problems in the process of learning and teaching mathematics. NCF (2005) highlights the major challenge of learning mathematics as students' fear towards the subject mathematics. Learners are unable to understand the basic concepts of mathematics due to various reasons. There is a strong teacher component- the mathematics teacher's role- to engage a student with a sense of success to boost his/her confidence to prompt him/her to take up further challenges in the subject.

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

The Position Paper on Teaching of Mathematics (NCERT-2006) by 'National Focus Group' also talks about the development of a mathematics programme that would ensure that everybody learns mathematics and does not fear it. However, the effectiveness of any such programme depends ultimately on the teachers' professional competencies and status.

In this context, as part of the present study, the researcher closely studied the following aspects, to understand the actual scenario of secondary-level Mathematics Education.

5.2.1 Status of Mathematics Teachers: Professional Competencies and Opportunities for Learning

The researcher reviewed many related literatures to understand the present status and understood that in many classrooms, mathematics is taught by teachers who are not very confident in their mathematics. 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 processes which would enable teachers to become more confident and to continue to engage them in learning new things.

5.2.2 Objectives of Teaching Mathematics at the Secondary Level

The researcher reviewed the objectives laid down by various State Education Boards and the Central Board of Secondary Education (CBSE). Concerned authorities have revised the curriculum and syllabus of Mathematics at the Secondary level by considering the learning needs of the learners of the time, by considering the objectives of teaching mathematics at secondary level, envisaged and drafted by various commissions and committees, as per the need of the hour.

To achieve all the objectives of teaching mathematics from a class of a heterogeneous group of students – students having diverse capabilities – the role of mathematics teacher of secondary level is seen more challenging. Researcher realized that more avenues to be opened for teachers, in order to achieve the expected learning objectives from the current generation learners.

In this context, the researcher explored more in the area of secondary mathematics education, studied and tried to understand the important skills required for a good mathematics teacher.

5.2.3 Important Characteristics and Skills Required for Mathematics Teachers

NCTE, NCERT, NEP-2020 and various other commissions have put forth on the skills and characteristics expected in a good mathematics teacher. The researcher understood, various teacher education institutes are making good efforts to make the student teachers acquire the required skills during their course of training. However, after the pre-service programme 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).

The education institutes of the country are now engaged with the implementation process of the NCF for School Education (NCF- 2023), drafted by NCERT, by understanding and extracting the essence of NEP-2020, which is expected to bring a paradigm shift in the education system of the country, not just a reform, but complete transformation, if implemented in its right sense and true spirit. NEP -2020 also emphasizes strongly for teacher preparation and sustaining the quality of teachers by providing opportunities for their continuous professional development. Yes, there is a need for a systematic mechanism for academic support for teachers and their professional development.

5.3 Need for Professional Enrichment Programmes of Mathematics Teachers

Professional development is a program designed to promote the development of teachers in terms of their content and pedagogical knowledge and skills through enrichment training provided to teachers over a period of time. Success as a teacher requires a continuous process which 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, the 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 also 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 change, 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 the recommendations 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).

5.4 Development of a Professional Enrichment Programme (PEP)

"Professional enrichment is the programme for teachers to promote their development in aspects of content and pedagogy. Understanding the concepts and skill development can be done through teachers' personal reflection, interaction with colleagues and mentoring which give confidence by engaging with their practices and reaffirming their experiences" (Manichander, 2016). Apart from these, the development of certain modules for relatively abstract and complex topics of the secondary level also enhances the teaching-learning of mathematics.

The Enrichment Programme, takes up and adds to the conceptual clarity of teachers, innovative methodologies, and teaching skills. It is usually to assist teachers to achieve the expected competencies in core academic skills and other methodological teaching skills required to make the teaching – learning more impactful.

The below diagram depicts the two major aspects of teaching mathematics which an effective Professional Enrichment Programme should include. [Based on Principles and Standards of NCTM (2000) and NCF (2005)]

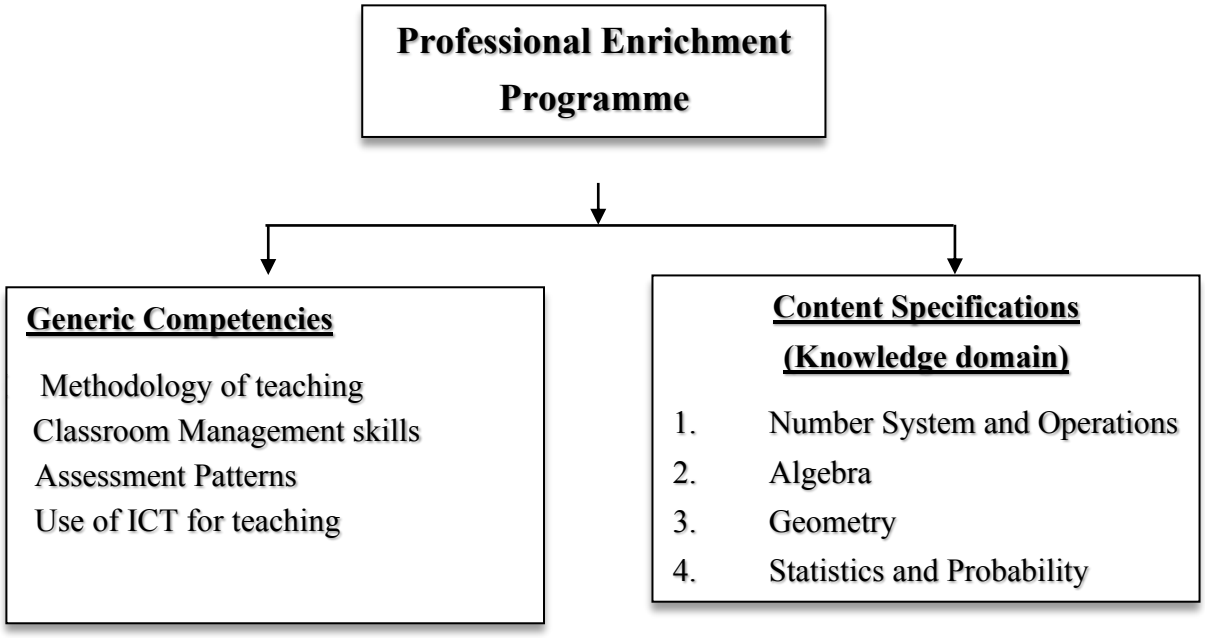

Figure - 5.1 Major Aspects of a Professional Enrichment Programme

While developing the programme, the researcher understood the fact that one should concentrate to develop and improve the skills of teachers in generic competencies of teaching mathematics as well as on the content specifications- the knowledge domain. It is very important to identify the content or the area where teachers generally find difficult to teach and the learners find difficult to understand.

5.5 Principles of Programme Design

The effectiveness of any enrichment programme depends mostly on the ability of the programme developer. All development and enrichment programmes are designed to make some differences and improvements in the existing scenario. If the participants involved show positive changes in their practices, then only the programme is said to have a broader impact on the system. To make that impact possible, there are certain principles to be followed while developing the programme.

Researcher considered several principles that need to govern the design of a professional enrichment programmes which were puts forth by National Curriculum Framework for Teacher Education (NCFTE, 2009).They include: a program design with clear goals and strategies for achieving those goals, providing teachers with opportunities to connect program content to their own experiences and find opportunities to reflect on their own experiences and the need to respect teachers' professional identity and knowledge and to collaborate with and work.

According to Manichander (2016), the process of professional development should be based on sound educational practices such as contextual teaching. The development of professional enrichment programs also should focus on: Enriching teachers' knowledge of the subjects/topics being taught, Developing teachers' classroom teaching skills, Generating and contributing new knowledge to the profession and Increasing teachers' ability to monitor students' work to provide constructive feedback to students and hence to redirect teaching.

The researcher closely reviewed the principles of programme development given by various researchers and the content developing body like NCERT.

NEP(2020) emphasizes "the increased importance on the necessity for the professional development of teachers and other concerned stakeholders in order to bring a qualitative change in the education system". So NCERT in 2022 has developed and published 'Guidelines for 50 Hours of Continuous Professional Develoment for Teachers, Head Teachers and Teacher Educators', Based on National Education Policy 2020. "This guideline covers all the major areas as well as the most recent pedagogies, such as arts-integrated, sports-integrated and storytelling-based approaches, among others. It also includes a variety of programmes and activities for participants that encourage pro-active learning engagement from the ground level" (CPD Guidelines based on NEP 2020,NCERT, 2022). The researcher reviewed and explored all such guidelines, incorporated and followed certain principles while developing the programme.

5.6 Importance of Technology in Teaching - Learning of Mathematics

The emerging technologies are making a greater impact on teaching and learning. Specially, to meet the challenges of physical distancing or social distancing caused by Covid-19 pandemic, people across the globe had to embrace technology for communication and education. Virtual

class rooms and online learning is not a novel discovery. Some educational institutions used to conduct distance education programmes prior to the emergence of Covid-19 pandemic.

The dependency of online learning on technological equipment and internet connections challenges the learning. In the present scenario, for 21st century learners, technology plays a crucial role in learning. Educators have major roles in ensuring technology to enhance students' learning and also to get the full advantages of educational technologies for their knowledge expansion.

Technology now plays a prominent role in mathematics class rooms. Appropriate and integrated use of technology can make a positive impact on mathematics education. Technology integration not only benefits the learners in class rooms, but it has become a need of the hour for all teachers for 21st century teaching profession. It is due to this reason that the application of up-to-date educational technology in high quality professional development and integrating it in the development of such professional enrichment programmes has a vital role in learners' improvement in learning as well as in school reform and change. Learners are definitely quick adapters of modern technologies. But preparation of teachers to use technology is an important aspect to be considered while preparing a teacher development programme. So in the present study, while developing the enrichment programme, the researcher has given due importance to the blended learning method of teaching various complex and abstract topics to teach at the secondary level. By focusing the teachers' understanding on few specific areas of teaching, the researcher has developed own video contents of explanation and hence involved technology in the developed enrichment programme.

The following research questions were kept at the main focus in each phase of the study and also while developing the programme by the researcher.

5.10 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?

5.11 Statement of the Problem

Development of Professional Enrichment Programme for the Secondary School Mathematics Teachers.

5.12 Objectives of the 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.

5.13 Explanation of the Terms

5.13.1 Professional Development Needs: Professional development needs of mathematics teachers include the content and methodological knowledge and skills required for effective mathematics teaching-learning in Secondary School Education.

5.13.2 Professional Enrichment Programme: The term Professional Enrichment programme means a comprehensive, sustained, and intensive approach to improving teacher's effectiveness in raising students' learning outcomes. It is the enrichment training provided to teachers over a period of time to promote their development in all aspects of skill, content and pedagogy that enable them to be professionally competent.

5.14 Delimitation of the Study

The study was delimited to Class IX and X Mathematics Teachers of CBSE English medium schools of GUJARAT. Though there are 30373 affiliated schools following CBSE curriculum across India and also abroad according to **School Affiliation Re-Engineered Automation**

System (SARAS 5.0) of CBSE, only the mathematics teachers of secondary section of CBSE English medium schools of Gujarat were considered for the sampling purposes, hence the study was delimited accordingly.

5.15 Research Design

With an aim to develop a programme, by considering both generic and content-based needs identified by the researcher during the first phase of the study through the need identification questionnaire-NAQPEMT-- and using the other tools like informal interviews, interactions and classroom observations, the researcher felt the need of a strong design for the programme. For the programme designing, many reviews have been made by the researcher in order to have its strong base. After studying several programmes earlier designed by various researchers, the current programme was designed and developed by focusing the objectives of the study. The reviewed literature, study of the other programmes, teaching modules and programme principles have given a direction to the researcher for the present programme designing and development.

The review of the above such literature categories enhanced the researcher to identify, decide and design the kind of programme required and suitable for the particular instructional and other needs identified through the need identification process.

The present study was focused to develop and implement a Professional Enrichment Programme for secondary school mathematics teachers. After setting such a strong base for the study, the researcher conducted the study in different phases.

A description about the 5 phases of the study is given below.

- **Phase – I: Identifying the Professional Development needs:**

  The Professional Development needs of mathematics teachers of secondary schools were identified by the researcher, focusing on the generic and content-specific areas. In the generic area, the researcher tried to study the following aspects practiced by teachers: Methodology of teaching, Classroom management skills, Use of technology and Assessment patterns.

  A need assessment survey was conducted using a self-developed questionnaire- **Need Assessment Questionnaire for Professional Enrichment of Mathematics Teachers (NAQPEMT),** to identify both generic and content-specific areas to focus on, for the programme development. Researcher also made review of various related literature, interaction with teachers and principals and classroom observations of teachers. Then the

researcher developed the tool: Need Assessment Questionnaire for Professional Enrichment of Mathematics Teachers (NAQPEMT) and administered the same on a sample of 112 secondary school mathematics teachers.

- **Phase – II: Developing a Professional Enrichment Programme (PEP):**

  Based on the needs identified through the survey and its analysis, the researcher developed a programme – which consisted of both the Standardized Teacher Professional Development (Split Model) and Self-Directed Teacher Professional Development aspects which are briefed below.

  Adopting the Split Model of the Standardized Teacher Professional Development helped the researcher to provide training by conducting offline and online sessions for teachers to have the proper understanding of the developed modules of the programme, then implementing the inputs in the actual classrooms, and then follow up on training through feedback and reflective and open discussions.

  Self-Directed Teacher Professional Development incorporated by the researcher was to provide self-learning modules to teachers through which they do independent learning, using the provided content and by using resources like computers, the internet, and other digital devices. Four modules on four identified topics were developed by the researcher.

- **Phase – III: Validation of the content of the developed programme:**

  The developed programme was reviewed by the experts of mathematics education. The expert's guidance and suggestions were considered, wherever felt necessary, for the modification of the programme content. Relevant and useful suggestions from experts were incorporated for the improvement of the programme.

- **Phase – IV: Implementation of the programme:**

  The developed programme was implemented in the following manner.

  A physical training session was conducted by the researcher for 62 selected mathematics teachers of the secondary section of the schools of Central Gujarat. Principals of the schools who are members of GYAN SAROVAR-The Central Gujarat CBSE Schools Sahodaya Complex (an association of CBSE Schools Principals of Central Gujarat)- were approached by the researcher to ensure the participation of the teachers for the training sessions.

After explaining the developed modules through the physical training session, discussions were made on the implementation. Further, out of 62 teachers who participated in the offline training session, selected 12 teachers from Vadodara city constituted as sample to implement the programme in their classrooms. The researcher was constantly guiding those 12 teachers through online training sessions and informal interactions. Also, they were asked to explore the Self Learning Modules.

- **Phase – V: Evaluating the effectiveness of the programme:**

  The effectiveness of the PEP was studied through-

  a) The feedback collected from the participant teachers and an analysis made on the collected feedback.
  b) Informal interviews and online interactive sessions were conducted to understand the effectiveness of the programme.
  c) Selected teachers' classroom observations were also made by the researcher.
  d) Feedback was collected from the students as well, for whom the programme was implemented by the participating mathematics teachers.

5.16 Population of the Study

Mathematics teachers working in the secondary schools constituted the population for the present study. According to School Affiliation Re-Engineered Automation System (SARAS 5.0) of CBSE, there are 30373 affiliated schools following CBSE curriculum across India and abroad. Many state boards also now adopted curriculum and syllabus which matches with the syllabus developed by NCERT. Though the present study was conducted in Vadodara, Gujarat by selecting the sample mathematics teachers from Central Gujarat and then few teachers of Vadodara for the implementation of the programme , the study was focused on the entire mathematics teaching community of secondary section of the schools , who are following the curriculum developed by NCERT.

5.17 Sample for the Study

For sampling, the researcher approached the President of GYAN SAROVAR Sahodaya and also various member school Principals to ensure the interest, regularity, and willingness on the part of the schools to depute Mathematics Teachers for the programme.

The following table shows the sampling techniques used for the different phases of the study.

Table -5.17.1 Sampling Techniques of the Study

PHASE	PURPOSE	SAMPLE & SIZE	SAMPLING TECHNIQUES
I	Identifying the Professional Development Needs.	112 Secondary School Mathematics Teachers.	Random Sampling.
IV	Implementation of the Professional Enrichment Programme	62 Mathematics teachers for the physical training session.	Convenience Sampling.
		12 Teachers to explore the Modules of the Programme.	Convenience Sampling.
V	Studying the Effectiveness of the Programme	12 Mathematics teachers.	Convenience Sampling.
		221 Students of Classes 9 &10	

5.18 Research Tools

The researcher adopted different techniques and developed different tools for data collection, development of modules and to check the effectiveness of the developed programme.

The following table shows the research tools which were used at different phases of the study.

Table -5.18.1 Research Tools & Techniques

PHASE	PURPOSE	TOOLS
I	Identification of Professional Enrichment needs.	Informal Interviews. Need Assessment Questionnaire for the Professional Enrichment of Mathematics Teachers (NAQPEMT). Classroom Observations.
II	Development of the Modules for the Professional Enrichment Programme.	Informal Interviews. Interaction with Experts.
V	Studying the Effectiveness of the Professional Enrichment Programme.	Feedback Form. Classroom Observations Informal Interviews.

A detailed description of tools adopted for the various phases of the study is provided below.

1) Need Assessment Questionnaire for Professional Enrichment of Mathematics Teachers (NAQPEMT):

In Phase I of the study, the researcher developed a questionnaire- Need Assessment Questionnaire for Professional Enrichment of Mathematics Teachers (NAQPEMT) to identify their professional development needs. The questionnaire developed by the researcher contained items with respect to content, methodology, classroom management, ICT resources, assessment practices etc. in order to understand the specific training needs and Professional Enrichment Programme needs of Secondary Section Mathematics Teachers.

The questionnaire comprised 8 different dimensions to identify and understand the information regarding the academic and professional background, instructional practices and attitude towards teaching mathematics of secondary section mathematics teachers. The 8 dimensions covered in the questionnaire for which questions were framed are:

1) Background information (16 Questions)
2) **I**. Mathematics as a subject (14 Questions)
   II. Pedagogy and Methodology Related (41 Questions)
   III. Assessment Practices (12 Questions)
   IV. Technology integration Practices (8 Questions)
   V. Other areas of Need for Professional Enrichment Program. (10 Questions)

VI. Teachers' familiarity with certain documents. (10 Questions)

VII. Content Related

1. Area of Proficiency (15 Questions)
2. Identifying the difficulty level of each topic of Class IX and X.

Apart from the questions to identify the 'Background Information' of the sample teachers, each question pertaining to all other 7 dimensions was given a 5-point rating scale.

Each item contained in the NAQPEMT was validated by experts like Principals and Professors from mathematics background and education department of various universities. According to their guidance and suggestions, required modifications were made and a pilot study was conducted with mathematics teachers of secondary section of 2 schools. This pilot study helped the researcher to understand the applicability, clarity, relevance etc., to validate the questionnaire. The NAQPEMT was then administrated upon 112 sample mathematics teachers of secondary section of various schools in Gujarat.

A copy of this tool - NAQPEMT- is given in **Appendix II.**

2) Informal Interviews:

During the initial phase of this study, the researcher conducted unstructured interviews and lots of interactions with different school Principals and secondary section mathematics teachers to understand the specific areas of problems while teaching Mathematics in class 9 and 10. These interactions and interviews helped the researcher to understand many methodological and pedagogical improvements required while teaching mathematics in secondary section.This enhanced the researcher's understanding about the findings which did emerge through the survey.

Inputs from such informal discussions gave the researcher a clear understanding and areas to focus while developing the enrichment programme. Such understanding gained through the interactions led the researcher to derive an appropriate design for the enrichment programme in terms of its usability and execution.

Before the implementation of the developed programme, the researcher conducted 2 – 3 interactive sessions online on each module of the programme to discuss with the selected teachers for the implementation. This helped the researcher to give an understanding and clarity

about the developed programme and also to understand the usability and adaptability of the programme.

Interactions and informal interviews were again held by the researcher during Phase –IV, the implementation of the developed programme and also during Phase –V while studying the effectiveness of the programme.

3) Classroom Observations:

During Phase I (identification of needs), the researcher did the classroom observations of selected mathematics teachers to understand the methodology used in classrooms, the content clarity and the learning outcomes in students, the learning gaps, the assessment practices, technology integration in classrooms and the classroom management skills of mathematics teachers. The researcher interacted with a few mathematics teachers and their principals to understand the training needs.

Also, to study the effectiveness of the implemented PEP, during Phase V, the researcher conducted classroom observations of few teachers who implemented the developed programme. These observations helped the researcher to study the impact of the programme on Teachers' Professional Development.

4) Feedback Forms:

In Phase V, to study the effectiveness of the programme, the researcher used the Feedback Form. 3 types of Feedback Forms were developed by the researcher.

- To collect feedback from the participant teachers who attended the physical and online training sessions.
- To collect feedback from the teachers who implemented the programme.
- To collect feedback from the students at schools where programme was implemented by the participating teachers.

Through the Feedback Form, the researcher collected their opinions and their experiences while implementing the program which helped the researcher to understand the effectiveness of the programme. Apart from the feedback form, the researcher's continuous interaction with the participating teachers helped in the implementation in its desired manner and also it gave a complete understanding of the participating teachers' understanding of the programme.

Copies of all the 3 Feedback Forms are given as **Appendix III** attachment

5.19 Data Collection Procedure

Since the study was carried out in 5 different phases, the researcher adopted different tools and techniques for the data collection procedure. A brief about the data collection procedure is given below.

PHASE - I: Identification of Professional Development Needs of Mathematics Teachers:

The data was collected by the researcher during this Phase of the study to identify the needs of the professional enrichment programme- from 112 mathematics teachers across Gujarat, by using the **NAQPEMT**. The researcher being the executive committee member of GYAN SAROVAR SAHODAYA, this very active Sahodaya of Central Gujarat played a major role in the data collection process.

The researcher also collected information by reviewing related literature and meeting and interacting with mathematics teachers and various school Principals to understand the exact needs for the development of a Professional Enrichment Programme.

The quantitative data collected in this phase through NAQPEMT was analyzed in terms of Percentage and Mean score calculations and the qualitative data collected through NAQPEMT, interactions, informal interviews and classroom observations were analyzed through narrative analysis method.

PHASE - II: Development of Professional Enrichment Programme:

The development of the content of the programme was done in phase 2, which was based on the analysis of the data collected during the first phase. For this, the researcher gathered information through a review of the previous studies and the other teaching–learning modules developed earlier. The researcher visited mathematics professors, teachers and experts in the area several times to gather innovative approaches and other understanding from them and also to get their review as well, during the programme development which the researcher used to modify the content of the programme.

PHASE - III: Validation of Content of PEP:

The validation of the content was done by visiting the experts – the professors, senior mathematics teachers, few school Principals having mathematics subject mastery -, by providing

them with the printed content and the soft copies to review and the suggested and required inputs were incorporated in the programme by the researcher.

PHASE - IV: Implementation of the PEP:

For the implementation of the developed programme, the researcher gathered 62 mathematics teachers of secondary schools of GUJARAT and had offline training session for them to have an exposure for the programme. Further, the researcher conducted online sessions, when and where required to give clarity about the programme. Their opinions about the programme were collected through the Feedback Form.

Out of thee 62 teachers, 12 teachers were chosen conveniently to implement the programme in their classrooms. The implementation of the programme was minutely monitored by the researcher by continuously interacting and guiding them telephonically and by interacting with them through the online platforms like WhatsApp – to provide them with guidance and support in making the clear understanding of the programme. Researcher collected the opinions from those 12 teachers through the Feedback Form.

Also, the researcher collected Feedback of 221 students of class IX & X, for whom the programme was implemented by the participating teachers, in order to understand the effectiveness of the programme.

PHASE - V: Evaluating the Effectiveness of the Programme.

For evaluating the effectiveness of the programme, Feedback forms were developed by the researcher for collecting the opinions of the participating mathematics teachers at various levels.

3 types of feedback were collected by the researcher:

- Feedback from 62 participant teachers who attended the physical and online training sessions.
- Feedback from 12 teachers who implemented the programme.
- Feedback from 221 students of class IX & X of the schools where programme was implemented by the participating teachers.

5.20 Data Analysis

Analysis and interpretation of the data gathered for the present study was carried out by the researcher, by keeping the research objectives in mind. Data collected during the various phases of the study were both qualitative and quantitative in nature. The mixed methods and triangulation were adopted by the researcher for the data collection, integration, analysis and interpretation of the collected data. The researcher followed the basic statistical analysis steps: collection of data, integration and presentation of data, analyzing the data, interpretation of data and the presentation of results-which were very essential for the research conclusion.

The quantitative data collected for the first phase of the study using the NAQPEMT and in the last phase of the study through Feedback Form were analysed through the descriptive statistical analysis techniques – percentage and mean score calculations. First, the raw data was converted into table form by assigning numerical scores for each response. A 5- point rating scale was adopted in the questionnaire and in the feedback forms to convert the data in quantitative manner. Then the data was explored thoroughly by the researcher to organize the same and to keep the data ready for analysis and interpretation using mixed methods.

The qualitative data obtained from NAQPEMT during the first phase of the study, Feedback Forms used to study the effectiveness of the programme during the last phase of the study, Informal Interviews, Interactions with participating teachers and Classroom Observations made at various phases of the study were analyzed through both inferential and narrative analysis methods and triangulation.

5.21 Major Findings of the Study

The following are the major findings of the study.

1 The study revealed that majority of the teachers teaching at secondary schools are female (59%). Almost half of the teachers (49%) are with less than 10 years of experience.

2 It is emerged from the study that majority of the teachers (99%) believe in the networking for sharing expertise and enhancing their knowledge. Majority of them (94%) opined that they are very keen to participate in the professional enrichment programmes, which will be offered to them.

3 Majority of the teachers opined that learning mathematics aids in real life problem solving, indicating the importance of mathematics education for life, hence the need of professional development programme focusing on introducing the concepts through real life situations.

4 It is revealed from the study that the majority of the teachers have the consensus on prioritizing understanding over memorization of mathematics and the majority opined that existing curriculum focuses more on learning procedures rather than the skills enhancement of learners, indicating the need of a systemic change in mathematics education.

5 Majority of the teachers opined that the practice of linking new topics with prior knowledge of students benefits for comprehension and retention of mathematics facts, which indicated the need of attention in this area while developing the professional enrichment programme.

6 The study revealed the need of inclusion of innovative methodological aspects of teaching mathematics, as majority of the teachers opined that reasoning in mathematics and using visual aids to relate the concepts are very essential in teaching mathematics.

7 The study revealed that the majority of the teachers follow CBSE Assessment pattern. It also revealed the mixed opinions of teachers on the effectiveness of the current assessment practices. Teachers showed moderate support only, for diagnostic tests, indicating the scope for improvement in implementing diagnostic tests to have a deeper understanding of learners' learning difficulties.

8 The study revealed that the professional development programme for mathematics teachers needs to include innovative methods of motivating students to learn mathematics; updating knowledge for applications of mathematics; preparing instructional and learning activities and also for evaluating students' progress, time to time.

9 It was emerged from the study that the mathematics teachers have specific professional development needs in the pedagogic areas. These include providing remediation for low achievers; updating knowledge of mathematics -related career opportunities; selecting appropriate instructional strategies and learning new methods of teaching mathematics.

10 ICT integration in teaching mathematics was found as a need for professional development for mathematics teachers.

11 The study revealed that most of the teachers have difficulty in conceptual understanding and explanation of the topics: NUMBER SYSTEMS & TRIANGLES of Class IX and REAL NUMBERS & TRIANGLES of Class X of the NCERT syllabus.

12 Majority of the teachers opined that the programme developed by the researcher was found interesting and insightful for the teachers.

13 Majority of the teachers opined that the Self-learning Modules integrated with Technology helped them to enhance their pedagogical competencies.

14 It was found from the study that the program inputs in terms of content presentation, illustrations, relevance to day-to-day life, current developments in mathematics research, and innovative pedagogies were found interesting and meaningful by the mathematics teachers.

15 The majority of the students have opined that the Experiential learning and Art integration in teaching mathematics were interesting and enhancing the concept clarity.

16 The study also revealed that the classroom activities incorporated in the modules and the video content support developed by the researcher were relevant, useful and helpful for the conceptual understanding and competency building in learners.

17 The study revealed that the programme developed by the researcher was found effective as perceived by the teachers in terms of content clarity, self-directed learning, relevant activities, and incorporation of NEP-2020 aspects, user friendliness and adaptability.

18 It was found from the study that the programme developed by the researcher was effectiveness as perceived by the participant teachers in terms of ;

a) Self -explanatory nature
b) User friendliness
c) Provided resources to many References and Assessment
d) Well-structured pedagogy and design of each module.
e) Relevant content and exercises.
f) Clarity in the content presented.
g) Outputs in terms of expected learning outcomes.

The following outcomes have also been emerged from the present study.

1) Though Mathematics teachers of Secondary Section are mostly equipped with content knowledge, their Pedagogical and Methodological aspects needed motivation and enhancement.

   Resources in terms of Text-books, Reference books, etc., are available plenty in market, but "how these resources are getting implemented" has emerged as a major aspect of concern and the researcher felt a need for developing enrichment programme by keeping this aspect in mind.

2) The study revealed that most of the teachers feel their content knowledge and pedagogical and methodological planning are excellent but still researcher found the learning outcomes from students under different teachers' guidance and teaching have variations and differences. This indicates that teachers need motivation in terms of variety of availability of enrichment programmes to take part.

3) It emerged from the study that though many teachers felt the need of taking part in various enrichment programmes available for them, time constraint to involve and participate in such programmes was reflected as a major concern.

4) Most of the teachers opined that establishing professional learning groups and peer group discussions and networking would be turning effective for enriching their professional competencies.

5) It also emerged from the study that a facilitator for motivation is required for any professional development or enrichment programme to make them more effective.

6) The study also revealed that many teachers were looking for a self-learning platform which can be used at their own convenience for their enrichment of professional competencies. User friendly programmes were expected by majority of the teachers.

7) Another finding of the study was the need of engaging and equipping the teachers with the use of multimedia and available technological aspects which are the needs of the hour to engage this 21st century learners in productive learning.

5.22 Discussions

It is evident that to ensure the quality of Mathematics Education at Secondary Schools, having competent Mathematics Teachers in the system is very essential. Secondary education is the pre-requisite of any kind of development of students. Assuring the quality of teachers at this level is a necessity. Qualification, not only in terms of their academic certificates, but providing opportunities for their professional development and growth is the key to maintain quality teaching.

Need for Professional Enrichment Programme for Mathematics Teachers:

In order to meet the demands of the present century secondary section mathematics learners, especially in this rapidly changing world, it becomes very necessary for mathematics teachers to have the practice of self-appraisal and reflective strategies. To fulfill their important roles, they need training, capacity building programmes at regular intervals. Government has also taken initiative in making new policies for teacher education as per the need of the hour and has provided strategies for improving professional development of mathematics teachers.

Professional development is the enrichment training provided to teachers over a period of time to promote their development in all aspects of content and pedagogy. Becoming an effective teacher is a continuous process that stretches from pre-service experiences to the end of the professional career. It is conceptually divided into pre-service and in-service teacher training. The ultimate beneficiary of In-Service Teacher Professional Development (ITPD) is the student though the receiver is the teacher. (Manichander, 2016)

Mathematics teaching is a complex and demanding process. Complexity is due to the need of unfolding new techniques and strategies for Mathematics teaching – learning, suitable to the current century learners. Mathematics education at secondary level aims to make the learners to think critically, to analyze and to make inferences. The skills that the learners of this century need and the competencies that teachers of Mathematics need to teach those skills to the students can be attained through continuous training, motivation and professional enrichment programme for Mathematics teachers.

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 "in the secondary stage students begin to perceive the structure of Mathematics as a discipline. So, it is very important to strengthen the secondary stage learners by improving quality in teaching in a significant way". There is a need for improving mathematics teachers' professional capabilities by providing opportunities to them to grow in order to strengthen the secondary school mathematics education.

Various Commissions and Policy makers also have made recommendations on the need of teachers' professional development. In 1998, the Government of India established 'National Council for Teacher Education (NCTE)' for the maintenance of standards and improvement of quality of teacher education in the country. It also emphasized that "every five years, the progress be reviewed".

National Curriculum Framework for Teacher Education (NCFTE, 2009) in its reports clearly mentioned about 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 of all subjects including Mathematics to meet the increasing demand of quality secondary education.
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).

In terms of implementation of NCF (2005), there has to be system improvement involving teachers. This situation creates a potential for change by way of designing or development of teacher's professional enrichment programme to comprehend the vision of teaching and learning as articulated in the NCF -2005 (Kumar et al., 2012).

In 2014, the country has restructured the teacher education programme from 1 year program to 2 years duration with an aim to enhance the teaching skills and competencies, much more, compared to what was happening in one year program. Apart from this 2 years pre-service program, it is felt necessary to engage the mathematics teachers to take part in professional enrichment program at frequent intervals or continuously to ensure the quality teaching learning happening in the class rooms.

It is noticed that the teachers having good content knowledge also fail to deliver the knowledge in an effective manner in the class rooms because of the lack of their pedagogical planning. Also, there is a lack of passion and motivation amongst the teachers. Most of them are simply focusing the content delivery and completion of syllabus task. Many teachers are failing to understand the gravity or the depth of learners understanding. By providing technology integrated self-learning enrichment programs which motivate them to change their methodology and approach towards learners can bring drastic positive changes and improvement in learners' academic performance and also their attitude towards mathematics subject.

The latest education policy, NEP -2020 has made recommendations to bring a paradigm shift in the education system of the country, by focusing the present century learners and the learners of the next decade. The policy has made strong emphasize on enhancing and enriching the teachers' quality also, due to which now the system has made 50 hours of CPD mandatory for the teachers, in every academic year. The policy has suggested good pedagogical and methodological strategies to improve the secondary mathematics education. After the launch of NEP(2020), mathematics teachers are now having an understanding that their teaching approach and methodology needs to be changed drastically. They are now open to go for that paradigm shift to bring in the classroom teaching of mathematics.

5.23 Implications of the Present Study

The implications emerged from the present study are given below:

1) To ensure the quality in Mathematics education at Secondary level, the opportunities for the continuous professional enrichment programme for teachers need to be assured / created.
2) It is necessary for Mathematics teachers of Secondary schools to equip and update them with the latest technologies and technology integrated teaching – learning to meet the demand of 21st century learners.
3) It is important to identify the professional enrichment and development needs of the Secondary Mathematics teachers, time to time, or at a regular interval.
4) Self-learning modules, integrated with technologies can enable the teachers to enhance their competencies and can implement and experiment innovations in real classroom situations, hence enabling the students to improve their performance academically.

5.24 Suggestions

The researcher has made suggestions in 3 different categories, on the basis of the findings from the present study.

a) Suggestions for Secondary School Mathematics Teachers.

b) Suggestions for Curriculum Designers and Policy Makers.

c) Suggestions for further Research.

5.24.1 Suggestions for Secondary School Mathematics Teachers

1) Commit and involve into continuous personal and professional development by self motivation.
2) Set high expectations for students' achievement and accordingly plan instructional strategies and apply appropriate, classroom management techniques.
3) Adopt the most recent educational technology in class rooms and keep track of the latest developments in teaching – learning.
4) Involve and engage in Professional Learning Network. Discussions and sharing experiences in peer-groups have learning opportunities which enhance and enrich the professional development.
5) Analyse whether there is a need and scope for self-development. Update by dynamic reading, browsing online, consulting experts, interacting with peers, parents and students.
6) Understand the direct relationship between effective mathematics teaching and producing socially responsible citizens, the ultimate aim of professional enrichment program and activities being learning improvement and academic achievement of students.

5.24.2 Suggestions for Curriculum Designers and Policy Makers

The quality of school education depends mostly on the quality of few important aspects like curriculum planning, methods of teaching and pedagogical planning. NCERT is the curriculum advisor to the Ministry of Human Resource Development (HRD) of the country. By considering the important role played by NCERT in country's educational activities like development of curriculum, methods of teaching, techniques of evaluation etc., the researcher has attempted to make few suggestions to NCERT (the autonomous organization of Government of India) and other policy makers.

1) Along with curriculum, it is necessary to provide period wise lesson plan and well-structured pedagogical plan. This must compel the teachers to follow the plan which will yield good academic achievement of learners.
2) Pre-knowledge checking, Assessment practices and Diagnostic test practices to be made compulsory for execution for the teachers, after the completion of teaching every topic.
3) Specific technology and multimedia integration to be emphasized to use in the required area/s.
4) Teachers need motivation. So, Policy Makers need to think about rewarding the teachers in terms of best innovation practices in teaching – learning at regular intervals at District, State and National level.
5) In-service assessment of teachers should be a part of the teaching profession. Teachers must be assessed at regular intervals in terms of their self-motivation, updation in recent advancement of content and technology and also the innovation in teaching – learning.

5.24.3 Suggestions for Further Research

1) Study on development of professional enrichment programme for Secondary Mathematics Teachers by focusing the virtual classroom needs.
2) Similar studies to develop enrichment programmes on the other topics of Secondary Section Mathematics.
3) Comparative studies in terms of Kendriya Vidyalay or other Government Schools' Mathematics teachers' professional development needs and Private Schools Mathematics teachers' professional development needs.
4) Studies on impact of professional enrichment programmes on school's quality improvement.
5) Studies on development of professional enrichment programmes by focusing the Generic Competencies.
6) Comparative studies on professional development needs of Mathematics Teachers for the offline and online classroom- teaching of Mathematics

5.25 Conclusion

The world is continuously changing and the education system of various countries demands changes as per the requirement of the learners of the country and the need of the time. It is hence expected that mathematics education will continue facing challenges due to its evolving nature. In the present Indian scenario, for the improvement of mathematics teaching – learning, the focus must be expanded from the improvement of individual teacher to the system improvement. A system which engage more mathematicians, mathematics teachers, researchers in mathematics education to learn about the professional development activities which can enhance the skills and quality of works of teachers. More contributions in this area are expected to solve the problems in achieving quality Mathematics Education.

The ultimate aim of any professional enrichment programme for teachers is the learning improvement, academic achievement and competency enhancement of the learners. There is a strong need and scope for self-development, and self-updating by dynamic reading, online browsing, consulting experts, peer discussions and learning on the part of secondary school mathematics teachers. To ensure the quality of education in mathematics at the secondary level, continuous professional enrichment opportunities are to be created for the teachers.

New National Education Policy (NEP) – 2020 has emerged as the quenching thirst for all such requirements. The policy is a new ray of hope because it emphasizes much on teacher preparation, teaching career, enrichment and empowerment of teachers. It discusses about 'ensuring Performance Standards of Teachers', and also, 'Teachers Audit or Performance Appraisal' as a system. Policy is also mentioning the importance of engaging teachers 50 hours every year in Continuous Professional Development (CPD) by attending workshops or exploring online teachers' development modules.

Education sector of India is waiting with hope, to see the reform happening in mathematics education through the immediate and urgent measures of implementation of the recommendations made by the National Education Policy (NEP)-2020. The expectation is to achieve the improvement in education system as a whole and the quality of teaching – learning, Mathematics, as it seems the end of the years' long wait for the desired reformation to shape the future generation.