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# Reimagining STEM Education in India: A Conceptual Framework Aligned with NEP 2020

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**Abstract**

The existing education system in India, largely influenced by colonial models, continues to emphasize rote learning and examination-oriented practices, thereby limiting the development of creativity, critical thinking, and problem-solving skills among learners. In the context of rapid technological advancement and the growing demands of the Industrial Revolution 4.0, there is an urgent need to transform educational practices to prepare students for 21st-century challenges. This study explores STEM (Science, Technology, Engineering, and Mathematics) education as an integrated and interdisciplinary approach to address these concerns.

Adopting a conceptual and literature-based methodology, the study examines the evolution, definitions, and pedagogical foundations of STEM education, along with its relevance in the Indian educational context. It highlights the role of inquiry-based, problem-based, and experiential learning in fostering higher-order thinking skills, innovation, and collaboration. The study further analyzes existing gaps in implementation, including lack of infrastructure, teacher preparedness, and rigid curriculum structures.

The findings suggest that STEM education, when effectively integrated with problem-based learning and supported by national initiatives such as Atal Tinkering Labs and NEP 2020, can significantly enhance students' competencies and engagement. The study underscores the need for systemic reforms, capacity building, and curriculum restructuring to successfully implement STEM education in India and promote a culture of innovation and self-reliance.

**Keywords:** STEM Education, Indian Education System, Problem-Based Learning, 21st Century Skills, NEP 2020, Experiential Learning, Innovation, Interdisciplinary Learning

## 1. Introduction

The country's conventional education system relies on the foundation laid by the British education system for creating factory workers and office clerks. In order to create order-takers and followers and to consciously shun imaginative and creative thought, the British developed and introduced the said educational model. So instead of creating independent thinkers and innovators, the entire aim of education was to create a workforce to function in the factories.

Unfortunately, despite the country being free for the last 70 years, we are still carrying the old model of education and there have been very insignificant changes in the education processes in this country. There is a clear urgency to rethink and reinvent our education system with the advent of globalization, technological growth and automation, scrapping the many conventional work concepts, and introducing it at the earliest if we want our country to play a significant role in rapidly evolving global realities. As,

despite having the top-quality talent, the exam-focused education model of the past has limited these students when it comes to innovation, problem-solving and creativity. With the whole world almost becoming a connected global village, there is a need for a paradigm shift in education - to prepare students to be global citizens while providing them with the skills and abilities for them to survive and thrive in the new economic and social order. This is where the well-designed STEM (Science, Technology, Engineering, and Mathematics) curriculum should be adopted and implemented as per the needs of the industry of the future (Saxena, 2020).

A nation's stability is characterized by the degree of quality of its students, scholars, innovators and academic leadership vision. Historically, the Indian subcontinent was a powerful and vibrant centre for abstract intellectual practice such as the discipline of philosophy and mathematical disciplines. Science is well knitted into our customs, resulting in a deep community of physical and applied sciences such as astrophysics, material science, medicine, etc. In areas such as architecture, urban planning, water processing technologies, warfare techniques, pharmacy, surgery, etc., heavy content of intellectual rigour, strong foundations of scientific thought being transformed into innovative engineering and technology is more than evident. This traditional strength has enabled us to have scientists like Srinivasa Ramanujan, C.V. Raman, S. Chandrasekhar, S.N. Bose, Homi Bhabha to name a few in modern times.

A vibrant and creative society, be it the arts, crafts, engineering, science or any other scholastic practice, is characterized by creativity and innovation in every field of life. Societies continue to stagnate without ingenuity and innovation, and gradually begin to decay. They become dependent upon new ideas from other societies. This is true for any human activity, but more so for science and technology. In India, we are heavily dependent on changes occurring elsewhere, often absolutely. Our status in the field of science and technology is that of' takers' and not' givers' with very little to prove as original. It is not as if there is any lack of basic temperament. The answer to this lies in the current state of affairs in STEM education itself. It's an open secret that science and engineering education in India today has been unable to produce quality employees to resolve the nation's problems. It is difficult to import the solution to those problems. To solve these issues, we need an out of the box solution. STEM education provides the basis for such a high degree of imagination and an innovation culture.

Hence the need of the hour is a thorough re-evaluation of our higher education program.

The number of STEM jobs is growing at the fastest ever rates. According to the National Science Foundation, it is predicted that 80% of the jobs created in the next decade will require some form of math and science skills. These skills are appropriately labelled as 21st-century skills or STEM skills (Aravind, 2018).

The industrial revolution paved the way for formal education, (a system we follow to date), where many people did not require to be educated to high levels, so schools promoted a few who could do managerial and professional work and sent the rest away to assembly lines. Today, however, such repetitive processes are being easily accomplished through automation (Robotics being the latest). The abilities of the 21st century, especially 'creativity and critical thinking,' require a higher degree of awareness, one that is not so compartmentalized and slanted. We can not cope with a system that is trained to leave behind a lot of children.

It is high time we left behind the outdated system and ushered in one that’s integrated and inclusive. Something that will equip children with the skills required for the 21st century and promote creativity, critical thinking, and innovation for a future. A sound foundational knowledge, mathematics and science, critical thinking, creativity, communication and collaboration skills would then be the minimum required

education for every student. STEM (Science Technology Engineering Mathematics) offers the perfect solution. STEAM and STREAM are the variants with Art and Reading added to it.

As of today, in order to encourage STEM in colleges, the USA has set aside upwards of $2 billion. In order to encourage STEM education, Japan, the UK, Australia and New Zealand have all allocated a reasonable share of their education budgets. As part of the 'Skill India' initiative, the government of India has pumped in a total of 488.2 crore to help more than 2000 schools equip themselves and help students gain hands-on experience with Atal Tinkering Labs in futuristic technology (ATL) (Aravind, 2018).

The incorporation of science, technology, engineering and mathematics, known as STEM education, is a growing field in developed and developing countries. STEM education is commonly represented, but there are varying definitions of what it actually means. STEM education seeks to change teaching practices from conventional lecture-based teaching to inquiry-based, project-based and problem-based learning as a means of delivering interdisciplinary, practical learning experiences which may involve two or more of the four main disciplines defined in STEM education. Within such interdisciplinary philosophy, deep conceptual understanding and what is termed as 21st century skills could be developed (H. El- Deghaidy, 2015).

Nonetheless, study results indicate that science and math teachers lack pedagogical expertise and effectiveness in STEM education (Louis S. Nadelson, 2013)

## 2. Meaning And Definition of STEM Education

American National Science Foundation first used the acronym SMET for science, mathematics, engineering, and technology in the early 1990s, but determined that this acronym would cause issues of vulgarity, and SMET was changed to STEM (Sanders, 2009). The first use of the acronym STEM was introduced in 2001 when Judith A. Ramaley, a former director of the NSF's Education and Human Resources Division, used STEM to refer to science, technology, engineering, and mathematics curriculum (Breiner JM, 2012).

The 2014 report from the American National Research Council titled, STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research, presents a more holistic definition of integrated STEM:

*Rather than a single, well-defined experience, it involves a range of experiences with some degree of connection. The experiences may occur in one or several class periods, or throughout a curriculum; they may be reflected in the organization of a single course or an entire school, or they may be presented in an after or out-of-school activity (p.39).*

**According to Johnson (2013)** – STEM education is an instructional approach, which integrates the teaching of science and mathematics disciplines through the infusion of the practices of scientific inquiry, technological and engineering design, mathematical analysis, and 21st century interdisciplinary themes and skills. This definition also brings to bear a focus on STEM thought processes and skills instead of the traditional emphasis over content.

**According to Tsupros et al. (2009)** – It is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons in contexts that make connections between school, community, work, and the global enterprise.

**According to Merrill (2009)** - STEM education is a standard-based, meta-discipline residing at the school level where discipline specific content is not divided, but addressed and treated as one dynamic, fluid study. Here, STEM is addressed as transdisciplinary.

**According to Koonce et al. (2011)** STEM stands for the four primary discipline families of Science. Technology, Engineering, and Mathematics.

**Breiner et al. (2012)** discuss it contextually, suggesting "most stake- holders who hold interests in promoting STEM would claim to understand the meaning, yet the finer points of this construct often cause confusion."

Arguably, the most robust and detailed definition of STEM education is provided by **Moore et al. (2015),** whose definition was adopted for this study (as such). They define it as "the teaching and learning of the content and practices of disciplinary knowledge which include science and/or mathematics through the integration of the practices of engineering and engineering design of relevant technologies."

**Kelly and Knowles (2016) defined** STEM as an approach in which students are taught the content of two or more STEM domains in applications that relate science, technology, mathematics, and engineering in contexts involving real-life problems to enrich their learning.

According to these definitions, STEM education is employed as

1. it involves an application that relates at least two of the science, technology, mathematics and engineering fields,
2. these fields are brought together in a context based on real-life problems, and
3. it helps teaching students the subject-matters or enriches their learning.

### 3. Interdisciplinary STEM / Integrated STEM

Education in science, technology, engineering, and math (STEM) is typically known as a meta-discipline. It is the creation of integrated knowledge across disciplines to form a new curriculum to be taught as a whole. In the early 2000s, STEM was first introduced as an educational term by the American National Science Foundation.

Building upon the past two decades of STEM education reform efforts, Sanders (2009) argues that integrated STEM education focuses on integrating the four disciplines in Science, Technology, Engineering and Mathematics and on new integrative approaches that explore teaching and learning between and among any two or more of the STEM subject areas. Engineering design-based learning can be an effective pedagogical approach for effectively teaching crosscutting concepts across these four content areas. Further, STEM education Emphasises that it is critically important to foster opportunities to increase problem-solving skills, especially in light of developing economic competitiveness (TJ Moore, 2015)

STEM education gives opportunities to students to understand the world around them and solve real-world problems. According to the Organization of the Economic Co-operation and Development (OECD) report, productive individuals should have a high level of technical skills and also be independent, cooperative, and flexible in improving their qualifications (Johnson, 2013).

In order to understand STEM, it is significantly important to understand the relationship between its disciplines. Science seeks consistency and understanding of the external world. There is a strong link found between science and technology to the extent that most individuals think that technology is applied science. The processes that are used in learning about science encompass exploring, discovering, or inquiring. The use of scientific method is the most important to apply science. Technology has been defined as what is human made ([NRC], 2011). It is driven by human genius and creativity and offers an efficient and productive life to make the lives of people easier by solving problems. Engineering is the profession that needs study, experience, application, and knowledge of science and math in order to utilize economically

the materials that could benefit the humanity. The National Academy of Engineering supports technology and engineering literacy because of the strong relationship between the two disciplines. Finally, Mathematics investigates the patterns and relationships of sciences, as explained by mathematicians today that mathematics is the study of patterns real or imagined, visual or mental, arising from the natural world or from within the human mind. Mathematics is a common discipline that is used in many disciplines such as science, technology, and engineering not only for numbers, measurements, probability, but also for use of minimum formulas, precision and purity (Esra Bozkurt Alan, 2016)

There are a number of ways that STEM can be taught in schools. The first option is to teach each discipline of STEM as an independent subject with no or little integration. This is known as S-T-E-M.

The second way is to teach each of the STEM disciplines with emphasis on one or more subjects and this is referred to as SteM.

Another strategy is to integrate the three disciplines into one discipline that can be taught. For example, robotics is an engineering project, but requires integration between science, technology, and mathematics. In this case, the engineering teacher will take responsibility in teaching the subject. However, the collaboration between teachers of the other disciplines is very important in teaching the subject. This is known as E→STM (Sayary, 2015).

In STEM education, there are two ways to incorporate Science and Mathematics fields into the Engineering field as Context and Content (Moore, 2014). In context integration, engineering design is seen as a motivating tool for teaching the content of mathematics and science fields, whereas for integration of content, engineering skills form a part of the learning objectives together with science and mathematics content. Based on these integration approaches, the STEM curricula should involve (i) a process and product based evaluation (ii) in a digital format (iii) using inquiry, problem and performance based and constructivist teaching approaches (iv) with an interdisciplinary approach and understanding by design (Knowles, 2016).

In general, pedagogical techniques such as inquiry-based instruction, argumentation, interactive learning, programming, and robotics are used during curriculum implementation. Students are required to identify everyday problems in inquiry-based teaching, shape hypotheses, gather data, test hypotheses, generalize them and test themselves in this process. Students are expected to engage in a logical debate in the argumentation, make a claim based on the evidence, explain and defend these arguments, and determine the conditions under which the arguments should be correct. Throughout the learning-teaching phase, they are to use electronic devices such as cell phones, tablets and notebooks while they are in digital learning. In coding and robotics, students are asked to program a robot using one of various coding languages (Kanadh, 2019).

**4. Problem Based Learning**

Problem-based learning is a student-centred pedagogical approach that combines the inquiry approach and problem solving process. Learning with PBL occurs when students go through three steps: What do they know? What do they need to know? And how can they find out what they need to know?

There are other theoretical concepts supporting PBL which are constructivist methods, metacognition, and cultural and social influences. The PBL theory is a constructivist philosophy, because learners need to create their own interpretation of new concepts. The constructivist process is contained in "What do they know? What do they need to know? How do they know?" In other words, explicit attention should be paid to students' prior and existing knowledge, and the ability to construct new knowledge based on prior knowledge.

In three stages, Piaget described this cognitive process: assimilation, accommodation, and equilibrium, in which learners integrate new experiences into existing experiences. The cognitive structure of the learner is thus adjusted in reaction to the context, and maintains a balance between what is known and what needs to be learned. The co-constructed mechanism in which individuals communicate and work together to solve problems is internalised by the person and is part of the cognitive growth of the student (Sayary, 2015).

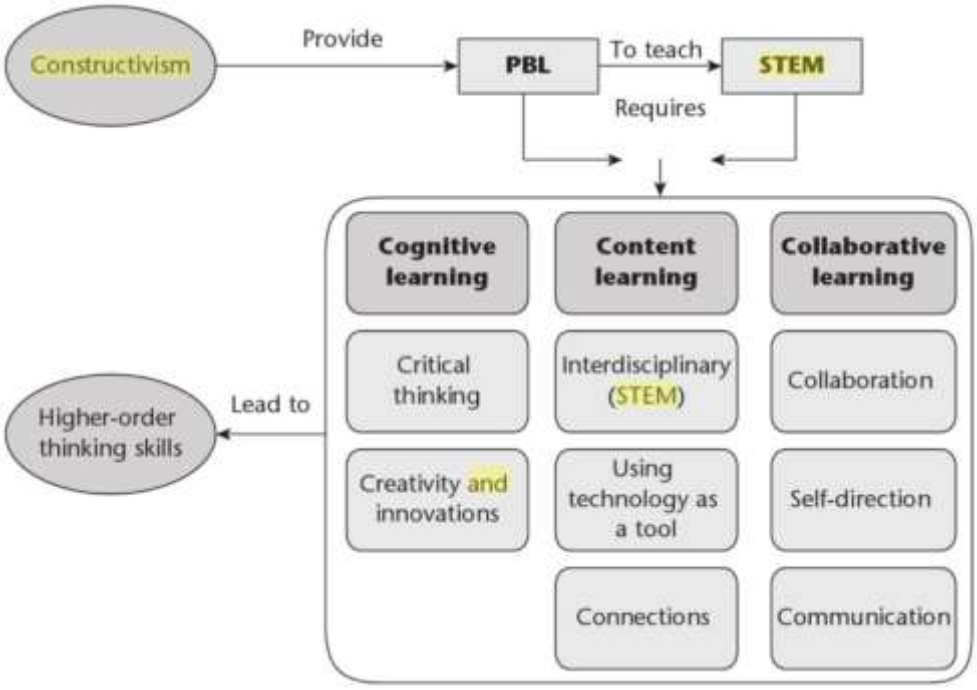
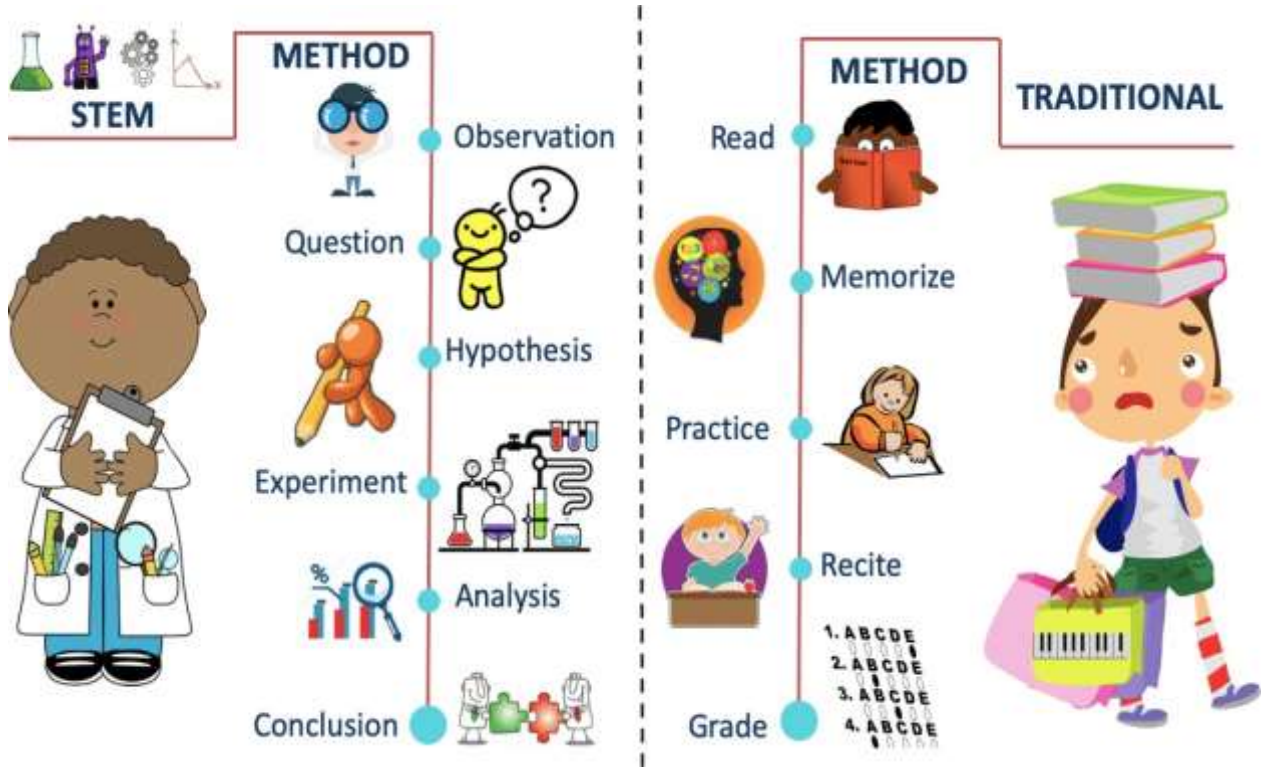



**Fig. 1 A Conceptual Framework illustrates the relationship between PBL and STEM**
**Source:** (Sayary, 2015)

A large and growing body of literature has revealed that there are three types of learning included in PBL models: cognitive learning, content learning, and collaborative learning. The above figure 1 illustrates these three elements' relationships with PBL and STEM. The figure 1 shows that cognitive learning focuses on critical thinking, creativity, and innovation skills while collaborative learning focuses on collaboration, self-direction, and communication skills. Finally, content learning focuses on the integrated knowledge through STEM disciplines, use of technology, and connection to real life which lead to fine outcomes, such as, higher-order thinking skills (Sayary, 2015).

**5. How Is It Different From Traditional Education Methods?**

A STEM program is structured to provide full, realistic exposure and hands-on experience in a specific area for its students. It provides a great mix of course modules with a few obligatory laboratory assignments and community projects that assist in learning through the practical application of theoretical knowledge. This kind of vocational training is being introduced at the K-12 level in many schools worldwide. Though science lovers, who do not have any prior experience of such a learning environment, may experience this learning through higher education, that is, the bachelors and masters level education STEM is not just an acronym for Science, Technology, Engineering and Mathematics but an education method that integrates all these subjects. It addresses the concerns that these subjects or disciplines are often taught in isolation when they are all interconnected in reality. It is an interdisciplinary approach focused on hands-on learning that is coherent.




It is difficult to dissimilate certain fields from one another in today's world. Choose any thing from your home or office and try to fit it into only one of the STEM topics. It would be hard for you to do so because everything is interconnected with one another. Science and math contribute to the advancement of technology, which is then incorporated into engineering to make it usable in our lives. Instead of depending on what the textbook says, STEM allows children to experiment, make mistakes and learn from their own experiences to achieve right results.

Critical thinking, logical analysis, inquiry and project-based learning are the keystones in STEM education. It boosts the curiosity in the kids, making learning process fun, relevant and everlasting. This is a paradigm shift from traditional education, which vitally lacks in hands- on learning, to a learning that is much better and deeper.

A major flaw with isolated learning is that students are often unable to apply the concepts taught to specific problems, limiting their efficiency or comprehension capacity and thus execution. Problem solving is an important skill set that is not covered by the existing educational system. If questions or learning gaps are not resolved in the early years, as the difficulty level of the subjects increases with time, things get worse. This loose end in basic
education, all due to the inherent lag in conventional education, contributes to fear of the topic going forward. By helping students work on the applications, STEM education ensures that there is no disconnection in the interpretation of concepts. Taking a very basic example for initial years, math is introduced to kids with number learning, like 1, 2, 3 and so on. Kids don't understand why they are being taught numbers and why less/more cannot suffice in place of numbers. On the other hands, asking questions like how much more or how less can immediately get them to understand the sense behind numbers and quantification.

What is important to consider is how the concepts taught apply to the real world and how understanding them will help children overcome their everyday problems. Similarly, playing board games, mixing math with surrounding arts & patterns will increase the awareness and interest of children in the subject, leaving no room for anxiety. For any discipline, this is how STEM learning occurs.

**6. Challenges In Implementing Stem Based Learning In Schools**

In order to build STEM skills on a scale, there are some really difficult pressing obstacles to address before India can really tap on the benefits of these global opportunities. Designing the facilities, curriculum and equipping children with the best instruction and support is one of the main challenges involved in introducing STEM education.

Another biggest hurdle is our unitary reliance on marks – focused and exam-oriented education system. We definitely need some sweeping changes in our teaching-learning and evaluation processes. Many teachers still assume that students will be distracted from their studies by implementing STEM and they will not be able to complete their given curriculum in that specified period of time. The best way to fix this is to make them aware and change their views by showing them the positive effects of exposing their children to the methodology of STEM learning. This approach is being implemented by countries around the world by adopting national curricula that set frameworks and projects that implement the STEM methodology.

Quality infrastructure and the funds needed to build such infrastructure are the third major challenge for STEM education. Here the business world needs to cooperate and contribute through its CSR activities to enhance education. Over the decades, the cost of doing quality education and science has risen, and the facilities need to be cutting edge for cutting edge developments to happen.

**7. Context of STEM Education In India**

The situation has changed in the present world despite the commendable work of ancient Indian scholars such as Charaka, Susruta, Aryabhata, Bhaskaracharya, Chanakya, Patanjali and Vatsayayna, and numerous others in various fields of science and technology. It should be noted that while the school education system in India places growing emphasis on the two end subjects of the philosophy acronym STEM, neither engineering nor technology form part of the regular curriculum of pedagogy (National Policy on Education, 2016).

Science education is facing three practical challenges in India: availability and access of basic infrastructure and scientific equipment to be used while teaching science, shortage of quality teachers who are equipped with in the latest know how in their respective fields and the nation's science curriculum, which needs immediate attention (Malti, 2017). Lack of critical thought, inquiry-based learning, and hands-on learning are the key reasons for the significant number of high school dropouts from science education. Besides strong infrastructure and professional teachers, a remarkable administrative divide, in addition to the academic and casual attitude of the regulators, has all led to the diminished quality parameter of Indian education system The parallel business of paid academic coaching is a clear indicator of the lack of credibility of the Indian school system (National Policy on Education, 2016).

**7.1 NATIONAL STEM POLICIES**

India has made remarkable progress since independence and established the department of education and literacy under the ministry of human resource development on August 29, 1947 with the objective of expanding educational facilities. The National Policy on Education, as formulated in 1968, 1986 and modified in 1992, recognises education as a precondition for development and sets out three critical issues – equity, accessibility and quality. Despite the robustness in conception and orientation, earlier education policies failed to change the state of education in last several years. However, the 'National Policy on Education, 2016' during 12 Five Year Plan (recent policy planning) recognises education as the most important tool for social, economic and cultural transformation and emphasises on innovation, critical thinking and skill development. This identifies four essential components: building values, awareness, knowledge and skills to enable citizens accomplished and competent for contribution in the nation's well-being, strengthens democracy, fosters and social cohesion (National Policy on Education, 2016)

In conjunction to its education policy, India's Scientific Policy Resolution (SPR) of 1958 also resolves to 'foster, promote and sustain' the 'cultivation of science and scientific research in all aspects'. Science, technology and innovation have been identified as the drivers that have the potential to accelerate India's sustainable and inclusive growth (Science, Technology and Innovation Policy, 2013)

Studies examining undergraduate educational approaches that integrate the humanities and arts with Science, Technology, Engineering, and Mathematics (STEM) have consistently reported positive learning outcomes, including enhanced creativity, innovation, critical and higher-order thinking, problem-solving abilities, teamwork, and communication skills. Such interdisciplinary approaches also promote deeper understanding across disciplines, as well as increased social and ethical awareness, learner engagement, and enjoyment of the learning process, aligning with the holistic and multidisciplinary vision emphasised in the National Education Policy (NEP, 2020).

**7.2 'STEM FOR SCHOOL' INITIATIVES: GOVERNMENT OF INDIA**

Through numerous interesting initiatives, the Indian government is working hard to promote scientific disposition among school students, and to provide them with research training opportunities to develop a professional workforce.

The major science and technology programmes of the Indian government for school students are as follows:

1. **The Ministry of Human Resource Development has launched the Rashtriya Avishkar Abhiyan (RAA)** in July 2015, across School Education and Higher Education to encourage children towards learning Science and Mathematics through activities related to Science and Mathematics. Some of the interventions under RAA for promotion of science are strengthening of school Science and Mathematics laboratories, Science Fair/Exhibition and Talent Search at district level; provision of mathematics and

science kits to schools, visit of students to higher educational institutions and learning enhancement of students.

**2. National Children's Science Congress**

National Children's Science Congress (NCSC) is a nationwide flagship programme of the Department of Science and Technology (DST), government of India, initiated in 1993. DST is an apex nodal department of Government of India, established in May, 1971 to organise, promote and coordinate science and technology (S&T) activities in the country (National Children Science Congress, 2017)

NCSC invites open-ended scientific projects from an individual or team of young innovators, based on different themes since its inception and provides platform to approximately 1 million

children aged between 10 and 17 years every year, to exhibit their creativity and innovation to address societal problems through the intervention of S&T.

**3. Innovation in science pursuit for inspired research programme**

Innovation in Science Pursuit for Inspired Research (INSPIRE) is an innovative programme developed by DST in 2008 during the 11th Plan with long term foresight for attracting young talent to the excitements of a creative quest for science as a career option and building the required critical human resource pool for strengthening and expanding the research and development base in the country. The INSPIRE scheme includes three components to facilitate all categories from school students to young researchers to do research (See figure2)

Recently the INSPIRE Award – MANAK (Million Minds Augmenting National Aspiration and Knowledge) has been revamped to align with the action plan for the 'Start-up India' initiative launched by the Honourable Prime Minister of India (INSPIRE Awards - MANAK., 2017)




Fig. 2 INSPIRE (Source : http://mhrd.gov.in/sites/upload_files/mhrd/files/raa/Presentation_by_INSPIRE_PROGRAMME.pdf).

**4. Atal Tinkering Laboratories**

Atal Innovation Mission is setting up Atal Tinkering Laboratories (ATLs) in schools across India with a goal to' Cultivate one million children in India as Neoteric Innovators.' The purpose of this scheme is to promote curiosity, innovation, and imagination in young minds; and to inculcate skills such as mind set design, analytical thinking, adaptive learning, physical computing, etc.

ATL is a work space in which young minds can form their ideas through hands on do - it- yourself mode; and learn skills in innovation. Young kids will have the ability to work with tools and equipment to grasp STEM concepts (Science, Technology, Engineering and Math). ATL will include' do it yourself ' kits and equipment on educational and learning–science, electronics, robotics, open source microcontroller boards, sensors, and 3D printers and computers. Certain desirable services include meeting rooms and facility for video- conferences.

To promote inventiveness among students, ATL can conduct various activities at regular intervals, ranging from regional and national competitions, exhibits, workshops on problem solving, product design and manufacturing, lecture series, etc.

AIM provide grant-in-aid of Rs. 20 Lakh to each school that includes a one-time establishment cost of Rs. 10 lakh and operational expenses of Rs. 10 lakh for a maximum period of 5 years to each ATL. (ATAL Tinkering Labs, 2017)

To date , 5441 Schools have already been selected for ATL grants and in Gujarat, we have 250 schools that have ATLs (ATAL Tinkering Labs, 2017).

With the National Education Policy 2020 recognising the need for flexibility in choosing the subjects that a student wants to study, implementation of this policy will boost science, technology, engineering and mathematics (STEM) education in India (National Education Policy (NEP)-2020).

The National Curriculum Framework (NCF) 2005, suggested a paradigm shift in science education in India. As per NCF 2005, inquiry skills should be supported and strengthened by language, design and quantitative skills. Schools should place much greater emphasis on activities aimed at stimulating investigative ability, inventiveness, creativity and transfer of learning in varied situations. The perspective of NCF-2005, on science has been translated into syllabi, textbooks and teacher support material developed by the National Council of Educational Research And Training (NCERT). The NCERT has continuously been building capacity of science teachers and teacher educators at the secondary stage for content and pedagogies which promote inquiry, thinking and problem-solving skills in students. NCERT also conducts National Science Exhibition every year to further promote scientific temper among students.

We are now at a stage where the number of STEM jobs is increasing at a fast pace and the number of STEM graduates actually exceeds that. It is estimated, according to the National Science Foundation, that 80 percent of the jobs generated in the next decade would require some sort of math and science skills (Malti, 2017) While possessing the highest quality talent, these students have been constrained by the exam-focused education paradigm of the past when it comes to innovation, problem-solving and creativity. It's here where the STEM players come in to fill this void.

It is important to provide the schools with the resources and funding to incorporate STEM into their curriculum and bring it to life in the classroom, inspiring the next generation of coders. STEM engineers have been implementing creative strategies for the last couple of years to ensure children are more inclined and involved in the' do it yourself ' approach (The Hindu, 2018).

## 8. Conclusion

The present study highlights the urgent need to transform the traditional, exam-oriented education system in India to better align with the demands of the 21st century and the evolving global knowledge economy. STEM education emerges as a powerful interdisciplinary approach capable of fostering essential competencies such as critical thinking, creativity, problem-solving, collaboration, and innovation. By integrating science, technology, engineering, and mathematics through inquiry-based, problem-based, and experiential learning, STEM education addresses the limitations of fragmented and content-heavy pedagogical practices.

The analysis of the Indian educational context reveals that, despite policy-level support through initiatives such as the National Education Policy (NEP) 2020, Atal Tinkering Labs, and INSPIRE programmes, significant challenges persist in terms of infrastructure, teacher preparedness, curriculum rigidity, and assessment practices. These barriers hinder the effective implementation of STEM education at scale.

The study concludes that a systematic and well-structured integration of STEM, supported by adequate resources, teacher training, and curriculum reforms, is essential for nurturing a generation of innovative and self-reliant learners. Furthermore, aligning STEM education with real-life contexts and societal needs can enhance its relevance and impact. Future efforts should focus on strengthening interdisciplinary curriculum design, promoting hands-on learning environments, and ensuring policy-practice coherence to realize the full potential of STEM education in India.

## 9. Recommendations

In alignment with the vision of the National Education Policy (NEP) 2020, which emphasizes multidisciplinary learning, experiential pedagogy, and skill development, the following recommendations are proposed to strengthen the implementation of STEM education in India:

### 1. National-Level Institutional Collaboration

STEM education initiatives should be systematically organized through coordinated efforts between the Ministry of Education and Indian universities. Such collaboration would ensure standardization, quality assurance, and large-scale implementation of interdisciplinary STEM programs across institutions, as envisioned in NEP 2020's focus on integrated and holistic education.

### 2. Establishment of STEM Centres of Excellence

Dedicated STEM centres should be established at regional and institutional levels, equipped with advanced infrastructure and authentic learning resources. These centres should be staffed with trained STEM experts and linked with industry to provide hands-on, experiential learning opportunities, thereby fostering innovation, creativity, and 21st-century competencies among learners.

### 3. Strengthening Industry–Education Linkages

STEM education should be strategically utilized to bridge the gap between vocational education and industry. Partnerships with industries can facilitate practical exposure, internships, and real-world problem-solving experiences, aligning educational outcomes with the demands of Industry 4.0, as advocated by NEP 2020's emphasis on skill-based and vocational integration.

### 4. Capacity Building and Teacher Training

Continuous professional development programs should be designed to equip teachers with interdisciplinary pedagogical skills, enabling effective implementation of STEM-based, inquiry-driven, and problem-based learning approaches.

**5. Curriculum and Assessment Reforms**

STEM integration should be embedded within the curriculum through flexible, multidisciplinary course structures and supported by assessment practices that emphasise application, critical thinking, and innovation rather than rote memorization

**10. References**

1. [NRC], N. R. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering and mathematics.*
2. Washington,DC: The National Academic Press.
3. Aravind, S. (2018, October). *STEM Education – Game Changer In Education And Industry.* Retrieved from BW EDUCATION: http://bweducation.businessworld.in/article/STEM-Education-Game-Changer-In-Education-And-Industry/10-10-2018-161853/
4. *ATAL Tinkering Labs.* (2017). Retrieved from Atal Innovation Mission: https://aim.gov.in/over-view.php
5. Breiner JM, H. S. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. *Sch Sci Math*.
6. Buyruk, B., & KORKMAZ, Ö. (2016). Teacher Candidates' Stem Awareness Levels. *Participatory Educational Research (PER)*, 272-279.
7. Chia, P. L., & Maat, S. M. (2018). An Exploratory Study of Teachers' Attitudes towards Integration of STEM in Malaysia. *International Journal of Electrical Engineering and Applied Sciences*, 45-50.
8. Esra Bozkurt Alan, S. E. (2016). STEM Education Program for Science Teachers:Perceptions and Competencies. *Journal of Turkish Science Education*, 103-117.
9. H. El-Deghaidy, N. M. (2015). Science Teachers' Perceptions of STEM Education: Possibilities and Challenges. *International Journal of Learning and Teaching Vol.1, No. 1*, 51-54.
10. Han, S., & Yalvac, B. (2015). In-service Teachers' Implementation and Understanding of STEM Project Based Learning. *Eurasia Journal of Mathematics, Science & Technology Education*, 63-76.
11. *INSPIRE Awards - MANAK.* (2017). Retrieved from http://nif.org.in/inspire- awards Johnson, C. (2013). Conceptualising Integrated STEM education. *Sch Sci Math*, 367-368.
12. Kanadh, S. (2019). A Meta-Summary of Qualitative Findings about STEM Education. *International Journal of Instruction*, 959-976.
13. Kavya, M. R. (2019). A study on awareness of academicians on Atal Tinkering Labs- Atal Innovation Mission. *Think India Journal*.
14. Knowles, T. R. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM education*.
15. Louis S. Nadelson, J. C. (2013). Teacher STEM Perception and Preparation: Inquiry-Based STEM Professional Development for Elementary Teachers. *The Journal of Educational Research*, 157-168.
16. Madden, L., Beyers, J., & O'Brien, S. (2016). The Importance of STEM Education in the Elementary Grades: Learning from Pre-service and Novice Teachers' Perspectives. *Electronic Journal of Science Education*, Vol. 20, No. 5 .
17. Malti. (2017). Need and Importance of STEM education in Indian Schools. *Indian Journal of Research*, 852-853.
18. Moore, T. &. (2014). Advancing the State of the Art of STEM Integration. *Journal of STEM Education*, 5- 10.

19. *National Children Science Congress.* (2017). Retrieved from Ministry of Science & Technology. Government of India: www.ncsc.co.in
20. *National Education Policy (NEP)-2020.* (n.d.). Retrieved from MHRD: https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_E nglish_0.pdf
21. *National Policy on Education.* (2016). Retrieved from http://www.nuepa.org/New/download/NEP2016/ReportNEP.pdf
22. Saxena, S. (2020, September). *STEM Education: An overview.* Retrieved from Shiksha study abroad: https://studyabroad.shiksha.com/stem-education- an-overview-articlepage-2661#:~:text=The%20best%20feature%20of%20the,chances%20of%20t heir%20academic%20success.
23. Sayary, S. A. (2015). STEM education and Problem based learning. In L. L. Rupert Wegerif, *The Routledge International Handbook of Research on Teaching Thinking* (pp. 357-365). Routledge.
24. *Science, Technology and Innovation Policy.* (2013). Retrieved from http://dst.gov.in/sites/default/files/STI%20Policy%202013-English.pdf
25. Sharma, P. K. (2018). "Perspectives of 'STEM education and policies' for the development of a skilled workforce in Australia and India.

***INTERNATIONAL JOURNAL OF SCIENCE EDUCATION.***

1. Tekerek, B., & Karakaya, F. (2018). STEM education awareness of pre-service science teachers. *International Online Journal of Education and Teaching (IOJET)*, 348-359.
2. Timur, S., Timur, B., & Cetin, N. I. (2019). Effects of Stem Based Activities on In-Service Teachers. *Educational Policy Analysis and Strategic Research*, 102-113.
3. TJ Moore, C. J. (2015). The need for a STEM road map. *Routledge.*

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