



A. P. J. ABDUL KALAM'S VISION ON SCIENCE AND TECHNOLOGY-BASED EDUCATION FOR NATIONAL DEVELOPMENT

Md. Dablu Sk¹, Dr. Dilip Kumar Mondal²

¹Research Scholar, Department of Education, West Bengal State University, Barasat (W.B), India,

²Associate Professor & Head, Department of Education, Mrinalini Datta Mahavidyapith, Birati (W.B), India

ABSTRACT

This study examines the vision of A. P. J. Abdul Kalam on science and technology-based education and its significance for national development. Using a qualitative and descriptive methodology based on secondary sources, the study analyzes key dimensions such as the concept of a knowledge society, the role of science and technology in economic and social progress, and the changing responsibilities of teachers in a digital learning environment. The findings indicate that Kalam's vision advocates an education system that moves beyond rote learning to foster scientific temper, creativity, innovation, and problem-solving abilities among learners. It further highlights that the effective integration of technology can enhance access, inclusivity, and quality in education, thereby contributing to the development of skilled human resources essential for a self-reliant nation. However, the study also identifies significant challenges, including the digital divide, infrastructural gaps, and inadequate teacher preparedness, which hinder the practical realization of this vision. The paper suggests that aligning curriculum, policy, and classroom practices with contemporary reforms such as the National Education Policy 2020 can strengthen the implementation of technology-based education. The study concludes that Kalam's educational philosophy offers a comprehensive and relevant framework for transforming education into a powerful instrument for building a knowledge-driven and globally competitive nation.

KEYWORDS: Science and Technology-Based Education, National Development, Knowledge Society, Digital Inclusion, Educational Innovation, A. P. J. Abdul Kalam

1. INTRODUCTION

Dr. A. P. J. Abdul Kalam, widely known as the "Missile Man of India," envisioned education as the most powerful instrument for transforming a developing nation into a knowledge-based society. His educational philosophy was deeply rooted in the integration of science and technology with human values, creativity, and innovation. He believed that education should not merely focus on the transmission of knowledge but aim to nurture young minds to think critically, solve real-life problems, and contribute meaningfully to national development (Kalam, 2002).

Kalam emphasized that science and technology-based education plays a crucial role in building a self-reliant and developed nation. He advocated for research-oriented learning, practical application of knowledge, and fostering innovation in students. According to him, creativity leads to thinking, thinking generates knowledge, and knowledge ultimately contributes to national growth (Kalam & Rajan, 1998). In this context, educational institutions should act as centers of innovation, promoting scientific temper, technological competence, and ethical responsibility among learners.

Furthermore, Kalam's vision links education with national development by emphasizing economic progress, technological self-sufficiency, and global competitiveness. He believed that empowering youth through quality education in science and technology would enable India to achieve sustainable development and emerge as a global leader. His ideas continue to inspire policymakers, educators, and researchers to view

education as a dynamic tool for nation-building in the 21st century.

2. CONCEPTUAL FRAMEWORK OF SCIENCE AND TECHNOLOGY-BASED EDUCATION

The conceptual framework of this study includes the integration of science and technology within the curriculum, the effective use of digital tools in teaching-learning processes, the promotion of innovation and creativity, and the development of a scientific temper among learners, all of which align with A. P. J. Abdul Kalam's vision of education for national development.

The integration of science and technology in the curriculum, the use of modern digital tools and resources, the promotion of research and innovation, and the development of scientific temper among learners. It also emphasizes learner-centered pedagogy, where students are encouraged to question, explore, and experiment. In addition, the role of teachers as facilitators and mentors is crucial in guiding students to effectively use technology while nurturing values such as responsibility, collaboration, and ethical awareness. Infrastructure support, such as digital libraries, laboratories, and internet connectivity, also forms an essential part of this framework.

The scope of science and technology-based education is broad and transformative. It extends from formal classroom settings to distance and digital learning platforms, making education more accessible and inclusive. In line with Kalam's vision, this approach has the potential to bridge the gap between knowledge and application, promote lifelong learning, and contribute to the



development of a skilled and innovative workforce. Ultimately, it plays a significant role in building a self-reliant, knowledge-based nation capable of achieving sustainable development and global competitiveness.

3. REVIEW OF LITERATURE

In the context of science and technology-based education for national development, the ideas of A. P. J. Abdul Kalam have been critically examined by **Jindal (2021)**, who highlighted the growing need for technology-enabled learning in response to the limitations of time, space, and the rapid obsolescence of knowledge in modern scientific fields. The study emphasizes that distance education has become increasingly important, creating a demand for diverse courses and flexible learning systems. To address these challenges, Kalam (2005) strongly advocated for the development of digital library systems that can ensure seamless and universal access to knowledge resources across institutions. He envisioned a system where students could easily access books and academic materials online, supported by tele-education tools that enhance learning opportunities beyond traditional classrooms. This perspective reflects Kalam's broader vision of building a knowledge society through accessible, technology-driven education that contributes to national development.

In relation to science and technology-based education for national development, **Chhabra, (2019)** examined the educational ideology of A. P. J. Abdul Kalam with special reference to women's education and the contemporary relevance of scientific learning. The study highlights Kalam's belief that science, when guided by reasoning and enriched with spirituality, becomes a powerful force for societal advancement. He viewed science and technology as essential drivers for national growth and global competitiveness, emphasizing the need to nurture scientific temper from an early age by encouraging children to ask questions and explore their curiosity. Chhabra further noted that Kalam consistently advocated for motivating young minds toward scientific inquiry, linking creativity with a questioning attitude. His broader vision, reflected in initiatives like *India 2020*, underscores the integration of technological progress with human values to build a developed nation. Thus, the study reinforces that Kalam's approach to education promotes innovation, inclusivity, and holistic development as key components of national progress.

Lal, (2011) analyzed the educational ideas of A. P. J. Abdul Kalam and emphasized the growing importance of technology in learning. The study notes that Kalam advocated for equipping students and universities with modern technological resources to enhance educational quality, while also highlighting that the role of teachers would become even more significant. He envisioned technology as a tool to expand the reach of effective teaching, enabling quality education to be accessible across regions, thereby supporting national development.

While existing studies highlight Kalam's emphasis on technology-enabled education and its social relevance, they offer limited critical insight into the practical challenges

associated with implementing such a vision across diverse socio-economic and institutional contexts. This gap indicates the need for a more comprehensive analysis that connects Kalam's educational ideas with present-day realities and policy frameworks.

4. OBJECTIVES OF THE STUDY

1. **To examine the vision of A. P. J. Abdul Kalam on science and technology-based education** and understand its core principles in shaping a knowledge-driven society.
2. **To analyze the role of science and technology in promoting national development** as reflected in Kalam's educational ideas and their relevance in the present context.
3. **To explore the implications of Kalam's educational vision for modern teaching-learning practices**, particularly in fostering innovation, scientific temper, and accessible education for all.

5. METHODOLOGY OF THE STUDY

The present study adopts a qualitative and analytical research design based on secondary sources. Relevant books, research articles, policy documents, and official reports were carefully selected on the basis of their credibility, relevance, and alignment with the objectives of the study. A thematic analysis approach was employed to examine key ideas related to science and technology-based education, knowledge society, and national development, enabling a systematic interpretation of Kalam's vision in the contemporary educational context.

For the analysis, the study employs content analysis as the main method to interpret and organize the collected information. Key themes related to science and technology in education, innovation, digital learning, and national development have been identified and systematically examined. The researcher has carefully analyzed these themes to understand the relevance and applicability of Kalam's vision in the present educational context.

This methodological approach helps in presenting a clear and meaningful interpretation of Kalam's educational philosophy without involving any primary data collection. It ensures that the study remains focused on conceptual understanding and theoretical analysis, making it suitable for exploring the role of science and technology-based education in fostering national development.

6. KALAM'S VISION OF A KNOWLEDGE SOCIETY

The vision of a knowledge society, as articulated by A. P. J. Abdul Kalam, places education at the core of national transformation. He believed that a nation's true strength lies not merely in its natural resources or economic wealth, but in the intellectual capacity, creativity, and skills of its people. In this context, a knowledge society is one where individuals are empowered with education, guided by values, and equipped with scientific and technological capabilities to contribute productively to society. Kalam envisioned such a society as



inclusive, innovative, and forward-looking, where knowledge becomes the driving force behind development.

Education, according to Kalam, is the primary foundation for building this knowledge-driven nation. He emphasized that the education system should go beyond rote learning and focus on developing critical thinking, problem-solving abilities, and a spirit of inquiry among learners. He believed that when students are encouraged to ask questions, explore ideas, and engage in experiential learning, they develop a deeper understanding of concepts and become capable of applying knowledge in real-life situations. Such an education system nurtures not only intellectual growth but also character, responsibility, and a sense of national commitment.

Innovation is another key pillar in Kalam's vision of a knowledge society. He consistently highlighted that creativity leads to innovation, and innovation, in turn, drives progress. He encouraged young minds to think differently, take risks, and work towards finding solutions to real-world problems. In his view, educational institutions should act as centers of innovation where research, experimentation, and discovery are actively promoted. By fostering an environment that supports innovation, a nation can generate new ideas, technologies, and solutions that address societal challenges and enhance economic development.

Technology plays a crucial role in connecting education and innovation in Kalam's vision. He strongly advocated for the integration of modern technologies into the teaching-learning process to make education more accessible, effective, and inclusive. Tools such as digital platforms, virtual classrooms, and online resources can bridge geographical barriers and provide equal learning opportunities to students across urban and rural areas. Kalam also emphasized the importance of digital libraries and tele-education systems, which can ensure that knowledge is available to all, regardless of location. Through the effective use of technology, education can reach the remotest corners of the country, thereby promoting equality and inclusiveness.

Furthermore, Kalam believed that the synergy between education, innovation, and technology is essential for national development. A well-educated and technologically skilled population can contribute to economic growth, scientific advancement, and global competitiveness. He envisioned a nation where knowledge is continuously created, shared, and applied for the common good. This requires collaboration among educational institutions, research organizations, industries, and policymakers to create a strong ecosystem of learning and innovation.

In essence, Kalam's vision of a knowledge society is holistic and transformative. It emphasizes the development of human potential through quality education, the encouragement of innovation and creativity, and the effective use of technology to expand opportunities. By aligning these elements, a nation can move towards sustainable development, self-reliance, and global leadership. His vision continues to serve as a guiding

framework for building a future where knowledge becomes the most valuable resource for national progress.

7. ROLE OF SCIENCE AND TECHNOLOGY IN NATIONAL DEVELOPMENT

Science and technology play a crucial role in strengthening the economic foundation of a nation. In the vision of A. P. J. Abdul Kalam, technological advancement is a key driver of productivity, industrial growth, and global competitiveness. Innovations in sectors such as agriculture, industry, and information technology enhance efficiency, create employment opportunities, and promote self-reliance. A technology-driven economy not only accelerates growth but also enables a nation to compete effectively in the global arena, ensuring long-term sustainability and progress.

From a social perspective, science and technology significantly improve the quality of life by addressing basic human needs and reducing inequalities. Advancements in healthcare, communication, and infrastructure help in delivering essential services more efficiently and inclusively. Kalam emphasized that technology should be used to bridge the gap between urban and rural areas, making education, healthcare, and information accessible to all sections of society. In this way, scientific and technological progress contributes to social equity, empowerment, and overall human development.

In the field of education, science and technology have transformed the teaching-learning process by making it more interactive, flexible, and accessible. The use of digital platforms, e-learning tools, and virtual resources allows students to access knowledge beyond the boundaries of traditional classrooms. Kalam strongly advocated for the development of scientific temper among learners, encouraging curiosity, inquiry, and innovation. This integration of technology in education not only enhances learning outcomes but also prepares individuals to actively participate in national development and build a knowledge-based society.

8. ROLE OF TEACHERS IN TECHNOLOGY-BASED EDUCATION

In the context of technology-based education, the role of teachers has undergone a significant transformation, yet it remains central to the success of the teaching-learning process. As envisioned by A. P. J. Abdul Kalam, technology does not replace teachers; rather, it strengthens their ability to guide, inspire, and support learners. Teachers are no longer just transmitters of information but facilitators who help students navigate vast digital resources, develop critical thinking skills, and apply knowledge in meaningful ways. Their role is to create a learning environment where technology enhances understanding rather than becoming an end in itself.

Teachers play a vital role in integrating technology effectively into the classroom. This includes selecting appropriate digital tools, designing interactive learning experiences, and encouraging students to engage with technology responsibly. They help learners develop essential skills such as problem-solving, collaboration, and digital literacy, which are necessary in a technology-based world. Moreover, teachers ensure that the



use of technology remains aligned with educational objectives, making learning more engaging, personalized, and relevant to real-life situations.

Another important responsibility of teachers is to nurture values and human qualities alongside technological skills. While technology provides access to information, it is the teacher who shapes attitudes, ethics, and social responsibility among students. Kalam emphasized that teachers should inspire curiosity, encourage questioning, and motivate students to explore and innovate. By balancing technological integration with value-based education, teachers contribute to the holistic development of learners.

Furthermore, in a diverse and unequal society, teachers act as bridges to ensure inclusive education. They support students who may face challenges in accessing or using technology and help reduce the digital divide. Through guidance and continuous support, teachers make technology-based education more accessible and effective for all learners. Thus, in line with Kalam's vision, teachers remain the backbone of education, playing a crucial role in transforming technology into a meaningful tool for learning and national development.

9. CHALLENGES AND CONSTRAINTS IN IMPLEMENTATION

While science and technology-based education holds great promise for national development, its effective implementation faces several challenges and constraints. One of the most significant issues is the digital divide, which creates a gap between those who have access to modern technologies and those who do not. In a diverse country like India, many students in rural and economically weaker sections lack access to devices, reliable internet connectivity, and digital literacy. As highlighted in the vision of A. P. J. Abdul Kalam, although technology can democratize education, unequal access can instead widen existing disparities if not addressed properly.

Another major constraint is the lack of adequate infrastructure in educational institutions. Many schools and colleges still struggle with insufficient technological facilities such as computer labs, digital libraries, smart classrooms, and stable electricity supply. Without these basic requirements, the integration of technology into the teaching-learning process becomes difficult. Additionally, there is often a shortage of trained teachers who are confident in using digital tools effectively. This gap in teacher preparedness limits the potential of technology-based education and affects the quality of learning outcomes.

Access inequality also extends beyond infrastructure to include differences in language, socio-economic background, and regional development. Students from marginalized communities may find it difficult to adapt to technology-based learning due to limited exposure and support. Furthermore, the rapid pace of technological change makes it challenging for institutions to keep their systems updated, leading to issues of obsolescence. These challenges highlight the need for inclusive policies, continuous teacher training, and investment in infrastructure to ensure that the benefits of science and

technology-based education reach all sections of society and contribute meaningfully to national development.

10. FINDINGS AND DISCUSSION

The analysis suggests that although Kalam's vision of science and technology-based education is conceptually robust and forward-looking, its implementation remains uneven due to infrastructural limitations, digital disparities, and varying levels of institutional preparedness across regions. One of the key findings of the study is that Kalam placed strong emphasis on developing a knowledge-based society where education goes beyond theoretical learning and focuses on building skills, scientific temper, and problem-solving abilities. His approach highlights that the integration of science and technology in education can significantly enhance the quality of human resources, which in turn contributes to economic growth and global competitiveness.

Another important finding is the central role of technology in making education accessible, flexible, and inclusive. The study shows that tools such as digital learning platforms, tele-education, and digital libraries can bridge geographical and social barriers, enabling equal learning opportunities for all. However, the discussion also brings out a critical gap between vision and practice, as challenges like the digital divide, inadequate infrastructure, and lack of trained teachers continue to limit the effective implementation of technology-based education. This indicates that while Kalam's vision is highly relevant, its success depends on systematic planning, policy support, and investment in educational resources.

The study further finds that teachers remain the backbone of the education system even in a technology-driven environment. Rather than replacing teachers, technology enhances their role as facilitators, mentors, and motivators. Kalam's emphasis on encouraging curiosity, questioning, and innovation among students underscores the importance of teacher guidance in developing scientific temperament. At the same time, the need for continuous professional development of teachers emerges as a crucial factor for effectively integrating technology into teaching-learning practices.

In discussion, it becomes evident that the successful realization of Kalam's vision requires a balanced approach that combines technological advancement with human values and inclusive practices. The synergy between education, innovation, and technology has the potential to transform India into a self-reliant and knowledge-driven nation. However, addressing existing challenges such as access inequality and infrastructure gaps is essential to ensure that the benefits of this transformation reach all sections of society. Overall, the findings suggest that Kalam's vision provides a strong conceptual and practical framework for rethinking education as a catalyst for sustainable national development.

11. EDUCATIONAL IMPLICATIONS OF KALAM'S VISION

The educational vision of A. P. J. Abdul Kalam offers significant practical implications for curriculum design, educational policy, and classroom practices. At the curriculum



level, his ideas call for a shift from content-heavy and examination-oriented structures to more dynamic, skill-based, and application-oriented learning. The curriculum should integrate science and technology across disciplines, promote interdisciplinary learning, and include components that foster creativity, innovation, and problem-solving. Emphasis on research-based activities, project work, and experiential learning can help bridge the gap between theoretical knowledge and real-world application, thereby preparing learners for the demands of a knowledge-driven society.

From a policy perspective, the vision of A. P. J. Abdul Kalam closely resonates with the principles of the National Education Policy 2020, which emphasizes holistic, flexible, and technology-integrated education. NEP 2020 advocates for the development of robust digital infrastructure, including smart classrooms, virtual labs, and digital libraries, to ensure equitable and inclusive access to quality education across diverse regions. It also stresses the importance of bridging the digital divide by promoting the use of technology in both urban and rural settings. Furthermore, the policy highlights continuous professional development of teachers through training in digital pedagogy and innovative teaching methods. In addition, NEP 2020 encourages multidisciplinary learning, collaboration between educational institutions and industries, and the promotion of research and innovation through initiatives such as the National Research Foundation. Thus, the policy framework strongly aligns with Kalam's vision by aiming to create an inclusive, technology-driven, and knowledge-based education system that supports national development.

In terms of classroom practices, Kalam's vision advocates for a learner-centered and inquiry-based approach to teaching. Teachers are expected to act as facilitators who encourage questioning, exploration, and independent thinking among students. The use of digital tools, multimedia resources, and interactive platforms can make learning more engaging and effective. Classroom activities should promote collaboration, critical thinking, and problem-solving, enabling students to actively participate in the learning process. At the same time, equal importance should be given to the development of values, ethics, and social responsibility. By aligning curriculum, policy, and classroom practices with Kalam's vision, the education system can play a transformative role in fostering innovation, inclusivity, and national development.

12. SUGGESTIONS AND RECOMMENDATIONS

To effectively implement the educational vision of A. P. J. Abdul Kalam within the framework of a digitally evolving India, the following recommendations are proposed:

1. **Strengthening Digital Infrastructure with Equity Focus:** The success of technology-based education depends on reliable digital infrastructure. It is essential to expand high-speed internet connectivity, provide affordable digital devices, and develop smart learning environments, particularly in rural and marginalized areas. Bridging the digital divide must remain a priority to ensure inclusive participation in the learning process.

2. **Continuous Professional Development of Teachers:** Teachers should be equipped with digital competencies and pedagogical skills to integrate technology effectively in classrooms. Regular training, workshops, and exposure to innovative teaching practices will enable teachers to act as facilitators of knowledge, aligning with Kalam's emphasis on inspiring and guiding learners.
3. **Curriculum Reform for Innovation and Skill Development:** The curriculum should be redesigned to promote scientific temper, creativity, and problem-solving abilities. Integrating STEM education, project-based learning, and research-oriented activities will help learners apply knowledge in real-life contexts and contribute meaningfully to national development.
4. **Promoting Collaboration and Research Ecosystem:** Strong linkages between educational institutions, industries, and research organizations should be encouraged to foster innovation and skill development. Initiatives that support start-ups, incubation centers, and student-led research can create a culture of inquiry and technological advancement in line with Kalam's vision of a knowledge society.

13. CONCLUSION

The educational vision of A. P. J. Abdul Kalam underscores the transformative potential of science and technology in shaping a progressive and self-reliant nation. This study highlights that integrating scientific knowledge, technological innovation, and value-based education can significantly enhance the quality and relevance of the education system. Kalam's emphasis on nurturing curiosity, promoting research, and ensuring inclusive access to education reflects a forward-looking approach essential for national development.

In the contemporary context of Digital India, his vision remains highly relevant as the nation strives to build a knowledge-driven society capable of addressing global challenges. By aligning educational practices with technological advancements, strengthening institutional frameworks, and empowering both teachers and learners, India can move toward sustainable growth and innovation. Thus, Kalam's ideas continue to serve as a guiding force for reimagining education as a powerful instrument for national progress and global competitiveness.

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