Vision of Science Education in National Education Policy-2020

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Abstract

Science and technology have profound impact on our lives. The advancements in the various fields of science such as telecommunication, medicine, agriculture and energy on one hand have made our lives easy but at the same time have resulted in environmental degradation and other concerns related to health and mental well-being. Our education system has a crucial role to play in understanding and addressing these concerns right from the beginning of school education. It is well understood and emphasised in several policy documents that all citizens should develop a scientific temperament, possess basic process skills and knowledge of scientific concepts in order to make informed and meaningful choices in the situations concerning science, technology and society. This ability is also called scientific literacy. National Education Policy (NEP) 2020 has envisaged bringing major educational reforms to achieve the Sustainable Development Goals (SDGs) of Agenda 2030. This paper discusses the vision of NEP 2020 with respect to science education in schools and how our education system can possibly contribute towards making scientifically literate citizens and achieving the SDGs of Agenda 2030.

Key Words: National Educational Policy, Science Education, Scientific Literacy, Scientific Temper, Experiential Learning

Introduction

On May 16, 2020 a channel, TV9 aired a story about dangerous and infected tomatoes. The news video titled Mystery Virus in Tomatoes was widely circulated through various social media groups. It was claimed that a new version of coronavirus will be transmitted to humans if they consume infected tomatoes. Covid 19 is transmitted through person to person. When an infected person coughs, sneezes, talks or breathes within six feet or shakes hands with any other person then the infection (virus) is transmitted to another person. Then at that time (April-May 2020) it was also understood that Covid 19 is also transmitted by touching contaminated surfaces (like lift buttons or tables). This news suddenly added another angle in people's thought that Covid 19 can be transmitted by eating tomatoes. It had an impact on the market (for a few days till the time it was countered) and people stopped buying tomatoes. A lot of people believed random news without questioning any data or verifying findings. It is not only a single instance, there are many instances when people circulate fake news and morphed videos. Most of the people in this chain of forwarded messages believed those to be true. Dr Tedros Adhanom Ghebreyesus, Director General, WHO, said on February 15 2020, that "fake news travels faster and more easily than this virus and is just dangerous;

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…. we are fighting an *infodemic*". According to Merriam-Webster dictionary "*Infodemic* is a blend of 'information' and 'epidemic' that typically refers to a rapid and far-reaching spread of both accurate and inaccurate information about something, such as a disease. As facts, rumours, and fears mix and disperse, it becomes difficult to learn essential information about an issue." In this world of information explosion, why are we unable to differentiate between accurate and inaccurate information? Why is it that we circulate or forward information without verifying its authenticity? It seems the spirit of scientific temper is not developed through our educational processes.

Pt. Jawaharlal Nehru in his book *The Discovery of India* said that, "scientific temper is the refusal to accept anything without testing and trial, the capacity to change previous conclusions in the face of new evidence, the reliance on observed fact and not on preconceived theory". Constitution of India under Article 51A (h) states, "It shall be the duty of every citizen of India to develop the scientific temper, humanism and the spirit of inquiry and reform. It shall be the duty of every citizen of India to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem."

The Curriculum for the Ten-year School — A Framework (1975) focused that the science curriculum at the upper primary level should be integrated and "should provide enough opportunities to learners to attain some basic levels of scientific literacy". Thus, science along with skills of scientific temper should also focus on developing scientific literacy.

In India science is a compulsory subject till Class X. One of the aims of Science Education at school level is to "acquire the skills and understand the methods and processes that lead to generation and validation of scientific knowledge" (*Position Paper on Teaching of Science*, NCERT, 2006). It implies that curriculum, classroom transaction, and learning spaces within the school setting should focus on creating opportunities for learners to innovate and verify the given facts and theories and be scientifically literate. Who is a scientifically literate person? What is the vision of National Educational Policy 2020 on Science Education? How can these issues be addressed?

Scientific Literacy and its Importance

The term 'scientific literacy' was coined in the late 1950's and since then, various conceptual definitions, purposes and ways of assessment have been suggested by science educators, researchers and policy makers. In the most common sense, a scientifically literate person possesses the basic knowledge of scientific concepts, has necessary skills and scientific attitude to use science and technology in an informed and meaningful manner. The Organization for Economic Co-operation and Development (OECD) conducts an international assessment for Mathematics, Science and reading for different countries worldwide. This test is known as Programme for International Student Assessment (PISA). It assesses students across nations on aspects beyond academic achievements. PISA (2015) defined scientific literacy as "the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. A scientifically literate person, therefore, is willing to engage in reasoned discourse about science and technology which requires the competencies to: (1) Explain phenomena scientifically: recognize, offer and evaluate explanations for a range of natural and technological phenomena. (2) Evaluate and design scientific enquiry: describe and appraise scientific investigations and propose ways of addressing questions scientifically. (3) Interpret data and evidence scientifically: analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions."

PISA believes that every individual should be able to think scientifically about the evidence they encounter in their real-life challenges. Students are required to use the knowledge that would be gained from the

science curriculum and apply it in novel and real-life situations.

Scientific literacy has been advocated as one of the most significant goals of science education across the world. National science education standard overview (NRC, 1996) states several reasons for promoting scientific literacy for all Americans:

- We need scientific information to make choices in our daily lives.
- Important issues that involve science and technology require informed public debate.
- The collective decisions of an informed citizenry will determine how we manage vital natural resources, such as, air, water, and forests.
- There is personal fulfilment in understanding how the natural world works.
- Science contributes to vital workplace skills of decision-making, creative thinking, and problem solving.
- To compete on a global scale in the world market, we need a capable citizenry.

In Indian context, the need to promote scientific literacy has been explicitly stated by various policy documents. National Curriculum for School Education 2000 talked about teaching of 'science and technology' in place of 'science' at upper primary and secondary stages so as to familiarise learners with various dimensions of science and technological literacy. NCF 2005 further emphasised the distinction between science and technology and how technology and science are related to each other. It mentions that our progress is linked with advances in science and technology. It clearly stated scientific literacy as one of the guiding factors of teaching science at the upper primary and secondary stages.

Further NEP 2020 states that "the purpose of the education system is to develop good human beings capable of rational thought and action, possessing compassion and empathy, courage and resilience, scientific temper and creative imagination, with sound ethical moorings and values." It emphasises that there should not be any hard separation between arts and science; curricular and extra-curricular; and academic and vocational spheres. The constitutional values like empathy, respect for others, cleanliness, courtesy, democratic spirit, spirit of service, respect for public property, scientific temper, liberty, responsibility, pluralism, equality, and justice should be of great importance and individuals must think critically and logically to bring and achieve sustainable development. The policy also aspires to focus on developmental goals of the 21st century including Sustainable Development Goals of Agenda 2030. While SDG 4, that is, access to inclusive and equitable quality education is the prime focus of NEP 2020, the other SDGs such as, SDG 3 — good health and well-being; SDG 6 — clean water and sanitation; SDG7 — affordable and clean energy; SDG 13 — climate action directly relates to scientific literacy and have been emphasised in the policy at several places. The policy acknowledges that with the growing advancements in science and technology there may be high demand for skilled workforce trained in multidisciplinary fields of science, social science, humanities along with specific abilities to deal with machines, data science and artificial intelligence. It also mentions that the entire education system may have to be re-configured to support and foster learning so that all the targets and goals (SDGs) of Agenda 2030 can be achieved.

With so much of focus on integration of science and technology with societal need and sustainable developmental goals for future, it becomes imperative that science classrooms in our country are ready to embrace these changes. While the changes would affect all levels of education including higher education, the changes in school education are of prime importance as all citizens need to develop the fundamental understanding of their role in society and should be able to contribute meaningfully and productively towards a sustainable

environment for the future generations. In fact, NEP 2020 has specifically highlighted that we need to understand and address the issues concerning climate change, pollution, depleting natural resources and outbreak of epidemics and pandemics with collaborative research in social and scientific spheres.

Despite understanding the importance of scientific literacy and its mention in various policies, the situation at the ground is not very encouraging. As per the assessment conducted by PISA-2009, India has not done very well in this regard. PISA aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students who have completed the end of their compulsory education. It is designed to assess how well they can apply what they learn in school to real-life situations. Over 90 countries have participated in the assessment so far, which has taken place at three-year intervals since 2000. India participated in the PISA test in 2009. In this test of PISA, students from Himachal Pradesh and Tamil Nadu sat for the test, and India ranked 72 out of 73 countries. This kind of scenario surely asks for a reflection and action so that scientific literacy does not remain a distant dream. The PISA test is unlike any school examination which is mainly focussed on content learnt in classroom through specified textbooks; rather it focuses on the application of skills and knowledge in real life situations. It intends to assess students' overall ability to solve problems, take action and preparedness for the future. This goes beyond their academic achievements. In the context of scientific education, a test like PISA is clearly related to assessment of scientific literacy. Scientific literacy is basically related to persons' ability to use their knowledge and skills in solving real life problems and take informed decisions about various socio-scientific issues like global warming, health, environment, etc., which are also the themes under SDGs. The poor score of Indian students in PISA is a reflection of lack of scientific literacy among them and suggests that our science curriculum, pedagogy and assessment need to be oriented towards building scientific literacy. Certain aspects of NEP 2020 resonate well with the idea of extending scientific knowledge for addressing issues related to health, environment and disaster management. Also, the policy has indicated the use of indigenous knowledge as well as technology integration in science teaching which seems to be a positive step towards adopting a more flexible and context driven system.

Below is an attempt to capture the essence of NEP 2020 with regard to science education in India.

NEP 2020 and Science Education

Experiential learning

National Education Policy (NEP 2020) advocates experiential learning. It is learning through reflection and doing. The idea of experiential learning in the modern context was given by Kolbe (1970), which was influenced by the works of John Dewey and Jean Piaget.

Let's take classroom examples in which learners are expected to identify good conductors in their homes.

Case 1: Learners follow the instructions of the teacher and set up a circuit. They test the given objects and classify those into conductors and insulators. They record their findings in their notebook.

Case 2: Learners set up the circuit using their previous knowledge of flow of electric current and electrical circuits. Then, they make a list of things they would like to test. They predict the nature of each object before passing electric current through them. After that they conduct the experiment and see whether their predictions were right or wrong. Then they reflect on findings like why is tap water a good conductor of electricity and bottled water is not?

In the first case learners are doing experiments and learning science process skills – —observation, classification and recording. While in case 2, learning goes beyond the 'hands=on experience'. Here

learners are thinking and reflecting on the findings, questioning results. In the words of Martin (2003) it is also called a 'hands-on minds-on' approach. NEP has emphasised the need of reducing the curriculum load so that focus in the classroom can be shifted from dissemination of information to conducting inquiries, discussion, discoveries in the classroom; thus, promoting experiential learning and thereby making spaces for critical thinking and rational thought and developing skills like problem solving, computational thinking, scientific temper and hence, scientific literacy. Experiential learning is not essentially doing the experiments but using learners' experiences to not only verify the existing fund of scientific knowledge but also to question it if needed. The specific experiences of learners coming from diverse backgrounds should find a place in the classroom and they should be used to enrich the textbook knowledge. For instance the experiences emerging from agriculture sector in different landscapes should integrate with the textbook chapters on plants in both science and social science books thus helping the learners to not only learn what about basic concepts of photosynthesis, nutrition and reproduction in plants but also to enable learners to reflect upon and contribute towards issues concerning agricultural practices, environmental concerns, use of pesticides, socio-economic condition of farmers and future course of action.

Flexible and Multidisciplinary Approach in Curriculum

In the current education system subjects are classified in different streams – Sciences, Arts (Humanities) and Commerce. Students who have opted for commerce should study the subjects — Commerce, Business Studies, Accounts and Economics with or without mathematics. Under no circumstances can they opt for biology or political science, as these subjects are different cohorts. NEP (2020) has advocated this kind of flexibility to students that understanding of biology or political science cannot be limited to only one particular group of students. Thus, students can choose subjects as per their interest and also the difficulty levels (core or advanced). In Section 11.3, the policy has advocated for multidisciplinary education, without any hard separation between subjects. Such an approach will change the current nature of undergraduate education programmes in the country. Its implementation would mean that students studying science can opt for history or music or any other subject, depending on their interests and abilities. At the same time, they can even decide the level (core or advanced) and rigour (major/minor) of that subject. In today's rapidly changing world, choices of subjects cannot be restricted. The policy also emphasised on introducing new subjects like Artificial Intelligence, Design Thinking, Organic Living and Environmental Education. All these are offshoots of sciences and linked to various professions. For instance, nowadays everyone is expected to have basic knowledge of science concepts associated with our lives. For example-should genetically modified foods be introduced in the Indian market? Should India promote growing crops like jatropha for fuels? Is organic farming sustainable considering the larger areas of land requirement? Would a plastic ban lead to increased deforestation?

It is only possible when flexibility is given to students in choosing disciplines and also at the same time science education should focus on scientific literacy. With this flexibility available to students, curriculum developers need to design courses as per their requirement. Student who would like to pursue research in science and technology will study a different course when compared to students who would like to make informed decisions about science and technology in their everyday lives. The implementation of such decisions will not be easy, especially in our country where every student is used to study the same course. The implementation will focus on providing a basket of courses as the need, ability and interest of learners.

Blend of Traditional and Modern Knowledge

Have you heard of the name of Mokshagundam Visvesvaraya (also known as Sir MV) or Dr Muthulaksmi Reddy? Sir M Visvesvaraya (1860- 1962) was a civil engineer and designed the water supply and drainage system of several cities in India. He designed and patented automatic water flood gates for reservoirs. It was first installed at Khadakvasla, Pune. Dr Muthulaxmi Reddy (1886-1968) was the first woman student in the medical college. She was the first woman surgeon appointed in Government Maternity and Ophthalmic Hospital Madras. In the history of India there are numerous Indian scientists (some of them are —Ancient India: Bhaskaracharya, Shustra, Kanak, Aryabhata; Modern India: Jagdish Chandra Bose, Satyendra Nath Bose, Meghnad Saha, C.V. Raman, Har Govind Khurana, Vikram Sarabhai, Homi Bhabha, Salim Ali) whose contributions, if incorporated in curriculum and textbooks will develop a sense of pride among learners. Such "knowledge of India' as emphasised in NEP, 2020 will develop a sense of appreciation for the country among learners.

In another example from history of science, some tribes in India (Bengal) were practicing 'inoculation' to prevent smallpox in the tenth century (Fenner etal., 1980). It was much before Jenner discovered vaccination (1896) for it. These tribes used to collect pus from individuals suffering from smallpox, keep it for a year and then inject it into healthy people. They had noticed that people thus inoculated got a mild fever but never suffered from smallpox. Through their experience and observation, they had discovered the process of inoculation. Reading and understanding such tribal knowledge would promote indigenous and traditional ways of learning. The policy has also suggested a separate course on Indian Knowledge system and inter-state cultural exchange programme at the secondary school level. These curriculum and methodologies would develop a sense of tolerance, diversity and pluralism among learners.

Focus on Health and Hygiene

The Sustainable Development Goal 3 (SDG3) focuses on good health and well-being of individuals and SDG 6 emphasises clean water and sanitation. These goals will be achieved if we focus on developing concepts of health, mental health, good nutrition, personal and public hygiene, and sanitation that are linked to the practical situations in life. We need to understand which water is fit for drinking? What are the standards of drinking water? Industrial effluent pollutes water. If this kind of polluted water is used for growing vegetables, then it is like a slow poison for the health of individuals. All these are complex questions which require a clear understanding of scientific concepts and informed decision making. It is only possible when the science curriculum focuses on real life issues and makes students understand linear cause-effect relationship does not exist. All concerns (whatever they may be — use of plastic in our lives, loss of biological diversity, rising air pollution levels in cities, climate change, natural disasters etc) have multiple perspectives. Only science and technology can offer solutions to the problems the world is facing today. It is of utmost importance that science education develops open mindedness, inquiring minds and scientific literate learners.

Textbooks with Local flavour and Content

If science textbooks have too much content to be covered in an academic year, then there is a pressure on students and teachers to complete the entire syllabus before the examination. Teachers and learners resort to the lecture method and memorise content in the textbook. This methodology of teaching (classroom interaction) reduces the spaces for experimenting, inquiry and discussion. For developing conceptual clarity

in learners, it is of utmost importance that fewer concepts with greater depth be taken up at each level of schooling. The Yashpal Committee report (1993) emphasised the idea of reducing the academic burden of content load on learners. The report was instrumental in reducing content load but still a lot of rethinking is required on further reducing the too much information given in science textbooks. NEP 2020 advocated reduction in content of textbooks with local contexts. The multidisciplinary and integrated approach may be quite helpful in this direction. For instance, the concepts of science and social science at least till middle school are overlapping and a theme-based approach to concepts may be used instead of subject based approach. A common example is that of 'water cycle'. The concept is taught is science by explaining the processes like evaporation, condensation and precipitation. Through a very simplified process, children are explained that rain occur due to water cycle. The process of evaporation and condensation results in the formation of clouds which when become heavy pour in the form of rain. A lot children ask questions like, why does it rain more in certain month(rainy season); Why certain parts of the country have more rainfall then others?; If evaporation and condensation is happening every day especially in costal areas, why does it not rain everyday. The science teachers often do not deal with questions and tell the children to ask these in their social science(geography) class. Such as fragmented approach not only hinders the acquisition of concepts in holistic manner, it also increases their curriculum load.

The section 4.6 of the policy focussed on pedagogies that "must evolve to make education more experiential, integrated, inquiry-driven, discovery-oriented..." It is only possible when any inquiry is based in the context of the learner. For instance, learners are able to relate to the biodiversity more if they are living in and around forests. Probably they know much more than the content given in the textbook. In such situations, pedagogies should be discovery oriented or project work or case studies. Such kind of local flavour to the content given in textbook will make learning more meaningful to children. The other argument in favour of reducing content load often cited is that it is not possible to teach everything and everything to learners. There is information overload. The need of hour is to reduce the information basedcontent in the textbooks and to focusmore on development of 21st century skills like critical thinking, logical reasoning, decision making among learners.

Transforming Assessment

Teaching, learning and assessment are essential components of education. Any change in one component will influence the other. If information is disseminated through teaching, then learning would be rote memorization and assessment would be done through recall-based questions. In science if we would like to focus on experiential learning then our questions should be assessing skills of critical thinking, logical reasoning and other higher order skills. NEP (2020) advocates the idea of adaptive/ formative system of assessment wherein students will be assessed on various dimensions making the assessment more holistic andalso in a continuous manner.Also, the progress card of the learner should be reported in a manner that it covers all aspects of learning and also makes sense to parents and students. In the words of NEP(2020) it should be "holistic, 360, multi-dimensional report card". The source book on assessment (2008) also focussed on meaningful reporting of progress of learning to different stakeholders. With reference to science, the report card should mention how learners have made progress in different skills – observation, classification, communication, experimentation, prediction and estimation and others.Thus, there is an urgent need to make assessment multi-dimensional by using project work, laboratory work, case studies and field work in addition to classroom based paper-pencil test.

Inclusion in Science Education

One of Focus areas of NEP (2020) has been ensuring inclusion at all levels including gender, persons with physical and learning disabilities and socio-economic disadvantaged groups. The spirit of inclusion has to been embraced by making structural and philosophical reforms in our education systems. The NEP (2020) talks about making various provisions such constituting a gender inclusion fund, identifying special education zones where schemes for SEDGs (socio-economic disadvantaged groups) could be implemented and implementation of recommendations of Right of persons with disabilities(RPWD)2016 act for inclusion and equal participation of children with disabilities in ECCE and school education. NEP(2020) also suggests measures like organizing activities/ workshops in the form of clubs, called 'science circles' for encouraging and motivating students to participate. Such circles may provide supplementary enrichment materials and hands-on activities for engaging learners in science.The other suggestion is to provide free boarding facilities for girls on the line of Jawahar Navodaya Vidyalaya. Moreover, it is also important to sensitise teachers that they do not discriminate between boys and girls in their participation in activities. They need to ensure that girls do take interest in science and motivate them to opt for science courses in school and in higher education.

It is very much needed that the science classrooms embrace and align with this spirit of inclusion. It is commonly witnessed that science education knowing or unknowingly keeps certain social groups at the margin. For examples persons with physical or learning disabilities are usually negligible in science classroom especially at higher education as they not considered fit for research and field work that might be required in science. NEP (2020) has emphasized the importance of using assistive technologies and software, special textbooks and training of teachers to overcome all barriers to inclusion. All India Higher Education Survey (AIHES, 2018-19, pp38) showed that number of females per 100 males are 70 in Bachelor of Computer applications, 79 in Bachelor of Pharmacy, 106 in Bachelor of Sciences, 40 in Bachelor of technology and 54 in Master of technology. The low number of female enrolments in professional science and related courses at higher education is worrisome. PISA report (2015) on learning achievement of 15 years old found that boys and girls perform at similar levels. This result was the same across 40 countries under study. There is a need to challenge the prevalent stereotype that boys perform better in sciences and mathematics.

The question however is the successful implementation of all provisions and most importantly changing the mind of all stake holders including teachers, administrators and society at large.

Conclusion

National Education Policy (NEP-2020) has set very ambitious goals which are not limited to immediate and national concerns but are in alignment with sustainable development agenda of 2030. The policy seems to resolve the social and environmental concerns through educational reforms. It also acknowledges that the relentless advancements in the field of science and technology demand collaborative research and integration of science and social science. NEP (2020) has proposed flexible curriculum to make it possible but the question is whether the infrastructural and human resources would support this change and what shall be done to make it successful. The policy has also highlighted the significance of blending traditional knowledge with modern scientific knowledge. From the point of view of science classrooms, it would mean changes in textbooks and pedagogical approaches which should not become lopsided. It would require focus on an important dimension of scientific literacy called "cultural scientifc literacy" but at the same scientific temperament and

spirit of inquiry should prevail. Inclusion is another significant aspect of NEP 2020 and concrete steps like making institutions in terms of physical infrastructure, curriculum and pedagogies accessible to differently able learners needs to be taken to make it possible especially in the context of science education.

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