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Governance Reforms in School Education Through Virtual Labs: Vision of A Developed India @2047

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Abstract
India's journey towards becoming a 'Developed India @ 2047' traverses the path of quality, equitable, and accountable education. This objective can be realized in the current era by modernizing the education sector through the continuous and rapid global advancements in Information and Communication Technology (ICT). This is because the lack of high-standard laboratories and resources poses a significant impediment to the acquisition of practical knowledge in rural and semi-urban schools. Due to the high costs associated with the construction and maintenance of physical laboratories, not every student receives an equal opportunity to acquire practical knowledge, and obstacles also arise in the effective administration of school governance. The present research study is grounded in the objectives of the National Education Policy 2020 and existing technological capabilities; through logical analysis, it demonstrates how the principle of 'Maximum Governance, Minimum Government' can be implemented in educational administration by utilizing virtual laboratories to address the scarcity of physical laboratories and resources. The study reveals that virtual laboratories are not only cost-effective but also capable of bridging the urban-rural educational divide. This paper recommends, under the ambit of governance reforms, the establishment of a 'Virtual Lab Resource Centers' to mitigate the lack of practical knowledge and prepare citizens with a scientific temper for a 'Developed India.'

Keywords: Virtual Lab, Practical Knowledge, Maximum Governance and Minimum Government, Governance Reforms, Virtual Lab Resource Centers

INTRODUCTION

India is currently in a position where every Indian citizen wants to project a strong and exemplary image of their Indianness to the entire world. To achieve this goal, the vision of "Developed India @ 2047" presents an ambitious journey for Indian society to transition from the category of "developing nations" to "developed nations". The long-term and ambitious journey of Developed India @2047 does not only mean economic progress, but its main foundation is quality, equitable and accountable education, because education is the main foundation of development of any nation (Kothari Commission, 1966). In this changing era of information and communication technology, education is no longer limited to literacy, but it is about an education system and educational structure that can develop citizens with innovation, maximum governance and minimum government, and a scientific outlook.

With the rapid advancement of information and communication technology globally, modernization of

the education sector has become not just an option but a fundamental necessity for nations like India with a large population and education system. This innovative technology has made every aspect of education, from governance to monitoring of quality of education, transparent, convenient, easy, time- and cost-effective, and accountable. Information and communication technology has opened new doors to the democratization of education, making the teaching-learning process more effective and interactive. The National Education Policy 2020 emphasizes the integration of digital tools and technologies in education, and proposes the establishment of the National Education Technology Forum (NETF) to implement it. It promotes the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach to teaching. The National Education Policy 2020 proposes the use of virtual and real-life laboratories to make science teaching practical. It also advocates equity, quality, accountability, practical knowledge, innovation, and technology integration in education (National Education Policy 2020). The National Curriculum Framework 2023 also places special emphasis on digital technology and experiential learning in education (NCFSE 2023).

The gap between theoretical knowledge and practical knowledge has been a major reason for the lack of quality education in the Indian education system. In India, the world's largest country in terms of population, providing real laboratories in all schools for all students is a challenging task in itself. Because the construction, maintenance, and administration of physical laboratories are expensive, and even in schools that do have them, not all students are able to use them due to the school administration's system of functioning. Physical laboratories contain a variety of chemicals and electrical equipment, which can lead to accidents if not used properly. Therefore, most schools keep their laboratories closed. This lack of resources leaves millions of students without practical knowledge, ultimately hindering their skill development and scientific understanding. This "digital and resource gap" further deepens educational inequality in society.

The present research study is based on the goals of National Education Policy 2020, existing technological capabilities, in which it has been demonstrated through logical analysis that how the principle of 'maximum governance and minimum government' can be implemented by overcoming the lack of physical laboratories and resources in educational governance through virtual labs, that is, what role can virtual labs play in achieving the goal of developed India? And how the concept of Virtual Lab Resource Centre is useful in bridging the educational divide of theory, practical and resource gap through high quality digital resources at low cost.

Objectives of the Study

1. To study the role of virtual labs in achieving the vision of a developed India @ 2047..
2. To introduce the concept of a 'Digital Lab Resource Centres' to develop a scientific attitude.

Maximum governance and minimum government

Maximum governance and minimum government refers to minimizing government interference in the basic functions of daily life through a decentralized system, developing a system free of red tape and corruption. When viewed in school education, this principle refers to school functioning such as management, curriculum development, pedagogy, educational quality, maintenance of resources, and monitoring their proper use. The digital revolution has been at the forefront of implementing "maximum governance, minimum government." The Digital India program, launched in 2015, has been significant in this regard. It reduces decision-making levels within government departments, improves efficiency in

policy implementation, and increases accountability of public officials. It implements this principle by doing the following:

Digital Governance and e-Services	• Umang, Digilocker, Jan Dhan mobile app, Direct Benefit Transfer
Ease of Doing Business	• Single Window Clearance, Labour Code Reforms, Insolvency and Bankruptcy Code
administrative reforms	• Empowered Committees, Lateral Entry, Mission Karmayogi, Faceless Assessment Scheme
Citizen Empowerment and Participation	• MyGov Platform, Right to Information Act, Centralized Public Grievance Redress and Monitoring System (CPGRAMS)
Decentralisation and local governance	• Recommendations of the 15th Finance Commission, Panchayat Act

The implementation of "minimum government, maximum governance" in India has shown promise in reducing unnecessary government interference and empowering citizens.

Virtual lab

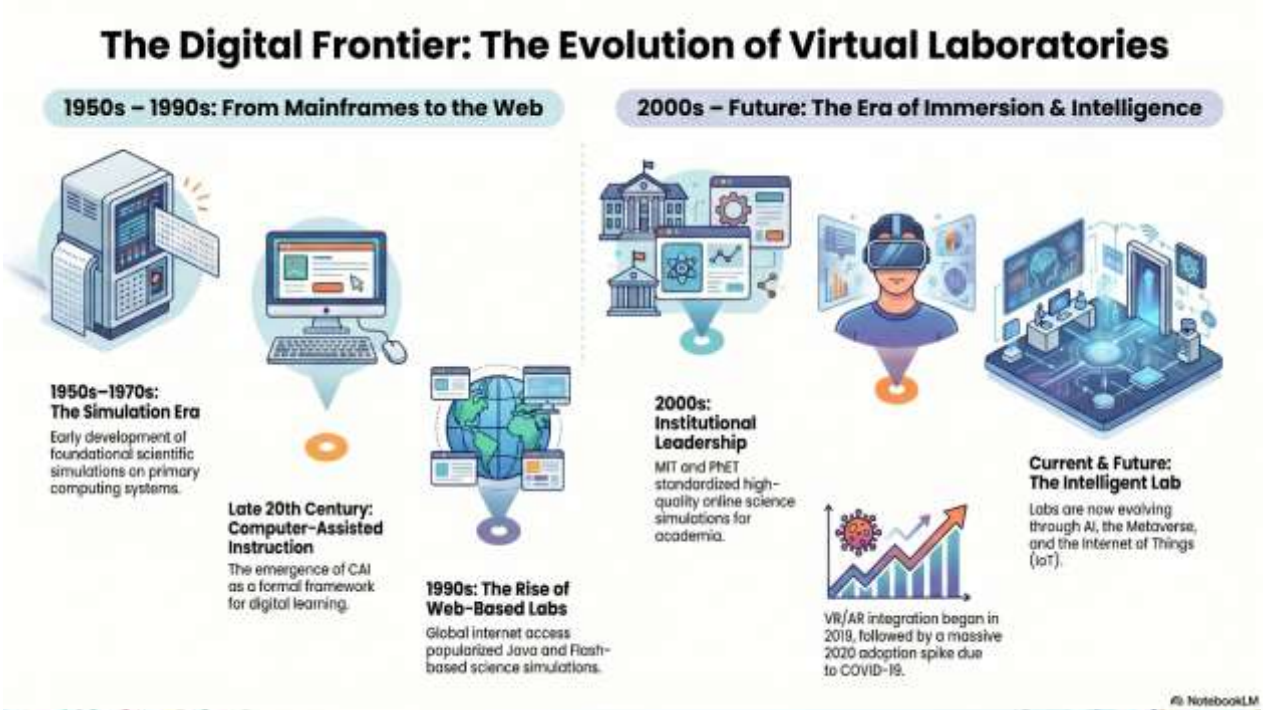
The virtual laboratory word was first used by the National Science Foundation to improve the stage of STEAM education, where population aging is one of the biggest challenges to the quality education (Borgman et al., 2008). It is a digital tool that provides a virtualized experience of a real laboratory. Experiments are conducted through simulations, animations, and interactive tools, allowing students to learn experiments in various subjects such as physics, chemistry, biology, and computer science. Virtual laboratories allow students to learn on their own time and are an effective solution to resource constraints.

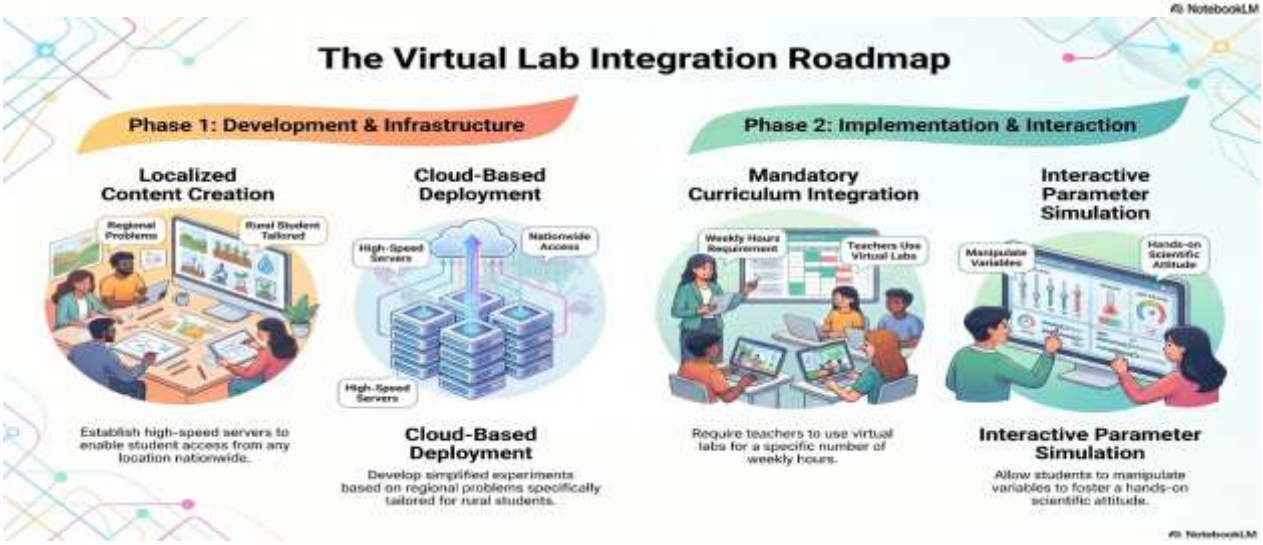
A virtual lab is "a virtual learning space that allows students to conduct experiments interactively, individually or in groups, via the Internet" (Aljuhani et al., 2018). Virtual laboratories use information and communication technology to provide quality and accessible practical education to students and teachers, even with limited resources. Virtual laboratories enable practical work to be conducted at a low cost, in a safe environment without physical resources. This enables education even in schools with limited resources and provides access to practical education even in remote areas. User can repeat experiments may times at their own pace, which fosters interest in learning and develops creative thinking.

History of virtual lab

- The concept of a virtual laboratory emerged in the late 20th century as part of computer-assisted learning (CAI).
- Scientific simulations were developed in the 1950s and 1970s.
- With the spread of the Internet in the 1990s, web-based laboratories, such as Java and Flash simulations, became popular.

- In the 2000s, MIT, PhET (University of Colorado Boulder), and other institutions developed online science simulations.
- After 2010, virtual reality (VR) and augmented reality (AR) were integrated, making laboratories more interactive and effective.
- During the COVID-19 pandemic (2020) uses increased significantly.





Virtual laboratories are currently evolving with technologies such as AI, Metaverse, and IoT.

Proposed Virtual Lab Resource Centre

Concept

It will be a 'digital knowledge hub' with the primary objective of "democratizing the laboratory." It is based on the concept that practical knowledge should not be depend to a physical building. The centre will adopt a 'bottom-to-top' approach, meaning that content development will begin at the grassroots level (local needs of students and teachers) and progress to national standards. It will provide world-class simulations across all subjects and all Indian languages. It will promote experiential learning,

digital integration into school education, and develop critical and problem-solving thinking, with accessibility from anywhere and at any time for all.

Methodology

- **Bottom-to-top content development:** Content will be created based on local problems and regional scientific examples. Experiments will be simplified and made interesting, tailored to the understanding of children from rural areas.
- **Cloud-based access:** Through a high-speed server, students from will be able to log in and conduct virtual experiments.
- **Mandatory Usage:** This will be made a mandatory part of the curriculum, not just an option. Teachers will be required to teach through virtual labs for a certain number of hours each week.
- **Interactive Simulation:** In this programme, students will not only watch videos but will also be able to observe the results of experiments by changing the parameters themselves, which will develop a 'scientific attitude' in them.

Operational and Administrative Structure

- **Institutional Structure:** According to your concept, it should function as an autonomous body. While it will coordinate with NCERT and the Ministry of Education, its decision-making power will be independent so that technological changes can be implemented quickly.
- **The Chairperson:** The Chairperson should not be an 'administrator' but an 'eminent scientist' or 'Ed-Tech Expert' appointed directly by the Central Government. He or she will be assisted by a council of technical experts, educationists, and psychologists.
- **Working Days:** Since it is a digital institution, its servers and support systems will be available 24x7, 365 days a year. While administrative and training functions will operate according to the national calendar, it will provide 'anytime-anywhere' access for students.

Implementation

It can be implemented in the following phases:

1. **National Digital Infrastructure:** First, a central data centre will be established from where content will be streamed.
2. **Teacher Training (Master Trainers):** 'Master Trainers' will be created in each district to teach teachers how to effectively use and teach through virtual labs.
3. **Pilot Project:** In the first phase, it will be implemented in rural and semi-urban areas where physical labs are most scarce.
4. **Curriculum Integration:** It will be added as a 'compulsory practical' in the curriculum of all state boards and the CBSE.
5. **Assessment:** Performance in virtual lab experiments will also be included in the annual examination marks of students.

In other words, this model is a living example of "minimum government" (less physical infrastructure) and "maximum governance" (widespread access and transparency). The VLRC is not only cost-effective, but also capable of providing world-class scientific experience to even the remotest students in the country, a prerequisite for developing a "developed India."

Role of Virtual Labs in Developing India and Governance Reforms

Successful implementation of the National Education Policy 2020 is essential to achieving the goals of a developed India @ 2047. it will significantly contribute to school governance and educational quality by integrating technology and innovation into education. Virtual laboratories are an important part of this policy. It has been developed under the National Mission on Information and Communication Technology in Education (NME-ICT), a project launched in 2009. The Virtual Lab for School Education, developed jointly by CDAC, Amrita Vishwavidyapeetham, and the National Council of Educational Research and Training, is being disseminated and used through the open educational resources platform DIKSHA (Digital Infrastructure for Knowledge Sharing), a national platform developed by the education ministry of India and launched in 2017. The DIKSHA platform aims to provide quality e-learning content and resources to teachers, students, and parents. It focuses on making education more inclusive and accessible, particularly through digital means. School education has developed a tradition of teaching science exclusively through hands-on learning, which can be overcome by using virtual labs, which offer many advantages: accessibility, low cost, a safe environment, and student-paced learning. Apart from this, the role of virtual lab can be understood through the following points-

- **Educational Equity and Inclusiveness:** A developed India means that every citizen of India should be able to take advantage of every advantage and resource and contribute shoulder to shoulder in India's development. When we talk about education, it means that even a student from the remotest village of the country should have access to the same resources as a student from a big city. Virtual Lab is an Internet-based software that can be used in a diverse geographical area like India, where building and maintaining a physical laboratory is a cost-prohibitive challenge. To overcome this problem, a high-quality laboratory can be made available to all students through virtual labs via the Internet, fulfilling the principle of equitable education in which lack of resources does not hinder the development of any student.
- **Scientific temper and innovation:** A nation's development depends on the skills, social attitude, scientific outlook, and innovation of its citizens. Virtual labs inspire students, who are the future of the country, to learn by doing. This reduces the fear of chemical explosions or equipment breakdowns in a real laboratory, allowing students to practice multiple times without fear. This enhances students' creativity, and abstract scientific concepts can be easily understood through 3D simulations, laying the foundation for scientific thinking.
- **Economic and administrative efficiency:** Just as minimal interference in the process is essential for the successful completion of any task, the principle of "minimum government, maximum governance" holds immense relevance for the development of a nation. Virtual labs negate the millions of rupees spent on building physical laboratories, purchasing equipment and chemicals, and maintaining them. This allows millions of students to access and experience the lab simultaneously. It helps school administrations monitor student progress, the government monitor school progress, and manage resources, and establishes an effective communication system between the government and schools. Virtual labs can be operated through a single management entity.
- **Skill Development and Global Competitiveness:** A key goal of Viksit Bharat @2047 is to make India a world knowledge superpower by 2047. To achieve this objective, it is crucial for Indian students to be technologically proficient and equipped with 21st-century skills. Through virtual Lab, users not only learn science but also master digital literacy by adopting technical knowledge and

software operations. It generates scientific curiosity in students due to which they become competitive on the global platform and make important contributions to the developed nation.

- **Virtual Lab Resource Centre:** The Virtual Lab Resource Centre will serve as a central pillar in realizing the principle of "maximum governance and minimum government" essential for a developed India. It will provide digital services from a single location, eliminating the complex and costly process of establishing physical laboratories in each school. This will ensure social justice and educational equity through accessibility and democratization of resources in society. The Virtual Lab Resource Centre (VLRC) will function as a knowledge hub where practical knowledge of all subjects will be stored in different languages, through which every student of the country will get equal and high quality teaching-learning and there will be equity and equality in the education of the country. The VLRC will conduct workshops and online training modules for teachers at regular intervals and will be a single window support centre through which teachers will be able to operate digital devices effectively. Virtual labs can easily monitor the number of students and teachers using them, bringing transparency to educational governance. Virtual lab resource centres will be a "Force Multiplier" for a developed India, bridging the gap in practical knowledge through administrative reform and ensuring maximum efficiency with minimum resources.

Conclusion

The present research study clearly demonstrates that modernizing and democratizing education is essential to realizing the vision of a "Developed India @ 2047." Virtual labs offer an effective and powerful solution to overcome major barriers such as the high cost and lack of resources of physical laboratories in rural and semi-urban areas. This technology is not only cost-effective but also enables the successful implementation of the administrative principle of "minimum government and maximum governance" within the educational system. Through the proposed concept of the "Virtual Lab Resource Centre" (VLRC), even students in the remotest corners of the country will be able to access world-class scientific experiences and equitable education. Ultimately, the Virtual Lab is not just a technological tool, but a means of administrative reform that will prove to be a "Force Multiplier" in developing a scientific outlook among students and making India a "Global Knowledge Superpower."

Suggestions

1. **Establishment of an autonomous body:** The Virtual Lab Resource Centre (VLRC) should be established as an autonomous body to enable rapid implementation of technological changes without administrative delays.
2. **Compulsory inclusion in the curriculum:** The use of virtual labs should be made compulsory as a practical subject in the curriculum of all state boards and the CBSE, rather than making it merely optional.
3. **Teacher training and empowerment:** Master trainers should be created in each district to train teachers at regular intervals on the effective operation of virtual labs.
4. **Bottom-to-top approach:** Content should be developed in 22 Indian languages, keeping in mind local needs and regional scientific examples, making it accessible to children in rural areas.
5. **Integration of the assessment system:** Performance of experiments conducted through virtual labs should be compulsorily included in students' annual examination results and grading.

6. **Real-time monitoring:** Student and teacher participation should be continuously monitored through digital dashboards to ensure transparency and accountability in educational governance.
7. **Expansion of the pilot project:** It should first be implemented in remote and resource-poor areas where the lack of physical laboratories is the greatest.

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