Mathematics Education in India through Policy Documents

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Abstract

The Government of India approved the National Education Policy 2020 in July 2020, which envisions many systemic changes in school and higher level education. Mathematics education is considered one of the significant components of school education as a compulsory subject up to Class X after the Kothari Commission, which continued to be the most difficult one. In this paper, we observed developments in mathematics education in India in accordance with the policy documents from the Kothari commission up to the NEP 2020. A critical analysis of the policy documents was done to portray the significant challenges of Mathematics education in Indian schools, which still prevail. We expect that this paper will contribute to the on-going discussions about the National Curriculum Framework while offering valuable inputs for the development of mathematics textbooks.

Introduction

The Government of India released a 60 page National Education Policy (NEP) 2020 on 29th July 2020. New Educational Policy (NEP 2020) as a document has invited many debates, arguments, and discussions among the populace. Here is an attempt to analyse Mathematics education in India after independence that is reflected in various policy documents and curriculum frameworks made by the Indian Government from time to time in light of the National Education Policy (NEP) 2020.

One should understand the fact that the education policy systems are incredibly complex. A policy document is a vision and path for the future. However, it will turn out as expected only if all the supporting systems work well. A change in one

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policy can have unexpected effects elsewhere in the system. Some unintended effects may take years to emerge.

For example, curriculum reform that aims to match international standards will require other policies, such as teacher education and professional development, to succeed. Understanding interactions and interdependencies in education policy are challenging, particularly within short political timescales.

Brief History

Before colonisation, our education was majority ruled by a caste system which did not allow lower-class people to learn *Vedas*, which is of prime importance. Lower-caste people have to stick to the learning of vocations allotted to them by the caste system. There were indeed, many contributions to the knowledge domain by ancient India, which included vast areas like Mathematics and Astronomy, Medicine, Language (grammar), and Technology. Also, the people who contributed to these areas faced different societal issues. For example, those who practised *Ayurveda* were considered untouchable. The first change came during the period of Buddhism. However, after the decline of Buddhism in India, caste politics came into power, which also had long-lasting implications in education. The second incident that tried to make education reforms in India was Christian missionary attempts. Even though they had a vested interest in providing education to all, irrespective of caste and creed, its after-effects were enormous.

One major aim of education in British India was to develop clerks to run the government. So the Indian knowledge system has very little space in the curriculum. Another reason is the reluctance of Westerners to accept the contributions of Eastern civilisations. When India got independence our education system was primarily inherited from Britain. However, most Indians were not getting the privilege of being educated which is evident from the data provided stating that Indians woke up to freedom with a 14 per cent literacy rate. So the national leadership in India gave prime importance to reforms in education. (Arora and Sinha, 1992)

Various committees and commissions were formed, and their suggestions were discussed in detail. The first major commission in this regard was the University Education Commission of 1948, under the chairmanship of Dr. S. Radhakrishnan, which aimed to report on the status of Indian university education and suggest improvements. The Secondary Education Commission was set up under Dr A. Lakshmanaswami Mudaliar in 1952 and submitted their reports in 1953, which included suggestions for establishing multi-purpose high schools and setting up technical schools.

At the end of the 1950s, educationists and stakeholders agreed that all was not well with school (mathematics instruction). They required the explicit listing of objectives of mathematics education. There were two other problems brought to notice. The first was that school dropouts were mathematically illiterate. The higher education sector and the job market raised the second problem by complaining that the mathematics aptitude intake was not satisfactory. These concerns give more emphasis to teacher education.

National Council of Educational Research and Training (NCERT) was formed in 1961 by merging seven existing national government institutions, namely the Central Institute of Education, the Central Bureau of Textbook Research, the Central Bureau of Educational and Vocational Guidance, the Directorate of Extension Programmes for Secondary Education, the National Institute of Basic Education, the National Fundamental Education Centre, and the National Institute of Audio-Visual Education. Thus, NCERT was established with the agenda to design and support a national education system that enables and encourages diverse cultures across the country.

Kothari Commission

In 1964–66, Kothari commission was set under the chairmanship of Dr Daulat Singh Kothari. Kothari commission very clearly expressed its vision in the opening paragraph "the destiny of India is now being shaped in her classrooms. In a world based on science and technology, education determines people's prosperity, welfare and security. The quality and number of persons coming out of our schools and colleges will depend on our success in the great enterprise of national reconstruction whose principal objective is to raise the standard of living of our people". This commission evaluated the school education system at the micro and macro levels. The Commission proposed the idea of universalisation of primary education and the 10+2+3 pattern. The committee suggested that Science and Mathematics must be integral to school education in the first ten years of schooling (Arora and Sinha, 1992).

Two main things related to mathematics education in the Kothari commission and 17-point National Policy resolutions; firstly, the nation understood the importance of Mathematics education at the school level and mathematics became a compulsory subject up to the school level. The second one was more gender-related. As we observed earlier, Mathematics was not a compulsory subject in school (Arora and Sinha, 1992). Children who feel mathematics is difficult to start taking different other easy-to-learn subjects. In mathematics education, there is a common myth that mathematics is not the cup of tea for girls. So girls were permitted to choose the so called

'lighter subjects' like household arithmetic and domestic science in place of serious mathematics. One should also look into the following data that when the literacy rate in India in 1951 was 18.3 per cent, the female literacy rate during that period was 8.9 per cent to understand the role of gender in education (Arora and Sinha, 1992).

The commission should have addressed the issues and concerns of mathematics education at that time more profoundly. Herman Rosenberg explained some of the issues that mathematics education in US schools faces which are relevant to the Indian context also (Rosenberg H, 1962). The first one was due to the concerns of the public. The Kothari commission recommended mathematics as a compulsory subject in school education (Kothari Comission, 1970). But this created another problem in the school curriculum. The curriculum and syllabus should be designed in such a way that it should have a balance between mathematics and non-mathematics subjects. The commission document should have clearly stated which areas of mathematics, whether in pure or applied form, should receive emphasis in school classes. Later this was addressed by NCERT at the time of syllabus and textbook formation.

Another primary concern raised by Herman Rosenberg was diversity VS unity. People who supported diversity in mathematics curriculum demanded diversity in the content, arguing that it will help students and teachers to pick up mathematics insights via alternative structures of the same content. However, the opposite argument was to bring the maximum amount of agreement on the nature and content of mathematics (Rosenberg H, 1962).

The Kothari commission and 17-Point National Policy Resolutions should have been more vocal on these concerns and pedagogy-related issues. Many mathematics educators consider mathematics teaching to be done logically, as logical thinking is the subject's heart. Nevertheless, psychologists concerned about children's mental processes feared that so much formalism might repel students from Mathematics.

The 1950s are marked in the history of mathematics education as the beginning of a movement called New Math which started in the US and spread through many parts of the world (Hayden, 1981). The Kothari commission and 17-Point National Policy Resolutions gave scope for this movement. Even though the commission did not mention this movement in detail, mathematics textbooks tried to incorporate some of these approaches. Our classrooms of 1960–80, did not use the discovery method as a learning strategy envisioned by New Math. After a period, New Math was criticised in the USA, and another movement called 'Back to Basics' started in mathematics education which was not reflected in the documents.

The Debate about Mathematics Education

Mathematics education—its objectives, learning strategies and assessment techniques were critically analysed, and new models were also suggested as part of worldwide debates. The continuous erosion of mathematics abilities has become a concern of educationists worldwide. Studies worldwide showed similar trends in mathematics education, and India was also not different. It was observed that our children know things but they need help in understanding the concepts as an after-effect of rote learning in place of assimilating the concepts. (Ramanujam and Subramaniam, 2012). The NCERT developed a document named, *The Curriculum for the 10 Year School: An Approach Paper* in 1975 through seminars and workshops throughout the country and in a continuation of this document, mathematics for various levels was defined (Morris, 1980).

Teacher education and mathematics education have significant changes after these documents. Textbooks were revised, and teachers were given training on content and pedagogy. However, the issues were not resolved entirely. Mathematics textbooks and teachers focused on fixed procedures, with less emphasis on real-world problems in classrooms. Many times, mathematics was separated from other subjects and a vicious circle formed in teaching-learning of mathematics. Arora and Shirali (Arora and Shirali, 1981) have observed that the root cause of the problem lies in teacher education. Upon completion of their pre-service training, teachers require greater motivation and a deeper understanding of the underlying philosophy behind the syllabus, rather than simply completing it without conviction. In the absence of well-informed and engaged teachers, there is a risk of perpetuating a cycle in which students are similarly disinterested and lacking in knowledge, thereby hindering the learning process.

As many students drop education due to financial problems, the dropout rate in the 1980s was more than 60 per cent as per the document by NCERT *Curriculum for the Ten Year School: An Approach Paper* (NCERT, 1975). The students, who become dropouts, go to work. Nevertheless, they needed to become more skilled workers, which affected the quality of the work. It was observed in (Arora and Sinha, 1992) that the students who went to school did not work, and those who went to work did not go to school. This emphasised vocational education from an earlier stage. Even though these issues were anticipated and suggestions were given in the National Policy Resolution in 1968, they still needed to be implemented with the true spirit for various reasons.

National Policy of Education 1986

The National Policy of Education in 1986 (NPE 1986) suggested that mathematics should be visualised as a vehicle to train a child to think, reason, analyse and articulate logically. Mathematics should be considered concomitant to any subject involving analysis and reasoning, as it is one of the essential tools in understanding the cause effect relationship and interplay between the variables. India has a rich heritage of ethno-mathematics, including calculations by carpenters and astrologers, geometrical drawings by artists, pattern formations by women in the form of rangoli and kolam, etc. It was suggested that the curriculum should be standardised. However, it should provide space for language, culture and economic diversity and need to be redesigned to bring it with modern technological devices.

One of the significant suggestions in the NPE 1986 was about emphasising the Minimum Levels of Learning (MLL) for each stage of education as a prerequisite for setting performance goals for the teachers for which a committee was constituted under the chairmanship of Prof. R. H. Dave (Dave, 1991). This committee draws up MLL for each level of learning, which can be considered the preliminary form of Learning Outcomes (LOs). As considered by the committee, some basic features of the MLL are achievability, communicability, evaluability and learning continuum. According to MLL for primary children who complete their lower primary classes should develop numeracy skills and be able to do calculations with speed, accuracy and ease. They should be able to think logically and should be able to identify the pattern. MLL suggests that teachers use concrete objects and mathematical equipment for mathematics education. In upper primary mathematics, curriculum should be functional with the child's day-to-day life. As the child progresses from upper primary to secondary class, there should be a smooth transition from functional mathematics to matured mathematics. Arithmetic should be viewed through the eyes of algebra. Students should be able to appreciate the beauty of mathematics. It was also suggested that computers can be taught at this stage, not as a subject but as a tool to help teaching-learning (Gabriele et al., 2002).

National Curriculum Frameworks

NCERT came out with the National Curriculum Frameworks (NCFs) in 1975, 1988, 2000 and 2005. Between the NCF 1988 and 2000 Yash Pal committee was constituted in 1993 to advise on how and means to reduce the load on school students at all levels, particularly the young students, while improving the quality of learning, including the capability for life-long self learning and skill formulation. This committee analysed the root

causes and provided suggestions that they are still relevant regarding mathematics education. Yash Pal Committee recommended that "Mathematics curriculum for primary classes in all parts of the country be reviewed with a view to slowing down the pace at which children are required to learn basic mathematical concepts, and broadening the scope of primary mathematics to include areas other than number work (For example, space and shape-related concepts and problem-solving). The tendency embedded in the syllabi and textbooks of primary mathematics to accelerate children's mathematical skills by teaching them mechanical rules at the expense of understanding and intelligent application ought to be discouraged in future syllabi and texts" (Yash Pal Commitee, 1993). This document starts looking at mathematics textbooks and mathematics in a broader sense.

The following central document was the NCF 2005 and its position paper in mathematics education, which emphasised the main aim of mathematics teaching as the mathematisation of a child's thought process. The NCF 2005 emphasised constructivism and textbook revision. As per the position paper in the NCF 2005, school mathematics takes place in a situation where: (i) Children learn to enjoy mathematics, (ii) Children learn essential mathematics, (iii) Mathematics is a part of children's life experiences which they talk about, (iv) Children pose and solve meaningful problems, (v) Children use abstractions to perceive relationships and structure, (vi) Children understand the basic structure of mathematics and (vii) Teachers expect to engage every child in class (NCF Position Paper 2005).

The NCF also analysed the problems in mathematics education in schools. The document identified core areas of concern, such as a sense of fear among children, the curriculum's non-participatory nature, the crude assessment method and the lack of teacher preparation. Structures of social discrimination reflected in mathematics education aggravated the situation, especially the gender dimension, leading to a stereotype that boys are better at mathematics than girls. However, this observation shows that the issue of gender bias and myth was not resolved entirely.

Based on these analyses, the NCF recommended shifting the focus to higher goals, engaging students by offering conceptual challenges, focusing on mathematisation in assessment and enriching teachers with various resources.

In *Mathematics education in India—An overview*, Ramanujam gives an overview of the challenges and issues which are continuing in mathematics education in India (Ramanujam and Subramaniam, 2012). It is observed that even though the Kothari commission indirectly addressed the myth that girls are not suitable for learning mathematics, the same preconceptions persist in rural areas. Another issue pointed

out is that since board exam patterns have not changed much, the textbook and pedagogy of mathematics in secondary and senior secondary classes do not show a positive change compared with the elementary classes. Along with this, the entrance coaching culture also took a toll on meaningful mathematics. The authors noted a similar observation based on the feedback received during the various content-cum-pedagogy training program for the mathematics teachers conducted at Regional Institute of Education, Mysuru. It was found that the participants were most engaged in problem-solving sessions that focused on board exam and competitive exam questions. In such sessions, the teachers are interested in the preparation, analysis and solving through shortcut methods that essentially use routine procedures rather than non-routine or concept-based problems.

R Ramanujam and K Subramaniam say that the significant challenge in school mathematics education is "creating a pool of good mathematics teachers in the required numbers". He also observed that the educational reforms like *Learning without Burden,* NCF 2005, etc., has seen a churning across the country within the school mathematics in terms of attitude and approaches. However, he says that even though the trend is positive, it is too early to tell whether these efforts will lead to radical shifts (Ramanujam and Subramaniam, 2012).

During the 1960s and 1970s onwards, social science methods became common to examine the effect of various factors on educational development, accompanied by a debate on the relative merits of quantitative versus qualitative studies (Gabriele et al., 2002). In different global scenarios, all the countries, whether they participated or not, started looking at and analysing the results of international tests like the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS).

NCERT also conducts a nationwide survey called the National Achievement Survey (NAS), initially planned and designed to be an independent project. The Baseline Achievement Survey (BAS) was carried out during 2001–2004 followed by the Mid-term Achievement Survey (MAS), carried out during 2005–2008. Over the last decade of SSA implementation, the focus shifted from dealing with challenges around access to improving the quality of learning. Hence, NAS emerged as a tool to provide periodic feedback to the system on the health of education in the country, which became a regular and ongoing cycle in the Indian education system.

After 12 years of the NCF, a report of NAS 2017 (NAS-2017) point out that children who study mathematics are facing difficulties in the following areas:

- Measuring length in standard units and comparing. Estimating

the volume of a solid body. Finding surface area and volume of cuboidal and cylindrical objects. Finding out the approximate area of closed shapes by using units-square grid or graph sheets.

- Extending patterns in shapes and numbers.
- Solving problems related to converting percentages to fractions, decimals, and vice versa.
- Generalising properties of addition and subtraction, multiplication and division of rational numbers through patterns. Using the exponential form of numbers to simplify problems involving multiplication and division of large numbers.
- Applying operations of numbers in daily life situations.
- Arranging given or collected information in the form of table, pictograph and bar graph and interpreting them.

The articles by Ramanujam and Subramaniam (2012) and report of NAS 2017 give a rough status of Mathematics education in India highlighting a positive trend in lower primary classes. According to them, there have been notable changes in textbooks and pedagogical approaches used in lower primary classes. However, the pressure exerted by the society on students who are preparing for board exams can have a detrimental effect on their ability to develop mathematical mind-set and thought process.

Even after no retention policy and the Right to Education act, the dropout rate was reduced to 17 per cent in secondary classes (1.8 per cent in upper primary and 1.5 per cent in lower primary classes) (Gohain, 2021). Some studies show that more than 60 per cent of students want to drop their schooling after the pandemic and lockdown. Even though the number may not be accurate, in tribal areas, the number is high. The quality of online classes and the digital divide increase these issues. Other than this, the universal issues of mathematics education, 'Why are the literates from the school so mathematically illiterate?' which is raised in (Arora and Shirali, 1981), still exists.

NEP 2020

The Government of India has published the National Education Policy, 2020, in short the NEP 2020. At a glance, the NEP 2020 gives more emphasis on structural reforms than the pedagogical paradigm shift. In the case of mathematics education, the NEP 2020 does not put forward a motto like the NCF 2005's *Mathematisation of Thought Processes*. The pedagogical philosophy is almost the same as that of the NCF 2005, which are constructivist and child centred. The following are the significant suggestions in the NEP 2020 related to mathematics education (GoI, 2020).

1. It is recognised that mathematics and mathematical thinking

will be essential for India's future and leadership role in the numerous upcoming fields and professions that will involve artificial intelligence, machine learning, and data science. Thus, mathematics and computational thinking will be given increased emphasis throughout the school years, starting with the foundational stage, through various innovative methods, including regular puzzles and games that make mathematical thinking more enjoyable and engaging. Activities involving coding will be introduced in the Middle Stage.

2. 'Knowledge of India', its contributions to modern India and its successes and challenges, and a clear sense of India's future aspirations concerning education, health, environment, etc. These elements will be incorporated accurately and scientifically throughout the school curriculum wherever relevant; in particular, Indian Knowledge Systems, including tribal knowledge and indigenous and traditional ways of learning, will be covered and included in mathematics, astronomy, philosophy, yoga, architecture, medicine, agriculture, engineering, linguistics, literature, sports, games, as well as in governance, polity, conservation.
3. All subjects and corresponding assessments, beginning with mathematics, could be offered at two levels, with students doing some of their subjects at the standard level and some at a higher level. Board exams in certain subjects could be redesigned to have two parts—one of an objective type with multiple-choice questions and the other of a descriptive type.

The NEP 2020 does not suggest drastic changes and does not critically analyse the textbooks or teaching-learning methods adopted after the NCF 2005. Policy needs to mention the present status of mathematics education in India, referring to the National Achievement Survey. Nevertheless, at the same time, it states that in the foundational stage, puzzles and games have to be used as a learning strategy. Present NCERT textbooks in lower classes use puzzles and games as a learning strategy.

The curriculum framework on the other hand, will serve as a guide or roadmap that outlines the steps needed to achieve the goals outlined in the policy document. As such, it will need to provide more detailed information on the issues and concerns identified in the policy document.

The NEP put forward some suggestions as mathematics education should equip the learner to handle 21st century skills rather than specifically. The 21st century skills differ from the skills in the previous century due to the prominent use

of technology. In the blog of Applied Educational Systems, Bri Stauffer lists 12 skills including critical thinking, creativity, collaboration and communication, as essential skills imparted through Mathematics learning (Maya, 2012). One can agree with the fact that the general thinking skills can be taught and learned, their effectiveness is strongly influenced by the specific domain knowledge in which they are applied and they are most effectively learned when integrated within a particular domain rather than presented in isolation. This approach is consistent with the constructivist ideas of Jean Piaget, which suggests that the students learn more effectively when given opportunities to explore and experiment with concepts in a particular domain rather than simply being instructed in general principles and asked to apply them. So while considering twenty-first century skills in Mathematics education, the emphasis should be on children's analytical thinking and problem-solving skills and better communication in mathematics classrooms. These skills were the essence of the mathematisation of the thought process as envisioned in the position paper 2006 (NCF; Position Paper, 2005).

The part of the NEP 2020 mentioning the Indian knowledge system should be read in the context of the 42nd amendment to the Indian Constitution in 1976, which included 'development of scientific temper, humanism and the spirit of inquiry and reform' in the list of Fundamental duties of every Indian citizen. Abhishek Saxena points out that a nation where people (rulers and subjects alike) believe in miracles and supernatural beings and powers will neither understand and appreciate the developments of the modern philosophy of science, nor will it be able to progress based upon the innovations of modern science (Saxena, 2014). Pandit Jawaharlal Nehru, nation's first prime minister said that "no country or people who are slaves to dogma and dogmatic mentality can progress." Many people, including educationists, believe that scientific temper can be developed by teaching Science in the classroom. But according to Sharma et al. (2019), scientific temper will not be obtained only by teaching science, and this raises the question: Is the Indian social milieu scientific or non-scientific in nature? They claim that one can observe that scientific temper is not so common in the Indian context even though one can observe sparks of scientific temper in abundance, hence argue that the concept of developing scientific temper only from schooling is unscientific. They even suggest the idea of 'school the society' to develop scientific temper in society. Hence, to incorporate the Indian knowledge system as per the document in the classroom in a scientific manner, textbooks and other materials must be prepared with utmost care.

Another significant suggestion in the NEP 2020 is about a structural change that offers two Mathematics parts. This will help design Mathematics which is easy to go and deals with more narrow goals like numerical skills for the students who do not prefer Mathematics for higher studies. However, this also brings some concerns about the future of Mathematics education. We have to design the curriculum to keep it from a period before the 1960s. As per the data provided by the Centre Board of Secondary Education (CBSE), there is a rush to choose Mathematics as a subject. There were more than 6 lakh enrolments for Mathematics in 2018 (Kancharla, 2020) but the deciding factor in choosing Mathematics may be societal pressure and its demand in competitive examinations.

Conclusion

Tracing the suggestions reflected in policy documents is easily related to Mathematics education, but not so easy with its implementation and improvement. Periodic reporting has to be followed, focusing on different documents' content, methods, assessment, and enrichment. Reflecting the essence of improvements in the field through strengthened implementers like teachers, parents, and learners is still crucial. There is a need to develop dialogues with clarity of epistemological underpinnings in teaching. Engaging applied reasoning with a strong backbone of numeracy and functional literacy needs to be expected as a future possibility. Reasons for engaging in Mathematics teaching and learning should get highlighted and valid meanings and forms of Mathematics education need to evolve. Negotiation on the various socio-economic-political-cultural meanings of Mathematics should be encouraged. As we reach Government of India, Ministry of Human Resource Development, Department of Education, New Delhi, 1993, a structural modification juncture; content, methods and support system for Mathematics education at various levels need to be seriously addressed, thus, embracing the varied needs of the learners and society.

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