DEVELOPMENT OF PROFESSIONAL ENRICHMENT PROGRAMME FOR THE SECONDARY SCHOOL MATHEMATICS TEACHERS

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1.0 INTRODUCTION:

The education system has a tremendous responsibility to transform a child into a fully developed individual. Over the ages, academicians and educationists of the country have been relentlessly working to develop a system of education which can express and promote its social and cultural identity, a system which can fulfil the requirements of the time. Continuously research studies are happening in the education sector for the improvement of the existing system and to establish a system wherein learners can be equipped with the skills necessary to prepare them to face the technological world and to prepare them for 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 also 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.

1.1 Importance of Mathematics Education in General and Secondary Education in Specific:

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.

At the secondary stage, 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 Math 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 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 Mathematics 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.

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.
- Teachers lack confidence, preparation, and support.

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 the Expected Learning Outcomes (ELO) in subject Mathematics is becoming difficult to achieve.

Due to the same reason, now NEP-2020 also is emphasizing doing away with Rote Learning and promoting Competency-Based Learning (CBL).

1.2 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 is 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.

Krishna, Mrinmoy, & Ranju (2012) give 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 teacher's 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.

The researcher studied:

1) **Status of Mathematics Teachers: (Their 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.

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 objectives of NCF (2005).

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. In this context, the researcher studied:

3) Important Characteristics to Become a Good Mathematics Teacher and Skills Required for Mathematics Teachers as suggested by NCTE, NCERT and also NEP-2020.

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 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). There is a need for a systematic mechanism for academic support for teachers and their professional development.

1.3 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 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 ultimate 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 in the secondary stage, students begin to perceive the structure of Mathematics as a discipline. So, it is very important to strengthen this stage learners 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.

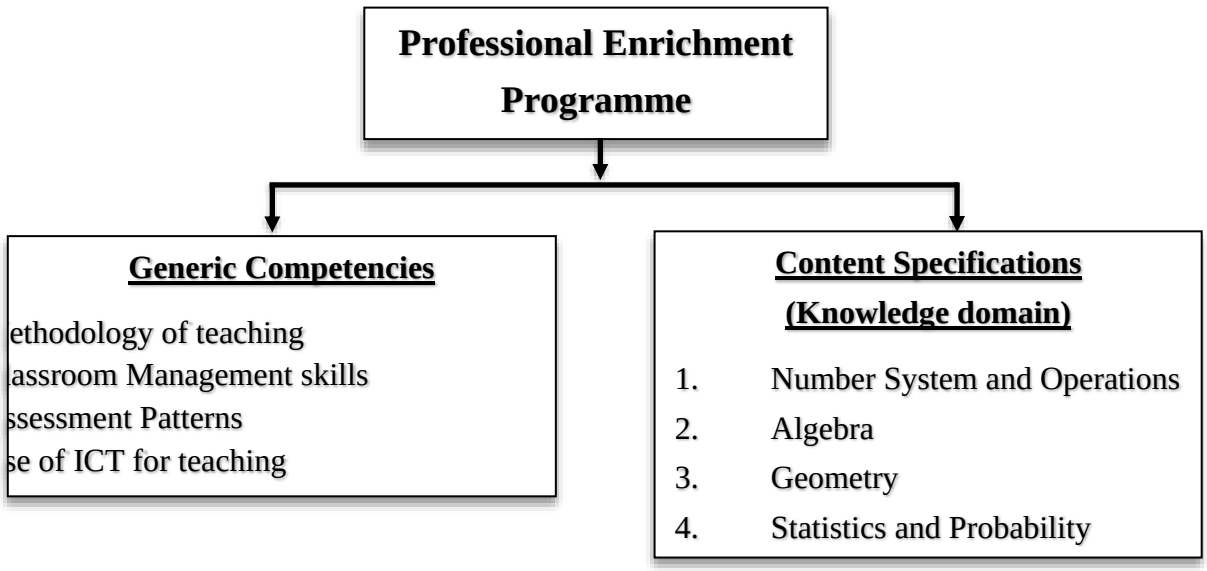
Mathematics teachers are now more open to the fact that their teaching approach needs to undergo fundamental change, to attain the expected outcomes, as per the objectives laid down by the recent NEP (2020). It is widely acknowledged that to support change in classroom teaching, in terms of implementation of 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). (Ruchi, Hridaykant, & Subramaniam, 2012).

1.4 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.

There is a significant difference between the Remedial and Enrichment programmes. The remedial Programme takes care of the errors committed by the students/teachers in specific topics and gets down to the root cause of the problem and rectifies it, whereas the Enrichment Programme on the other hand, takes up and adds to the conceptual clarity, innovative methodologies, and teaching skills. It is usually to assist students/teachers to achieve the expected competencies in core academic skills including liking the subject.

An effective Professional Enrichment Programme should consider the two major aspects of teaching Mathematics which are shown below: [Based on Principles and Standards of NCTM (2000) and NCF (2005)]



While developing a program, 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 the content specifications – from the knowledge domain. While developing a program 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.

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

- Design programs with clear goals and strategies for achieving those goals.
- Provides teachers with opportunities to connect program content to their own experiences and find opportunities to reflect on their own experiences.

- There is a 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.
- Increasing teachers' ability to monitor students' work to provide constructive feedback to students and hence to redirect teaching.

Teacher Professional Enrichment approaches can be divided into 3 different categories, as per the instructional needs. (Manichander, 2016). They are:

1) Standardized Teacher Professional Development:

a) Cascade Model: This approach generally focuses on the exploration of new concepts and the demonstration and modelling 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 of 6 – 8 days of training, the implementation of the inputs in the actual classrooms, and 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: The master trainer observes the classroom and provides structured feedback.

b) Open Lessons: Teachers develop lessons and ask colleagues to observe and get feedback focused on "teacher behavior".

c) Lesson Study: Teachers, in collaboration 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 a team select an issue, investigate, research it, plan actions to remedy it, act, and 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 professional development."

In this research, the researcher focused on developing a programme which is a combination of Standardized Teacher Professional Development (Split Model) and Self-Directed Teacher Professional Development.

1.5 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 practice, 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. The researcher incorporated and followed such principles while developing the programme.

2.0 REVIEW OF RELATED LITERATURE:

Numerous research studies have been conducted with various objectives and methodologies in the field of Mathematics. The researcher reviewed the studies on various factors influencing students' learning outcomes in Mathematics and studies related to Professional Enrichment Programmes in Mathematics and other subjects. The researcher also reviewed the studies showing the relation between teachers' Professional Enrichment Programmes and student's learning outcomes in Mathematics. Review was made on the studies on the difficulties faced by Mathematics teachers also.

The reviewed studies have been divided into 4 parts according to the objectives with which they have been carried out.

1) Studies on Learning Outcomes in Mathematics in School Education.
2) Studies on Difficulties faced by Mathematics teachers.
3) Studies on the Development of Professional Enrichment Programmes in Mathematics and other subjects.
4) Studies on the Impact of Professional Enrichment Programmes on Mathematics teachers.

2.1 Overview of the Review of Related Literature:

Though many research studies on Mathematics Education and Mathematics teacher's Professional Enrichment have been conducted, most of the studies have been carried out in foreign countries. Comparatively few studies are being done in India. The researcher observed that in most of the studies reviewed, the teacher's role is very significant in giving the learners a better understanding of the subject. Most of the studies reviewed made recommendations to improve the teaching style and to adopt innovative teaching methodologies to achieve the desirable learning outcomes from secondary Mathematics education.

An overview of the 4 categorized review is given below:

2.1.1 Learning Outcomes in Mathematics in School Education:

Reviews under the category have been made by the researcher mainly to understand the various factors affecting the learning outcomes in Mathematics in School education.

Baskaran (1991) in the study on the relationship of attitude towards Mathematics and achievement in Mathematics revealed the finding that there is a positive relation between both. Hiebert, & Grouws (2007) recommended teachers to use various Methodologies and Strategies to facilitate the student's learning outcomes. Gootenboer, & Hemmings (2007) stated that students' background factors have a connection in their Mathematics performances. Adebola, & Ademola (2011) recommended that instructional resources should be provided in schools. Simarekha (2011) in the study on the present scenario of Mathematics and Science learning mentioned that training programmes for teachers are to be arranged at regular intervals and all teachers must make positive use of computers. Mahanta (2012) found that the medium of instruction does not affect the student's achievement in Mathematics. Vijayan (2014) recommended that Mathematics teachers should spend extra time improving student's basic Mathematics skills.

2.1.2 Difficulties faced by Mathematics Teachers:

Studies reviewed under this category revealed lots of difficulties faced by teachers of Mathematics Ale (1980), Singha, Goswami, & Bharali (2012) and Sharma, & Ahmed (2013) found the common difficulties faced by Mathematics teachers a lack of tools to make teaching of Mathematics interesting and students' negative attitude and approach towards Mathematics learning.

2.1.3 Development of Professional Enrichment Programmes in Mathematics:

Professional Enrichment Programmes for mathematics teachers of any level proved effective, and studies reviewed emphasized the need for such enrichment programs and modules for the effective teaching of the subject of Mathematics. Souza, Lopes, & Mendonca (2014) who developed the programme of Probabilistic Simulations recommended that such programmes be developed to allow the teachers to get involved in the identification of problems and aspects that need to be improved in their approaches. Programmes like Multimedia Instructional Systems for Remedial Purposes for Fractional Numbers by Wagh (1991) , Planning and Teaching of Mathematics lessons by Sullivan, Zevenbergen, & Mously (2005), Professional development based on the Principles of Lesson Study by Ellen, & Mc.Donald (2009), Peer mentoring by Kensington (2013) etc. proved helping in increasing the pedagogical content knowledge of participant teachers and after the implementation of such models, students demonstrated improved learning outcomes.

2.1.4 Impact of Professional Enrichment Programmes of Mathematics Teachers:

Reviews made under this category by Ingvarson, Meiers, & Beavis (2005), Back, Hirst, Jenni, Geest,& Joubert(2009) showed that there is a significant and positive impact of Professional Enrichment Programmes of Mathematics Teachers on the learning outcomes of students. Watson (2004) stated in the findings of the study that professional development had an impact on teachers' self-efficacy. Also, the content knowledge increased among the teacher participants, after its implementation.

2.2 Implications for the Present Study:

The gist of all the related literature reviewed was that the success of any education in general and specifically mathematics education depends on the quality and professionalism of teachers. To achieve this, it is very essential to provide opportunities for teachers to improve their capacities. Developing a Professional Enrichment Programme is the tool by which policymakers' and curriculum reformers' visions for change can be disseminated and conveyed to teachers. The review of the related studies helped the researcher to conceptualize the present study. Studies have revealed the need to develop Professional Enrichment Programmes in complex topics of mathematics. Though many investigations and studies are made abroad, the researcher found a dearth of such modules and programmes developed in India. The researcher being in the field of education often observed the lack of quality teaching in secondary level mathematics education. Through the reviewed studies, the researcher understood the various topics so far covered in mathematics by researchers who developed Professional Enrichment Programmes in the past. This provided the researcher, with a framework for the present study.

3.0 RATIONALE FOR 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 with quality mathematics education.

Studying mathematics stimulates curiosity, promotes creativity and gives children the skills they need for life after school. NCF (2005) states that at the secondary stage only, students can perceive the structure of mathematics 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 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 formulas 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-2023 of Mathematics subject also reveal that several students were not clear with the various concepts taught in the subject.

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 through good Professional Enrichment Programmes for teachers. 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 recommendations and expectations of NCF (2005) and other recommendations made by various commissions for mathematics education in India and also now envisaged by NEP-2020.

For anybody who wishes to have quality mathematics teaching, it is important to look carefully into the summary of the outcomes of mathematics Education, 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 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 subject mathematics.

Through the literature reviews 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.

The recent 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 Programs and modules have been developed by scholars and academic reformers, mostly abroad and some in India, the researcher observed that very few programs 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 both the generic and content 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 a secondary stage which in turn will affect the students' learning outcomes. The researcher also had the desire to inculcate and develop the learners' interest in the subject of mathematics through the programme which is developed for mathematics teachers.

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

3.1 Research Questions:

1. What are the professional development needs of mathematics teachers at the Secondary School level?
2. How do mathematics teachers upgrade their professional competencies?
3. How will the Professional Enrichment Programme (PEP) develop the teaching skills of teachers?
4. What impact does the PEP make on the mathematics learning outcomes of students?

4.0 RESEARCH METHODOLOGY:

The methodology adopted by the researcher, in order to realize the objectives of the present study is mentioned below.

4.1 Statement of the Problem - Title of the Study:

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

4.2 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.

4.3 Explanation of the Terms:

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.
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.

4.4 Delimitation of the Study:

The study was delimited to class IX and X Mathematics teachers of CBSE English medium schools of GUJARAT.

4.5 Research Design:

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

The following table explains about the 5 different phases of the study

4.5.1. Table :1 Different Phases of the Study

PHASE	PURPOSE	DESCRIPTION OF THE ACTIVITIES
I	Identifying the Training Needs of Secondary School Mathematics Teachers.	1. Review of various related literature. 2. Interaction with teachers and principals. 3. Development of the tool: Need Assessment Questionnaire for Professional Enrichment of Mathematics Teachers (NAQPEMT). 4. Survey: Administering the NAQPEMT on a sample of 112 secondary school mathematics teachers .
II	Development of the Programme	1. Based on the outcome of the need assessment survey of Phase I, the content of the Professional Enrichment Programme (PEP) was developed.
III	Programme Validation	1. Validation of the programme by collecting the opinions of the experts -Professors, Principals, and experienced teachers of the relevant field.
IV	Implementation of the Programme	1. Physical training session of 62 mathematics teachers at secondary schools. 2. Selected 12 teachers were asked to explore the programme. 3. The programme was implemented on 12 teachers, conveniently selected by the researcher. 4. Online sessions with 12 teachers who implemented the programme.

V	Studying the Effectiveness of the Programme	1. Opinions were collected through feedback form from 62 teachers who attended the training session. 2. Feedback and opinions were collected from 12 Teachers who implemented the programme. 3. Feedback was collected from students for whom the programme was carried out by the participating teachers. 4. Informal interviews were conducted to study the effectiveness of the programme.

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 practised 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.

- **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. Four modules on four identified topics are developed by the researcher.

  a) Split Model: It consists of an explanation of modules by conducting training sessions for selected teachers, then implementing the inputs in the actual classrooms, and then following up on training through reflective and open discussions.

b) Self-Directed: Teacher Professional Development: The developed programme is also aimed to provide self-learning modules for teachers through which they can do independent learning, using the provided content and resources like computers, the internet, and other digital devices.

- **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 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, selected 12 teachers from Vadodara city were asked to implement the program 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.

4.6 Population of the Study:

All Mathematics Teachers working in Secondary School Education constitute the population for the study.

4.7 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.

4.7.1 Table: 2 Sampling Techniques Used

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. 12 Teachers to explore the Modules of the Programme.	Convenience Sampling. Convenience Sampling.
V	Studying the Effectiveness of the Programme	12 Mathematics teachers. 200 Students of Classes 9&10	Convenience Sampling.

4.8 Research Tools:

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

4.8.1 Table: 3 Research Tools & Techniques

PHASE	PURPOSE	TOOLS
I	Identification of Professional Enrichment needs.	Informal interviews & Interactions. Need Assessment Questionnaire 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 and Interactions.

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

1) Need Assessment Questionnaire:

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 contained the items with respect to content, methodology, classroom management and ICT resources.

2) Classroom Observations:

For 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 among students and the classroom management skills of selected mathematics teachers. The researcher interacted with a few Mathematics teachers and Principals to understand the training needs.

3) Feedback Form:

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.

4) Informal Interviews:

To study the effectiveness of the PEP, (Phase V), the researcher also conducted informal interactions and interviews with teachers who implemented the developed programme and to study what is its impact on Teachers' Professional Development.

For Phase V (evaluating the effectiveness of the programme) the researcher observed the classrooms of the selected Mathematics teachers who implemented the programme to understand the effectiveness of the programme.

5.0 DATA COLLECTION AND ANALYSIS:

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

PHASE- I: 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**. In this data collection process, GYAN SAROVAR SAHOD AYA played a vital role, the researcher being the executive committee member of this very active Sahodaya of Central Gujarat. 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 was analyzed in terms of Percentage and the qualitative data collected through interactions, unstructured interviews etc. were analyzed descriptively.

PHASE- II: 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.

PHASE- III: 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: The implementation of the program was minutely monitored by the researcher by continuously interacting and guiding the 12 selected Mathematics teachers of secondary level, through offline training sessions and online interaction.

PHASE- V: For evaluating the effectiveness of the programme, a feedback form developed by the researcher was provided to each selected teacher and the quantitative data collected were analyzed in terms of percentage and qualitative data collected were analyzed descriptively.

5.1 EMERGING FINDINGS:

The analysis of the data is in progress. The following are some of the emerging findings of the study.

1) The study revealed that most of the teachers have difficulty in conceptual understanding and explanation of the topics: NUMBER SYSTEMS & TRIANGLES of Class 9 and REAL NUMBERS &TRIANGLES of Class 10 of the NCERT syllabus.
2) It was found 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.
3) The study revealed that mathematics teachers' professional development needs include innovative methods of motivating students to learn mathematics; updating knowledge of applications of mathematics; preparing instructional and learning activities and evaluating students' progress.
4) ICT integration in teaching mathematics was found as a need for professional development for mathematics teachers.
5) Majority of the teachers opined that the programme developed by the researcher was found interesting and insightful for the teachers.
6) Majority of the teachers opined that the Self-learning Modules integrated with Technology helped them to enhance their pedagogical competencies.
7) 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.
8) The majority of the students have opined that the experiential learning and Art integration in teaching mathematics were interesting and enhancing the concept clarity.

9) 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.
10) The study revealed that the program developed by the researcher was found effective as perceived by the teachers in terms of content clarity, self-directed learning, relevant activities and NEP-2020 aspects incorporation, user friendliness and adaptability.

5.2 CONCLUSION:

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 mathematics education at the secondary level, continuous professional enrichment opportunities for the teachers are to be created.

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