Rs. 50.00
ISSN-0566-2257

UNIVERSITY NEWS

A Weekly Journal of Higher Education

Association of Indian Universities

Vol. 64 • No. 07 • February 16-22, 2026

Special Issue

on

CREATING ARTIFICIAL INTELLIGENCE AND QUANTUM-ENABLED HIGHER EDUCATION INSTITUTIONS

on the occasion of

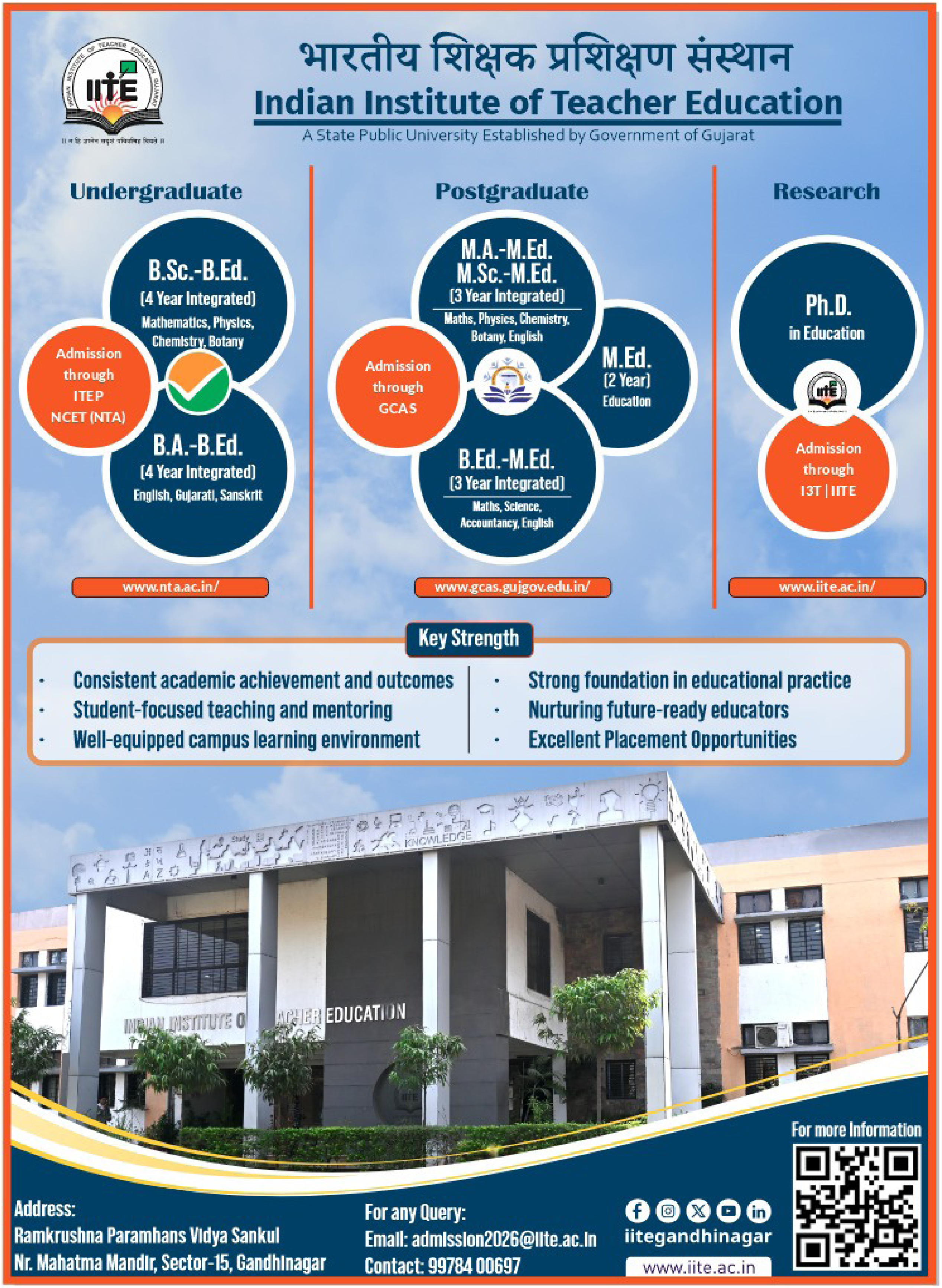
AIU CENTRAL ZONE VICE CHANCELLORS' MEET—2025-26

hosted by

OSMANIA UNIVERSITY, HYDERABAD

on

FEBRUARY 19-20, 2026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(FEBRUARY 19-20, 2026)

Association of Indian Universities

&

Osmania University, Hyderabad

Welcome

the delegates to the

AIU Central Zone Vice Chancellors' Meet—2025-26

(February 19-20, 2026)

From the President's Desk...

I am delighted to extend a warm welcome to all the esteemed Vice Chancellors and distinguished participants attending the *AIU Central Zone Vice Chancellors Meet-2025-26* on the theme '*Creating AI & Quantum enabled HEIs'* to be held at *Osmania University, Hyderabad, Telangana,* during *January 19-20, 2026*.

Creating AI & Quantum-enabled Higher Education Institutions (HEIs) is essential for advancing knowledge while responding thoughtfully to the demands of a rapidly changing world. By integrating these technologies into teaching, research, and institutional practices, HEIs can foster deeper inquiry, interdisciplinary collaboration, and innovative problem solving. Such environments equip learners and scholars not only with advanced technical capabilities but also with the intellectual flexibility needed to engage with complex scientific and societal questions.

The theme of this ***AIU Central Zone Vice Chancellors' Meet 2025-26***, ***'Creating AI & Quantum-enabled HEIs'*** is especially relevant in today's rapidly changing world. AI & Quantum enabled HEIs also serve as spaces where technological progress is guided by ethical reflection and social responsibility. These institutions can cultivate values such as inclusivity, equity and public good by encouraging critical engagement with the implications of emerging technologies. In doing so, they reaffirm the role of higher education as a steward of knowledge that advances human well-being, democratic values, and sustainable development.

The *AIU Central Zone Vice Chancellors' Meet 2025–26* provides an important forum for Vice Chancellors, educators, and policymakers to come together, reflect on the ongoing transformations in higher education, and collectively shape a shared vision for the future. Centered on the theme *'Creating AI & Quantum Enabled Higher Education Institutions',* the Meet underscores the growing responsibility of universities to thoughtfully integrate emerging technologies in ways that enrich teaching and learning, advance meaningful research, and enhance institutional resilience. It is hoped that the deliberations will foster constructive dialogue, encourage forward-looking reforms, and strengthen our collective commitment to building institutions that harmonise technological progress with social responsibility and environmental stewardship. Such a balanced and inclusive approach will enable higher education institutions to nurture graduates who are not only technologically proficient but also conscientious citizens dedicated to sustainable development.

On behalf of the *Association of Indian Universities*, I extend my sincere thanks to *Osmania University, Hyderabad, Telangana,* for hosting this meaningful conference and to all the distinguished Vice Chancellors of the *Central Zone* and delegates for their generous participation. Your presence and engagement add great value to this dialogue.

I look forward to the meaningful exchange of ideas and the spirit of collaboration that will shape the discussions during this Meet. The insights, reflections, and experiences shared by the participants will play a valuable role in guiding the development of a higher education system that is more sustainable, inclusive, and responsive to the needs of the future.

Vinay Kumar Pathak
President
Association of Indian Universities, New Delhi
E-mail: president@aiu.ac.in

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Setting the Tone for AIU Central Zone Vice Chancellors' Meet —2025-26 on *Creating AI & Quantum-enabled HEIs*

Pankaj Mittal*

The Association of Indian Universities (AIU), one of the premier apex higher education institutions of the Country established in 1925, is a research-based policy advice institution to the Government of India in the field of Higher Education, Sports & Culture and internationalisation. Dr. Sarvepalli Radhakrishnan, Dr. Zakir Hussain and Dr. Syama Prasad Mukherjee are among some of the stalwarts who served AIU as its president. It currently has a membership of 1145 universities including 20 international universities. Since its inception, it has been playing a vital role in shaping Indian higher education. Being an apex institution, it constitutes an integral part of decision-making and facilitates cooperation and coordination among Indian universities and liaise between the universities and the Government and also national and international bodies of higher education in other countries in matters of common interest. Also, AIU plays a dynamic role in shaping Indian higher education by being a research-based policy advice institution to the Government of India in the fields of Higher Education, Sports, and Youth Affairs & Culture. As a National Sports Promotion Organization (NSPO) it promotes sports among Member-Universities.

One of the significant activities of the AIU is to convene the Vice Chancellors Meets at the Zonal and National levels to discuss various issues related to higher education. India is a country with a large geographical area. For ease of reaching out, AIU has grouped the member HEIs into 5 zones i.e., North, South, East, West and Central. Thus, 5 Zonal Meets and one National Conference of Vice Chancellors are organised annually. These Meets are important platforms not only to discuss the significant issues of higher education but also to play a catalytic role in finding solutions for different problems of higher education through collective wisdom. Further, AIU carries forward the voice of the participating leaders of higher education to appropriate agencies and authorities for their consideration. Every year in the National Conference of Vice Chancellors, a specific theme that is of topical significance for the higher education community is taken up for discussion. As a run-up, subthemes related to the main theme are discussed in the AIU Zonal Vice Chancellors Meets.

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Themes for The AIU Zonal Vice Chancellors Meet –2025-26

Based on current drifts and latent progresses, it is the right time to discuss the role of India in shaping the future of higher education. Therefore, for the year 2025-26, AIU has chosen the main theme ***'Shaping Self-Reliant Bharat through Knowledge and Innovation'*** for the ***AIU 100th National Conference of Vice Chancellors*** and all the five Zonal Vice Chancellors Meets for the year *2025-26*. Under this overarching theme, the following themes are proposed for the AIU's Zonal Conferences:

North Zone: ***Integrating Traditional Wisdom in Curriculum and Research.***

East Zone: ***Promoting Sustainability and Social Responsibility in HEIs.***

South Zone: ***Promoting Entrepreneurship & Startups in Higher Education Institutions (HEIs).***

Central Zone: ***Creating AI & Quantum-Enabled HEIs.***

West Zone: ***Self-reliant Bharat through Swadeshi, Economic Patriotism and Techno-nationalism.***

Creating AI and Quantum enabled Higher Education Institutions (HEIs) is essential to prepare students for a rapidly changing world shaped by advanced technologies. By embedding Artificial Intelligence and Quantum Computing into education, HEIs can transform the way students learn, think and innovate. These technologies enhance research capabilities, personalise learning experiences, and encourage interdisciplinary problem solving, enabling graduates to develop critical skills that are highly relevant to future careers in science, technology and emerging industries.

Beyond academic advancement, AI and quantum-enabled HEIs can play a powerful role in national progress and societal well-being. They can serve as centers of innovation, supporting industry partnerships, entrepreneurship, and indigenous technology development. At the same time, such institutions can promote ethical and responsible use of advanced technologies by emphasising digital inclusion, transparency, and sustainability. In this way, AI and Quantum-enabled HEIs not only strengthen technological capacity but also contribute to building a more equitable, resilient and forward-looking society.

Format And Approach

The two-day event will include the Inaugural Session, Session on Interface with Officers from Apex Bodies, i.e. UGC, AICTE, NAAC and ICAR, AIU Business Session, Valedictory Session and 3 Technical Sessions to discuss the concerned topics.

The three Technical Sessions will be held on the following sub-themes:

Technical Session 1: Integrating AI and Quantum Technologies into Higher Education Curriculum, Pedagogy and Governance

Technical Session 2: AI-Driven Indigenous Research and Product Development

Technical Session 3: Global Regulatory Framework for AI and Ethics in AI

Each Technical Session will be approximately 1 Hour and 30 minutes. In each Session, there will be 1 chairperson and 3 speakers, including experts from the government and HEIs. Presentations will be followed by an interaction and Question and Answer session. Based on deliberations, a commitment statement will be framed for the universities to further the cause of Higher Education in India.

Technical Session Details

The following three sub-themes shall be deliberated upon during the Technical Session of the ***AIU Central Zone Vice Chancellors Meet 2025-26***:

Technical Session 1: Integrating AI and Quantum Technologies into Higher Education Curriculum, Pedagogy and Governance

Integrating Artificial Intelligence (AI) and Quantum Technologies into higher education is not only about keeping pace with technological change but also about preparing students to engage thoughtfully and creatively with the future. By weaving these emerging fields into the curriculum, universities can inspire learners to think critically about how technology shapes the world and their role in it. Courses that blend science, ethics, and social understanding help students see AI and quantum tools not just as technical instruments, but as extensions of human curiosity and problem-solving. Through hands-on projects, collaborative research, and real-world applications, learners can develop both the technical expertise and the moral awareness needed to use these technologies responsibly and imaginatively.

At the same time, integrating AI and quantum technologies into pedagogy and governance transforms how education itself operates. AI driven learning platforms can personalize education, making it more inclusive and responsive to individual needs, while governance structures that embrace transparency and ethical oversight ensure that innovation remains aligned with human values. By fostering collaboration among educators, researchers, industry experts, and policymakers, universities can build ecosystems that encourage innovation grounded in empathy and purpose. The integration of AI and Quantum Technologies becomes more than a technological upgrade it becomes a movement toward a more reflective, humane, and forward-looking model of education.

Technical Session 2: AI-Driven Indigenous Research and Product Development

AI-driven indigenous research and product development offer a powerful way to blend modern technology with the wisdom and creativity rooted in local cultures. When artificial intelligence is used to study, preserve, and enhance indigenous knowledge, it not only accelerates innovation but also ensures that progress remains meaningful and inclusive. AI can help decode traditional farming practices, analyse native medicinal systems, or revitalise endangered languages, turning centuries of lived experience into solutions for today's challenges. By valuing both advanced computation and human heritage, this approach nurtures self-reliance while keeping innovation connected to community life, ethics, and sustainability.

At the same time, fostering AI-based indigenous product development within universities and research institutions builds bridges between science and society. When researchers, students, and local communities collaborate, technology becomes a shared tool for empowerment rather than exclusion. Innovation hubs and incubators that focus on indigenous problem-solving can generate products that serve real needs, tools for farmers, artisans, or educators, while preserving cultural identity and promoting economic growth. Hence, AI becomes not just a technological force but a humanistic one, helping to harmonise modern progress with ancestral wisdom and guiding society toward a more balanced, inclusive, and sustainable future.

Technical Session 3: Global Regulatory Framework for AI and Ethics in AI

A global regulatory framework for Artificial Intelligence (AI) is vital to ensure that technology serves humanity responsibly and equitably. As AI becomes increasingly embedded in our daily lives from healthcare and education to governance and communication, it is essential to establish shared global principles that protect human dignity and foster trust. Such a framework should emphasise transparency, fairness, accountability, and inclusivity, ensuring that AI systems are designed to benefit all rather than a privileged few. Collaboration among nations, industries, and academic communities can create common standards that guide innovation while safeguarding individual rights, privacy, and social harmony. This collective effort is not only about regulating technology but about shaping a global vision of progress rooted in ethical responsibility.

At its core, the regulation of AI must be guided by empathy, justice, and respect for human values. Ethical governance should ensure that AI enhances rather than replaces human judgment, empowering people to make better decisions while maintaining agency and control. Policies that encourage openness, diversity, and cross-cultural dialogue can help address global inequalities and ensure that technological growth reflects humanity's shared aspirations. A human-centered approach to AI regulation can transform the technology from a source of uncertainty into a tool for collective well-being one that strengthens trust, promotes social inclusion, and supports a more compassionate and sustainable digital future.

Participation and Organization

Vice Chancellors/ Directors of Indian Universities/ Institutes, experts from the Government of India, senior officials of Apex Bodies of Higher Education and Academia will be Chairpersons and Speakers during the various sessions of the Meet. Experts from international organisations will also be invited to contribute during the discussion. All the deliberation will take place in the English language. The sessions will be conducted in physical mode.

The AIU *Central Zone Vice Chancellors Meet 2025-26* will also be attended by more than *100* Vice Chancellors/ Directors of AIU member Universities/ Institutes of the Central Zone covering the states of *Chhattisgarh, Madhya Pradesh, Maharashtra, Odisha, Telangana* and *Uttar Pradesh*.

Conclusion

In conclusion, the *AIU Central Zone Vice Chancellors Meet 2025-26* being hosted at the esteemed *Osmania University, Hyderabad, Telangana* from *February 19th to 20th, 2026*, promises to be a dynamic and insightful event, featuring significant gathering that will bring together the brightest minds and leaders from HEIs across the states *of Chhattisgarh, Madhya Pradesh, Maharashtra, Odisha, Telangana* and *Uttar Pradesh* to delve into the broad theme of '*Creating AI & Quantum Enabled HEIs'*. ❑

Invitation to Authors

Authors are invited to contribute articles on contemporary issues in higher education in general and Indian higher education in particular for publication in the 'University News'. The articles addressing the Editor University News be sent as an e-mail attachment in MS WORD to: unaiu89@gmail.com; ramapani.universitynews@gmail.com; universitynews@aiu.ac.in.

Dr Sistla Rama Devi Pani, Editor

Osmania University, Hyderabad: A Profile

Osmania University, Hyderabad is hosting the Central Zone Vice Chancellors' Meet—2025-26 of the Association of Indian Universities from February 19-20, 2026.

A Beacon of Heritage and Academic Excellence

Founded in 1917 by His Exalted Highness Mir Osman Ali Khan, Asaf Jah VII, Osmania University stands as a monumental pillar of Indian higher education. As the seventh-oldest university in India and the oldest in Telangana, its pioneering legacy of initially offering instruction in Urdu, which laid the foundation for a unique, inclusive academic culture. Today, the university proudly carries forward this heritage while dynamically aligning itself with global standards of excellence, as evidenced by its consistent NAAC 'A+' grade, UGC 'Category I' status, and rising trajectory in national (NIRF) and international (QS, THE) rankings.

The Four Pillars of Transformative Leadership

Under the dynamic leadership of Vice Chancellor Sr. Prof. Kumar Molugaram, Osmania University has embarked on a year of remarkable transformation, structured around four core pillars:

Academic Excellence & Student Empowerment

The university has vigorously implemented the National Education Policy (NEP) 2020, strengthening the Choice-Based Credit System and introducing multidisciplinary Four-Year Undergraduate Programmes. New, industry-aligned courses in Artificial Intelligence, Data Science, Cybersecurity, and Forensic Science have been launched. A student-centric approach is paramount, demonstrated by the allocation of ₹2 crore in tuition fee assistance, transparent Ph.D. admissions, and comprehensive support through the Hyderabad Career Development Centre (HCDC), including UGC-NET and civil services coaching. The 84th Convocation—conferring 1,261 Ph.D.s and 121 Gold Medals, alongside the institution of a special Gold Medal for the Best Ph.D. Thesis by a tribal student—celebrated academic rigor and inclusivity.

Research, Innovation & Development

Research excellence remains a cornerstone. The university has secured over ₹75 crore in extramural funding in the past year, filed 73 patents (4 granted), and produced over 2,000 indexed publications, elevating its H-index to 121. Groundbreaking applied research includes the development of an indigenous semiconductor chip—a first for a state university—and innovations in biochar, waste-to-fuel technology, and smart irrigation. Collaborative projects with DRDO, ISRO, and international partners under schemes like UKIERI underscore its research vitality. The Osmania Technology Business Incubator (O-TBI) continues to foster an entrepreneurial spirit among students and faculty.

Infrastructure Modernisation and Green Governance

A historic ₹1,000 crore grant from the Government of Telangana has catalysed a massive infrastructure revival. This includes the renovation of hostels (Dundubhi, Bhima), foundation stones for a new Digital Library and Tribal Welfare hostels, and the meticulous restoration of heritage structures like the Mah Laqa Bai Stepwell. The campus is transforming into a 'Smart and Green OU' with a 2-TPD biogas plant, 185 rainwater harvesting pits, expanded Wi-Fi, and a comprehensive digital overhaul of administrative services through an integrated ERP system. A commitment to accessibility and gender inclusivity is reflected in campus audits and the historic appointment of the university's first woman Joint Registrar.

Global Engagement and Community Connect

Osmania University is steadily expanding its international footprint. With 419 students from 54 countries, it has signed strategic MoUs with institutions such as Governors State University (USA) and DAAD (Germany). The Office of

International Affairs facilitates active engagement, highlighted by the Vice-Chancellor's participation in the NAFSA 2025 conference. The university's mission extends beyond its walls through robust NSS/NCC programs, community outreach, and specialised training for tribal students, embodying its commitment to societal transformation.

Vision 2030: The Road Ahead

Building on this transformative year, Osmania University's vision for 2030 is ambitious and clear:

- To achieve a QS World Ranking in the 801-1000 band and secure an NIRF rank below 25.
- To become a carbon-neutral campus and fully implement 'Digital OU 2.0'.
- To construct a Centenary Convention Hall, establish international satellite campuses, and launch industry-embedded degree programmes.
- To significantly expand its endowment fund and international student enrolment.

Balancing its revered history with a progressive vision, Osmania University is not merely adapting to the changing landscape of higher education; it is actively shaping it. Through strategic investments in academics, cutting-edge research, sustainable infrastructure, and global partnerships, the university is decisively marching toward its goal of becoming an institution of global reckoning while remaining deeply rooted in its service to the nation and the region. It stands today as a testament to the transformative power of visionary leadership and institutional resilience. ❑

Ignition of Quantum Revolution in India: Status and Expected Impact

Amarendra Pani* and Yogita Kanwer**

Knowledge has been the primary driving force of development since the evolution of *Homo sapiens*. The advancement of scientific thinking and research practices greatly accelerated the creation and application of knowledge to improve human life. The modern Knowledge Revolution that began in the 1950s progressed at extraordinary speed, and within seven decades, it disrupted earlier technologies, leading to an explosion of knowledge beyond human imagination. Now, we are passing through the Fifth Industrial Revolution which primarily focuses on *human-centric, sustainable,* and *resilient industry.* Industry 5.0 emphasises collaboration between humans and advanced technologies, where machines are increasingly undertaking learning and problem-solving tasks once performed exclusively by humans. Quantum technologies can support these goals in a very effective and impactful manner. The re-emergence of a transformative scientific frontier known as quantum technology is revolutionising the world once again. We are now celebrating the centenary year of the first quantum revolution by initiating the second quantum revolution. Based on the principles of quantum mechanics—such as superposition, entanglement, and quantum tunnelling—this second quantum revolution promises breakthroughs in computing, communication, sensing, and cryptography.

The First Quantum Revolution began in the early 20th century, around the 1920s, following the development of quantum mechanics by scientists like Max Planck, Albert Einstein, Niels Bohr, and Schrödinger. The products of the First Quantum Revolution include technologies based on quantum mechanics that transformed modern life, such as Transistors (the foundation of computers and electronics), Semiconductors, Lasers, LEDs, Solar cells, MRI scanners, atomic clocks, etc. These inventions laid the foundation for today's digital and communication technologies.

The digital revolution started with the invention of Turochamp, the first computer chess algorithm by Alan Turing and David Champernowne in1948. In 1950, Allen Newell and Herbert Simon, with Logic Theory (LT) and Automatic Theorem (AT), implemented the perception of the external world with the computer. Newell and Simon's Logic Theorist was considered to be the first Artificial Intelligence Program. Allen Newell and Herbert Simon contributed the General Problem Solver (GPS), written in Information Processing Language (IPL), a program that simulated some mental activities in solving complex problems. The terminology 'Artificial Intelligence' was proposed by John McCarthy in 1956. The Digital Revolution began in the late 20th century, mainly during the 1970s–1980s, with the development of computers, microprocessors, and digital communication technologies. Internet, artificial intelligence, big data, and innovation-driven economies further accelerated the digital revolution in artificial intelligence and Generated Artificial Intelligence.

Now, when the AI and GAI revolution is at its surge, the second Quantum Revolution is ignited. The second quantum revolution is characterised by the translation of quantum mechanical principles into transformative technological applications (Dowling & Milburn, 2003). Unlike the first quantum revolution, which enabled the development of semiconductors and lasers, contemporary quantum technologies (QT) focus on quantum computing, quantum communication, quantum sensing, and quantum simulation. These three core pillars of QT—quantum computing, quantum communication, and quantum sensing together are shaking the world.

QT, along with AI are leading the world to totally different planes of development. Quantum computers can process massive amounts of data and complex calculations much faster, improving machine learning and optimisation tasks. AI helps in designing quantum algorithms, correcting errors, and controlling quantum experiments. Together, AI and quantum technology can transform fields like healthcare, cybersecurity, finance, climate modelling, and drug discovery. Thus, the key connection between Quantum Technology and AI is that quantum computing boosts AI, and AI improves quantum systems. Precisely, AI provides

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intelligence, quantum technology provides power — together they redefine computing and accelerate innovation. Quantum technology leverages the unusual behavior of particles at the atomic and subatomic levels. Unlike classical bits used in conventional computers, which exist as either 0 or 1, quantum bits (qubits) can exist in multiple states simultaneously. This enables quantum computers to solve certain complex problems far more efficiently than classical machines. These technologies promise exponential computational advantages, ultra-secure communication systems, and unprecedented measurement precision (Preskill, 2018). The accelerated innovations will impact all fields, including Higher Education.

The year 2025 was declared as the International Year of Quantum Science and Technology (IYQ) by UNESCO to celebrate 100 years of quantum mechanics, foster global collaboration, and promote awareness of its transformative potential in computing, medicine, climate, and communication. The year-long initiatives of building capacity, addressing the quantum divide, and inspiring the next generation of scientists succeeded in bringing quantum into the mainstream. The Year of Quantum Science and Technology marked a broad shift in public and institutional awareness. Quantum moved beyond research labs and specialist circles, entering boardrooms, policy discussions, and mainstream coverage. What had long been framed as a distant scientific frontier became a strategic topic with economic, national security, and industrial implications. Now, in 2026, the attention is turning from awareness to application, and a momentum is gaining across governments, industries, and the research communities to take it to the next phase of quantum's evolution, which will be defined not by discovery but by deployment.

McKinsey's fourth annual *Quantum Technology Monitor* covers 2025's breakthroughs, investment trends, and emerging opportunities in this fast-evolving landscape. The report indicates that the three core pillars of QT–quantum computing, quantum communication, and quantum sensing–could together generate up to $97 billion in revenue worldwide by 2035. Quantum computing will capture the bulk of that revenue, growing from $4 billion in revenue in 2024 to as much as $72 billion in 2035. Significant private and public entities investing in QT start-ups in 2024 include SoftBank's partnership with Quantinuum and Aramco's investment in Pasqal. Japan's National Institute of Advanced Industrial Science and Technology's collaboration with QuEra and IonQ, and Qatar Investment Authority's partnership with Alice & Bob are other examples of major investments in this space.

The Quantum Insider (TQI), a leading industry-focused intelligence platform, is presenting 2026 as the *Year of Quantum Security*, a coordinated, year-long global effort focused on post-quantum cryptography, quantum resilience, and the responsible protection of quantum technologies and the intellectual property that underpins them. The initiative is intended to carry forward the momentum of 2025 while addressing a reality that is becoming increasingly difficult to ignore: quantum security is no longer theoretical. It is operational.

India's Response to the Quantum Revolution

The Government of India has recognised the strategic, economic, and technological significance of quantum technology as a transformative force across multiple sectors. Determined to secure a leadership position in the emerging global quantum ecosystem, the government has initiated a series of coordinated measures to strengthen national capabilities.

In a written reply to the Rajya Sabha on 31 July 2025, Union Minister of State (Independent Charge) for Science and Technology, Dr. Jitendra Singh, outlined the country's progress. He stated that India is taking concerted steps to advance quantum technologies through the National Quantum Mission (NQM), which has been allocated ₹60.04 billion for an eight-year period.

Led by the Department of Science and Technology (DST), the NQM has established four Thematic Hubs (T-Hubs) dedicated to key verticals: quantum computing, quantum communication, quantum sensing and metrology, and quantum materials and devices. These hubs are supported by 14 technical groups operating across 17 states and two Union Territories. Their mandate includes technology development, human resource training, startup incubation, industry collaboration, and international partnerships.

To foster innovation and entrepreneurship, the government has introduced formal guidelines to support quantum technology startups. The Technology Innovation Hub (TIH) at the Indian Institute of Science Education and Research

(IISER), Pune, has operationalized these guidelines and has already extended support to eight startups developing quantum solutions.

Several government departments are contributing through specialized initiatives. The Ministry of Electronics and Information Technology (MeitY) has established a Centre of Excellence in Quantum Technology and launched the Metro Area Quantum Access Network (MAQAN) in Chennai, creating a secure quantum communication testbed. The Defence Research and Development Organisation (DRDO), in collaboration with the Tata Institute of Fundamental Research (TIFR), Mumbai, has developed a 6-qubit quantum processor based on superconducting circuit technology. The Centre for Development of Telematics (C-DOT) has integrated Quantum Key Distribution (QKD) and Post-Quantum Cryptography (PQC) into its communication products and has also established a Centre of Excellence in quantum communication.

The Department of Space (DoS) has demonstrated free-space Quantum Key Distribution over a 300-metre distance with real-time processing, showcasing secure quantum communication capabilities. Meanwhile, the Department of Atomic Energy (DAE) has developed a cold atom-based gravimeter at the Raja Ramanna Centre for Advanced Technology in Madhya Pradesh.

Importantly, the National Quantum Mission has articulated clear, time-bound objectives. These include the development of intermediate-scale quantum computers with 20–50 physical qubits within three years, 50–100 qubits within five years, and 50–1000 qubits within eight years. The Mission also aims to establish satellite-based secure quantum communication links spanning up to 2,000 kilometres, both domestically and internationally. In addition, a national call for proposals to design indigenous quantum algorithms is currently open to researchers and academic institutions.

Collectively, these initiatives reflect a coordinated, multi-institutional effort to position India as a serious and competitive player in the global quantum landscape.

Key Schemes and Initiatives in India's Quantum Ecosystem

India has undertaken a range of strategic initiatives to accelerate the development and deployment of quantum technologies. These efforts span research, infrastructure, industry collaboration, skill development, and startup promotion, reflecting a comprehensive national approach.

National Quantum Mission (NQM)

Launched by the Union Government, the National Quantum Mission aims to build a robust quantum technology ecosystem in India. It focuses on advancing quantum computing, communication, sensing, and materials, while fostering the development of indigenous quantum hardware and software capabilities.

National Mission on Quantum Technologies and Applications (NM-QTA)

Announced with an outlay of approximately ₹8,000 crore over five years, NM-QTA seeks to strengthen India's quantum research and innovation landscape. Its key objectives include:

- Advancing research and development in quantum computing, communication, and cryptography.
- Establishing dedicated research institutes and state-of-the-art laboratories.
- Promoting academia–industry collaboration to accelerate innovation and commercialization.

Quantum Computing Research Initiatives

Premier institutions such as the Indian Institute of Science (IISc) and the Indian Institutes of Technology (IITs) have launched specialised research programs in quantum computing and allied domains. These initiatives often involve international collaborations, interdisciplinary research, and partnerships with global research organisations.

Startup Promotion and Innovation Support

The government actively encourages quantum technology startups through funding schemes, incubation support, and mentorship programs. National initiatives such as the Startup India campaign provide financial assistance, infrastructure, and policy support to foster innovation and entrepreneurship in the quantum sector.

Skill Development and Capacity Building

Recognizing the need for a highly skilled workforce, various training programs, workshops, and academic courses have been introduced. These initiatives aim to equip students, researchers, and professionals with expertise in quantum mechanics, quantum computing, and related applications, thereby strengthening India's human capital base.

Public–Private and International Collaboration

India promotes strong collaboration between government agencies, private enterprises, and international partners. Joint research projects, technology transfer agreements, and knowledge-sharing platforms are integral to enhancing India's technological capabilities and global competitiveness in quantum research.

Research Funding and Grants

Multiple funding schemes support quantum research and innovation. Agencies such as the Department of Science and Technology (DST) and the Ministry of Electronics and Information Technology (MeitY) provide grants for fundamental research, applied projects, and technology development in quantum domains.

Proposal for a National Quantum Laboratory

The establishment of a National Quantum Lab has been proposed to centralise research efforts and provide advanced infrastructure and shared facilities for scientists and innovators working in quantum technologies.

Challenges for Implementing the Initiatives

Despite significant progress and promising prospects, several challenges remain. These include the shortage of highly skilled manpower, the need for advanced and scalable infrastructure, and the development of clear regulatory and ethical frameworks. Furthermore, increasing public awareness and understanding of quantum technologies is essential to ensure societal acceptance and responsible integration.

Addressing these challenges through sustained investment, institutional coordination, and long-term strategic planning will be critical for India to fully realise its quantum ambitions and emerge as a global leader in this transformative domain.

Initiatives at NITI Aayog

The NITI Aayog report, *"Transforming India into a Leading Quantum-Powered Economy,"* released in December 2025, underscores the Government of India's proactive commitment to positioning the country as a global quantum leader. The report highlights that, recognizing both the immense opportunity and strategic risks associated with quantum technologies, India launched the National Quantum Mission (NQM) in April 2023 with an allocation of ₹6,003.65 crore (approximately USD 730 million) through 2030–31. The Mission aims to "seed, nurture, and scale up" domestic quantum research and development while establishing India as a key player in the global quantum ecosystem. However, the report cautions that although this investment marks a critical first step, the scale of global momentum demands far greater ambition and urgency (NITI Aayog, 2025).

Serving as a strategic roadmap, the report articulates a comprehensive vision for India's quantum future by 2035. It identifies India's inherent strengths—particularly in software and engineering—while acknowledging critical gaps that must be addressed. The document outlines actionable recommendations and warns of the risks of inaction at this pivotal juncture.

The 2035 Quantum Vision: Key Aspirations

- Incubate at least 10 globally competitive quantum startups, each surpassing USD 100 million in revenue.
- Capture over 50% of the global quantum software and services market by leveraging India's established software and engineering capabilities.
- Achieve meaningful, large-scale deployment of both indigenous and global quantum technologies across strategic sectors in India.
- Secure critical positions in the global quantum supply chain for both hardware and software, thereby creating strategic value and interdependencies.
- Emerge as a source of foundational scientific breakthroughs through world-class research and significant intellectual property creation in quantum science and engineering.

Strategic Priorities for Realising the Vision

To achieve these ambitions, the report emphasises the need for coordinated national action and accelerated execution across several priority areas:

- Expand the Quantum Workforce: Increase the number of deployment-ready scientists, engineers, and professionals by an order of magnitude within 2–3 years.
- Catalyze Industry Engagement and Investment: Enhance awareness among industry leaders and government sectors about quantum technologies and significantly boost private and public investment within 2–5 years.

- Accelerate Lab-to-Market Transition: Improve the ease of conducting research, validating technologies, and commercializing innovations, ensuring smoother lab-to-market pathways within 2 years.
- Strengthen Fundamental Science and Risk Appetite: Substantially enhance both the quality and quantity of foundational research while encouraging greater risk tolerance within funding agencies and research institutions over 2–5 years.
- Retain Deep-Tech Startups in India: Create a favorable regulatory, financial, and innovation ecosystem so that more than 90% of Indian deep-tech startups choose to remain domiciled in India.
- Lead Global Standard Setting: Actively participate in and lead international standards development for quantum technologies to ensure global market access for Indian products and solutions.
- Strengthen Trade and Technology Flows: Build robust trade relationships and streamline the export and import of quantum-related technologies to support ecosystem growth.

The Amaravati Quantum Valley

The Amaravati Quantum Valley (AQV), launched in Amaravati, Andhra Pradesh, is envisioned as India's first integrated quantum ecosystem. Designed to bring together quantum computing hardware, software development, algorithm design, and workforce training within a single campus, the initiative marks a significant milestone in advancing India's National Quantum Mission.

Chief Minister of Andhra Pradesh, Shri Nara Chandrababu Naidu, laid the foundation stone for the project, describing it as a bold step toward positioning Amaravati as a global destination for quantum research, talent, and applications. Declaring that "Andhra Pradesh will not follow—it will lead," he expressed confidence that Amaravati would emerge as a global hub for quantum innovation. His vision—that when the world seeks quantum solutions, it will look to Amaravati—serves as a powerful call for national participation in realizing India's quantum ambitions.

Subject to regulatory approvals from both the United States and India, AQV plans to host an IBM Quantum System Two, potentially making it home to the most advanced IBM quantum computer available in the country. The project brings together more than 50 partners, including IBM, Tata Consultancy Services, Larsen & Toubro, CDAC, CDOT, leading Indian Institutes of Technology, and emerging quantum startups. Through this collaborative ecosystem, the state aims to position itself among the world's top five quantum hubs.

Union Minister of State for Science and Technology, Dr. Jitendra Singh, emphasized that the initiative aligns with India's ₹6,000-crore National Quantum Mission. Reaffirming central support, he described AQV as a bold and integrated model essential for India's emergence as a global quantum superpower and as a national partnership aligned with the vision of Viksit Bharat 2047.

The Valley will provide cloud-based access to IBM's quantum systems across India, enabling researchers, academic institutions, and enterprises to run quantum algorithms remotely. By bringing advanced quantum computing capabilities to Amaravati, AQV is expected to expand nationwide access to world-class quantum resources and accelerate innovation across sectors.

This initiative reflects India's commitment to becoming a leader in quantum technologies, fostering innovation, and enhancing national capabilities in this cutting-edge field.

Role of Higher Education in Promoting Quantum Mission

Higher education institutions (HEIs) play a pivotal role in shaping the intellectual foundations and human capital necessary to advance quantum innovation. Universities are not only sites of scientific discovery but also arenas where theoretical knowledge is translated into applied skills, interdisciplinary research cultures are cultivated, and ethical frameworks for emerging technologies are debated. The growing strategic investments by governments and industry in quantum initiatives underscore the urgency of embedding quantum technology education within mainstream academic structures.

Quantum technology education is not just about teaching students how quantum computers work, but also about preparing them to think differently—encouraging curiosity, innovation, and the ability to solve problems that were once deemed unsolvable. By integrating quantum computing into educational pathways, we will not just be training the next generation of quantum scientists, but we will also be equipping future leaders with the skills necessary to shape the next wave of technological innovation. From developing new medicines to improving energy efficiency and cybersecurity, the impact of quantum education will be felt across industries.

At the outset, we need to assess how quantum technology can be incorporated into higher education, the pedagogical transformations it necessitates, and the systemic challenges institutions face in its implementation. The implications of quantum education for workforce development, research productivity, and global academic competitiveness also need to be pondered upon.

The Rationale for Quantum Education in Higher Institutions

Workforce Development and Economic Competitiveness

The emergence of a global quantum economy necessitates a workforce equipped with quantum literacy, computational thinking, and interdisciplinary problem-solving skills. Governments and industries increasingly seek graduates proficient in quantum algorithms, hardware architectures, error correction, cryptographic systems, and quantum-aware software engineering. Higher education institutions thus function as strategic incubators for national innovation ecosystems.

Advancing Research Frontiers

Quantum technologies demand sustained research in both foundational theory and applied technology. Universities serve as critical hubs for experimental laboratories, collaborative networks, and knowledge dissemination platforms. Graduate education, in particular, plays a decisive role in producing scholars capable of advancing quantum theory while translating discoveries into practical solutions.

Curriculum Modernisation and Pedagogical Innovation

Quantum concepts challenge classical intuitions and conventional computational paradigms. Integrating quantum studies into higher education catalyses pedagogical innovation through inquiry-based learning, simulation-driven instruction, and experiential laboratory models. This transition fosters deeper epistemic engagement and encourages students to explore non-classical reasoning frameworks.

Curriculum Integration of Quantum Technology

Undergraduate-Level Initiatives

At the undergraduate level, quantum education typically begins with foundational modules in modern physics and linear algebra, followed by introductory courses in quantum information science. Emerging curricula incorporate:

- Quantum programming using frameworks such as Qiskit, Cirq, and PyQuil;
- Problem-based learning modules on quantum algorithms (e.g., Grover's search, Shor's factoring);
- Laboratory simulations using cloud-based quantum computers.

These initiatives promote early exposure and reduce cognitive barriers associated with abstract quantum formalisms.

Graduate-Level Specializations

Graduate programmes increasingly offer specialised degrees in quantum computing, quantum engineering, and quantum information science. These programmes emphasise:

- Advanced quantum mechanics and quantum field theory;
- Quantum error correction and fault-tolerant computing;
- Cryogenic hardware systems and superconducting qubit architectures;
- Quantum communication protocols and post-quantum cryptography.

Interdisciplinary degree structures encourage collaboration among departments of physics, engineering, mathematics, and computer science.

Interdisciplinary and Professional Education

Quantum education is also expanding into business schools, law faculties, and public policy programmes, focusing on quantum entrepreneurship, governance frameworks, intellectual property rights, and ethical implications. Executive education modules and micro-credentials provide reskilling pathways for industry professionals transitioning into quantum domains.

Research Ecosystems and Institutional Infrastructure

Quantum Laboratories and Centres of Excellence

Universities worldwide are establishing quantum research centres equipped with cryogenic laboratories, photonics platforms, nanofabrication facilities, and high-performance computing clusters. These centres function as interdisciplinary hubs facilitating collaborative research, industry partnerships, and technology transfer.

Cloud-Based Quantum Platforms

Access to cloud-based quantum computers provided by global technology firms enables students and researchers to experiment with real quantum hardware without requiring costly infrastructure. This democratisation of access enhances global equity in quantum education and supports pedagogical scalability.

Collaborative Research Networks

International consortia, multi-university research clusters, and public–private partnerships are increasingly shaping quantum research agendas. Higher education institutions play a coordinating role in fostering collaborative ecosystems that accelerate discovery while ensuring ethical oversight and societal alignment.

Faculty Development and Pedagogical Challenges

Faculty Capacity Building

The limited availability of trained quantum educators presents a critical challenge. Faculty development initiatives, including sabbatical training, industry fellowships, and interdisciplinary workshops, are essential for expanding teaching capacity. Collaborative teaching models and open educational resources further support curriculum dissemination.

Pedagogical Complexity and Cognitive Barriers

Quantum mechanics defies classical logic, posing conceptual challenges for learners. Effective pedagogical strategies include:

- Visualisation tools and quantum simulators;
- Scaffolded learning approaches emphasising mathematical intuition;
- Inquiry-based and experiential learning models.

Blending theory with hands-on experimentation enhances conceptual retention and learner engagement.

Assessment and Learning Outcomes

Traditional assessment frameworks often fail to capture conceptual understanding in quantum studies. Authentic assessments emphasising algorithm design, simulation-based experimentation, and research projects are better aligned with learning outcomes in quantum education.

Ethical, Social, and Policy Dimensions

Quantum technologies raise critical ethical and governance concerns, particularly regarding cryptographic disruption, data security, technological monopolisation, and equitable access. Higher education institutions are uniquely positioned to embed ethics into quantum curricula by integrating philosophy of science, technology governance, and responsible innovation frameworks.

Universities also contribute to policy development by advising governments on quantum standards, workforce planning, export controls, and international collaboration frameworks. This dual role of knowledge production and societal stewardship underscores the broader civic responsibility of quantum education.

Global Trends and Institutional Case Patterns

Across North America, Europe, and the Asia-Pacific regions, national quantum initiatives have catalysed large-scale investments in academic infrastructure and talent development. Universities increasingly function as anchors within national quantum ecosystems, hosting research hubs, coordinating interdisciplinary degree programs, and facilitating industry translation pipelines.

Emerging economies are adopting capacity-building strategies through international collaborations, faculty exchange programs, and cloud-based learning platforms to bridge infrastructural gaps. These developments signal a shift toward globally networked quantum education systems rather than isolated institutional efforts.

Challenges and Constraints

Despite its transformative potential, quantum education in higher education institutions faces significant challenges:

- High infrastructural costs, particularly for experimental laboratories;
- Shortage of trained faculty and instructional designers;
- Curriculum rigidity within traditional disciplinary structures;
- Equity and access disparities, particularly in resource-constrained institutions;
- Rapid technological evolution necessitates continuous curriculum revision.

Addressing these challenges requires strategic investment, institutional agility, policy coordination, and sustained public–private collaboration.

Strategic Framework for Integrating Quantum Technology in Higher Education

Following a multi-pronged approach will enable a seamless integration of Quantum Technology in to Higher Education.

I. Curricular Innovation – Embedding quantum modules across STEM and interdisciplinary programmes;

II. Faculty Development – Expanding professional training and interdisciplinary teaching collaborations;

III. Infrastructure Expansion – Leveraging cloud-based platforms and shared research facilities;

IV. Research Integration – Promoting cross-sectoral research partnerships and translational pathways;

V. Ethical and Policy Embedding – Incorporating responsible innovation and governance education;

VI. Global Collaboration – Facilitating international mobility, joint degrees, and shared research agendas.

Such a holistic approach ensures that quantum education evolves as a sustainable institutional ecosystem rather than a fragmented technical specialisation.

Conclusion

The quantum technology revolution represents far more than a scientific breakthrough; it is a strategic imperative. As a transformative frontier in science and engineering, it places higher education institutions at the centre of a profound global technological shift. For India, quantum technology offers a unique opportunity to enhance national security, accelerate economic growth, and establish technological leadership on the world stage. Through sustained investment in research, talent development, and robust institutional frameworks, India is laying the foundation for a resilient and competitive quantum ecosystem. As the world enters the quantum era, India's proactive stance reflects its ambition not merely to adapt to global trends, but to shape them. While the journey is complex and demanding, the potential rewards—scientific, economic, and strategic—are immense. The quantum revolution in India is no longer a distant possibility; it is an unfolding reality poised to redefine the nation's technological landscape in the decades ahead.

At the heart of this transformation are higher education institutions. Universities must respond with curriculum reform, faculty capacity building, strengthened research ecosystems, interdisciplinary collaboration, and the integration of ethical governance frameworks. Embedding quantum literacy across academic programs and expanding inclusive access to emerging knowledge systems will be essential. The success of these initiatives will determine not only scientific progress but also workforce readiness, economic competitiveness, and societal resilience. Ultimately, the future of quantum innovation depends as much on educational foresight, institutional leadership, and responsible governance as on scientific discovery itself.

Acknowledgement

The Article is compiled from various reports of the Government of India, NITI Aayog, Government of Andhra Pradesh, Department of Science and Technology and various reports available on the Internet, ChatGPT, and various other sources mentioned in the References and Readings column to harness and promote quantum science as part of the Fifth Industrial Revolution. The authors are thankful to all of them. Through this Article the Authors made a humble attempt to reach a wider audience to sensitise them to develop a better understanding of Quantum Technologies and the nuances of using them judiciously.

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Reimagining Higher Education in India for the AI–Quantum Age

Yogesh C Goswami*

Introduction: A Moment that Demands Academic Leadership

Higher education has always evolved alongside human progress. From the age of manuscripts to the industrial revolution, from digital classrooms to global campuses, universities have served as custodians of knowledge and catalysts of transformation. Today, we stand at yet another defining moment. The rapid maturation of Artificial Intelligence (AI) and the emergence of quantum technologies are not merely technological milestones; they signal a fundamental shift in how knowledge is created, transmitted, and governed. For universities, this moment is not about chasing trends. It is about shaping futures. The integration of AI and quantum technologies into curriculum, pedagogy, and governance is no longer optional. Institutions must remain relevant, responsible, and resilient in a world characterised by uncertainty, complexity, and accelerating change. As academic leaders, our task is clear: to ensure that universities do not become passive consumers of technology but active architects of the AI–Quantum era.

Understanding the Next Frontier: Beyond Incremental Change

Artificial Intelligence has already permeated classrooms, research labs, and administrative systems. From predictive analytics in student retention to machine-learning models in scientific discovery, AI has emerged as a general-purpose technology influencing nearly every discipline. Quantum technologies, on the other hand, represent a more profound leap. Quantum computing, sensing, and secure communication promise capabilities far beyond classical systems, with implications for cryptography, drug discovery, climate modelling, logistics, and national security. While still evolving, quantum technologies demand early academic engagement to build foundational skills and research capacity. Globally, leading universities are recognising the convergence of AI and quantum sciences. Institutions such as MIT, Stanford, Oxford, and ETH Zurich have established interdisciplinary centres that combine computer science, physics, mathematics, ethics, and policy. The lesson is clear: the future belongs to convergence, not silos.

Reimagining Curriculum for the AI–Quantum Age

One of the most pressing imperatives before universities is curriculum transformation. Traditional discipline-bound structures are no longer sufficient to prepare graduates for a world where AI systems assist doctors, lawyers, engineers, artists, and policymakers alike. In alignment with the National Education Policy (NEP) 2020, curriculum frameworks must become flexible, multidisciplinary, and learner-centric. Foundational AI literacy and introductory quantum concepts should be embedded across undergraduate programmes, irrespective of discipline. Engineers must understand ethics and policy; humanities students must acquire data and algorithmic literacy. Several Indian institutions have begun this journey. Select private universities have introduced AI minors open to students from law, management, and liberal arts. Others have launched interdisciplinary programmes combining data science with healthcare, finance, or sustainability. Internationally, universities such as the University of Toronto and the National University of Singapore have adopted modular, stackable credentials, allowing learners to build competence progressively over their academic journey.

Equally important is embedding ethics, societal impact, and responsible innovation as core curricular components. AI and quantum technologies must be taught not only as tools of efficiency but as forces that shape society, equity, and human values.

Transforming Pedagogy: Teaching for a Non-linear World

Curriculum reform must be accompanied by pedagogical transformation. AI offers unprecedented opportunities to personalise learning, moving away from one-size-fits-all education. Adaptive learning platforms can identify gaps, support diverse learners, and enable competency-based progression. In classrooms, AI-enabled assessment tools can free faculty from repetitive tasks, allowing them

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to focus on mentorship, inquiry, and creativity. Virtual laboratories and quantum simulators are already helping students visualise abstract concepts that were once accessible only through expensive infrastructure.

Globally, universities are experimenting with immersive pedagogies using Extended Reality (XR) to teach complex systems in physics, engineering, and medicine. In India, digital platforms combined with faculty-led mentorship are enabling scalable yet human-centred learning models, particularly in emerging technology domains. However, technology must augment, not replace, the teacher. In the AI–Quantum era, the role of faculty evolves from information transmitters to mentors, facilitators, and co-learners. Continuous faculty development, supported by institutional investment, is therefore critical.

Research and Innovation: Universities as Knowledge Creators

Research lies at the heart of a university's mission. AI and quantum technologies open new frontiers for interdisciplinary research, innovation, and entrepreneurship. India's National Quantum Mission reflects a strategic commitment to building indigenous capability in quantum computing, communication, sensing, and materials.

Universities must align themselves with this national vision by establishing interdisciplinary research centres, fostering industry partnerships, and encouraging early student involvement in research. Global experience shows that strong university–industry collaboration accelerates translation from lab to market. Quantum startups emerging from university ecosystems in the United States and Europe offer valuable lessons for Indian institutions. Newly emerging Universities, in particular, can act as innovation accelerators by investing in advanced infrastructure, attracting global faculty, and piloting agile research models. When aligned with public policy and national missions, such efforts significantly strengthen the country's innovation ecosystem.

Reimagining Governance: Smart, Ethical, and Agile Institutions

The impact of AI and quantum technologies extends beyond teaching and research into university governance itself. AI-driven analytics can support evidence-based decision-making in admissions, academic planning, resource allocation, and student support services. At the same time, the use of AI in governance raises important ethical questions. Data privacy, algorithmic bias, transparency, and academic integrity must be addressed proactively. Universities must develop clear institutional policies, ethics committees, and governance frameworks to ensure responsible use of emerging technologies. Leadership in this era requires agility without compromising academic values. Vice Chancellors and governing bodies must act as digital stewards, balancing innovation with inclusivity, efficiency with empathy, and autonomy with accountability.

India's Opportunity: From Policy Vision to Global Leadership

India stands uniquely positioned at the intersection of demographic advantage, digital capacity, and policy vision. NEP 2020 provides a forward-looking framework for multidisciplinary education, research integration, and institutional autonomy. National initiatives in AI and quantum technologies signal long-term strategic intent. The challenge now lies in execution. Universities must translate policy into practice through sustained investment, capacity building, and collaboration. By doing so, Indian higher education can move from being a consumer of global knowledge to a creator of globally relevant solutions.

Conclusion

Reflection on the Road Ahead

AI and quantum technologies are not ends in themselves. They are instruments that can either deepen inequalities or expand opportunities, depending on how wisely they are integrated into our institutions. Universities have always been spaces where knowledge meets purpose. In shaping the AI–Quantum future, our responsibility is not merely to produce skilled graduates but to nurture thoughtful, ethical, and adaptable citizens. The true success of this transformation will be measured not by the sophistication of our laboratories, but by the values our graduates carry into society. As academic leaders, we must have the courage to reimagine, the humility to learn, and the wisdom to lead. If we succeed, universities will not merely respond to the next frontier; they will define it. ❑

India's Path-breaking Quantum Science and Technology: A Giant Leap to Become Quantum Savvy

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Preamble: India's Progressive Quantum Revolution

21st Century being a Quantum era, India is rapidly growing with this technology and aims to become the global hub for Quantum technologies, thereby leading to the Quantum Skill capital. With the launch of the National Quantum Mission (NQM) [1] in 2023, aligned with national priority missions like 'Digital India' and 'Make in India', India is spearheading frugal innovations across quantum fields such as quantum communication, quantum sensing, quantum computing, quantum materials, and devices. India stands in fifth position across the globe as a highly productive country in the world, especially in the research of quantum dots [2].

To recognise the one hundred years of successful achievement in quantum technology, the year 2025 is being celebrated globally as the International Year of Quantum Science and Technology. India has special significance in quantum science and technology through pathbreaking innovations by Satyendra Nath Bose's work on quantum statistics, 100 years ago, which led to the concept of Bose-Einstein condensation, a cornerstone of quantum physics and has significant achievements in grassroots technological advancements.

Four thematic hubs established under the National Quantum Mission at IISc Bengaluru, IIT Bombay, IIT Delhi and IIT Madras, specifically focus on facilitating innovations and technology commercialisation on quantum products and solutions. The thematic HUBS have well-established R&D infrastructures to empower the talent pool through academia-startups-Industry- Government interface.

India has reached a quantum state where quantum computing products are being developed in India, and are available in MSME GeM portal. This unique feature is the first of its kind in the world.

Groundbreaking Quantum Accomplishments in India

India is among the top countries in the globe that has accomplished much groundbreaking research in the quantum field (Figure 1)

Centre for Development of Telematics (C-DOT)

C-DOT: India has successful case studies on conducting the field trials of the Quantum Key Distribution System developed. The experiment was the first of its kind in India that was conducted between the Sanchar Bhawan, Department of Telecommunications and National Informatics Centre (NIC's) CGO Complex in Delhi.

Banaras Hindu University

Quantum photocatalysts are employed for the high quantum throughput production of Green Hydrogen, thereby introducing a next-generation quantum-power that has a charge transfer system and high proton availability and mobility, which can drive quantum catalytic processes. Green Hydrogen production at lab scale was achieved at about one litre/min per 10 g of Quantum Photocatalysts.

C-DAC

C-DAC has developed a Quantum Computing Simulator (Qsim), capable of simulating the quantum gate model.

S.N.Bose Bose National Center

A path-breaking discovery of quantum bits – qubit from S.N.Bose Bose National Centre for Basic Sciences, an autonomous institute of the Department of Science and Technology, working alongside the teams from the Henan Key Laboratory of Quantum Information and Cryptography,

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Figure 1: Quantum Discoveries in India Leading to Quantum Savvy

Laboratoire d'Information Quantique, University Libre de Bruxelles, and ICFO-the Barcelona Institute of Science and Technology, surpassed classical physics. This proves our nation's capability to technologically utilise the ideas and concepts of the principles of superposition, entanglement, and measurement in physics.

Raman Research Institute (RRI)

RRI is one of the first quantum labs in India to technologically manufacture and establish the usage of quantum-based entanglements with single photon sources towards different quantum applications.

The Society for Electronic Transactions and Security (SETS)

SETS, under the Office of the Principal Scientific Adviser (PSA), has been progressively performing research in Post-Quantum Cryptography (PQC). It has successfully implemented Quantum algorithms - PQC algorithms that find potential applications like Fast IDentity Online (FIDO) authentication tokens and Industrial Internet of Things (IoT) security.

Indian Institute of Technology, IIT Bombay

Quantum Sensing and Metrology Hub, an initiative of the National Quantum Mission at the Indian Institute of Technology, IIT Bombay. Photonics and quantum. The research group at IIT Bombay has been pioneering in developing precise magnetic field and temperature sensors works. It involves defects called Nitrogen Vacancy (NV) centre, especially in diamonds. The tangible outcomes are to develop technology that can manipulate them to probe neurons or delve into human cells**.**

Indian Space Research Organisation [ISRO]

ISRO made a big quantum breakthrough by successfully demonstrating free-space Quantum Communication over a range of distances covering 300 m free-space QKD. The experiment was conducted at the Space Applications Centre (SAC), Ahmedabad.

Dayalbagh Educational Institute (Deemed to be University) [DEI], Agra

DEI has been working on *Quantum Jugaad,* quantum teleportation that involves sending quantum states around various locations without a quantum channel, involving only classical communication. DEI has modelled a framework for quantum teleportation [3]. It has a Quantum and Nano computing virtual Centre that also focuses on quantum consciousness studies as well.

QNu Labs

QNu labs a pioneering quantum startup, has developed computing products such as [Armos (QKD) and Tropos (QRNG)] which are aligned with India's national vision - '*Aatmanirbhar Bharat'* and 'Vocal for Local.' QNu Labs has achieved quantum innovation, which is the World's-First 5KM Self-Aligning, innovative 1.1KM Free Space Quantum Key Distribution solution technology. This quantum technology is a breakthrough in data transmission. The data is transmitted in a safe and secure mode. Technology also enables encryption keys to be exchanged in a secure manner across space - air gaps without the requirement of physical cables.

India's Quantum Standards - First of its Kind in the World

India is among the global leaders to launch the first-of-its-kind standards on the "Test Guide of Quantum Key Distribution (QKD) System" and "Quantum-Safe and Classical Cryptography System" in 2023 by the Department of Telematics [4].

(i) Test Guide for "Quantum Key Distribution System" (TEC No. 91001:2023)

(ii) Generic Requirements on "Quantum-safe and Classical Cryptographic Systems" (TEC No. 91010:2023)

The Science and Technology clusters in India, under the flagship of the Office of Principal Scientific Advisor of the Government of India, have clusters focusing on quantum science and technology.

India's Aim to Become Quantum Skill Capital

Indian Institute of Science (IISc) Bengaluru has established Quantum Park under the flagship of Foundation for Science Innovation and Development in collaboration with KITS (Karnataka Innovation and Technology Society), Government of Karnataka. The focus of this park is to facilitate the science and technological innovations in quantum computing, leading to reskilling and upskill talent pool, academia-industry interface, and startup collaborations. The future vision of the quantum park is to function as a Global Quantum Hub for the Indian nation.

Quantum Park also offers students an internship program, such as Q-Daksha Student Internship Program. The internship is the first of its kind in India that creates an opportunity for students to engage with faculty members and researchers.

QNu Labs, a pioneering startup, offers SparQ Summer Internship for students and awards a project fellowship for the best students' quantum projects.

All India Council for Technical Education (AICTE), Ministry of Education, Government of India, has been facilitating the development of quantum skills among faculty members through the "Training of Trainers" (ToT) program in alignment with the National Skill Qualification Framework (NSQF), thereby upgrading the knowledge and skills with the evolving quantum landscape. AICTE aims to develop quantum skills among students through minor degree programs offered in quantum technologies in higher educational institutes.

Electronics and ICT Academy, in Collaboration with AICTE, Department of Science and Technology, under the National Quantum Mission, is training the faculty members through short-term and long-term training programs, thereby equipping the faculty members across higher educational institutes to become Quantum Savvy.

Indian Institute of Science Education and Research, Pune, offers a Master's program in Quantum Technology.

Indian Institute of Technology, IIT Delhi, is awarding certification program on Quantum computing.

Acknowledgement

The research study is the tangible outcome of the plan of action of the research project funded by the Asian Productivity Organisation, Tokyo, Japan, in collaboration with the National Productivity Council, under DPIIT, Ministry of Commerce & Industry, Government of India. The research project titled Title Research on Emerging Trends in APO Members, Project Code: 23-RC-24-GE-RES-A.

The authors acknowledge and thank the support of Department of Science and Technology, Government of India, Ministry of Education, All India Council for Technical Education, Ministry of Micro Small and Medium Enterprises, Government of India, Office of Principal Scientific Advisor, Government of India and Niti Aayog, QNu Labs, Indian Institute of Technology Bombay, Indian Institute of Science, Bengaluru, Dayalbagh Educational Institute (Deemed to be University), Dayalbagh, Agra, C-DOT, C-DAC,

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Artificial Intelligence in Education: A Review of Applications, Ethical Issues, and Effects on Student Learning

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Artificial Intelligence (AI) is transforming the educational sector radically by creating innovative educational resources that address essential moral quandaries and scholarly challenges. The application of AI intelligent tutoring programmes results in customised learning that accommodates the needs of individual students, thereby enhancing student engagement and improving outcomes in comprehension (Mayer, 2020). Student performance levels will be predicted to enable the college to intervene early enough, as scheduling automation will ensure that the institution is efficient (Siemens 2023; Popenici & Kerr 2022). All of this makes the disparity in technology distribution bigger since different students and educational institutions find themselves in different positions of disadvantage (UNESCO, 2023). Privacy invasion takes place because of the massive data gathering, where ethical issues arise, where AI systems are used by institutions, and third parties may misuse such information (Zuboff, 2019). Using biased algorithms results in poor treatment of certain groups of students, but overreliance on AI causes the loss of human contact that makes educational interaction dehumanising (O'Neil, 2016; Selwyn, 2022). The nature of implementation of suggested ethical systems, transparency, and accountability solutions complicate the process of establishing the responsibility of AI errors, as suggested byFloridi et al. (2021) and Alzoraiki et al. (2024). The combination of AI-powered tools delivers substantial learning outcomes to students because they boost academic results by 15–40% and develop critical thinking skills and problem-solving competencies through individualised assistance (Baker et al., 2020; VanLehn, 2011). Students who attend financially strained schools still need to overcome barriers that prevent them from using interactive education platforms combined with virtual reality technologies (McIntire et al., 2024; UNESCO, 2023). AI fulfils two instructional purposes through direct content delivery, which concurrently generates ethical principles that require proper implementation methods. Application of technological frameworks allows educational advantages to be maximised while minimising risks of failure, which eventually enables universal access to education. Combining analysis of long-term evolution datasets with culture and teacher perception needs to be integrated as per Zawacki-Richter (2023). The change in the education system guided by AI requires technological and ethical considerations for privacy and supportive inclusion policies. To protect inclusive practices, policies aimed at fostering the equitable use of the technology must target comprehensive evaluations of the implications of AI technology on educators and learners. This review paper analyses various research from three central domains about AI applications in education and ethics, and learning effect assessments. This research paper seeks to provide an overview of various researches on AI applications in education.

Researches on Usage in Education

Artificial Intelligence establishes itself as a major educational driver through which instruction and education happen in educational settings and beyond. Mayer (2020) explains in his work that STEM education benefited from the implementation of intelligent tutoring systems (ITS), which adjust instructional content based on student performance data, although he demonstrates equivalent retention rates to traditional classroom education. AI technology exposes personalised learning content through digital e-learning platforms, which use student behavioural patterns to enhance retention rates, according to Johnson and Lester (2021). Van Lehn (2011) demonstrates that it delivers 20% better performance than traditional instruction in mastery learning for technical subjects by using specific adaptive feedback that addresses the current student level. AI's use of massive data processing enables students' success prediction and detection of potential risks, which leads to early educational intervention to improve retention rates in higher education, according to Siemens (2023). The use of AI for grading Massive Open Online Courses (MOOCs) received attention from Baker et al. (2020)

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because automated systems manage large student populations well, yet need human monitoring when evaluating subjective work. The implementation of AI analytics enables educators to track student progress precisely, which subsequently allows them to develop teaching methods using actionable insights according to Roll et al. (2020). The administrative sector receives advantages through the automation of scheduling, resource allocation, and enrolment processes that reduce staff workload according to Popenici and Kerr (2022). STEM education via AI-based gamification systems uses automatic controls in interactive learning spaces to boost student engagement despite eliminating teaching duties to produce flexible environments, according to Khalil and Er (2020). Brown and Green (2023) examine how AI generates administrative reports and discover that the technology reduces time but fails to reach optimum standards in complex cases. Medical students benefit from automatic voice recognition systems that analyse their pronunciation in real-time, according to Wang et al. (2021), because the applications deliver superior practical outcomes compared to traditional learning methods. Through interactive STEM challenges, Ng et al. (2022) state that students develop motivational drive because these challenges convert difficult abstract learning content into meaningful educational opportunities. Dede and his team (2022) evaluated how students learn through direct experience when using VR technology for virtual science lab simulations. The article by Fischer et al. (2023) explains the programming expertise advancement enabled by AI coding support, which provides automated debugging features for handling complex programming issues. AI technology enables virtual reality training for teachers through environments that duplicate classrooms to establish a novel, practical method for theory implementation per Lopez et al. (2021). The implementation of new technological solutions becomes challenging because UNESCO (2023) identifies in their AI deployment examination of underdeveloped areas that insufficient infrastructure, particularly limited internet access, obstructs deployments, leading to educational inequality between wealthy and disadvantaged districts. The application of AI varies across universities because their capabilities differ, which enables some institutions to achieve superior results, according to Zawacki-Richter (2023). Holmes et al. (2022) demonstrate that AI-generated teaching resources eradicate teacher engagement, and this undermines educational methods independently while producing concerns regarding AI technology dependence. The scalability of predictive AI in MOOCs remains restricted when used to prevent dropout among student populations that lack sufficient resources, as Kizilcec (2021) demonstrates. The article by Goodyear (2023) evaluates AI applications in informal learning through the lens of independent educational contexts, yet it finds barriers to equitable access for non-traditional students who are outside formal education structures. Many educational works, such as Mayer (2020), Johnson and Lester (2021), Siemens (2023), Baker et al. (2020), and Popenici and Kerr (2022), introduce AI as a multifunctional educational tool capable of enhancing the efficiency of operations by involving the students and broadening the learning scope in the teaching learning process. Educational tools, including VR technology and coding systems developed by Dede et al. in 2022 and Fischer et al. in 2023, extend opportunities for enhancing educational delivery in all academic disciplines. The unequal access and integration challenges that UNESCO (2023) and Zawacki-Richter (2023) highlight create a discordant distribution of benefits that primarily benefit the privileged users, following the literature. AI technology will achieve success in education through the proper management of its transformative capabilities and its ability to include every student, particularly those with limited educational resources. Educational institutions need to embrace artificial intelligence tools as support systems for human instructors, and government institutions must resolve educational infrastructure gaps to distribute AI capabilities so they become powerful tools of universal learning. Through adaptive educational platforms, Al-Zahrani (2024a) demonstrates how AI improves student involvement in Saudi higher education institutions. AI-based approaches in transnational education are investigated by Al-Zahrani (2024) to show their ability to handle online classes while simplifying enrolment processes. Ateeq et al. (2024) show how AI enables educational operations when used for student support through chatbots that eliminate repetitive work to enhance operational performance. Williamson and Prybutok (2024) explain how artificial intelligence powers virtual teaching assistants to enhance educational efficiency at different stages of higher education. Niu et al. (2024) explore how AI automates institutional scheduling tasks to enhance operations within higher education institutions. Students improve their participation rates when AI is applied to gamified learning spaces in K-12 institutions, according to McIntire et al. (2024). In the words of Artsmart (2024), almost nine out of ten students depend on AI tools, including ChatGPT, to help with their homework tasks. Educational institutions in Scandinavia benefit from AI technologies to support teaching staff in developing student emotional learning skills, according to the Future of Life Institute (2025). Alier et al. (2024) studied AI applications in coding education by assessing tools that supply programming students with instant feedback to augment their skills in code development. The research by Zheng et al. (2025) examines how AI learning analytics affects Chinese educational institutions' design of university education and the development of student support frameworks. It was also found that various educational benefits of AI create favourable effects on global academic performance based on research findings.

Research Studies on Ethical Implications in Education

The use of AI in education creates new opportunities but also poses a great danger, necessitating constant supervision. O'Neil's (2016) critique of educational algorithmic bias reveals that admission and grading AI systems perpetuate discrimination in the teaching and learning process. This suggests that AI technologies applied to education need to operate under an advanced ethics system. The racial bias resulting from some security and attendance facial recognition systems in schools leads to accentuated incorrect attribution of certain pupils as non-attending students poses ethical concerns along with punishment-related concerns Raji et al., 2020). The biases exemplified by programmes that apply algorithms contrary to equity principles demand equality in educational access for differing algorithms. According to Leslie (2021), while there is an obligation to ensure the protection of vulnerable students, these policies need to be carefully monitored to prevent discriminatory practices from being deployed in education. Zuboff (2019) argues that capitalism is a new threat to education because journalists harvest students' learning data while cropping students' freedoms. As noted by Pasquale (2015), the educational use of "black box" AI systems remains a concern because the algorithms conceal the data processing cycle and erode the trust that students have in their teachers. Selwyn (2022) noted that the implementation of AI proctoring systems into digital classrooms creates a distrustful environment by controlling student movement and generating watchful conditions detrimental to student autonomy, support, and participation. Research by Mittelstadt et al. (2016) demonstrated that students experiencing unfair grading due to a lack of transparency face considerable cognitive dissonance within the trust in the system placed, with absolutely no means of knowing who, if anyone, is held accountable in an AI-introduced grading framework. In the context of AI ethics, Floridi et al. (2021) provided an ethical system relevant to the lack of opacity and exclusion, but noted that hostility from technological providers and regulatory slowness hampers AI ethical objectives. Jobin et al. (2019), examining global ethics guidelines for AI, expose diverging lines in the approach which undermine, for standardisation purposes, the setting of universal teaching policies on school education. Further, Hagendorff (2020) argues that unrestricted AI usage in education seeks to control students' learning in harmful ways. Selwyn (2022) illustrated that the greater risk of dehumanisation exists due to the rapid development of AI. The insufficient ability of AI to replicate human empathy challenges its ethical faculty in school settings, which worries Coeckelbergh (2022) and Holmes et al. (2022) because they view AI-generated material as detrimental to teacher creativity and human teaching methodology. Eubanks (2018) compares the educational system to welfare automation due to AI errors in financial aid distribution that cause harm to disadvantaged students who demonstrate the need for equity in the classroom. UNESCO (2023) explains that AI benefits primarily aid rich schools, yet leave underserved schools behind because of financial and technological barriers that seek to widen existing educational gaps. The authors Whittaker et al. (2019) view this phenomenon as a systemic power imbalance because powerful school districts gain from AI implementation, which results in marginalised and privileged students. The authors of Morley et al. (2020) emphasise the need for ethical checks in AI education systems, even though most institutions fail to employ this method, which could identify and prevent both discrimination flaws and privacy violations at the implementation phase. The examination by Zawacki-Richter (2023) shows that AI produces variable effects in higher education systems because of uneven access to services, and she recommends implementing fair policies. The combination of ethical issues explored by O'Neil (2016) Raji et al. (2020), Zuboff (2019), Véliz

(2021), and Mittelstadt et al. (2016), with Floridi et al. (2021), along with Selwyn (2022) and Holmes et al. (2022) demonstrates the troubled nature of AI in educational contexts. The combination of technical issues produces social consequences affecting educational equity, as explained by Whittaker et al. (2019) and UNESCO (2023). Operational challenges arise in educational AI applications from data security issues, discrimination practices and transformations in interpersonal relationships, thus providing evidence for both standards and AI design guidelines. Educational instructors need information about opposing movements that advocate both student freedom and support the implementation of AI systems to reduce educational controls. Educational institutions require immediate technical solutions to develop ethical standards to solve this complex problem. User experiences with artificial intelligence education systems present ethical problems because they face problems with unclear information about personal data privacy and assessment methods at the same time as they experience uncertainties about fairness during system implementation. Al-Zahrani (2024) stresses the need for secure protection solutions because they ensure Saudi Arabia's learning systems based on Artificial Intelligence remain secure. Nguyen et al.'s (2024) study investigated student educational data privacy problems in the context of AI assessment before proposing protective ethical frameworks. Ateeq et al. (924), together with Megahed et al. (2024), demonstrate that problems with overall assessment biases and student data management errors need immediate elimination since they directly impact student participation. The trustworthiness oversight systems of AI educational resources detect false information while interrupting its transmission, according to Williamson and Prybutok (2024). McIntire and team (2024) document how K-12 educational deployments of AI tools create academic integrity issues that lead to plagiarism-related ethical dilemmas. Strunk and Willis (2025) compiled research to show how generative AI develops monitoring frameworks designed to keep human oversight active. Bessen et al. (2024) present numerical assessments of ethical integration expenses that quantify their impact on multiple population segments' access to educational technology. The Future of Life Institute (2025) works to determine safety risks that result from AI applications in African educational systems, which affect worldwide fairness standards. AI-based education generates significant ethical issues that Alzoraiki et al. (2024) found in their research on accountability matters. Research scientists need fully developed ethical structures to recognise all security risks emerging during AI-based educational implementations.

Studies on Learning Outcomes

The implementation of AI-driven educational performance enables the adoption of different strong advantages to resolve existing issues that occur in traditional classrooms and electronic learning settings. Research by VanLehn (2011) proves that mastery learning leads to better results through specific feedback processes that enhance exact skill development, especially in STEM subjects. The educational AI tools used with K-12 students generate 15–40% point score enhancements on standardized tests by focusing on academic remediation that detects learning gaps (Baker et al. 2020). Koedinger et al. (2022) discussed the teaching results of AI tutors versus human instructors to highlight AI's potential for delivering conventional mathematics instruction. According to Mitrovic (2021), constraint-based Artificial Intelligence directs student assignments to develop technical problem-solving abilities in their disciplines Fischer et al. (2023) examined the way AI can offer instant automatic debugging applications that contribute to learners developing improved programming skills. The works of Johnson and Lester (2021) provided lessons that helped to realize that as AI interprets the behavior of students and makes their lesson materials more interactive, the student-learning resource interaction will be maximised, enhancing the effectiveness of online learning. The paper by Chen et al. (2022) assesses natural language processing (NLP) in language learning as it uses interactive systems to enhance fluency by providing immediate feedback while maintaining classroom-like responsiveness. Ng et al. (2022) discuss how AI gamification enhances STEM education through interactive challenges because these motivating elements convert complex material into engaging adventures. Kizilcec (2021) supports the use of AI in MOOCs because personalised interventions help retain learners who are at risk of leaving the course. Garrison (2023) explains that artificial intelligence in blended learning enhances performance by creating a personalised combination of physical and digital learning environments. Cognitive development emerges as a deep and subtle achievement, as shown by Mayer (2020), which teaches students to monitor and improve their thinking while enhancing metacognitive abilities which prove beneficial to students after their educational years. The ways AI tools impact creativity in education have been described in detail by Holmes et al. (2022), but the authors warn against the risk of diminishing students' self-driven idea-generation skills through overreliance on AI. Russell (2019) applauds AI's application towards self-paced learners, citing the proliferation of training simulations that exceed textbook instruction as a positive step toward hands-on technical skill mastery. As noted by Perkins (2022), there is a consensus that AI tools enhance mental functions and critical thinking by promoting analysis rather than rote recall, which fosters improved cognition. Deep reflection is made possible with AI feedback, as noted by Aleven et al. (2020), allowing learners to remember revised mistakes as learning opportunities. UNESCO (2023), on the other hand, has exposed disparities concerning equity, noting that schools with fewer resources suffer the most due to technology constraints, such as unreliable internet connections or outdated computers, missing out on the benefits of AI. Siemens (2023) links retention improvement to AI analytics, but these advantages pertain only to well-equipped institutions, leaving struggling schools behind. Results from Zawacki-Richter (2023) stem from a review of AI's impact on higher education, citing divided access as resulting in inequitable outcomes among privileged and underprivileged populations as the cause. Woolf et al. (2021) contend that AI can cater to various learners, but only in regions where there is adequate infrastructure, an assumption that disregards many. Goodyear (2023) looks at the informal learning AI enables—like studying on your own—and observes that non-traditional learners without access to technology are largely ignored. Risks round out the picture with Selwyn's (2022) warning of over-automation cutting away human-to-human interactions which, although thinly, nonetheless knit education together, with the loss being acutely felt in relationships with peers and teachers. Baker et al. (2020) concede AI's limitations on complex forms of evaluation such as essay writing, suggesting its unsupported use has bounds. Holmes et al. (2022) identify dependence risks where the use of AI resources may remove some motivation from students, leaving educators in a difficult position. Dede et al. (2022) investigate the positioning of AI in VR contexts and describe benefits of rich experience but also oppose that the high price excludes many smaller schools. Roll et al. (2020) argue AI's analytical capabilities tend to scan and reduce developments to quantifiable benchmarks, overlooking the learning processes that are complex, flawed, and fundamentally human. VanLehn (2011) alongside Baker et al. (2020) evaluating the performance of Johnson and Lester (2021) and Chen et al. (2022) on angles of participation, then to Mayer (2020) and Perkins (2022) on the role of cognition illustrated how AI enables improvement of learning outcomes with accuracy and artistry. UNESCO (2023) Siemens (2023) Selwyn (2022) and Holmes et al. (2022) demonstrated that there exists a reality that equity gaps create unequal benefits for students. The academic literature demands a precise combination of using AI to develop capabilities and fire-up motivation alongside the maintenance of access equity and human social ties which will shape its educational outcome. Al-Zahrani (2024) discovers how artificial intelligence delivers customized learning experiences to boost academic results in Saudi Arabian higher education settings for individual students. The use of artificial intelligence for individualized learning in Chinese universities according to Zheng et al. (2025) resulted in a significant 30% improvement in student retention. The innovative tools of AI have led to a 12% growth in university graduation figures according to Artsmart (2024). Research conducted by Ateeq et al. (2024) proves that AI-based holistic assessments enhance student learning while increasing their performance metrics. According to Williamson and Prybutok (2024), AI virtual assistants enhanced academic achievement in university education because they optimize course distribution. The use of automated learning tools powered by AI enhances student motivation within higher educational programs according to Niu et al. (2024). The study conducted by Alier et al. (2024) established that AI coding tools possess vital significance when developing problem-solving abilities for secondary school students. McIntire et al. (2024) demonstrated how AI gamification caters to K-12 classroom engagement but the research presents unstable results in critical thinking skill development. The implementation of AI helps traditional education methods in the words of Haijing (2024) achieve better results in environmental education learning. The Future of Life Institute reports (2025) that AI systems deliver better outcomes in social-emotional learning within Nordic educational institutions which proves their essential role in total educational growth. The educational landscape changes due to increased enrolment numbers yet AI enhances academic success from kindergarten through university education.

Conclusion

The education sector undergoes a fundamental change brought by AI, but the exact impact of Artificial intelligence is difficult to articulate. The advantages of this are also hard to comprehend. The learning system gets rewarded as well as get complicated with problems that require resolution coming up with sophisticated technology. The educational uses of AI show obvious opportunities for application in educational systems. The intelligent tutoring systems are the ones that make use of the needs of the students in determining how to modify the learning content in subjects like mathematics and science that are considered difficult to learn. Educational analytics allows teachers to detect red flags that can be used to avert undesirable outcomes in advance and manage the fundamental tasks of schools, including assessment and appointments. Coding assistants in virtual reality systems are interactive teaching aids that help students to focus on computer programmes, as well as classroom discussions. Other schools have issues where they do not have the basic digital tools, such as adequate internet connectivity and funds, as well as the relevant equipment, so that students languish without the essential tools. There is a good demonstration of performance capability within the system, but these functions are performed according to different technical standards across organisational groups. The AI education systems must address the intricate ethical issues that lead to the real impediments to implementation. The unbalanced inputs in the data processing by AI systems create certain biases in the education participants due to their specific education processing. In the course of AI data intelligence processes, two privacy concerns evolve due to the monetary gain being a priority on top of the learning progress and unintended data exposure. The implementation of AI systems compels institutions to eliminate student care and emotional care since the systems will require long class times that will lead to a decreased capacity of teachers to instruct students effectively. When teachers use AI grading systems, they become disoriented about official accountability practices and have doubts about the solutions. Past arguments result in strong aggregate observable consequences of trust and school educational quality, and fairness. The introduction of AI systems into the business of educational organisations presupposes the guidelines that are pre-designed to establish positive results in the area of educational safety and fair practice. The integration of the systematic competencies builds up in the AIS systems after attaining the preferred academic deliverables. These educational tools make use of computers under the supervision of the teacher and enhance the academic performance of the students as well as assist in the development of learning by facilitating the use of virtual learning materials that enable the students to become interested. The platform has superior practical training based on the abilities of the learners, as it develops around the knowledge bases of students. The initial positive influence is missed when the students realise that something is wrong in the course of learning. Schools that have students in low-income neighbourhoods develop this limiting technology policy, as the existing education standards do not show that their programs fail to address the needs of the students accordingly. The cognitive ability functions of students may deteriorate in case AI tools over-depend on them, since the dependence may result in the lack of their independence in terms of thinking and the destruction of the key relationships with teachers and classmates. AI plays a major role in boosting the academic standards and offering consistent modifications to the instructional methods that either lead to positive or negative results. AI technology provides essential educational value to the schools, and it requires additional solutions to address existing issues in education. When used well, AI teaching systems assist education institutions to achieve excellence in not only combining superior education seeking with student-focused activities. AI-based education involves full access for the students to the system in addition to the data protection and maintenance of the human teaching presence. To ensure the successful operation of educational AI systems, human administrators must apply limitations to them and avoid any negative effects on the human population in terms of reducing the diversity of instruction and educational equality, as well as social connections. The use of AI as an ideal example provides learning institutions with an opportunity to benefit from one of the most essential changes in the modern technological sphere today.

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Preparing AI and Quantum-enabled HEIs: Curriculum, Pedagogy, and Governance Frameworks

J Madegowda*

Globally, higher education systems are undergoing a phenomenal transformation driven by the convergence of accelerated digital change, artificial intelligence (AI), and Quantum Technologies (QTs). Unlike earlier phases of reform that primarily focused on administrative efficiency, access, and connectivity, the present technological shift is reshaping the epistemic foundations of knowledge creation, dissemination, and evaluation within universities and other higher education institutions. AI increasingly influences how knowledge is generated, curated, assessed, and applied, while QTs introduce fundamentally new computational and analytical possibilities. Collectively, these developments are encouraging and forcing Higher Education Institutions (HEIs) to re-examine their governance arrangements, academic missions, and organisational structures.

Recent studies underscore that AI is no longer a peripheral instructional tool but a general-purpose technology with systemic implications across administration, teaching, and research (Zawacki-Richter et al., 2019; Rose Luckin et al., 2016). Simultaneously, quantum computing and communication are transitioning from predominantly theoretical domains to applied research and education agendas, necessitating early and thoughtful institutional engagement (Dowling, 2002). Accordingly, HEIs are increasingly positioned as critical sites where societal values, technological capability, and human capital formation intersect in shaping future knowledge societies.

From Digital to Intelligent and Quantum-Ready HEIs

The digital university model, featured by basic data analytics, learning management systems, and online delivery platforms, has reached its functional limits in addressing contemporary societal and academic demands. While digitalisation improved access and efficiency, it has not fundamentally changed how HEIs learn, adapt, and govern themselves. The present phase marks a transition of HEIs from digitalised to intelligent and quantum-ready ones capable of embedding adaptive decision-making, advanced computation, and predictive analytics into core administrative and academic processes (Zhang, 2025).

AI-enabled universities and other HEIs deploy decision-support tools, learning analytics, and adaptive systems to personalise education, strengthen research performance, and augment institutional effectiveness (Ben & Envonb, 2020). By contrast, quantum-ready institutions focus on the development of foundational literacy, interdisciplinary research capacity, and collaborative ecosystems that anticipate future scientific and industrial transformations (NASEM, 2019). This signifies a shift from automation toward augmentation, where intelligent systems improve, but do not replace, human creativity, judgment, and ethical reasoning.

Strategic Relevance of AI and QTs

At the national level, AI and QTs are increasingly recognised as strategic assets enhancing geopolitical influence, economic competitiveness, and technological sovereignty. Across advanced and emerging economies, governments are placing universities at the centre of their AI and quantum strategies, considering them as hubs for talent development, frontier research, and innovation ecosystems. The ability of a country to design, govern, and ethically deploy these technologies depends, to a greater extent, on the strength and adaptability of its higher education system.

Universities play a vital role in ensuring knowledge sovereignty, i.e., the capacity of countries to generate, retain, and apply crucial knowledge domestically rather than depending excessively on external sources (Mazzucato & Kattel, 2020). Innovation ecosystems anchored in HEIs facilitate cross-sectoral collaboration among government, academia, and industry, increasing the translation of research into socio-economic value (Rachel et al., 2025). Therefore, AI- and quantum-enabled HEIs function not only as educational providers but also as strategic instruments of national development and global knowledge leadership.

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Rationale for Institutional Preparedness

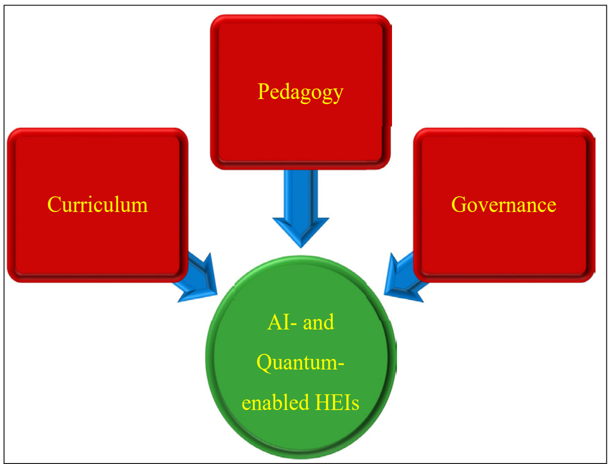
Although there is a growing awareness of AI and QTs, institutional responses within the higher education sector remain uneven and fragmented. Many of the initiatives are in the form of pilot projects, isolated technology deployments, or short-term experiments driven by availability instead of strategic alignment. This type of piecemeal adoption risks reinforcing inequalities, undermining academic integrity, and creating governance gaps. Therefore, experts caution that without proper preparedness, advanced technologies may magnify existing institutional weaknesses rather than addressing them effectively (Selwyn, 2020).

Institutional preparedness focuses on coordinated capacity-building, alignment with academic values, and integration across teaching, research, governance, and institutional culture. However, this demands the development of faculty competencies, organisational structures, ethical frameworks, and evidence-informed decision-making processes, enabling responsible and sustainable technological integration (UNESCO, 2023). The core issue/ question shifts from "which technologies universities adopt" to "how institutions evolve" as complex socio-technical systems in response to technological change (Cai & Zainudin, 2025; Rane, N. L et al., 2025).

Scope and Objectives of the Study

This paper argues that preparing AI- and quantum-enabled HEIs needs a holistic institutional framework anchored in three interdependent pillars: curriculum, pedagogy, and governance (Figure 1).

Figure 1: Interdependent Pillars of AI- and Quantum-enabled HEIs



- Curriculum determines what knowledge, skills, and values are prioritised,
- Pedagogy is about how learning experiences are designed and delivered through technology, and
- Governance ensures that innovation aligns with institutional mission, ethical norms, and public accountability.

Fragmentation across these domains undermines transformation, whereas integration strengthens institutional effectiveness.

In the above backdrop, this paper seeks to (i) analyse how AI and quantum technologies require curriculum redesign across academic levels and disciplines, (ii) examine pedagogical innovations enabled by intelligent systems while safeguarding human agency and academic rigour, and (iii) propose governance frameworks that support future-ready, responsible, and inclusive HEIs. By adopting an institutional and policy-oriented perspective, the study intends to assist regulators, policymakers, and academic leaders engaged in shaping the next phase of higher education transformation.

Conceptual Foundations

This section presents the conceptual foundations required to understand how AI and QTs are reshaping HEIs. Instead of viewing these technologies as discrete tools, the paper positions them within the broader governance, institutional, and epistemic transformations. Understanding their core concepts, applications, and trajectories offers a shared analytical lens for researchers, policymakers, and academic leaders engaged in higher education reform.

AI and Higher Education

AI has evolved as a general-purpose technology with far-reaching implications for HEIs. Its importance lies not only in automation or efficiency gains, but also in its ability to transform how learning is designed, knowledge is produced, and institutional decisions are made. Understanding AI in the context of higher education needs clarity regarding its principal typologies and functional domains.

AI broadly refers to computational systems capable of performing tasks that typically require human intelligence, including reasoning, pattern recognition, learning, and decision-making (Norvig, 2010). Within HEIs, several AI typologies are particularly relevant. Machine learning systems learn patterns from data and underpin predictive analytics, adaptive learning platforms, and institutional forecasting tools. Generative AI models, including large language models, generate new content such as text, code, and explanations, providing opportunities for learning support while raising apprehensions about academic integrity and epistemic trust (Bannert et al., 2023).

Learning analytics denotes another critical AI application in higher education. By examining student engagement, performance, and progression data, learning analytics platforms enable institutions to identify patterns, predict outcomes, and design targeted interventions (Zawacki-Richter et al., 2019; Dong Zhao et al., 2025). These data-driven approaches strengthen evidence-based curriculum design, instructional enhancement, and accountability mechanisms. Furthermore, AI-driven decision-support systems integrate data from multiple institutional sources to enable resource allocation, admissions forecasting, strategic planning, and scheduling (Dong & Zhang, 2025).

Across institutional functions, AI applications span teaching, research, and administration. As far as teaching and learning are concerned, AI supports and strengthens personalised and adaptive learning environments, intelligent tutoring systems, automated assessment, and early identification of at-risk students (Holmes et al., 2019; Simone et al., 2025). In the area of research, AI facilitates data analysis, literature survey, simulation, and hypothesis generation, particularly in data-intensive and interdisciplinary domains. Administratively, AI improves governance capacity through predictive enrolment models, process optimisation, and performance dashboards (Ben & Envonb, 2020). These applications illustrate that AI's relevance lies in its systemic reach across institutional domains instead of isolated use cases.

QTs and the Academic Ecosystem

QTs refer to a qualitatively distinct technological frontier, founded on the principles of quantum mechanics instead of classical computation. Although QTs are still emerging, their long-term implications for national, science, and industry capability are significant. Universities and other HEIs are, therefore, increasingly regarded as foundational actors in building quantum knowledge, skills, and innovation capacity.

Quantum computing exploits phenomena such as superposition and entanglement to perform computations that are infeasible for classical computers. This is more so in the case of optimisation, materials science, cryptography, and complex system simulation (Dowling, 2002; Nkolika, 2025). Quantum communication leverages quantum mechanical properties to ensure ultra-secure information transfer, particularly through quantum key distribution, where any interception attempt is inherently detectable (Li, 2025). Furthermore, quantum sensing applies quantum effects to achieve unprecedented measurement precision, with applications in fundamental science, healthcare, navigation, and environmental monitoring (Antonio Acín et al., 2018; Norvig, 2010).

Notably, the relevance of QTs to higher education lies less in immediate large-scale deployment and more in early-stage knowledge development and human capital formation. Therefore, quantum literacy is increasingly recognised as a cross-disciplinary competence instead of a niche specialisation. While engineering and physics remain central, disciplines such as public policy, chemistry, materials science, economics, law, and management must engage with QTs to address issues associated with strategic governance, cybersecurity, intellectual property, and regulation (NASEM, 2019; Noahlana & Franklin, 2025). As quantum applications mature, professionals across various domains require a solid conceptual understanding to participate meaningfully in interdisciplinary teams and make informed decisions.

Worldwide, higher education systems are investing heavily in capacity-building and quantum education. Canada, China, the European Union, the United States, and other advanced economies have designed/established dedicated degree programs, interdisciplinary centres, and national quantum initiatives that place HEIs at the centre of human resource development and frontier research (Tian, 2025). Similarly, India's National Quantum Mission focuses on human resource development, research, and infrastructure across HEIs (Angwaomaodoko, 2025). These trends signify that quantum readiness is becoming necessary for both institutional and national scientific maturity.

From Digitalisation to Intelligence Enablement

The transition from digitalisation to intelligence enablement denotes a crucial inflection point in the transformation of higher education. While digitalisation is about converting analogue processes into digital formats, intelligence enablement focuses on data-driven cognition, predictive capability, and adaptive institutional behaviour. Comprehending this shift calls for attention to an institutional maturity continuum.

Digitised institutions denote the foundational stage, featured by communication infrastructure, information systems for administration, learning management platforms, and digitised libraries (Walter, 2024). Although these systems improve access and efficiency, they do not inherently support advanced decision-making or institutional intelligence. The next stage consists of data-driven institutions, which systematically collect and analyse institutional data to comprehend learning patterns, research performance, and operational efficiency (Vehrer & Pálfalusi, 2025). However, at this stage, human expertise remains central to interpretation and strategic decision-making.

Intelligent institutions integrate AI and advanced analytics into core administrative and academic processes. AI-enabled systems support and strengthen adaptive learning, AI-assisted research, and predictive governance tools, while maintaining human oversight and accountability (Jha et al., 2025). Furthermore, quantum-ready institutions extend this trajectory by incorporating quantum communication and computing capabilities, either through cloud-based access or on-site facilities, and by developing sufficient quantum literacy among faculty members and students (Chen et al., 2025). At this stage, institutional governance explicitly recognises QTs within long-term strategic planning and resource allocation.

This continuum highlights that readiness for AI and QTs develops progressively. HEIs at earlier stages must prioritise advancement toward intelligence enablement before pursuing extensive quantum integration. Notably, progression along this continuum needs not only technological infrastructure, but also coordinated transformation of curriculum, pedagogy, governance, and institutional culture (Liang et al., 2024).

Curriculum Transformation for the AI and Quantum Era

Curriculum is at the core of institutional preparedness for AI and QTs. Although governance frameworks and infrastructure offer necessary enabling conditions, it is curriculum design that ultimately moulds graduate competencies, research orientation, and societal impact. Therefore, preparing AI- and quantum-enabled HEIs requires a rethinking of curriculum architecture, learning pathways, and policy alignment. This is necessary to ensure relevance, inclusivity, and long-term adaptability of the curriculum.

Rethinking Curriculum Architecture

Historically, higher education curricula have organised knowledge into discipline-specific silos, with students progressing through sequential courses within narrowly defined academic domains. Although this structure has provided depth and coherence, it has limitations in addressing the complex, multi-dimensional challenges of the AI and quantum era (Tillmanns et al., 2025). Emerging technologies increasingly cut across disciplinary boundaries, combining policy considerations, computational methods, domain knowledge, and ethical reasoning.

- *From Discipline Silos to Inter- and Trans-disciplinary Designs*

  AI applications in social policy, healthcare, finance, governance, and climate science demonstrate that meaningful innovation frequently occurs at disciplinary intersections. Similarly, quantum technologies implicate not only engineering and physics, but also public administration, cryptography, economics, law, and management. Interdisciplinary curricula integrate knowledge from different but related disciplines while retaining disciplinary identity. Moreover, transdisciplinary approaches organise learning around real-world problems, drawing flexibly from diverse knowledge systems (Patricia Santos et al., 2024; Zhi Jian Zhao et al., 2025). Experts argue that such approaches support epistemic plurality and better prepare graduates for the complex challenges (Barnett & Bengtsen, 2017).

- *Embedding AI and Quantum Concepts Across Academic Levels*

  Curriculum transformation must be vertically integrated across undergraduate (UG), postgraduate (PG), and doctoral levels. At the UG level, all students will benefit from foundational courses on AI and quantum literacy, including basic principles, applications, and ethical implications. Therefore, UG programs should include AI and quantum concepts within general education and discipline-specific courses. At the PG level, curricula should focus on applied competence, allowing students to use AI and QTs to address domain-specific professional and research challenges (Monzon & Hays, 2025). Doctoral programmes should accord preference for advanced methodological training and frontier research, combining deep domain expertise with AI- or quantum-enabled approaches (Tian, 2025). This tiered integration and transformation ensure continuity and coherence across the academic lifecycle.

AI and Quantum Literacy for All Disciplines

The democratisation of AI and quantum knowledge is necessary for the inclusive and sustainable transformation of higher education. It may be noted here that restricting these technologies to a narrow set of technical disciplines risks deepening educational and social divides. Therefore, AI and quantum literacy should be conceptualised as core attributes across all fields of study.

- *Core Competencies Across Disciplines*

  Across disciplines, AI literacy comprises understanding fundamental machine learning concepts, data requirements, model limitations, and ethical considerations such as accountability, bias, and transparency (Walter, 2024). Quantum literacy includes awareness of key principles such as understanding the current developmental status of quantum technologies, superposition and entanglement, and recognition of problem classes where quantum advantage may emerge (Adeoye et al., 2025). For the students of management and commerce, AI literacy supports strategic analysis and data-driven decision-making. Quantum awareness is about risk management, cybersecurity, and long-term technological strategy (Zhang, 2025). In social sciences and humanities, AI competencies focus on ethical reasoning, critical interpretation, and social impact, while quantum literacy informs engagement with governance and science policy debates (Angwaomaodoko, 2025). In the case of sciences and professional programmes, deeper technical competence may be necessary, including experimental methods, algorithm design, and simulation (UNESCO, 2023).

- *Differentiating Literacy, Competence, and Specialisation*

  Effective and successful curriculum design needs clear differentiation between foundational literacy, applied competence, and advanced specialisation. Foundational literacy aims at equipping all students with conceptual understanding and ethical awareness (Liang et al., 2024). On the other hand, applied competence facilitates students in relevant disciplines to use AI and quantum tools for problem-solving and interdisciplinary collaboration (Li, 2025). On the other hand, advanced specialisation is suitable for PG students and researchers focused on developing new algorithms, theoretical advances, or frontier applications (Chen et al., 2025). This systematic differentiation avoids curriculum overload while ensuring that all students possess essential future-oriented capabilities.

Modular, Flexible, and Stackable Learning Pathways

The rapid pace of technological development and change requires curriculum structures that are learner-centric, adaptable, and aligned with lifelong learning. Traditional fixed-degree pathways, although they provide depth, often fail to provide the flexibility required by diverse learner profiles and evolving skill demands.

- *Micro-Credentials, MOOCs, and Certificate Programs*

  Modular curricula organised into discrete competency units provide flexible pathways to learning and credentialing. Micro-credentials recognise narrowly defined competencies, while massive open online courses (MOOCs) expand access to high-quality instruction across geographic boundaries. Certificate programs provide focused learning without full degree requirements. When aligned with institutional quality standards, such modular offerings improve employability and support continuous professional development (Leesa & Gavin, 20221).

- *Integration with Credit Frameworks and Lifelong Learning Models*

  For modular learning to be meaningful, micro-credentials must be integrated into formal credit frameworks and qualification structures. Mechanisms such as the Academic Bank of Credits (ABC) enable the accumulation and transfer of credits across diverse learning experiences, including formal programs, experiential learning and online courses (Liang et al., 2024). The National Education Policy 2020 (NEP 2020) explicitly supports such flexibility through multiple entry and exit points, as well as lifelong learning pathways. Global experience suggests that quality assurance processes and robust articulation mechanisms are essential to ensure academic credibility and coherence (Vehrer & Pálfalusi, 2025).

Alignment with Global and National Policy Frameworks

Curriculum transformation for AI and quantum readiness must align with broader policy ecosystems to ensure scalability, coherence, and legitimacy. National missions, global benchmarks, and regulatory frameworks provide essential direction for institutional reform.

- *National Policy Alignment*

  In India, NEP–2020 provides a strong foundation for curriculum innovation through its emphasis on multidisciplinary education, future skills, flexibility, and digital learning (Nkolika, 2025). The National Quantum Mission underlines the strategic importance of quantum education and research, emphasising the role of HEIs in workforce development and innovation. Furthermore, Digital India and National Skilling initiatives position AI as a crucial enabler of economic transformation and social inclusion (Emilia et al., 2025). Embedding these priorities within curricula supports and strengthens institutional relevance and national impact (Department of Science & Technology, 2023).

- *International Benchmarks and Best Practices*

  Globally, leading universities and other HEIs are including AI and quantum education within interdisciplinary and transdisciplinary frameworks, supported by sustained public funding and international collaboration. Examples from institutions such as Massachusetts Institute of Technology (MIT), the University of California Berkeley, and ETH Zurich demonstrate integrated approaches that combine technical depth with ethical grounding and workforce readiness (Mqaqa, 2024). Learning from these benchmarks helps Indian HEIs to adopt globally competitive yet contextually appropriate curriculum models.

AI and QTs, and Pedagogical Innovations

Pedagogy is an important, visible interface between emerging technologies and the learner experience. While curriculum defines what is taught, pedagogy is about how learning unfolds and how students engage with knowledge, technology, and society. AI and QTs are catalysing a shift from standardised, instructor-centric models toward inquiry-driven, adaptive, and ethically grounded learning environments that respond to diverse learner needs.

AI-Driven Teaching and Learning Models

AI-driven pedagogical models denote a departure from one-size-fits-all instructional delivery toward personalised, data-informed learning experiences. These models leverage intelligent systems, learner data, and predictive analytics to adapt pacing, content, and feedback to individual student profiles. For HEIs, the pedagogical value of AI lies in improving learner engagement and effectiveness while maintaining academic rigour.

- *Personalised and Adaptive Learning Systems*

  Adaptive learning systems employ machine learning algorithms to analyse student interactions, identify knowledge gaps, and recommend learning pathways tailored to individual preferences and progress (Khan et al., 2025; Zhang, 2025). These systems are capable of accelerating learning for advanced students while providing targeted support for learners who need additional reinforcement. Empirical studies reveal that well-designed adaptive platforms enhance learning outcomes and reduce dropout risks, particularly in large and heterogeneous classrooms (Holmes et al., 2019). However, successful implementation demands careful pedagogical design to preserve instructional coherence and to avoid over-reliance on algorithmic recommendations.

- *Intelligent Tutoring, Assessment Analytics, and Feedback Mechanisms*

  Intelligent tutoring systems apply AI to offer real-time guidance, individualised instruction, and scaffolded support traditionally associated with one-to-one human tutoring (Rane, N. L et al., 2025). Moreover, assessment analytics extend these capabilities by examining student responses to identify misconceptions, model understanding, and ensure timely instructional interventions (Zawacki-Richter et al., 2019; Tillmanns et al., 2025). AI-enabled feedback mechanisms, including generative AI tools, are capable of delivering quick, detailed feedback on writing and problem-solving tasks, supporting iterative learning and refinement (Cai & Zainudin, 2025; Simone, C. O et al., 2025). However, to maintain fairness and trust, such systems must operate within transparent assessment frameworks and under human oversight.

Role of Faculty in AI-Augmented Pedagogy

The integration of AI into pedagogy requires a significant redefinition of the role of faculty members and professional identities. Instead of diminishing the role of educators, AI increases human capability by shifting the emphasis of faculty members from content transmission to facilitation, mentoring, and critical inquiry. This transition needs institutional recognition and sustained professional support.

- *From Content Delivery to Facilitation and Critical Inquiry*

  In AI-augmented learning environments, faculty members increasingly curate high-quality learning resources and design learning experiences that leverage analytics, adaptive platforms, and tutoring systems (Khan et al., 2025). Routine administrative tasks and content delivery can be supported by intelligent systems, enabling faculty members to focus on discussion, reflection, collaborative learning, and problem-solving (Ben & Envonb, 2020). Faculty members also function as intellectual role models, illustrating how to question sources, evaluate evidence, and critically interrogate algorithmic outputs and assumptions (Rachel et al., 2025).

- *Faculty Upskilling and Pedagogical Capacity-Building*

  Successful AI-enabled pedagogy relies on sustained faculty development initiatives integrating ethical awareness, technological fluency, and pedagogical design. Faculty development programmes should support skills in learning design, facilitation, assessment interpretation, and discipline-specific AI integration (Jha et al., 2025). Communities of practice linking faculty members across disciplines enable shared learning and collective problem-solving around AI-augmented pedagogy (Liang et al., 2024). Institutional support structures, including appropriate incentive mechanisms and learning technology specialists, are essential to ensure that pedagogical innovation is valued alongside research productivity (Walter, 2024).

Experiential and Inquiry-Based Learning

AI and QTs considerably expand opportunities for experiential and inquiry-based learning by enabling virtual laboratories, simulations, and real-world problem engagement. These pedagogical approaches align with Constructivist Learning Theories that emphasise knowledge co-creation, active participation, and experimentation.

- *Simulation-Based Learning and Virtual Laboratories*

  Simulation-based learning adopts computational models to ensure realistic yet controlled environments where students can experiment and learn from consequences without real-world risks (Vehrer & Pálfalusi, 2025). Virtual laboratories extend these opportunities by enabling remote access to experimental systems, combining physical apparatus with computational control and observation (Guido Makransky et al., 2020; Zhi Jian Zhao et al., 2025). In quantum education, virtual platforms and cloud-based simulators enable students to explore quantum phenomena and algorithms without requiring on-site quantum hardware (Patricia Santos et al., 2024).

- *Quantum Experimentation Platforms and Industry-Linked Learning*

  As QTs mature, cloud-accessible quantum experimentation platforms increasingly facilitate students to execute programs on real quantum hardware, bridging the gap between theory and practice (Chen et al., 2025). Furthermore, problem-based learning and industry-linked projects improve relevance by linking academic instruction to authentic challenges faced by organisations and research institutions (Tian, 2025). These collaborations ensure access to innovation contexts, real-world datasets, and practitioner expertise, strengthening employability and innovation capacity (Monzon & Hays, 2025; Walter, 2024).

Preservation of Academic Integrity and Human Agency

Although AI provides substantial pedagogical benefits, it also presents a few complex challenges related to learner autonomy, academic integrity, authorship, and equity. In particular, Generative AI tools challenge traditional assessment practices and integrity frameworks designed around plagiarism detection and supervised examinations (Liang et al., 2024).

- *Responsible Use of Generative AI in Teaching and Assessment*

  Institutional responses must comprise clear, transparent policies defining appropriate and inappropriate uses of generative AI in teaching and learning. Appropriate uses may comprise idea generation, formative feedback, and explanatory support, while inappropriate uses consist of submitting unmodified AI-generated work as original student output (Mcdonald et al., 2025; Walter, 2024). UNESCO (2023) emphasises that AI should support learning instead of replacing cognitive engagement. Therefore, assessment design should prioritise critical thinking, synthesis, and application over routine content production (Qureshi, 2023).

- *Maintaining Academic Rigor, Originality, and Ethical Practice*

  Safeguarding human agency calls for reaffirming the centrality of human judgment, creativity, and ethical reasoning in education. Objectives of learning should focus on capabilities that AI cannot replicate, including ethical reflection, critical analysis, and contextual reasoning (Selwyn, 2020; Canan, 2025). AI systems should function as cognitive tools that improve learning instead of substituting intellectual effort (Bower et al., 2024). Academic integrity frameworks must also incorporate ethical AI principles, including accountability, fairness, transparency, and alignment with human values, embedded across curricula rather than confined to standalone ethics courses (Liang et al., 2024).

Governance Frameworks for AI- and Quantum-Enabled HEIs

Governance denotes the central nervous system of AI- and quantum-enabled HEIs. While curriculum and pedagogy shape academic practice, governance determines how technologies are adopted, regulated, and aligned with institutional values and public accountability. In the absence of robust governance frameworks, technological adoption risks becoming opaque, fragmented, and ethically contentious. Against this context, this section examines how institutional governance must evolve to remain effective, legitimate, and future-ready in the intelligent era.

Reimagining Institutional Governance in the Intelligent Era

University/institutional governance structures historically evolved to manage relatively stable academic environments characterised by incremental technological change. These structures typically separate academic decision-making from administrative and technology governance, depending on hierarchical and collegial processes (Walter, 2024). AI and QTs challenge these arrangements by introducing complexity, speed, and cross-domain implications that strain conventional governance models.

- *Limitations of Traditional Governance Models*

  Traditional collegial and bureaucratic governance models are often reactive, slow, and rule-bound, making them ill-suited to managing rapidly evolving technologies. Faculty governance processes may prefer consensus-building, inhibiting timely responses to emerging technological risks and opportunities (Kezar & Holcombe, 2017; Walter, 2024). Fragmented authority across administrative units and departments further contributes to inconsistent adoption practices and accountability gaps, particularly where academic, administrative, and technological decisions intersect.

- *Toward Anticipatory, Adaptive, and Evidence-Based Governance*

  Experts increasingly advocate governance approaches that are adaptive, anticipatory, and evidence-based. Adaptive governance calls for flexible structures capable of adjusting policies as technologies, regulations, and institutional contexts evolve. Anticipatory governance is associated with horizon scanning and foresight activities to identify technological trends and implications before large-scale deployment occurs (Zhao et al., 2024). Evidence-based governance leverages data analytics and institutional intelligence to ensure informed decision-making, while preserving deliberative processes and academic autonomy (Tlili, 2025). In AI- and quantum-enabled HEIs, governance must balance institutional autonomy with public responsibility, agility with legitimacy, and innovation with caution.

Institutional Structures and Decision-Making Mechanisms

Effective governance of advanced technologies demands dedicated institutional structures and clearly defined decision-making mechanisms. Embedding AI and quantum considerations within existing bodies without specialised expertise risks diluting oversight and strategic coherence. Purpose-built structures improve accountability, coordination, and transparency across administrative and academic domains.

- *AI Governance Committees, Ethics Boards, and Steering Groups*

  Many universities and other HEIs have established AI governance committees to oversee institutional AI strategy, review proposed implementations, monitor impacts, and recommend policy adjustments (Walter, 2024; Zhao et al., 2024). These committees usually comprise technical experts, academicians, students, administrators, and external stakeholders, ensuring multidimensional deliberation. Ethics boards offer specialised review of algorithmic fairness, societal impact, bias, privacy, transparency, and accountability (Floridi et al., 2018; Slimi, 2023). Furthermore, technology steering groups coordinate investment priorities, infrastructure, and cybersecurity, ensuring alignment between academic goals and technology strategy.

- *Integration of AI-Driven Decision Support*

  AI-driven decision-support systems are increasingly used in admission forecasting, student retention analysis, research management, and financial planning. When appropriately governed, such systems can augment transparency and strategic foresight (Ben & Envonb, 2020; Siminto et al., 2023). However, governance frameworks must ensure that algorithmic outputs inform instead of replacing human judgment. Clear protocols for explainability, accountability, human override, and appeals are essential to prevent over-reliance on automated recommendations (Palmer et al., 2023).

Data Governance, Ethics, and Accountability

Data constitutes the foundational resource of AI- and quantum-enabled universities, making data governance a central dimension of institutional accountability. Expanded data collection and analytics raise critical questions about ethical use, ownership, privacy, and security, directly affecting trust among faculty members, students, and society.

- *Data Ownership, Privacy, and Cybersecurity*

  AI-enabled campuses generate voluminous data about learning behaviours, research activities, and institutional operations. Data governance frameworks must clarify ownership, consent mechanisms, stewardship responsibilities, retention policies, access rights, and deletion protocols (Walter, 2024; Zhumaniyaz Mamatnabiyev et al., 2024). Privacy protection demands transparency, data minimisation, and privacy-by-design approaches that embed safeguards into system architecture instead of adding them retrospectively (Slimi, 2023). Cybersecurity risks are amplified as institutions integrate cloud platforms and third-party tools, requiring robust protection of networks, applications, endpoints, and data repositories (Ekamdeep Singh et al., 2024). AI-specific vulnerabilities, including data leakage and adversarial attacks, need specialised security strategies.

- *Ethical Frameworks for AI Deployment*

  Ethical governance of AI extends beyond regulatory compliance to include commitments to human dignity, fairness, inclusivity, and transparency. If historical data reflect societal biases, AI systems trained on such data may reproduce inequitable outcomes (Qureshi, 2023). Institutions must conduct fairness assessments, implement mitigation strategies, and ensure the explainability of algorithmic decisions affecting faculty members and students (Floridi et al., 2018; Ke, 2025). Ethical frameworks should assist decisions on surveillance, profiling, and automated assessment, ensuring that efficiency gains do not undermine social justice or academic freedom (Liang et al., 2024).

Regulatory and Accreditation Implications

The emergence of AI- and quantum-enabled HEIs has significant implications for quality assurance mechanisms, regulatory systems, and accreditation processes. Frameworks designed for conventional academic models may not sufficiently capture the complexity of intelligent technologies, requiring regulatory adaptation.

- *Quality Assurance, Accreditation, and Rankings*

  AI-enabled pedagogy, flexible curricula, micro-credentials, etc., challenge traditional accreditation metrics based on contact hours, static curricula, etc. Quality assurance frameworks must centre around outcome-oriented and process-based evaluation, assessing whether technology integration improves learning quality while maintaining privacy and ethical standards (Williams & Harvey, 2016; Sridharan & Sequeira, 2024). Accreditation bodies may incorporate AI and quantum literacy expectations, adapted to institutional mission and context (Qingqing Chang et al., 2022). Although influential, rankings should avoid incentivising superficial technology adoption and instead recognise responsible, mission-aligned innovation (Hu, 2023).

- *Role of Regulators in Enabling Innovation with Safeguards*

  Regulators play a dual role in enabling innovation and protecting public interest. Instead of prescriptive regulation, enabling frameworks establish principles and guardrails such as ethical AI use, equity, transparency, and accountability, while permitting institutional experimentation (Ogunleye et al., 2024). Regulatory sandboxes provide promising mechanisms for piloting new pedagogies, assessments, and governance models within controlled environments, balancing innovation with learner protection. From the perspective of India, such approaches can support AI and quantum readiness while aligning accreditation norms with national missions and global best practices.

Institutional Readiness and Capacity-Building

Institutional readiness represents the crucial bridge between strategic intent and effective implementation of AI and quantum initiatives in higher education. It may be noted here that while curriculum, pedagogy, and governance define what must change, capacity-building assesses whether institutions can change sustainably. Readiness encompasses infrastructure, human capital, and ecosystem integration, all of which must evolve in a coordinated manner to support AI- and quantum-enabled HEIs.

Faculty and Leadership Development

Human capital lies at the centre of institutional transformation in the AI and quantum era. Emerging technologies call for new leadership competencies and continuous professional development models that extend well beyond traditional academic training. Without sustained investment in leadership and faculty development, technological initiatives risk remaining superficial, unevenly adopted, or misaligned with institutional values.

- *Leadership Competencies for the AI- and Quantum-Era HEIs*
- Academic leaders increasingly require a combination of technological literacy, strategic vision, and ethical sensitivity to guide institutional transformation. Vice-Chancellors, Deans, and Heads of institutions and departments must develop competencies in data-informed decision-making, digital governance, risk management, and interdisciplinary coordination. In the context of quantum, leadership is also associated with long-term research planning and alignment with national missions, even where immediate institutional capacity is limited. Leadership in AI-enabled HEIs is not confined to formal positions; distributed and shared leadership models are necessary to mobilise faculty expertise and foster institutional learning (Liang et al., 2024).
- *Continuous Professional Development Models*

  Faculty development for AI and quantum readiness necessitates multi-level interventions addressing awareness, practical competence, and research-level expertise (Walter, 2024). Awareness-level development enables all faculty members to understand AI capabilities and limitations, quantum technology trajectories, and responsible AI principles through workshops, seminars, and online modules (Zhao et al., 2024). Practical competence development supports faculty members in integrating AI and quantum tools into teaching and research, particularly in disciplines with direct applications, through hands-on workshops, mentoring, and specialised training (Liang et al., 2024). Research-level expertise develops through doctoral supervision, post-doctoral programs, and sustained research collaboration (Qingqing Chang et al., 2022). Effective continuous professional development (CPD) models are continuous, modular, and practice-oriented, often organised through communities of practice and interdisciplinary collaboration. These models support not only skill acquisition but also cultural change, enabling confident engagement with AI- and quantum-enabled pedagogy and research.

Infrastructure and Resource Requirements

Technological readiness needs robust and scalable infrastructure aligned with institutional mission, resource constraints, and capacity. AI and quantum initiatives are infrastructure-intensive, but requirements differ significantly across institutional types. Therefore, strategic prioritisation and collaborative approaches are essential to ensure inclusivity and efficiency.

- *Digital Infrastructure, Computing Resources, and Quantum Facilities*

  AI-enabled HEIs depend on high-performance computing resources, including high-memory systems, interoperable digital platforms, secure data architectures, and cloud-based AI services that reduce entry barriers while providing access to advanced tools (Liang et al., 2024). Quantum infrastructure may include partnerships with national quantum facilities, on-campus quantum laboratories for research-intensive institutions, or cloud-based access to quantum hardware (NASEM, 2019; Ekamdeep Singh et al., 2024). Each model involves trade-offs related to cost, control, and capability, requiring careful institutional analysis (Ogunleye et al., 2024). Infrastructure investment must be accompanied by governance mechanisms addressing cybersecurity, sustainability, and ethical use.

- *Shared Facilities, Consortia, and Public–Private Partnerships (PPPs)*

  Given the high costs involved with advanced infrastructure, shared facilities and institutional consortia play a vital role in reducing duplication and expanding access. Shared computing centres and quantum facilities permit multiple institutions to access high-end resources without maintaining independent infrastructure (Walter, 2024). Consortia approaches enable institutions to coordinate curriculum development, pool resources, share professional development programs, and collectively engage with policymakers (Liang et al., 2024). Furthermore, PPPs support infrastructure development by combining academic strengths with industry expertise, computing resources, and innovation pathways. Of course, it requires clear governance arrangements to protect academic independence and integrity (Siminto et al., 2023).

Research Ecosystems and Innovation Platforms

Beyond teaching and administration, AI and QTs are reshaping the research missions of universities and other HEIs. Therefore, institutional readiness depends on developing vibrant research ecosystems and innovation platforms that integrate education, discovery, and societal engagement.

- *AI and Quantum Research Clusters within Universities*

  Leading universities and other HEIs are establishing interdisciplinary AI and quantum research clusters that bring together faculty members and students across disciplines to work on shared research themes. These clusters support collaboration, shared infrastructure use, and coordinated research agendas, while improving doctoral training, post-doctoral development, and institutional visibility (Qingqing Chang et al., 2022). Research clusters can be scaled to institutional capacity, ranging from small thematic centres to networked collaborations supported by coordination structures and seed funding (Dai, 2024).

- *Collaboration with Industry, Startups, and National Missions*

  Institutional readiness is considerably influenced by structured collaboration with startups, industry, and national missions. Industry partnerships offer access to technical expertise, real-world problems, and datasets, while startups emerging from academic research translate discoveries into socio-economic value. Alignment with national missions, such as AI and quantum initiatives, enables strategic relevance, funding continuity, and policy coherence (Mazzucato & Kattel, 2020; Tedre et al., 2021). These collaborations position HEIs as active contributors to innovation-led development instead of passive knowledge providers.

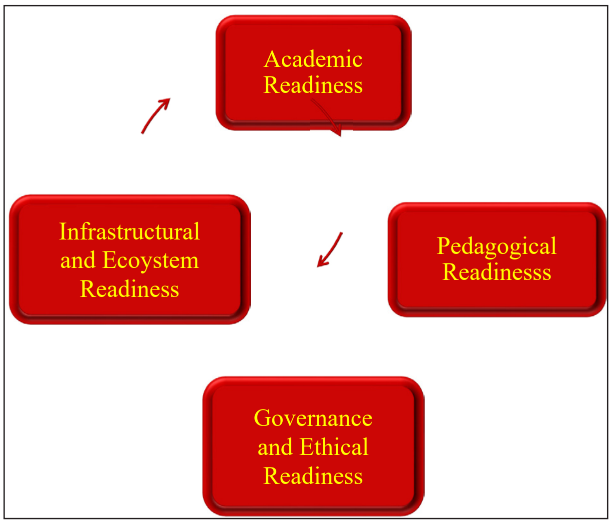
Toward an Integrated Institutional Framework for AI- and Quantum-Enabled HEIs

The preceding sections have analysed curriculum transformation, pedagogical innovation, governance reform, and capacity-building as distinct yet interconnected domains of institutional change. However, preparing AI- and quantum-enabled HEIs cannot be achieved through isolated interventions in any single domain. What is required is an integrated institutional framework that aligns academic purpose, technological capability, and governance responsibility within a coherent strategic vision. In this backdrop, this section synthesises the core dimensions of transformation and proposes a structured readiness framework, a phased implementation roadmap, and differentiated pathways for diverse institutional contexts.

Integrating Curriculum, Pedagogy, and Governance

Curriculum, pedagogy, and governance are the three foundational pillars of AI- and quantum-enabled HEIs, each shaping and reinforcing the others. Curriculum defines the knowledge, skills, and values HEIs seek to cultivate. Pedagogy determines how these outcomes are realised through learning design and instructional practice. Governance provides the structures, policies, and accountability mechanisms through which curriculum and pedagogy are implemented and sustained. An integrated approach recognises the fact that curriculum reform without pedagogical innovation fails to translate intended competencies into actual learning outcomes. Likewise, pedagogical experimentation not supported by curriculum redesign remains fragmented and unsustainable. Similarly, governance misalignment creates implementation friction, undermining institutional coherence and trust (Liang et al., 2024). Integration ensures that initiatives such as AI and quantum literacy are supported by adaptive pedagogy, while governance frameworks safeguard public accountability, academic integrity, and ethical standards. This shift moves institutions from technology-led experimentation toward mission-driven transformation founded in academic values and societal responsibility (Zhao et al., 2024).

Figure 2: Dimensions of Institutional Readiness Framework



A Conceptual Institutional Readiness Framework

Building on the above synthesis, institutional readiness for AI- and quantum-enabled HEIs can be conceptualised as a progressive and multi-dimensional condition instead of a binary state. A conceptual readiness framework emphasises four interdependent dimensions (Figure 2):

(a) Academic readiness involves interdisciplinary integration, curriculum redesign, and differentiated learning pathways across UG, PG, and doctoral levels.

(b) Pedagogical readiness encompasses learner-centred teaching models, faculty capability, experiential learning, and responsible use of AI in assessment and feedback.

(c) Governance and ethical readiness refer to data governance, decision-making structures, ethical oversight, and alignment with regulatory expectations.

(d) Infrastructural and ecosystem readiness represents human capital development, digital and research infrastructure, and external partnerships supporting innovation and capacity-building.

These dimensions function within dynamic institutional environments influenced by national policy priorities, global technological trends, and local constraints (Dai, 2024). Institutions usually progress through stages - from early awareness and limited experimentation to systemic integration and distinctive institutional capability. At advanced levels/stages, institutions embed AI and quantum capabilities across core functional areas and emerge as regional or national leaders in specific application domains (Ke, 2025). Therefore, the framework acts as a diagnostic and planning tool for institutional leaders, instead of a prescriptive blueprint.

Phased Roadmap for Institutional Transformation

Keeping in mind the resource intensity, complexity, and uncertainty of AI and quantum transformation, a phased roadmap, as suggested below, provides a pragmatic pathway for implementation aligned with institutional maturity:

- *Short-Term Actions (Years 1–2)*

  In the short term, institutions should prioritise strategic articulation, awareness-building, and baseline capacity development. Important actions include formulating an institutional AI and quantum strategy, conducting readiness assessments, constituting AI governance committees and ethics boards, and organising faculty awareness programmes. Pilot initiatives in selected courses, decision-support systems, and learning analytics enable HEIs to experiment, learn, and build stakeholder confidence (Liang et al., 2024).

- *Medium-Term Actions (Years 3–5)*

  The medium-term phase emphasises consolidation and scaling. HEIs can expand interdisciplinary curriculum reforms, formalise micro-credential and stackable learning pathways, strengthen AI and quantum research clusters, and integrate AI-driven decision support into key administrative processes. Faculty development programmes should deepen pedagogical competence, while partnerships with industry, other institutions, and national missions become institutionalised. This phase signifies the transition from experimentation to systemic integration.

- *Long-Term Actions (Years 5+)*

  In the long term, institutions aim to achieve sustained maturity as intelligent and quantum-ready HEIs. This includes advanced research capability, deep integration of AI and QTs across academic and administrative domains, and continuous adaptation to evolving ethical, regulatory, and technological landscapes. At this stage, institutions contribute actively to national and global knowledge ecosystems, shaping innovation trajectories, policy discourse, and societal outcomes (Liang et al., 2024).

Differentiated Pathways for Diverse Institutional Types

A critical insight of the integrated framework is that AI and quantum readiness must be pursued through differentiated pathways rather than uniform mandates. HEIs are inherently diverse, and institutional missions, capacities, and student populations vary significantly.

- *Universities and Research-Intensive Institutions*

  Research universities with strong PG programs and research infrastructure are well positioned to pursue advanced AI and quantum research, establish centres of excellence, and engage deeply with national missions. Their pathways focus on frontier research, doctoral training, comprehensive governance reform, and global collaboration.

- *Autonomous Colleges and Degree-Granting Institutions*

  Autonomous colleges can prioritise high-quality UG and PG education, applied AI literacy, and strong industry linkages. Their transformation pathways focus on curriculum flexibility, innovative pedagogy, selective research engagement, and participation in consortia or shared infrastructure arrangements (Qingqing Chang et al., 2022).

- *Teaching-Focused and Affiliated Institutions*

  Teaching-focused institutions play a crucial role in democratising AI and quantum literacy. Their pathways emphasise foundational competencies, student support, ethical awareness, and employability-oriented skills, often enabled through shared digital platforms and faculty development initiatives. Such institutions need not replicate research-intensive models but can contribute meaningfully to workforce readiness and social inclusion.

Implications for Institutional Leadership and Policy

The integrated framework underlines that leadership in AI- and quantum-enabled HEIs is fundamentally about institutional stewardship. Heads of HEIs, including those of universities, governing bodies, and academic leaders, must foster cultures of learning and ethical responsibility, navigate uncertainty, and balance innovation with academic values. At the policy level, regulators and funding agencies can use the framework to design enabling regulations, differentiated incentives, and capacity-building programs aligned with institutional diversity and national priorities.

Preparing AI- and quantum-enabled HEIs is not a technological project but an integral part of a long-term institutional transformation journey. By integrating curriculum, pedagogy, governance, and capacity-building within a coherent framework and phased roadmap, HEIs can respond proactively to technological change while reaffirming their public mission. The proposed framework provides a structured yet flexible approach to guide institutional leaders and policymakers in shaping resilient, ethical, and future-ready HEIs.

Conclusion and Way Forward

The accelerating diffusion of AI and the emergence of QTs signify a defining moment for HEIs worldwide. As this study has argued, the central challenge for HEIs is not whether to adopt these technologies, but how to integrate them in ways that strengthen academic purpose, institutional integrity, and societal relevance. Therefore, preparing AI- and quantum-enabled HEIs requires a comprehensive institutional response that aligns curriculum reform, pedagogical innovation, governance transformation, and capacity-building within a coherent strategic framework.

Key Insights and Policy Implications

Several key insights emerge from the analysis. However, the important insights are summarised below:

- AI and QTs are systemic rather than peripheral, influencing teaching, research, administration, and governance simultaneously. Therefore, institutional readiness demands more than technological acquisition; it requires coordinated transformation of curriculum, pedagogy, governance, and institutional capacity.
- While AI technologies have immediate and widespread applications across higher education, QTs remain largely at the research and capacity-building stage, necessitating differentiated institutional strategies and timelines.
- Curriculum transformation is foundational, as it moulds graduate capabilities, research orientation, and long-term societal engagement. Universal AI and quantum literacy across disciplines and academic levels have become essential preparation for participation in technology-driven societies and professions.
- Pedagogy must evolve to remain learner-centred, inquiry-driven, and ethically grounded, even as intelligent systems enhance personalisation, assessment, and feedback.
- Governance frameworks are critical to ensuring that technological innovation aligns with academic values, equity, and public accountability, while enabling adaptive and evidence-based decision-making (Zhao et al., 2024).

From a policy perspective, these insights highlight the significance of enabling rather than prescriptive approaches. Regulators and funding agencies should support differentiated institutional pathways, encourage experimentation through pilot initiatives, and integrate AI and quantum readiness into quality assurance and accreditation frameworks. National missions and policy instruments can play a catalytic role by aligning incentives, resources, and capacity-building programs with institutional diversity and regional needs.

Role of Institutional Leaders

Vice-Chancellors and senior institutional leaders occupy a pivotal position in steering transformation in the AI and quantum era. Their role extends beyond endorsing policies to strategic stewardship, encompassing vision-setting, institutional learning, and ethical leadership. Leaders must communicate compelling narratives of AI- and quantum-enabled institutions that inspire stakeholder engagement and justify sustained investment in transformation (Dai, 2024).

Effective leadership in this context requires technological literacy, openness to organisational learning, and the capacity to balance competing priorities such as academic autonomy, innovation, and inclusivity. Institutional leaders must also act as conveners, bringing together faculty members, students, industry partners, and regulators to co-create shared understandings and collective pathways. By embedding AI and quantum considerations into institutional planning, governance structures, and faculty development, leaders can ensure that transformation is thoughtful, inclusive, and sustainable rather than reactive or fragmented.

Balancing Innovation, Inclusivity, Ethics, and Academic Values

A major challenge in the AI and quantum era lies in balancing rapid innovation with inclusivity, ethics, and enduring academic values. Although advanced technologies provide unprecedented opportunities for personalisation, efficiency, and discovery, they also pose risks related to exclusion, algorithmic bias, surveillance, and erosion of academic integrity. Therefore, responsible technology deployment needs explicit attention to ethical frameworks that ensure AI and quantum systems amplify, rather than undermine, institutional commitments to equity and human agency (Liang et al., 2024).

Innovation, academic values, inclusivity, and ethics should be considered as mutually reinforcing rather than competing objectives. Innovation that produces inequitable access undermines institutional legitimacy and sustainability, while ethical frameworks that constrain experimentation risk limiting institutional relevance. Integrating these dimensions facilitates technology to serve educational mission, critical inquiry, and social responsibility, instead of replacing or weakening them (Ke, 2025).

Positioning Indian HEIs in the Global Knowledge Landscape

For India, the AI and quantum transition presents both an opportunity and a responsibility. With one of the world's largest and most diverse higher education systems, Indian HEIs are uniquely positioned to demonstrate how technological advancement can be harmonised with social inclusion, democratic values, and national development priorities. India's computational talent and mathematical strengths offer a strong foundation for leadership in AI and quantum domains, while its commitment to access and equity requires inclusive and scalable institutional models.

By aligning institutional transformation with policy frameworks such as the NEP–2020 and national AI and quantum missions, Indian HEIs can develop globally competitive yet contextually grounded models of innovation. Such models can contribute significantly to global knowledge ecosystems while addressing local and national challenges (Liang et al., 2024).

Way Forward

The way forward lies in embracing AI and QTs as instruments of institutional renewal rather than ends in themselves. Through integrated frameworks, phased implementation, and differentiated pathways, HEIs can navigate technological complexity while remaining faithful to their public mission. For policymakers, academic leaders, and regulators, the task ahead is to create enabling environments that foster innovation, protect academic values, and prepare future generations for a rapidly evolving knowledge society.

In doing so, AI- and quantum-enabled HEIs can emerge not merely as technologically advanced institutions, but as resilient, ethical, and socially responsive pillars of national and global development.

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The Purpose of University Learning: To Replace an Empty Mind with an Open One

Hema Raghavan*

"*If you have no knowledge, have no education, how then can you be called a human being?*"

-Savitri Phule

I came across the theme announced by the International Conference on Education (ICEDU) as its focus for the year 2026 to be held in Bali. The Conference theme read "Transforming Education for a Sustainable and Inclusive Future: Adaptive Teaching, Innovative Research, Local and Global Partnerships, and Policy Implications." In my five-decade-old engagement with higher education, I have listened to and participated in many conferences on one or more of the same themes listed above and noticed that the only change noticeable in the conference announcements has been that of the calendar year. Every year, every decade, every age and everywhere, the same themes are discussed, factoring in the needs and demands of that particular period or particular year. It seems the human mind finds it impossible to extend the span of education beyond these five themes that have been flogged and slogged over. I do not know if any research has been conducted to analyse the effects of transformation at the end of these annual deliberations towards the four objectives as listed above. Conferences continue, seminars abound, informal colloquium and structured symposium are held to discuss and debate these themes on Higher education. Otherwise, it is baffling that the same themes are rephrased and discussed all the time and all over the world.

The Challenges of the Age of Gadgets

The present Age is known as the Digital Age, more pertinent to name it as the Age of Gadgets, where the gadgets have taken over both human cognition and physical action. From the pre-Internet era (1950-89) to the post-internet era (1990-2006), to Mobile era (2007-2019) to the Post Pandemic era (2020-22) to the present AI Generative era (2022-the present), Digital transformation has effectively moved the world into the Age of Gadgets, generating a fresh problem for humans to cope with mental inertia superimposed on physical inertia. Hence, the focus of higher education has to shift towards strengthening it to counter the gadgetization of the human potential.

The digitalisation of information has led to information overkill, where information is euphemistically mistaken as knowledge. The need to develop an information filtering exercise cannot be overstated. It is ironic that even for the filtering job, we go again in search of devices like the firewall and other network security systems. Thomas Edison›s famous quote, «Genius is one per cent inspiration and ninety-nine per cent perspiration" can be re -routed to define the present era as 'one per cent innovation and 99 per cent dumbing down of society'. Education must be revived in its original aim to make humans dependent on their cognitive power and not on gadgets.

Impact of AI on Education

On AI, the new transformative technology, Geoffrey Hinton, the Godfather of AI, adopts the Portuguese writer Fernando Pessoa''s words and says that in a few decades from now, "work might be an exception, not the norm."[1] He cites Elon Musk and Bill Gates, who predict that there will be more free time, but no stable jobs. The question is what to do with the available free time? What to do with our lives that have nothing to do? While AI will relieve humans from repetitive, boring jobs, traditional employment will decline. Geoffrey Hinton concludes the new world of gadgets will be " materially richer, technologically dazzling and socially fragile".[2.] Yuval Harari had also warned a few years back about human beings becoming irrelevant in this Age of dependency on gadgets. In a recent address at the World Economic forum at Davos, Harari said that AI is going to cause two crises all over the world- (1) identity crisis as humans lose their ability to think because AI will soon outperform humans on thought process and (2)immigration crisis as AI will disrupt culture and take over jobs because AI will be the new immigrant to take over jobs of every other country. Harari says there will be a social and political, and geopolitical upheaval that no one can have predicted in advance. "The stone has been thrown into the pool, but it

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just hit the water,» he said. «We have no idea what waves have been created, even by the AIs that have been deployed a year or two ago."[3] Unfortunately, Universities do not factor in AI's insidious entry into education and the ensuing reality that where there were ten employees, industry now needs one or at most two (as skills to do a job are done by AI) and are going overboard imparting skills for graduates to serve industry.

And this can be done only through academic training to turn out greater number of Teachers, Care givers, Service providers, Community workers, in particular, to serve the cause of the poor and the marginalised among humanity, Creative Creators and Creative leaders with visionary thinking, adaptability, empathy, and resilience, to build cultures of transformation. In fact, the thrust is to be on creative learning to do something that can make us once more feel relevant. Education is the path to social mobility. In our language, education is to imbibe *Gyan* and *Gyan* is nothing but the removal of *agyan* or ignorance._ Social progress can be achieved only by removing ignorance through educating the minds.

The two contrasting stories of Thomas Hardy's *Jude the Obscure(*1894) *a*nd Willy Russell's *Educating Rita* (1980) illustrate the progressive thinking on education. In the 19th Century Thomas Hardy portrays a poor stone mason Jude, seeking university learning and fails and remains obscure. But in the 1980 Willy Russell's *Educating Rita* makes an impassioned argument for the significance and power of lifelong learning. Rita finds that her education is a chance to breathe and find herself. Russell, through Rita, shows that the value of education is not quantifiable nor measurable, but it remains profound. Education, per se education helps to know oneself and know the world around better and lends meaning to life.

Learning Vs Skill Training

The three possible approaches to the world of gadgets are as given by Prof. Geoffrey Hinton

"*Build at least one income stream that is not your main job Create one regular activity that gives you a sense of contribution beyond money Learn to collaborate with AI rather than competing with it head-on"*[3]

What is unmissable in Hinton's suggestions is that they are all skills to be acquired only when one is on job and not during the period of education. Hinton makes a case for developing new skills after getting into a job, as all skills become obsolete with changing technology. Policy makers in higher education have to distinguish between knowledge and skills and train young minds to learn, absorb, develop critical thinking, and foster personal and social growth. Knowledge is antecedent to skills. Skills are subsequent to knowledge. The currently attempted changes in higher education must focus on are like putting the cart before the horse. Education at the graduate level must expanding students' minds and help them to clearly articulate their thoughts both orally and in writing, grasp abstract concepts and theories, and increase their understanding of the world and their community. A proverb in Tamil says you cannot ladle soup unless there is soup in the pot. Knowledge is antecedent to skills. Skills are the practical application of knowledge by transforming theoretical understanding into the ability to perform tasks effectively. While knowledge is acquired through learning, skills are developed through practice, training, and experience. Skills without knowledge makes one a zombie, who goes through the motions of work listlessly and without real engagement. The gadget-educated zombies of today are almost the living dead, lacking higher thinking ability and slowly losing enthusiasm for work. The undue importance given to skill development over academic learning is like the tail wagging the dog.

The problem is the inability to distinguish between menial jobs like cleaning, washing, filing, stocking, etc., low-skilled, low-prestige, and routine tasks that are different from work that is highly skilled, prestigious, intellectual, professional, elevated, and noble, leading to managerial, expert, and superior roles. AI has taken the menial jobs, rendering them jobless. As for the highly skilled jobs, education and learning alone can be a bulwark against AI's intrusion. These skills require a good educational background, theoretical knowledge and the ability to adapt it to practical tasks and the ability to make interpersonal communication and forge interpersonal relationships to work as a team member. Higher education provides the foundation to build up these skills.

The two contrasting stories of Thomas Hardy's *Jude the Obscure*(1894) and Willy Russell's *Educating Rita* (1980 illustrate the progressive thinking on education. In the 19th Century Thomas Hardy portrays a poor stone mason, Jude, seeking university learning, fails and remains obscure. But in the 1980s we have Willy Russell's portrayal of Rita making an impassioned argument about the significance and power of lifelong learning. Rita finds that her education is a chance to breathe and find herself. Russell, through Rita, shows that the value of education is not quantifiable nor measurable, but it remains profound and lends meaning to life. Education, per se education helps to know oneself and know the world around better.

Foundational Knowledge

The NEP says that at the end of three years, a student can exit after securing 132 credits, out of which 72 are from the main and 60 from other courses (that include Discipline Specific courses or Generic Elective courses, Value Added courses, Skill Development courses, Ability Enhancement courses apprenticeship, etc.). Prior to NEP, credit requirements for degrees varied but typically involved completing core subject_papers, with around 120-132 credits for a 3-year Bachelor›s degree. Here lies the problem. 120-132 credits for the core subjects have been brought down to 72 credits, and if a student takes DSC, it will be 80 credits. Such drastic lowering of credits for a core subject amounts to lowering of standards and not doing justice to the academic coverage of the specific discipline.

The emphasis given to skill training kills the very soul of academic learning. In the current Age of Gadgets, employment is a major concern. Skill requirement is fast changing, as fast as the replacement of gadgets by human inventiveness. What is skill today is not skill tomorrow, but basic foundations of knowledge do not change; they remain a constant. Every graduate student must have factual, conceptual and procedural knowledge – what constitutes foundational knowledge. Foundational knowledge provides the structure to simplify complex ideas, allowing for confident progression to advanced topics. It involves the collection and understanding of information and ideas, and developing the ability to apply knowledge to acquire skills like flying a plane or driving a locomotive, performing a complex nursing procedure or dispensing medicines from a pharmacy, etc. As an illustration, a pilot needs to know Advanced flight manoeuvres, instrument flying, aviation regulations, and Multi-Crew Cooperation (MCC). Similarly, Commercial Pilot Licenses (CPL) demand theoretical knowledge and practical skills. A strong base in Physics and Mathematics, and proficiency in English communication are needed -most of which, barring English, are offered by a science degree course. So also a locomotive driver also needs Technical Knowledge, Understanding of engine layouts, fault identification, and safety system, signalling systems, route Knowledge about specific routes, signals, and restrictions and train Handling in controlling the locomotive, calculating braking distances and speed. This demands knowledge of geography, mathematics, mechanical engineering etc that university offers in its graduate curriculum. Higher education is essential for those working in Pharmacies to decode the doctor's scribble, know human physiology, and gain some knowledge of the side effects of the medicine. A physiotherapist must know human biology before seeking skills in physiotherapy. Once there is foundational knowledge, it is easy for the student to apply knowledge to skills related to it. Albert Einstein says, "The value of college education is not the learning of many facts, but the training of the mind to think." The new NEP-UGCF structure dilutes academic rigour by compounding it with non- academic courses like AEC, SEC and VAC, forgetting the fact that Knowledge precedes skills. The ideal universities must follow are four days of full academic rigour and two days of skill training with an industry organisation. The alternative is forenoons for academic learning and post-lunch training for skills.

University Education

What is University education? It is meant for imparting knowledge and preparing young graduates for employment after completing specific skill training by the industry. The university The environment offers scope for human interaction, teamwork, networking, and communication skills, essential for career growth and navigating complex social dynamics. It is time to rethink the aims and objectives of Higher education and its development of future citizens of India. Transforming means to change the character of something in order to improve it. When applied to education, it makes a plea for wholesale change to improve it. A more acceptable phrase for higher learning can be adapting education to the new era dominated by AI and gadgets, without losing the thrust on academic learning.

In this context, I would like to excerpt a speech by Michel D. Higgins, President of Ireland to the European University Association or EUA's annual conference on 7-8 April, 2026, as his remarks are equally relevant for Indian Universities and all World Universities. The points President Higgins made are as under:

- The University's prerogative to draft Education policies has now been handed over to policymakers belonging to the Government and not done by university Professors and educationists. The policymakers tend to narrowly view "*universities in a rather utilitarian way, not as foundations of new knowledge and innovative thinking, but as a means of advancing ... social and cultural dynamism irrespective of the distribution of the benefits." The hitherto* long- term social cohesion objectives *drilled into students by the university curricula* have been impaired.
- Universities must "*engage with new technologies and reap the dividends of innovation…, for a possible better future for our citizens."* Graduate education should enable students not to follow a collision path with new technologies but learn to judiciously use them. The learners don't have to waste time looking for information as it is available at the press of a button, but use the time to sift and sort the information, analyse and synthesise it to create new pathways for the challenging times.
- Instead of being stifled by an iron cage of bureaucracy that imposes its framed policies for the universities to follow, universities should rediscover the original moral purpose and *insist on "remaining open to originality in theory and research, and committed to humanistic values in teaching."*
- Universities should encourage creative and free thinking, which has remained their distinctive and defining quality, and take responsibility to enable and empower students to *"participate fully and effectively at all levels of society and address the great challenges of our time, which include questions of development and global poverty, of climate change and sustainability, and of conflict and displacement."*
- In this wider social understanding of the university, students should be exposed to an intellectual life and helped to develop a critical turn of mind along with an ethical concern towards their community and their world.
- While online learning has made education accessible to a large number of students," *students should not become disengaged from the teacher/student experience. Learning from those who are passionate about their subject, face-to-face collaboration and regular engagement in organic debate and discussion, participation on university societies and clubs, is central to a rich and fulfilling educational experience."*
- The thrust is to be on academic learning. It helps promote inclusive and interdisciplinary scholarship*, and "take a broader perspective, and learn to listen to the viewpoint of others, and bring disparate ideas into a coherent whole*".
- University graduates must be trained to be creative thinkers and make intelligent integration of science and liberal arts. *Walter Isaacson has said that "science gives us the empirical data and the theories to tie them together, but humans turn them into narratives with moral, emotional and historical meaning."*
- The present tendency to relegate humanities in our academic institutions to lower, less important status or position because they seem to have no economic value, is betrayal of the purpose of education *"If we wish to develop independent thinkers and questioning, engaged citizens, our universities must understand the necessary relationship between the liberal arts – the foundations on which much academic learning must be built – and the fields of science and technology in an integrated approach to learning. Indeed, throughout history, the best of our scientists have merged scientific endeavour with the arts, creating a common space in which the best possibilities could be realised."*
- Fostering the capacity to dissent is another core function of the university, *which plays a "crucial role in creating a society in which the critical exploration of alternatives to any prevailing hegemony is encouraged."*
- Universities must be made autonomous and adequately funded to pursue primary and original research. The Universities must be assisted to preserve *"their role as special places for the generation of alternatives in science, culture and philosophy, where minds are emancipated and citizens enabled to live fully conscious lives in which suggested inevitabilities are constantly questioned."*[4]

The foundational focus of Higher education cannot be bartered with and should not be replaced by skills for employment at the cost of academic learning. It is like hastening an unripe fruit in advance of its natural process of ripening. Skill training before learning the basics of knowledge is similar to artificial ripening in place of genetically programmed natural ripening to hasten a mature unripe fruit to an edible, sweetened fruit, *only for short-term gains.*

Information Vs Knowledge

The University has a formidable challenge in the digital revolution that has already left its footprints on the media, entertainment and retail shopping. But its entry into the field of education is fraught with danger. It functions like a double-edged sword---- provide instant information that gives the students the illusion of mastery over a subject under discussion. But information is not enough; it is like taking a horse to a water trough, but that itself cannot make the horse drink. Educationists and University academics must remember Einstein's words, "Information is not knowledge and knowledge is not wisdom". Knowledge is the practical application and internalisation of information. Scholars and researchers, transform information into knowledge with insight, sound judgment, and a deep understanding of its context and consequences. Einstein's quote outlines a journey of learning: we start with raw information, transform it into knowledge, which enables the learner to acquire skills based on it for the benefit of humanity.

The policymakers are looking for an enhancement of quantity over quality. India's higher education system is expanding at breakneck speed, but it does not translate to quality of learning. Universities have turned into Degree factories that neither serve the cause of higher education nor the employability of students. The classical objectives of a university from the time of Nalanda through John Henry Newman's and Humboldt's ideas of a university have been to integrate learning and research and generate ideas, and remain at the centre of economic and social power to promote the welfare of fellow human beings. The universities are established with "the distinctive mission of embodying and transmitting the culture of its society: 'research and teaching must be morally and intellectually independent of all political authority and economic power'. The guiding principle throughout many millennia has been to make teaching and research the two sides of education, to train students to function as the trustees of the humanist tradition. Those who advocate education for employment may have to understand that education, per se education instils in the young minds the moral and social responsibility of citizenship, and this will enable them to use their knowledge to acquire skills for contribution to the economic growth and just welfare of the society they live in without compromising their personal needs.

Every university in every Age and in every country faces the tensions between teaching and research, and between autonomy and accountability and resolves them in the best interest of the Age and time… Despite President Trump's embargo on foreign students' entry into American universities, other global universities in Europe, Canada, Australia and Asia value their universities' membership of an international scholarly community, and their role in shaping national cultures and forming national identity. They recognise the fact that ideal universities continue their search for truth unhindered by political ideologies and fulfil society's expectation that universities will impart qualifications and skills. They maintain a perfect balance between knowledge and skills so that society benefits from the integration of the two.

Innovations and promotion of ideas lead to new jobs that demand new skills, and the fear of AI resulting in the loss of traditional jobs is offset by fertile human imagination to create space for new jobs and new skills. We have to reimagine Einstein's words, *"Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand",* to make our universities centres for teaching as the encouragement of open and critical attitudes, and thereby meet society's expectation that universities impart qualifications and skills.

"*The Purpose of Education," Malcolm Forbes says, "is to replace an empty mind with an open one."*

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1. Times of India, December 5, 2025.
2. *ibid*
3. *Ibid*
4. Mmichael D. Higgins, Address to European University Association Annual Conference, April, 2025. ❑

Mathematics: The Engine of AI and Quantum Technology#

Rabinder Henry* and Rajan Welukar**

As Artificial Intelligence and Quantum Technology redefine global economic and technological structures, mathematics has emerged not merely as an academic discipline but as strategic capital. In service-led economies such as India, where decades of growth were driven by Information Technology (IT) services, IT Enabled Services (ITES) and process execution, a structural shift is underway. OECD economies are the primary sources of technology contracts that are rapidly transitioning towards automation-first, AI-native, and product-centric models. In this transition, tool-based learning without mathematical foundations risks creating a workforce optimized for obsolescence rather than innovation. This article argues that mathematics is the foundational language of AI and quantum systems, the differentiator between tool users and tool creators, and the decisive factor that will determine whether India remains a strategic technology partner or becomes a commoditized service provider. This paper critically examines the consequences of bypassing mathematics in education, the limitations of tool-centric skill development, and the urgent need to reposition mathematics at the core of future-ready education systems.

A Silent Shift Beneath the Noise (Chaos)

Artificial Intelligence tools are becoming easier to use. Quantum technologies are becoming more visible. Coding platforms, low-code systems, and AI copilots are being democratized at unprecedented speed. At the surface, this appears to be an era of inclusion wherein anyone can build, analyse, design, and deploy. Beneath this surface, however, a silent stratification is occurring. The global technology ecosystem is dividing into two distinct classes:

1. Those who use tools (Users)
2. Those who create, control, and evolve tools (Creators)

This divide is not defined by access to software or platforms. It is defined by mathematical depth. For countries like India whose service economy has historically depended on scale, manpower, and execution efficiency this divide carries existential consequences.

Mathematics a Subject or Cognitive Infrastructure

Mathematics is often misrepresented in education as a hurdle, a filtering mechanism and a prerequisite to be "gotten through" but in reality, mathematics is the cognitive infrastructure the internal operating system of scientific and technological reasoning. Here cognition defines the ability of artificial system to learn, think and take decisions. Mathematics trains the mind to abstract reality into models, reason under uncertainty, understand limits, constraints, and trade-offs, generalize solutions beyond specific cases and think in systems rather than instances

Every advanced technology including Artificial Intelligence (AI), quantum computing, robotics, cyber-physical systems, biotechnology entirely operates on these exact principles. When mathematics is avoided, removed or diluted, learners may still *operate* technology, but they lose the ability to understand, question, improve, or reinvent it.

Mathematics as the Language of Artificial Intelligence

Artificial Intelligence is not built on intuition or pattern recognition alone. It is built on formal mathematical structures. At the core, AI relies on linear algebra (vectors, matrices, tensors), probability theory and statistics, optimization theory, information theory, graph theory and topology. Training a neural network is a mathematical optimization process. Evaluating model bias is a statistical exercise. Understanding overfitting, generalization, and robustness requires probability theory. When AI is taught purely through tools models become black boxes, failures become mysterious, ethics becomes superficial and safety becomes reactive. Mathematics turns AI from magic into mechanism from something that is used into something that is understood. The foundational role of mathematics for building cognitive technology including AI is listed in Table 1.

Mathematics as the Only Language of Quantum Technology

Quantum technology represents an even

#*The Article is Re-printed form University News Vol 64 (03) January 19-25, 2026*

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Table 1: Mathematics as Language of AI

Artificial Intelligence (Learning, Reasoning, Decision, Autonomy)
Algorithm & Optimization (Machine Learning, Deep Learning, Search, Control)
Statistics & Probability (Uncertainty, Inference, Learning from Data)
Mathematics-Foundation (Logic, Calculus, Algebra, Geometry, Structure)

stronger case. Unlike classical systems, quantum systems do not align with everyday intuition. Quantum states are vectors. Quantum gates are operators. Measurement outcomes are probabilistic amplitudes. There is no alternative descriptive language as shown in Table 2.

Without mathematics:

- Quantum education becomes memorization.
- Simulation replaces comprehension.
- Hardware development becomes trial-and-error.
- Nations remain consumers, not contributors.

Quantum advantage is not unlocked through tools but it is unlocked through mathematical control of physical phenomena.

Table 2: Mathematics the only language of Quantum Technology

Quantum Applications (Quantum Computing, Communication|, Sensing, Cryptography)
Quantum Algorithms & Protocols (Shor, Grover, QAOA, Teleport.)
Quantum Information Theory (Entanglement, Entropy, Error Correction, Measurement)
Quantum Physics (Superposition, Interference, Wavefunctions, Operators)
Mathematics-Foundation (Linear Algebra, Complex Numbers, |Probability, Group Theory)

The Illusion of Tool-Based Learning

Tool-based learning is attractive because it is fast, marketable, measurable and immediately employable. However, it suffers from a critical flaw: tools are designed to eliminate the need for the user. Every successful tool follows a predictable lifecycle that includes expert-only usage, simplified interfaces, automation of best practices and replacement of routine users. AutoML replaces junior data scientists, Copilots replace routine coding, and low-code or no-code platforms replace configuration roles. Tool users are not future-proofed but they are scheduled for replacement.

Creators' vs Users: The Real Skill Divide

As AI tools become widely accessible and embedded across industries, mere tool literacy rapidly loses its value as a differentiator. When everyone is trained to use the same platforms, competitive advantage shifts upward in the value hierarchy. Routine tool users become easily replaceable, integrators retain relevance only temporarily, and demand increasingly concentrates around those who can extend, create, and architect systems. At the top of this hierarchy are system architects and tool creators, whose skills remain scarce and mission-critical. What fundamentally distinguishes creators from users is their ability to operate one abstraction layer deeper. Rather than focusing on execution, they understand why an algorithm works, the conditions under which it fails, the assumptions embedded within it, how it scales across contexts, and how it can be optimized or re-designed. This capability is not procedural or platform-dependent; it is rooted in mathematical reasoning and systems thinking, which enables enduring relevance even as tools, frameworks, and technologies evolve as listed in Table 3.

India's IT Service Model: A Structural Inflection Point

India's IT services industry has reached a structural inflection point that cannot be addressed through incremental reskilling or marginal efficiency gains. The long-standing model that has been built on labour arbitrage, process execution, and large-scale human-driven delivery was optimized for a previous era of global IT demand dominated by cost reduction and outsourcing. That era is decisively ending. OECD economies, which constitute the primary source of India's IT revenues, are rapidly adopting automation-first strategies, AI-native systems, and outcome-based contracts that fundamentally reduce reliance on manpower-intensive services. As routine development, testing, and support functions are automated, the comparative advantage of scale is eroding. What is now demanded is deep technical ownership that includes algorithmic expertise,

Table 3: Role, Functional and Market demand

Role Level	Primary Function	Market Demand Characteristic
Tool Users	Operate AI tools and platforms	Highly replaceable
Tool Integrators	Connect tools into workflows and systems	Temporary and transitional
Tool Extenders	Customize, fine-tune, and extend tool capabilities	Relatively stable
Tool Creators	Design core algorithms, models, and platforms	Scarce and high-value
System Architects	Design end-to-end intelligent systems and abstractions	Critical and strategically vital

system architecture, product engineering, and continuous optimization of intelligent systems. This shift represents a permanent realignment rather than a temporary market correction, compelling India's IT ecosystem to transition from service execution to intellectual leadership or risk progressive marginalization in the global technology value chain.

OECD Economies and the Automation Shift

OECD economies are undergoing a decisive transition toward automation-first and AI-native operating models that is reshaping global technology demand. Enterprises across manufacturing, finance, healthcare, logistics, and public services are systematically reducing dependence on manual and repetitive IT functions by embedding automation, machine learning, and autonomous decision systems directly into their core operations. As a result, the nature of external technology engagement is changing: contracts are increasingly outcome-based rather than effort-based, delivery teams are becoming smaller and more specialized, and value is being measured in terms of system performance, resilience, and continuous optimization rather than hours billed. What was once classified as "support" now involves mathematically intensive work such as model monitoring, drift detection, algorithmic optimization, safety validation, and real-time system orchestration. This shift fundamentally raises the skill threshold for participation in global technology supply chains and favours partners capable of deep algorithmic, mathematical, and system-level reasoning over those offering scale-driven service execution. Routine services are being automated internally and external vendors are expected to deliver intellectual value, not manpower.

Why Mathematics Determines Value Capture

In a service-led economy, the central challenge is no longer employment generation alone but sustainable value capture within global technology markets. Roles that require limited mathematical depth tend to deliver low margins, face intense competition, and remain perpetually vulnerable to automation and cost pressures. In contrast, mathematically intensive roles including those involving algorithm design, optimization, system modelling, and performance engineering that enable ownership of intellectual property, outcome-based pricing, and long-term strategic relevance are the need of the hour. Mathematics allows organizations to move beyond billing for effort toward commanding value for insight, reliability, scalability, and innovation. It is this mathematical foundation that determines whether firms remain interchangeable service providers or evolve into indispensable technology partners. As automation accelerates and tools become commoditized, mathematics increasingly defines where economic power, negotiation leverage, and durable value ultimately reside. Mathematics is the difference between billing hours and owning platforms. Table 4 shows the core mathematical area and their importance in building AI.

Artificial Intelligence is not driven by tools alone, but by a layered mathematical foundation that governs learning, reasoning, and decision-making.

Product and Platform Transition Requires Mathematics

The transition from service-based delivery to product and platform-led technology development is fundamentally constrained by mathematical capability. Unlike services, which can scale through process replication and manpower, products and platforms demand rigorous modelling of user behaviour, system performance, reliability, and long-term scalability. AI platforms, SaaS products, digital twins, and autonomous systems must operate under varying conditions, optimize continuously, and withstand

Table 4 : Role of Mathematical Domains in Building AI

Mathematics Area	Core Concepts	Applications in AI
Linear Algebra	Vectors, matrices, eigenvalues, tensors	Neural networks, embeddings, transformers, image and speech processing
Probability Theory	Random variables, distributions, expectation	Uncertainty modelling, Bayesian inference, generative models
Statistics	Estimation, hypothesis testing, regression	Model evaluation, bias detection, performance validation
Calculus	Derivatives, gradients, partial derivatives	Training neural networks, backpropagation, optimization
Optimization Theory	Convex/non-convex optimization, constraints	Loss minimization, hyperparameter tuning, reinforcement learning
Information Theory	Entropy, mutual information, KL divergence	Feature selection, representation learning, compression
Graph Theory	Nodes, edges, connectivity, traversal	Knowledge graphs, recommendation systems, social network analysis
Discrete Mathematics	Logic, sets, combinatorics	Search algorithms, rule-based systems, symbolic AI
Stochastic Processes	Markov chains, random walks	Reinforcement learning, sequential decision-making
Geometry & Topology	Manifolds, distance metrics	Dimensionality reduction, clustering, representation learning
Numerical Methods	Approximation, iterative solvers	Large-scale model training, numerical stability
Game Theory	Nash equilibrium, payoff matrices	Multi-agent systems, strategic decision-making
Boolean Algebra	Logical operations	Decision trees, logic-based AI systems

real-world uncertainties that are requirements that cannot be met through tools or frameworks alone. Mathematics underpins performance prediction, fault tolerance, optimization, and explainability, determining whether a product merely functions or sustains competitive advantage in global markets. Without a strong mathematical foundation, attempts to move up the value chain remain superficial, resulting in platforms that depend on imported intellectual depth rather than indigenous innovation. End of the day tools accelerate development but it is Mathematics which determines survival.

National Risk of Bypassing Mathematics

Systematically bypassing or diluting mathematics in education creates a long-term national vulnerability that cannot be corrected through short-term reskilling or tool adoption. An ecosystem deprived of mathematical depth produces shallow innovation pipelines, weak advanced research capacity, and limited ability to generate original intellectual property. Over time, this leads to dependence on imported technologies, reduced influence over global standards, and diminished strategic autonomy. While such systems may temporarily sustain employment through tool-based roles, they struggle to transition toward high-value product development, advanced AI, or quantum technologies. The cumulative effect is wage stagnation, declining global relevance, and an erosion of technological sovereignty, even in the presence of a large and active workforce. Such systems may produce employability, but not sovereignty.

Mathematics and Creativity: A False Dichotomy

The notion that mathematics suppresses creativity is a persistent but fundamentally flawed assumption. In reality, mathematics enables structured imagination by providing a framework within which ideas can be explored, tested, and scaled. Generative AI relies on probabilistic models to produce novel outputs, parametric and computational design use mathematical relationships to explore vast creative spaces, and quantum algorithms exploit interference patterns to achieve outcomes that defy classical intuition. In advanced robotics, architecture, music, and visual design, mathematics transforms creativity from isolated inspiration into repeatable, evolvable innovation. Far from limiting creative expression, mathematical thinking expands it by allowing creativity to move beyond intuition and into systems that can adapt, optimize, and endure. Mathematics enables scalable creativity which means that ideas can be tested, refined, and deployed reliably. The human ability to understand the entire Universe and its components is only through mathematics.

Education as a Strategic Design Choice

Education is not a neutral or purely academic endeavour; it is a strategic design choice that shapes a nation's economic trajectory, technological capability, and long-term sovereignty. Decisions about what is emphasized in curricula that foundational mathematics or transient tools, deep understanding or surface-level proficiency directly determine whether learners become system thinkers or platform-dependent operators. An education system optimized for immediate employability through tool-based training may deliver short-term outcomes, but it systematically erodes long-term adaptability and innovation capacity. In contrast, an education framework that prioritizes mathematical reasoning, abstraction, and systems thinking equips individuals to navigate technological shifts, create new platforms, and lead emerging domains. In the AI and automation era, educational design choices are inseparable from national competitiveness and strategic relevance.

Mathematics as Strategic Capital

In the era of Artificial Intelligence, quantum technology, and automation-driven economies, mathematics functions not merely as an academic discipline but as strategic capital. Much like physical infrastructure or financial capital, mathematical capability determines a nation's capacity to build, control, and scale advanced technologies. Countries and institutions that invest deeply in mathematical foundations are able to define technological architectures, influence global standards, and capture disproportionate economic value. Conversely, those that dilute mathematics become dependent consumers of externally developed platforms and frameworks. As AI tools proliferate and technologies commoditize, mathematical depth increasingly becomes the invisible asset that underwrites innovation, resilience, and long-term technological sovereignty.

Reframing Mathematics for the Future

Reframing mathematics education for the future requires a shift away from viewing it as a gatekeeping subject or a collection of abstract techniques, and toward recognizing it as a foundational language for understanding and shaping complex systems.

Mathematics must be taught as a tool for modelling, reasoning, and decision-making across Artificial Intelligence, engineering, natural sciences, design, and emerging technologies. When learners encounter mathematics through real-world contexts, algorithms, data-driven systems, physical processes, and intelligent machines and it fosters transferability, adaptability, and deeper comprehension. Such an approach enables individuals to remain relevant as tools, platforms, and technologies evolve, ensuring that mathematical thinking becomes a durable capability rather than a transient academic requirement.

Conclusion: Depth Over Scale

The earlier phase of global IT growth rewarded scale, manpower, and cost efficiency while the emerging era of Artificial Intelligence, automation, and quantum technologies decisively rewards depth of understanding, ownership of knowledge, and control over core abstractions. As tools become ubiquitous and automation replaces routine work, nations and institutions that rely primarily on scale-driven service delivery risk gradual marginalization. Mathematics-driven depth that is manifested through algorithmic insight, system architecture, and intellectual property creation have become the true source of enduring value. In this context, the vision of *Atmanirbhar Bharat* cannot be achieved through tool adoption alone, but through the development of foundational capabilities that enable technology creation rather than consumption. Similarly, the aspiration of a *Viksit Bharat by 2047* demands an education and innovation ecosystem rooted in mathematical intelligence, systems thinking, and long-term technological self-reliance. Depth, not scale, will ultimately determine India's capacity to shape its own future and remain strategically relevant in a rapidly transforming global economy.

("Nothing moves without mathematics!"

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Exploring the Philosophical and Scientific Intersections of Artificial Intelligence

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The article aims primarily to focus on an exposition of Artificial Intelligence and an understanding of the assumptions of the mind's power. The matter contained in this article is intended to serve the reader by providing a brief history of Artificial Intelligence; by providing a more adequate and balanced conception of intellectual power; and by providing a clearer perception of the logic, language, genetics, nano-technology, robotics, philosophy, and technological reductionism associated with Artificial Intelligence. Finding answers to "Why am I here?", "What is the meaning of life?" What is the mind? Is it located in the brain? How is consciousness represented? How is knowledge represented? How is it stored? How is it retrieved? Then, how is it used? How is mathematical reasoning and logical deduction understood? How do we identify the thought process of the mind? What is the role of Genetic Algorithms and Neural Networks? How is reasoning directly related to ideas? How are thoughts represented in the neocortical pattern? What is the role of language in the representation of complex ideas? How are concepts formed? Those are some of the questions frequently asked. As we explore and scientifically awaken to those subtle substances, many doors will open, and many new areas will be there for us to discover. Hence, rather than a critical evaluation, this article seeks to grasp the philosophical and scientific dimensions of Artificial Intelligence as a complex, evolving, still-developing phenomenon that is impacting our lives in unprecedented ways, and will continue to do so in the years to come.

Philosophical Roots of AI

"All our Knowledge begins with the senses, proceeds then to the understanding, and ends with reason. There is nothing higher than reason". –Immanuel Kant, 'Critique of Pure Reason'.

Immanuel Kant believes that 'Reason is the substance of the universe, ….the design of the world is absolutely rational'. This rationality is reflected in ideals, which are a group of relations, for e.g. signs, symbols, axioms, numbers, mathematical formulae, etc. This can be perceived through deductive or inductive logical reasoning. It indicates relations with consistency. Of course, in this whole process, our mind is an important organ that plays an indispensable role in perceiving the external world and developing ideas through the process of reasoning. Kant says that the external world is known to us through sense organs as sensation. Sensation, perception, learning, thinking, and conception are indeed brought in order, sequence, and unity by a mind. Science, wisdom, intuition, and curiosity is nothing but a greater degree of human understanding of the world. Here, I believe that laws of logic, laws of thought, and laws of nature are involved in the everlasting process of the mind. The essence of the mind is that it is *a priori* inconceivable, indispensable, clear, certain and contains the inherent process of understanding the concepts of space and time. Therefore, Kant says, "For 'Pure' reason is to mean knowledge that does not come through our senses, but is independent of all sense experience; knowledge belonging to us by the inherent nature and the structure of the mind."

Our mind speaks within us to reveal our identity and the epistemological nature of the cosmos. In Vedanta philosophy, it is 'Atma', which is immortal. In Christianity it is said that within you is the light. Human beings have the focus point, 'I', 'me', 'self', 'soul', 'consciousness', 'mind', from which we look at the universe.

आत्मा साक्षी विभुः पूर्ण एको मुक्तश्चिदक्रियः। असङ्गो निस्पृहः शान्तो भ्रमात्संसारवानिव।।

Ãtma sākshi vibhuhu purna ēko muktashchidakriyaha
Asangō nisprihaha shāntō bhramāt samsāravāniva.

("*Wake up and see you are infinite Self. You are free. You have just been overshadowed by the events in your mind. That is all that has happened. A cloud has covered the sun. What can any cloud do to the Sun? Can it destroy it? Remember your nature. You are only Soul, only Being. You are witness to all the events. They will all come and splash like waves on the shore, then go away from you. You are complete. Don't think you are incomplete, and have to do something to complete yourself.*" – Ashtāvakra Gita).

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Protagoras rightly pointed out that 'Man is the measure of all things.' Every soul is unbounded and expresses the whole universe in its own way. Every soul is like an entire world, and like a mirror of the whole universe, which it expresses each in its own manner. Thus, the cosmos is understood as many times as there are souls. Hence, Leibniz aptly said, "There is an infinity of human events which happen through reason and will. Everything belongs to an order, even miracles, though they may be contrary to certain subordinate maxims or laws of nature. I feel that every substance contains, in its present state, all its past and future states and even expresses the whole universe according to its point of view, nothing being so remote from anything else that there is no intercourse between them. Every substance perceives other things because it expresses them naturally, having been created in the first place in such a way that it can do this thereafter and can adapt itself as it should. It is in this obligation imposed from the beginning that what is called the action of one substance on another consists. As for corporeal substances, I hold that we consider only that which is divisible, mass is a pure phenomenon, that every substance has in metaphysical rigor a true unity; that it is indivisible, incapable of generation and corruption, that all matter must be filled with animated, or at living substances; that generation and corruption are nothing but transformation from small to great or the reverse; and that there is no particle of matter which does not contain a world of innumerable creatures, organized as well as massed together".

Since the ancient period, sages, philosophers and thinkers have asked questions about 'mind', 'soul', 'cosmos', 'wisdom', and 'knowledge'. Cognitive psychologists studied how we think, acquire information, store the information in memory and retrieve the required data from memory store for decision making. The research work of cognitive neuroscientists and cognitive technologists shows that the cerebral cortex, that make up or neocortex, where our vision, perception, learning, reasoning, memory and decision-making processes take place. It means the research into neural network of the brain has changed the whole scenario of biological patterns of computing, learning and adaptation. The neuron's neural activity is electrical and it contains the acid called neurotransmitters which stimulate the membrane. These attributes of neural networks play an important role in understanding symbolic representation as an experience of an external-world.

Equally every mind is of unbounded duration. Every mind is also implanted indissolubly in certain matter. As Leibniz said, "*This matter is of definite magnitude. Every mind has a vortex around it. All the mundane spheres are perhaps endowed with minds, such intelligence do not seem absurd. The objection too is that they will not have sufficiently free motion, but since they understand their duty (officium) and communicate with God through the mutual influences of the bodies which they sense, they will not affect a variety of motion. Everywhere there are innumerable minds. There are minds in the human egg even before conception and they are not lost even if conception never takes place. We are ignorant of the wonderful uses to which things are destined by providence….."* (Feb.11, 1676).

In view of the above paragraph, it can be said that the mind contains, in its present state, the whole universe. It means nothing is far away from anything else. Mind is simple, a monad which is mirror of the external world and self-aware of 'Who I am". So, Gurdjieff, a mystic, said, "I remember who I am." But, the fact is that the mind existentially dependent upon the body, particularly the brain. The mind would then cease to be a substance losing its capacity for independent existence. Therefore, Ambrose Bierce aptly said, "MIND, A mysterious form of matter secreted by the brain. Its chief activity consists in the endeavor to ascertain its own nature, the futility of the attempt being due to the fact that it has nothing but itself to know itself with."

The most important features of 'mind' are 'imagination' and 'Intelligence'. It is said that 'Intelligence' is the power of 'Imagination'. 'Perception' is to be able to 'imagine' the external world around us, and 'imagination' allows us to create a new world. Therefore, A. J. Ayer said, "Perception is a direct awareness of material object." Minsky and Seymour Papert, the two co-founders of the MIT Artificial Intelligence Laboratory, wrote a book and titled "Perception" that was inherently incapable of determining whether or not a printed image was connected.

In the search for 'Mind', there are certain questions which are most important. David Hume, a philosopher, said, "What we call a mind is nothing but a heap or collection of different perceptions, united together by certain relations and supposed, falsely, to be endowed with a perfect simplicity and identity."

John Locke in his famous book "An Essay Concerning Human Understanding," says, "All our knowledge comes from experience." But St. Augustine claims that, "the soul itself is more adequate starting point to know the truth. The rational soul of man exercises true knowledge and attains true certainty when it contemplates eternal truths." He adds, "Truths impose themselves upon our minds." "This divine light which illumines the mind, come from God, who is the 'intelligible eye', is whom and by whom and through whom all those things which are luminous to the intellect become luminous."

Mind 'Contains' innate ideas. Our 'Mind' is always aware of innate truth. John Locke denied this presupposition and said 'Mind a *tabula rasa'* (blank slate), which is void of all characters and without any ideas'. Rènè Descartes postulates that there is a natural light *(Lumen naturale)* of reason. It has direct relations to knowledge. It is understood when there is an awareness of it. There is no sensuous knowledge in his epistemology. So, Descartes said, 'I think, therefore I am' (*cogito ergo sum).*

According to Aristotle, perceptions, imagination, and memory are connected with the body and perish with it; passive reason, since it operates in the medium of sensuous images- such images are the occasion for the arousal of concepts in passive reasons- is likewise perishable. Creative reason is immaterial, imperishable, not bound to the body, and therefore immortal. Aristotle said, Body and Soul are related as 'Matter' and 'Form'. The 'soul' is thus the realisation of the body and is inseparable from it.

Nowadays, it is said that 'Ghost is in the machine', which is considered to be copy of our brain. If so, it is easier for us to understand how many of our highly sophisticated psycho-physiological process-work. As in a computer, information is first fed to us, coming as it does from our various sensory channels; this is the input. The next stage is the processing of this input, which is the main function of our mental and cognitive activity, and which may lead to storage of information and output- which is our behavior. Memory is the process that is responsible for the transformation of the input into the output. Memory includes several mental activities like recall, recognition and retention, etc. Information Processing Memory (IPM) is a mental activity about-

a. External World
b. Sensory Register
c. Attention
d. Rehearsal
e. Forgetting
f. Retrieval

Bentley and his followers said that, "Experience or learning acquired by a person leave impression or marks on the mind, which are memory traces. They are the basis of memory in the term of functional tendency, because retention ends when these traces are wiped off." These psychologists have established by giving proof that retention is a physiological process. The marks on the mind symbolise the memory, which is understood on the basis of the following laws:

1. The Law of Repetition is known as 'Law of Exercise'. The same matter repeated over and over. Overdoing repetition is nothing but the 'Principle of Overlearning'.
2. 'The Law of Primacy' is an effect on the remembering of the subject, event content in sequence and its importance. The logical connections, relations which have been established an advantage over all others as far as the ability of memory to recall them is concerned preferred position.
3. The Law of Recency- it determines the values of the retained matter.
4. The Law of Effect- determines whether to remember the matter.
5. The Law of Interest is an important law to remember our experiences and learned subject matter.

In this whole process, the 'learning process' is most important. Learning creates memory traces on the mind on the basis of which recollection is effected. The important factors in learning are:

a. Motivation
b. Association
c. Contiguity
d. Reinforcement
e. Repetition

Ray Kurzweil, in his famous book "How to Create a Mind" stated that the "Pattern Recognition Theory of Mind" (PRTM) describes the algorithm of the neocortex. The perception, memory and critical thinking are possible because of the neocortex. It is true that neocortex is part of the cerebral cortex, which plays an important role in psycho-physiological activities of the mind. According to Bartlett, some other psychologists have attempted to show that memory is a mental activity independent of memory traces. It means perception is a process of discriminating and differentiating the meaning of a stimulus. So, perception is the individual activity which links the experiences of the senses with behaviour. Fran Rosen proposed the concept of ‘perception’ can be understood in the line of Widrow’s concept for Artificial Neural Networks (ANN). To put it simply, the Information Processing Paradigm (IPP) of the human brain is: external world, through sense organs, cerebral cortex, memory stored in neocortex, retrieval, forgetting, and neural network.

Role of Language

“*Logical rules do not take their colouring from the local features of diverse languages*”.

-W. V. O. Quine.

The function of the brain and an innate ability of humans help to learn and recognise the external world through our language. The neocortex makes us understand the received information through our sense organs. Davis H. Hubel, a neuroscientist says “The brain is a tissue. It is a complicated, intricately woven tissue, like nothing else we know of in the universe, but it is composed of cells, as any tissue is. They are, to be sure, highly specialised cells but they function according to the laws that govern any other cells. Their electrical and chemical signals can be detected, recorded and interpreted, and their chemicals can be identified; the connections that constitute the brains woven feltwork can be mapped. In short, the brain can be studied, just as the kidney can”. It means the neocortex is responsible for sensory perception, recognition of everything from visual objects to abstract concepts, controlling movement, reasoning, language and thinking.

Ludwig Wittgenstein rightly pointed out in his book “Philosophical Investigations” as ‘But is it also conceivable that there be a language in which a person could write down or give voice to his inner experiences- his feelings, moods, and so on—for his own use? –Well, can’t we do so in our ordinary language? – But that is not what I mean. The words of this language are to refer to what only the speaker can know, to his immediate private sensations. So another person cannot understand the language. How do words refer to sensations? –There doesn’t seem to be any problem here; don’t we talk about sensations every day, and name them? But how is the connection between the name and the thing named set up? How do I use words to signify my sensations?

And sounds which no one else understands but which I ‘appear to understand’ might be called a “private language”.

In this regard, the account given by logic, language, mathematics, quantum physics, biology, genetics, physiology, nano-sciences, nanotechnology and robotics of the causation of our sensations, and the picture of the external world presented by cognitive technology is a representation of the mind. Cognitive technology brings together computer models from artificial intelligence and experimental techniques from cognitive psychology to construct precise and testable theories of the human mind. Therefore, Wilson and Keil aptly said “Cognitive science is a fascinating field in itself, worthy of several textbooks and at least an encyclopedia.”

“The innate ability of man is to learn because of his curiosity. But, other people cannot be said to learn of my sensations only from my behavior for I cannot be said to learn of them. I have them. The truth is it makes sense to say of other people that they doubt whether I am in pain; but not to say it of myself,” said Ludwig Wittgenstein. There is a certainty in $(A+B)^2 = A^2 + 2AB + B^2$ or $2+2=4$. Does ‘This man is in pain’ show the mathematical certainty? The outward criteria for inner processes and do not logically entail the truth of psychological assertions. But for all that they are logically adequate. Wittgenstein said, “There is a kind of mental disease which looks for and finds what would be called a mental state from which all our acts spring as from a reservoir.”

We have within us all the tools we need to become what we want. As we experience to sense energy, we can evolve the energy we learn. As we become conscious of the mind power around us, we can note when our mental power is high: this mental level allow us to evolve the pictures in our mind and focus our intent so that we can become clearer, distinct and understand the facts. The ability of the mind make us look inward and find solutions. Each of us have the ability to visualise, either a picture of the external world or feel it. It is a process of becoming aware of inner ability.

Can we get a picture of our mental state? Of course, pictures speak a universal language. Therefore, it is said, ‘a picture is worth ten thousand words.’ A picture is easily understood by people in all walks of life. So, Ludwig Wittgenstein in his famous book ‘*Tractatus Logico- Philosophicus*’ said: 4.022 ‘A proposition shows its sense. A proposition shows how things stand if it is true. And it says that they do so stand’. He added 4.023 ‘A proposition must restrict reality to two alternatives: YES or NO. In order to that, it must describe reality completely. A proposition is a description of a state of affairs. Just as a description of an object describes it by giving its external properties, so a proposition describes reality by its internal properties.

A proposition constructs a world with the help of logical thinking. So that one can actually see from the proposition how everything stands in logic if it is true. One can draw inferences from a false proposition. Here, we should remember Ockham’s discussion of neutral propositions, that is, propositions which are neither true nor false but indeterminate. Therefore, ‘are neither true nor false and must have a third value different from 1 or the True. These are indeterminate propositions which indicate this by 1/2: It is the “possible” which goes as the third value with the false and the true.

Ray Kurzweil says, “I agree with Watson’s sentiment about the brain being the grandest biological frontier, but the fact that it contains many billions of cells and trillions of connections does not necessarily make its primary method complex if we can identify readily understandable (and re-creatable) patterns in those cells and connections, especially massively redundant one”. To under this, the study of neurosciences helps how the human brain works, and also simulate or model this concept of Artificial Intelligence. Natural Language Generation (NLG) needs computer programs to create readable text in a human-understandable language such as English, Marathi, Kannada, Telgu etc. It is said, ‘every word in the language signifies something’. Ludwig Wittgenstein says the word ‘signify’ is perhaps most straightforwardly applied when the name is actually a mark on the object signified.

In the “New Essays Concerning Human Understanding”, Leibniz describes a ‘universal symbolism based on the principle of Sufficient Reason’. He emphasized the need for a universal language in which the order and relations of signs would so mirror the order and relations of ideals that all valid reasoning could be reduced to an infallible, mechanical procedure involving only the formal substitution of characters for e.g. !, “, #, $, %, &, ‘, (), *, +, -, /, :, ÷, ; , <, =, >, ?, £, {, }, §, «, ®. Symbols and pictures are easier for people to pick up than words. Equally, symbolic logic and meta-language play an important role in the representation of the external world and the revelation of the mind’s power.

In AI, Natural Language Processing (NLP) is used in Machine Translation (MT). It translates natural language between machine and human being. NLP is useful in information retrieval, report generation and tutoring. NLP is in accessing databases known as database inferences. NLP means the process of computer analysis when input is provided in a human language, and the inputs are translated in a useful form of representation. Therefore, NLP is known as ‘computational linguistics’.

Importance of Logic

“Logic is the investigation of all regularity; and outside logic all is accident”. Or “Logical propositions desirable the scaffolding of the world or rather they present it. They ‘treat’ of nothing”. – Ludwig Wittgenstein.

Logic is defined as ‘the art and method of correct thinking’. Logic can be used to reach assumptions for a specific problem. For the proper conclusion and problem-solving purpose, we may use deductive or inductive, symbolic or temporal or propositional or predicate or modal or description logic. Logic is concerned with the True or False propositions. Logic includes syntax, semantics and inference procedure. Therefore, logic is said as ‘Nothing is so dull as logic, and nothing is so important’. This is the ‘alpha’ and ‘omega’ of logic, the ‘heart’ and ‘soul’ of it, that every important term is subjected to definition. Charles Babbage, and Boole demonstrated the computational logic. Although, the great philosophers Bertrand Russell and A. N. Whitehead correlated the logic with mathematics in their very famous book ‘*Principia Mathematica*’, it was Alan Turing who developed the ‘Theory of Computation’ for mechanisation. The computer solved mathematical problems, for e.g. it was able to devise a proof to a theorem that was unsolved by Bertrand Russell and Alfred North Whitehead in the said book. Edward Feizenbaum studied mathematics and medicine with a philosophical dimension of Artificial Intelligence from theory to practical aspects. His logic of mathematics became famous in the early 1960s for its application to medicine-like domains where logic dominates computational mathematics. He proposed the ultra-intelligent computer to solve the problems.

Leibniz's philosophy is based on logic. He said, 'Logic is a rational language, the art of symbolic notations, which marvellously contracts and summarises the minds operations.' Therefore, it is said, 'Leibniz's logic is the encyclopedia of all knowledge conceived as an ordered systematisation of all knowledge as a portable library.'

It is said that "If logic is grammar, it is universal'. George Boole's "Algebraic Logic", 1847, was the basis of the whole development of universal language. Any language is an object language when it is being talked about. And any language is a meta-language when it is being used to discuss an object language. That has led us to the universal scientific language and a calculus of reasoning. 'In logic there are no morals. Everyone is at liberty to build up his own logic, i.e. his own form of language as he wishes. All that is required of him is that if he wishes to discuss it, he must state his methods clearly and give syntactical rules instead of philosophical arguments' said R. Carnap, in his book 'Logical Syntax of Language', New York: Harcourt Oracle, 1937. R. Carnap in his book, 'The Logical Structure of the World' (1928), defined an explicit computational procedure for extracting knowledge from elementary experiences. It was probably the first theory of mind as a computational process.

Today, logicians, scientists, researchers and cognitive technologists are playing a generative role in the imaginative process. The essence of their research work is not only problem-solving but to understand neuro-scientifically mind-body logical relations. Specifically, the research done by Warren McCulloch and Walter Pitts on memory and reason has helped to develop the machines to study the function of neocortex. It has been proven that the machines can work as the agents of the mind.

Leibniz believed that if the 'alphabet' or the basic simple concepts of human thought could be given, then all other concepts and propositions could be seen to be logical complexes of these simple notions. Thus, if we gave 'characters' or 'signs' to these simple concepts, all other concepts could be expressed as a result of operations based on them, and 'There will be no equivocations or amphibolies, and everything which will be said intelligibly in that language will be said with propriety. We will no longer need to have different signs to express very different thoughts we have. We will be able to see the logical relation of concepts by contemplating the signs alone. We will have a mechanical way of checking whether we have a clear and precise grasp of the complex concepts we are considering, we will be able to see beneath the surface grammar of propositions, while introducing a mechanical precision into our reasoning' (Hide Ishiguro, Leibniz's Philosophy of Logic and Language).

Artificial Intelligence

H. G. Wells in his famous book 'The Time Machine' said, "It's a success! It's a Success!" I told myself. "The machine has moved me through the fourth dimension –time!"

For a moment, I felt I'd built the Time Machine for nothing. "So this is future man", I thought. "Light-limbed, fragile-faced, and baby-brained!".

Three hundred years from home, I figured, I would reach the Golden Age of Science. as Prometheus, the Greek God who brought men fire, I'd return with some dramatic new way to help my fellow man".

It means that the scientific and technological nature of machines can be cultivated. The real object to understand the machines as the vehicle prepare for its use. The aspiration of the human being is to allow that light of intelligence to shine through and animate what we call the human potentiality. Machines aims at the infinite power of the human mind to explore the universe. If carefully machine is assimilated, tested and validated through reason, experience and intuition, each of us would become intellectually vibrant, problem-solver and creative centres of unknown areas of various disciplines.

Yes, machines are capable of learning and problem-solving of all such questions. Noam Chomsky rightly said that the innate ability of humans to learn the hierarchical structures in language reflects the structure of the neocortex. He said, 'The attribute of 'recursion' is the ability to put together small parts into a larger chunk, and then use that chunk as a part in yet another structure and to continue this process interactively. In this way we are able to build the elaborate structures of sentences and paragraphs from a limited set of words.' The human brain and molecules serve as machines that provide a structural component. The multiple intertwined technological developments brought the revolution in the field of Genetics, Nanotechnology and Robotics (GNR). Therefore, it is said that the neocortical patterns are the language of thought. That is Knowledge Based System (KBS) based on logical reasoning. Accordingly, Noam Chomsky's linguistic computational theory generated a model for Syntactic Analysis (SA) through a regular grammar (1956-57). Chomsky's attribute of recursion assumes both an infinite generativity and a universal grammar. Recursion is the engine that allows humans to generate and understand an infinite number of unique, grammatically correct sentences from a finite set of words. To expand Chomsky's logic, if this human attribute of recursion—of combining discrete words into infinite correct sentences—is replicated in machines, then these machines can also replicate human communication.

It is perfectly predicted that in the coming years, development in the fields of science and technology will lead us into an ever-evolving modern society. Alvin Toffler, in his famous book "Future Shock" aptly said, "In the coming decades, advances in all these fields will fire off like a series of rockets carrying us out of the past, plunging us deeper into the new society. It, too, will quiver and crack and roar as it suffers jolt after jolt of high-energy change. For the individual who wishes to live in his time, to be a part of the future, the super-industrial revolution offers no surcease from change. It offers no return to the familiar past. It offers only the highly combustible mixture of transience and novelty." To understand this futurology, there is a need of logical programming as follows:

- Logic Programming should have a set of axioms, and a goal statement.
- It should deduce the truth of the goal statement.
- It is needed to follow the rules for precision in inferences.
- It should specify the fundamental logical associations for drawing conclusions.

Accordingly, Alan Turing (1912-1954), the British mathematician, published an article titled "Computing Machinery and Intelligence" in the journal "Mind" in October 1950. Alan Turing asked a question in the said article is: Can machines think? He said 'Yes'. He believed that in about fifty years' time, it will be possible to program computers, with a storage capacity of about 10^9, to make them play the imitation game so well that an average interrogator will not have more than 70% chance of making the right identification after five minutes of questioning…. I believe that at the end of the century, the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted. Alan Turing articulated a complete vision of machine thinking. He proved that problem-solving was possible through only the machine. He elaborated his ideas on machine intelligence by reference to chess. Alan Turing, along with David Champernowne, developed Turochamp, probably the first computer chess algorithm, in around 1948. Turochamp used a heuristic approach—which is a problem-solving approach based on experimentation and trial and error—assigning points to pieces and evaluating positions to select moves, a foundational concept for modern AI. Turing also said that it was possible to let the machine alter its own instructions so that machines can learn from its stored information. Hence, Alan Turing rightly pointed out 'That machine intelligence would become so pervasive, so comfortable, and so well integrated into our information-based economy that people would fail even to notice it.'

Alan Turing's 'Turing Test' is based on the program behaving like a human. His 'The Imitation Game' is the first test which conceal its abilities. The Turing Test was conducted between two people Alice and Bob, sitting in two different rooms. The test person was Alice who was sitting in a locked room with two computer terminals. Alice can type in both terminals. One terminal was connected to a machine, and the other terminal is connected to the other person Bob, who is non-malicious. Basically, Alice has to decide after five minutes which terminal is belongs to the machine. Passing condition is that the machine has to trap Alice at least 30% of the time. Undecidability of the halting problem is the most important invention of Alan Turing. He said 'the potential for a machine is to serve as a Mechanical Brain.' His test is about the cognitive abilities that we express through language. This can be used to assess AI's abilities in various fields.

In 1950, Allen Newell and Herbert Simon, with Logic Theory (LT) and Automatic Theorem (AT), implemented the perception of the external world with the computer. Newell and Simon's Logic Theorist was considered to be the first Artificial Intelligence Program. Allen Newell and Herbert Simon contributed the General Problem

Solver (GPS), written in Information Processing Language (IPL), a program that simulated some mental activities in solving complex problems. The terminology 'Artificial Intelligence' was proposed by John McCarthy (1927-2011) in 1956. McCarthy's contribution is his method of knowledge representation and reasoning. He said, "The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can, in principle, be so precisely described that a machine can be made to simulate it. An attempt to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves." He adds, "This would ultimately automate every other field, be called 'Artificial Intelligence." John McCarthy invented the LISP programming language. List Processing (LISP) is basically made for processing symbolic structures.

Marvin Minsky developed a knowledge representation model, 'FRAME', in 1975, which treated objects as frames, their parts as slots and properties as attributes, arranged in a large hierarchical taxonomy. McCulloch and Pitts wrote a paper, "A Logical Calculus of Ideas Immanent in Nervous Activity," in 1943 and developed a Boolean circuit model in the brain which helps neural networks compute. Stochastic Neural-Analogue Reinforcement (SNAR) was developed by Marvin Minsky and Dean Edmonds in 1951.

John McCarthy, Marvin Minsky, Claude Shannon and Nathaniel Rochester organised a two-month workshop at Dartmouth in 1956:

"We propose that a two-month, ten-man study of Artificial Intelligence be carried out during the summer of 1956, at Dartmouth College in Hanover, New Hampshire. The study is to proceed based on the conjecture that every aspect of learning or any other feature of intelligence can, in principle, be so precisely described that a machine can be made to find how to make machines use language, from abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer."

This was the beginning of a computer program capable of thinking non-numerically, and thereby solved many problems. Herbert Simon in 1957 said, "It is not my aim to surprise or shock you—but the simplest way I can summarise is to say that there are now in the world machines that think, that learn and that create. Moreover, their ability to do these things is going to increase rapidly until—in a visible future—the range of problems they can handle will be coextensive with the range to which the human mind has been applied."

Herbert Gelerriter at IBM in 1959 designed the first written Artificial Intelligence Program (AIP) for geometry theorem proving in quick succession of time. In 1960, Bernard Widrow alone, and then with his student Ted Hoff, developed networks called 'Adaline'. They also developed the Widrow-Hoff Learning Algorithm, known as the Least Mean Squares (LMS) algorithm, which is used in machine learning, deep learning, and adaptive signal processing. The algorithm is primarily used for supervised learning, where the system iteratively adjusts the parameters to approximate a desired target function. It operates by updating the weights of the linear predictor so that the predicted output converges to the actual output over time. In the 1960s, Marvin Minsky developed the logical framework to integrate reasoning with knowledge. Reasoning is directly related to the representation. Reasoning means the process of obtaining logical conclusion from a fact. Durking said, "Reasoning is the process of working with knowledge, facts and problem-solving strategies to draw a conclusion." It is said that the world is a computation. It is believed that all the physical processes of nature are patterns of computation or information processing at the most fundamental level of reality. Edward Fredkin proposed the theory of digital physics, which posits that the universe is fundamentally a giant computer or a cellular automaton that computes its own next state, rather than simply simulating reality in real time: "It's not a 'simulation' of reality; it's not something that 'pretends' to be reality. It **is** reality."

On May 11, 1997, Blue Deep was a chess-playing computer developed by IBM. This Supercomputer beat world chess champion Garry Kasparov. The machine won a six-game match by two wins to one, three draws against the world champion. IBM computer, named Watson the natural language game Jeopardy and obtained a higher score than the best two human players in the world combined. A search engine helps to find the knowledge or required information in natural language. The Law of Accelerating Returns (LOAR) enabled a vast expansion of biological and technological evolution, says Ray Kurzweil.

The most widely accepted and meaningful concept, 'Artificial Intelligence', is very well expressed in the phrase "Master Machine". To gain a deeper understanding of its functioning, it is convenient to notice that there are several entirely different dimensions in its utility, that 'Artificial Intelligence' possess them all together to a supreme degree. Therefore, the innate ability to think and knowledge, if possessed by 'Artificial Intelligence', are perfections and insofar as they belong to DNA, have no limits. The more intelligent and informed we are about the application of 'Artificial Intelligence', the more we shall be knowledgeable about everything that might be expected. So, V. S. Ramachandran, the neuroscientist, says, "Our ability to perceive the world around us seems upside-down, distorted images inside your eyeballs, but what you see is a vivid three-dimensional world out there in front of you."

I believe that 'Artificial Intelligence' is going to be increasingly and incrementally perfect. Artificial Intelligence shall safeguard our interests and freedom. AI shall act in the most perfect and the most desirable way possible. The application of cognitive technology and the principle of reason will be in balance with the richness of the effects of AI is a most desirable goal. AI acts perfectly as an excellent technologist, or a good teacher, doctor, architect, leader, skilled machinist, author and other experts. The AI shall do the work with order as per our desire. Everything in AI is in conformity with the laws of reasoning and nature. So, it is said that AI is not only the science of computation but also the logic of cognition. The basic assumption in AI is that 'intelligence is concerned with reasoning in general and a logical approach in particular.'

Definitions of Artificial Intelligence

1. Patrick Henry Winston (1992): "Artificial Intelligence is the study of the computations that make it possible to perceive reasons, and act."
2. Richard Knight (2003): "Artificial Intelligence is the study of how to make computers do things at which, at the moment, people are better."
3. R. W. Young defines intelligence as "The faculty of mind by which order is perceived in a situation previously considered disordered."
4. The IBM website defines: "Artificial Intelligence (AI) is technology that enables computers and machines to simulate human learning, comprehension, problem solving, decision making, creativity and autonomy."
5. Google Cloud states, "Artificial Intelligence (AI) is a set of technologies that empowers computers to learn, reason, and perform a variety of advanced tasks in ways that used to require human intelligence, such as understanding language, analysing data, and even providing helpful suggestions. It's a transformational technology that can bring meaningful and positive change to people, societies and the world. It encompasses many different disciplines, including computer science, data analytics and statistics, hardware and software engineering, linguistics, neuroscience, and even philosophy and psychology. AI is about teaching computers to do the amazing things our own brains can do, from understanding the world around them to learning new things and even coming up with fresh ideas."

Salient Features of AI

1. AI acts like a human, thinks like a human.
2. AI encompasses many concepts and methods.
3. AI is the study of the computations that make it possible to perceive, reason and act.
4. The goal of AI is to solve real-world problems.
5. AI helps to understand psycho-philosophical questions.
6. AI create new opportunities in business, engineering, health sciences, agriculture, and many other application areas.
7. AI is designed to identify and understand the thought process of mind.
8. AI is based upon emulation of the intelligence which is exhibited by the human mind.
9. AI and cognitive technology along with tools such as Genetic Algorithms (GAs) and Artificial Neural Nets (ANN) provide techniques for simulating intelligence in decision making, evolution and learning in computers.
10. AI is concerned with the design of intelligence in an artificial device.
11. AI interacts with one's environment.
12. Through technologies like computer vision and speech recognition, AI systems can interpret sensory input from the environment.
13. AI systems are adept at handling and processing vast amounts of structured and unstructured data from various sources.
14. AI has the ability to automate repetitive, time-consuming, and often dangerous tasks.

15. By analysing historical data, AI can forecast future trends and events with high accuracy.
16. AI models are scalable and can handle large-scale applications, exponentially growing workloads and massive datasets without significant infrastructure investment.

Research in Biology

AI and biology are merging to revolutionise life sciences, with AI being capable of analysing vast datasets for genomics, drug discovery, protein folding (like AlphaFold), and personalised medicine, enabling faster insights, predictive modelling, and designing new biological solutions from proteins to metabolic pathways, impacting health, agriculture, and fundamental research. This synergy uses machine learning, deep learning, and foundation models to find patterns, automate complex analyses, and generate novel biological designs, accelerating discovery far beyond traditional methods. Some of the key applications of AI in biological research are in the areas of Genomics and Proteomics, Biomedical Imaging, Synthetic Biology, and Systems Biology.

Marian Diamond rightly said, "The brain is a three-pound mass you can hold in your hand that can conceive of a universe a hundred billion light years across." Molecular biology, molecular nanotechnology and synthetic biology provide—from the laboratories—new genetic knowledge as DNA as nanotubes play an important role in our heredity. So, Michael Sampson, a nanotechnologist, says that the study of bacteria is nothing but a readymade machine. Bacteria are natural nanobot-size objects containing liquids able to move its thread-size arms, which creates systems like natural design to our nanobot designs. Therefore, it is said, 'Never underestimate the power of microbes.'

Charles Darwin's 'On the Origin of Species', 1859; Friedrich Miescher's discovery of 'nucleus' in the cell, which turned out to be Deoxyribonucleic Acid (DNA), Nikolai Koltsov's giant hereditary molecule; James D. Watson and Francis Crick's research work on the structure of DNA helped to prove molecules can serve as machines. John Searle said, "We know that brains cause consciousness with specific biological mechanisms…. The essential thing is to recognise that consciousness is a biological process like digestion, lactation, photosynthesis, or mitosis….. The brain is a machine, a biological machine to be sure, but a machine all the same. So, the first step is to figure out how the brain does it and then build an artificial machine that has an equally effective mechanism for causing consciousness." The study of the human genome highlights the function of the neocortex. The research work in nanotechnology, robotics, biology and cognitive technology helped to widen the scope of study of the functions of neurons, many trillion connections and synapses in the brain. Ray Kurzweil rightly pointed out that 'the singularity is nearer'. A biological human is nothing but a large number of molecules functioning in harmony.

"Nature shows that molecules can serve as machines because living things work by means of such machinery. Enzymes are molecular machines that break and rearrange the bonds holding other molecules, and they haul fibres past one another. DNA serves as a data-storage system transmitting digital instructions to molecular machines, the ribosomes, that manufacture protein molecules. And these protein molecules, in turn, make up most of the molecular machinery."

-Eric Drexler.

Cognitive technologists have to endeavour their reductionism to the existence of '*a priori*' knowledge. An innate singularity that can manifest as diverse plurality. Can we reduce consciousness to the singularity because it is fundamentally irreducible in principle? It means consciousness is ubiquitous in the cosmos by itself. Consciousness interacts with the external world through the molecules and the neocortex. David John Chalmers, a cognitive scientist, says that an ontology of cognitive phenomena associated with consciousness, mechanisms controlling wakefulness and sleep and the underlying neural networks is easy because experiments to study them pose no conceptual difficulty. These mechanisms are inextricably associated with conscious processing but are not consciousness. Watching insects, Rodney Brooks, a pioneering roboticist, realised that they possessed little brainpower but were far more capable than robots and that mimicking animal biology, and this was smarter than trying to control every aspect of a robot's behaviour through code. His success led him to predict robots "everywhere in our world" (The Times of India, 14th December, 2025).

Let us suppose that neurophysiology would one day be able to make predictions with the help of comprehensive theories, as accurate and detailed as those of quantum physics today. Should we then be justified in saying that mental processes are brain events, just as we say today that 'light' is ‘electromagnetic radiation’ or ‘temperature’ is the ‘mean kinetic energy of a body’? Therefore, the correlation between brain events and mental processes will have to rely upon the introspective reports by the subject of experience. Here, the question is how we establish the general principle of correlation between mental and neural events. Therefore, Isaac Asimov says, “It is the nature of the mind that makes individuals kin, and the differences in the shape, form, or manner of the material atoms out of whose intricated relationships that minds built are altogether trivial.”

Quantum mechanics has discovered an essential nexus between matter and consciousness. Ray Kurzweil rightly pointed out that particles apparently do not make up their minds as to which way they are going or even where they have been until they are forced to do so by the observations of a conscious observer. We might say that they appear not really to exist at all retroactively until and unless we notice them. Therefore, David Moser said, “Quantum particles are the dreams that stuff is made of”. Quantum computing is a more effective approach than digital computing. Digital computing is based on ‘bits’ of information, which are either ‘zero’ or ‘one’. Quantum computing is based on qubits, which essentially are ‘0’ and ‘1’ at the same time. Peter Higgs, who predicted the existence of a new particle that explains how other particles acquire mass. The Higgs boson is known as the ‘God Particle’. The Higgs boson is the fundamental force-carrying particle of the Higgs field, which is responsible for granting other particles their mass. Because quantum field theory describes the microscopic world and the quantum fields that fill the universe with wave mechanics, a boson can also be described as a wave in a field. To put it metaphorically, the undulations of this wave affecting the field are like the evolutions of AI affecting our future. Stephen Hawking aptly said, “The singularity would always lie in his future and never in his past. While this would be fine for writers of science fiction, it would mean that no one’s life would ever be safe: someone might go into the past and kill your father or mother before you were conceived.”

There is less difference between AI and human intelligence. Meta AI Chatbots have learnt to hold meaningful conversations with people, to play chess, write novels, draft legal documents, medical prescriptions and so on. Deep seek, Deep fakes that can turn what we call reality inside out. Artificial Super Intelligence (ASI) lead us towards “thinking skills more advanced than any humans.” It is believed that Artificial Super Intelligence could surpass human control. Brain-Computer-Interface (BCI), with its origin in 1970 at the University of California, Los Angeles (UCLA), is a neurotechnology. Neuralink’s implant is wirelessly connected to an external device that interprets the signals of the motor cortex. These signals generated by the neurons are then translated by the external devices. As Elon Musk claims, “Neuralink’s brain-computer interface translates neural signals into actions. In our clinical trials, people are using Neuralink devices to control computers and robotic arms with their thoughts. This technology will restore autonomy to those with unmet medical needs and unlock new dimensions of human potential.”

The research in Optical Character Recognition (OCR), Text-to-Speech Synthesis, Speech Recognition Technology and Electronic Keyboard Instruments is most important in health, AI, Transhumanism, Technological Singularity, and Futurology. Nano Artificial Intelligence and Integral AI are significant models of our actual human intelligence. These are all manifestations of human potential and human scientific creativity, shaped into accelerating the capacities of human minds and improving the lives led by humans.

The AICTE (All India Council for Technical Education) declared 2025 to be the Year of Artificial Intelligence, with an aim to propel India as a global leader in AI. Even as AI becomes increasingly significant and indispensable in our daily lives as well as in global affairs, there is a need to acknowledge that this is just the tip of the iceberg. The philosophical and scientific dimensions of AI that were explored in this article imply how AI can challenge and change all our previously established notions and expectations. At this juncture, it may be apt to end with the words of Nietzsche, with his evolutionary concept of Übermensch or Superman: the self-improving human project that achieves self-mastery and a new set of values beyond traditional morality. Friedrich Nietzsche said that ‘God is dead’. He didn’t say the disappearance of ‘God’. He wanted to mean the humanity, intoxicated by scientific and technological development, and reason has been stripped of the ethical and spiritual impact that once anchored it. Therefore, humanity would need to create its own impact in its integrated values. In the present scenario, the ethical, social, cultural, and moral values are on the verge of civilizational collapse. Life is traumatized and culture is irretrievably damaged. The chaos, the inhuman brutality, the wretched poverty, cruelty, war, the unrest and the misery of the people are unimaginable. So, Friedrich Nietzsche aptly said,

"Dead are all Gods; now we will that Superman live… I teach you Superman. Man is a something that shall be surpassed. What have ye done to surpass him?... What is great in man is that he is a bridge and not a goal: what can be loved in man is that he is a transition and a destruction.

I love those who do not know how to live except in perishing, for they are those going beyond.

I love the great despisers because they are the great adorers; they are arrows of longing for the other shore.

I love those who do not seek beyond the stars for a reason to perish and be sacrificed, but who sacrifice themselves to earth in order that earth may some day become Superman's…..

It is time for man to mark his goal. It is time for man to plant the germ of his highest hope…

Tell me, my brethren, if the goal be lacking to humanity, is not humanity itself lacking?.....

Love unto the most remote man is higher than love unto your neighbour".

In conclusion, like Nietzsche's superman or Übermensch, it is important to remember that Artificial Intelligence is the product of human intelligence. Like all products of human intelligence, it carries both immense potential and unforeseen risks, risks that will unfold as the use of AI evolves. Which is why it is necessary to regard AI through the intersecting lenses of science and philosophy. Science is often amoral; it is philosophy that is concerned with ethics. The cause and effect of AI, like all scientific inventions, need to be viewed through the philosophical prism of 'good' and 'bad' if it is to attain the level of perfection that the great scientists, philosophers and thinkers—like Nietzsche and others—imagined.

"Two things fill the mind with ever-increasing wonder and awe… the starry heaven above me and the moral law within me".

-Immanuel Kant

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Reinventing Indian Higher Education: Navigating the Transition from Traditional Pedagogy to Quantum Technologies

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The evolution of higher education in India reflects a long and complex intellectual journey that began with the ancient Gurukul system, where learning was deeply rooted in holistic development, moral values and close teacher–student relationships. Knowledge in this period was experiential, inquiry-based and closely connected to societal life. With the advent of colonial rule, the education system underwent a structural transformation as Western models of education were introduced, emphasising formal curricula, standardised examinations and institutional administration. After independence, Indian higher education expanded rapidly to meet the developmental aspirations of the nation, focusing on access, equity and capacity building through the establishment of universities, regulatory bodies and national research institutions. In recent decades, however, the landscape of higher education has been reshaped by rapid technological advancement and the emergence of the Fourth Industrial Revolution, characterised by artificial intelligence, automation, data analytics and digital connectivity. This shift has moved education away from mere information transmission toward knowledge creation, innovation and problem solving, redefining the role of universities in society (Schwab, 2016).

Despite significant expansion, traditional pedagogical approaches in Indian higher education continue to rely heavily on rote learning, examination-oriented assessment and teacher-centric instruction. Such approaches are increasingly inadequate in addressing the dynamic and complex demands of the twenty-first century, where creativity, critical thinking, adaptability and interdisciplinary competence are essential. The growing influence of artificial intelligence, quantum computing and advanced digital technologies has introduced new possibilities for personalised learning, intelligent tutoring systems, data-driven decision making and enhanced research capabilities. These developments demand a rethinking of curriculum design, teaching methodologies and institutional governance. The rationale for this paper lies in the urgent need to understand how emerging technologies can be effectively integrated into higher education to enhance quality, relevance and global competitiveness while ensuring ethical use and equitable access.

The primary objective of this paper is to examine the transition from conventional pedagogical models to technology-enabled and quantum-informed educational practices within Indian higher education. It seeks to analyse how emerging technologies are reshaping teaching, learning and research processes and how institutions can respond strategically to these transformations. The paper also aims to identify key challenges such as infrastructural limitations, digital divides, faculty preparedness and policy constraints, while exploring opportunities for innovation, collaboration and sustainable development. By doing so, it intends to contribute to a deeper understanding of how higher education can evolve in alignment with national priorities and global knowledge economies.

The scope of this paper is confined to higher education institutions in India, with particular attention to universities and advanced learning environments. It holds significance for policymakers, academic leaders, educators and researchers who are engaged in reimagining educational systems for the future. By situating the discussion within the broader frameworks of Education 4.0 and Education 5.0, the paper contributes to ongoing scholarly discourse on human-centred, technology-enabled education. It seeks to provide conceptual clarity and practical insights that can inform policy formulation, institutional reform and sustainable innovation in the Indian higher education landscape (UNESCO, 2021 and World Economic Forum, 2020).

Traditional Pedagogical Paradigms in Indian Higher Education

The foundations of Indian higher education are deeply rooted in historical, philosophical and cultural traditions that have shaped teaching and learning practices for centuries. While these traditions have contributed significantly to knowledge preservation and social development, they have also created

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structural patterns that continue to influence contemporary academic systems. Understanding these paradigms is essential for evaluating the transition toward modern and technology-driven educational models.

Philosophical Foundations of Traditional Education

The earliest form of education in India emerged through the Gurukul system, which emphasised holistic development encompassing intellectual, moral, spiritual and physical growth. Education was value-oriented and experiential, focusing on character formation, discipline and ethical conduct. The teacher-student relationship was personal and immersive, fostering deep learning and moral responsibility. Knowledge was transmitted orally and integrated with daily life, promoting reflective thinking and self-realisation (Sharma, 2018).

The colonial period marked a significant shift in educational philosophy. The introduction of Western education prioritised administrative efficiency and the production of clerical manpower. English became the primary medium of instruction and education was standardised through formal curricula and examinations. This transition gradually replaced indigenous knowledge systems and reduced the emphasis on holistic learning. As a result, education became more content-driven and less connected to lived experiences and social realities (Kumar, 2005).

Teacher-centred pedagogy emerged as a dominant instructional model during this phase. Teachers were regarded as authoritative sources of knowledge, while learners assumed a passive role. This hierarchical structure limited dialogue, creativity and independent inquiry. Although effective for information transmission, it restricted critical thinking and learner autonomy, which are essential for innovation and problem-solving in contemporary contexts.

Structural Characteristics of Traditional Pedagogy

One of the defining features of traditional higher education in India is the rigidity of curricular structures. Academic programs are often compartmentalised into rigid disciplines with limited scope for interdisciplinary engagement. Such compartmentalisation restricts intellectual flexibility and prevents students from developing integrated perspectives necessary to address complex real-world challenges.

Another significant characteristic is the dominance of rote learning and examination-oriented assessment. Student performance has traditionally been evaluated through summative examinations that prioritise memory and reproduction of content. This approach undervalues analytical reasoning, creativity and application-based learning. As a result, learners tend to focus on examination performance rather than conceptual understanding or skill development.

The limited integration of technology further constrains pedagogical innovation. While digital tools have been introduced in recent years, their use has often been supplementary rather than transformative. Teaching continues to rely heavily on lectures and textbooks, with minimal adoption of interactive platforms, simulations or data-driven learning environments. This limits opportunities for personalised learning and experiential engagement.

Institutional and Pedagogical Outcomes

Despite its limitations, the traditional system has contributed significantly to the expansion of higher education in India. The establishment of universities, colleges and professional institutions has increased access to education and supported nation-building efforts. Institutions such as the Indian Institutes of Technology and central universities have gained international recognition for academic excellence and research output (Agarwal, 2009).

However, concerns regarding quality, relevance and employability persist. Graduates often face challenges in aligning their skills with evolving labor market demands, particularly in areas requiring innovation, digital competence and interdisciplinary thinking. The disconnect between academic curricula and industry expectations has become increasingly evident.

Moreover, traditional pedagogical models tend to limit creativity and collaborative learning. The compartmentalisation of knowledge restricts interdisciplinary exploration, while rigid evaluation systems discourage experimentation and risk-taking. These limitations hinder the development of critical thinking, problem solving and adaptability, which are essential competencies in a rapidly changing global landscape.

Need for Pedagogical Reorientation

The limitations of traditional pedagogical paradigms underscore the need for transformation in Indian higher education. While foundational values such as discipline, rigor and ethical learning remain relevant, they must be complemented by learner-centred approaches, interdisciplinary frameworks and technology-enabled pedagogies. Reimagining education requires a shift from content transmission to knowledge creation, from teacher dominance to learner engagement and from static curricula to dynamic learning ecosystems.

Such a transition is essential for preparing graduates who can navigate complexity, contribute to innovation and participate meaningfully in a knowledge-driven society. The evolving demands of the digital and quantum age necessitate a reexamination of traditional structures to ensure that higher education remains relevant, inclusive and future-ready.

Understanding Quantum Technologies

Quantum technologies represent a transformative shift in the way computation, communication and information processing are conceptualised and executed. Rooted in the principles of quantum mechanics, these technologies move beyond the limitations of classical computing by leveraging phenomena such as superposition, entanglement and quantum interference. Unlike conventional systems that process information in binary form, quantum systems enable simultaneous processing of multiple states, opening new possibilities for solving complex scientific, industrial and societal problems. The following aspects explain the foundational characteristics and implications of quantum technologies:

Fundamentals of Quantum Technology

At the core of quantum technologies lies the concept of the quantum bit or qubit. Unlike classical bits that exist strictly as either zero or one, qubits can exist in multiple states simultaneously due to the principle of superposition. This property allows quantum systems to process a vast number of possibilities in parallel, significantly increasing computational efficiency. Superposition forms the basis for the exponential computational power that distinguishes quantum computing from classical models.

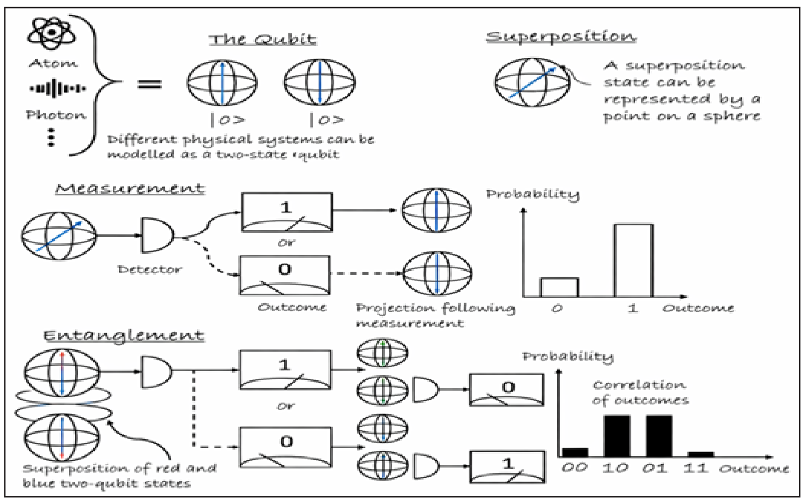
How Quantum Technologies Work

Quantum technologies operate by exploiting the unique properties of quantum bits (qubits)—the fundamental units of quantum information. Unlike classical bits that exist only as 0 or 1, qubits can exist in superposition, allowing them to represent multiple states simultaneously. This capability gives quantum technologies their exceptional computational and sensing power. At the core of every quantum system are three interconnected components:

1. *Initialisation System:* The qubit is prepared in a known starting state using classical devices such as lasers or microwave pulses.
2. *Control System:* External control fields manipulate the qubit's quantum state through precisely timed pulses. These operations enable superposition, rotation and entanglement, which are essential for quantum computation and sensing.
3. *Measurement System:* The final quantum state is measured using detectors that convert quantum information into classical signals (0 or 1). Measurement collapses the qubit's superposition into a definite outcome.

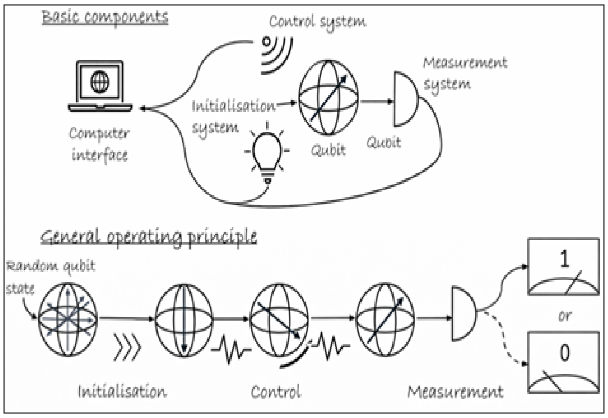
A classical computer coordinates all these processes—programming the control signals, managing timing, and collecting measurement results.

Figure 1: Fundamentals of Quantum Technology



Source: Adapted from Quantum Technology: An Introduction (Australian Army Research Centre, 2020).

Figure 2: How Quantum Technologies Work



Source*: Adapted from Quantum Technology: An Introduction (Australian Army Research Centre, 2020).*

Quantum Entanglement and Interconnected Systems

Another defining feature of quantum technologies is entanglement, a phenomenon in which two or more qubits become intrinsically linked regardless of physical distance. Changes in the state of one qubit instantaneously affect the other, enabling highly coordinated information processing. This unique property enhances computational speed, supports secure quantum communication and enables complex problem solving beyond the capabilities of classical networks.

Quantum Parallelism and Computational Advantage

Quantum systems leverage parallelism at an unprecedented scale. By processing multiple possibilities simultaneously, quantum computers can solve complex optimisation, simulation and cryptographic problems far more efficiently than classical machines. This capability is particularly valuable in areas such as molecular modeling, climate prediction, financial optimisation, and artificial intelligence, where classical computation faces significant limitations.

Transformative Potential Across Disciplines

The impact of quantum technologies extends beyond computing into diverse domains such as materials science, drug discovery, secure communication and artificial intelligence. Quantum-enhanced simulations enable researchers to model molecular interactions with high precision, accelerating innovation in medicine and energy. These transformative applications position quantum technologies as a foundational pillar of future scientific and industrial advancement.

Implications for Education and Skill Development

Understanding quantum technologies is increasingly essential for modern education systems. As these technologies become integral to scientific and industrial progress, educational institutions must prepare learners with foundational knowledge in quantum concepts, interdisciplinary thinking, and computational reasoning. Quantum literacy is emerging as a strategic competence, essential for developing a future-ready workforce capable of contributing to advanced research, innovation and technological leadership.

Towards a Quantum-Ready Educational Ecosystem

The integration of quantum technologies into education requires a shift in curriculum design, pedagogy and institutional vision. Emphasis on conceptual understanding, problem-based learning and interdisciplinary collaboration is crucial for cultivating quantum-ready learners. By embedding quantum literacy within higher education, institutions can play a pivotal role in shaping the next generation of scientists, technologists and innovators equipped to navigate and lead in the quantum era.

Quantum Technologies in Education

The integration of quantum technologies into education is transforming the ways in which knowledge is created, delivered and experienced. By combining advances in quantum science with digital innovation, educational systems are moving toward more immersive, data-driven and research-oriented learning environments. The way in which quantum technologies are reshaping contemporary education are discussed here.

Quantum Simulations for Advanced Learning and Research

One of the most significant applications of quantum technologies in education is the use of quantum simulations. These simulations enable learners and researchers to model complex physical, chemical and biological systems that are otherwise difficult or impossible to study through conventional experimentation. By visualising atomic interactions, molecular structures and quantum behaviors, students gain deeper conceptual understanding and practical exposure to abstract scientific principles. Simulation-based learning thus bridges the gap between theory and experimentation.

Integration of Artificial Intelligence and Data-Driven Learning

The convergence of quantum technologies with artificial intelligence and data analytics has accelerated the transformation of educational practices. AI-powered learning systems enable personalized instruction by adapting content to individual learner needs, pace and performance. Data analytics supports continuous monitoring of learning outcomes, helping educators refine pedagogical strategies and improve academic effectiveness. This integration fosters evidence-based decision-making and enhances the overall quality of education.

Cloud Computing and Scalable Learning Infrastructure

Cloud-based platforms play a critical role in supporting quantum-enabled education by providing scalable and accessible computational resources. Through cloud infrastructure, students and researchers can access advanced software, simulation tools and high-performance computing environments without the constraints of physical laboratories. This democratisation of access reduces infrastructure costs and expands opportunities for experimentation and collaborative research.

Virtual Laboratories and Digital Twins

Virtual laboratories and digital twin technologies represent a significant advancement in experiential learning. Virtual labs allow students to perform experiments in simulated environments, minimising risks and resource limitations. Digital twins, which replicate real-world systems in virtual form, enable learners to analyse, test and optimise complex processes. These tools enhance conceptual clarity and foster experiential understanding across scientific and engineering disciplines.

Immersive Learning Through Extended Reality Technologies

Immersive technologies such as virtual reality and augmented reality further enrich educational experiences by creating interactive and engaging learning environments. These technologies support visualisation of abstract concepts, spatial understanding and experiential engagement, making learning more intuitive and impactful. By transforming passive instruction into active exploration, immersive learning technologies redefine how knowledge is constructed and retained.

Collectively, these developments illustrate how quantum technologies, when integrated with digital and intelligent systems, are reshaping education into a more dynamic, personalised, and innovation-driven ecosystem.

Quantum-inspired Curriculum Design

Quantum thinking encourages non-linear, probabilistic and systems-based reasoning. Integrating quantum-inspired concepts into curricula promotes higher-order cognitive skills such as uncertainty management, multi-perspective thinking and complex problem solving. This paradigm shift moves education beyond deterministic learning models toward adaptive and interdisciplinary knowledge construction.

Quantum-assisted Research and Knowledge Discovery

Quantum computing holds transformative potential for academic research by accelerating data analysis, optimisation, and pattern recognition. In disciplines such as materials science, chemistry, climate studies and genomics, quantum algorithms can process massive datasets and simulate complex systems more efficiently than classical approaches. This capability enhances research productivity and enables discoveries that were previously computationally infeasible.

Enhanced Assessment and Learning Analytics

Quantum-inspired analytics can significantly improve educational assessment systems by enabling multidimensional evaluation of learner performance. Instead of linear grading models, quantum-based analytics can capture probabilistic learning paths, cognitive uncertainty and conceptual interdependencies. This leads to more holistic, fair and personalized assessment frameworks.

Quantum-safe and Secure Educational Infrastructure

As educational systems increasingly rely on digital platforms, data security becomes paramount. Quantum cryptography and Quantum Key Distribution (QKD) offer ultra-secure communication channels that protect academic data, intellectual property and student records from cyber threats. This ensures trust, integrity and confidentiality in digital education ecosystems.

Interdisciplinary Skill Development and Workforce Readiness

Integrating quantum technologies into education promotes interdisciplinary learning across physics, computer science, mathematics, engineering and data science. Students gain exposure to emerging fields such as quantum algorithms, quantum communication and quantum machine learning, preparing them for future careers in advanced science and technology sectors.

Global Collaboration and Open Science

Quantum-enabled digital platforms facilitate international collaboration by enabling shared access to experimental tools, datasets and simulation environments. This fosters global research networks, democratizes access to advanced technologies and promotes inclusive knowledge creation across institutions and nations.

Global Trends and Benchmarks

Across the world, countries are increasingly recognising quantum technologies as strategic enablers of scientific advancement, economic competitiveness, and national security. Governments and higher education systems are investing heavily in quantum research, education and innovation ecosystems to prepare future-ready human capital. The key global trends discussed below illustrate how leading nations are advancing quantum education and research through coordinated policies, institutional frameworks and international collaboration.

United States: National Integration of Quantum Education and Research

The United States has emerged as a global leader in quantum science through comprehensive national initiatives such as the National Quantum Initiative Act. This framework promotes collaboration among universities, government agencies and private industry to advance quantum research and workforce development. Higher education institutions play a central role by offering specialised degree programs, interdisciplinary research centers and industry-linked training initiatives that integrate quantum computing, information science, and engineering.

European Union: Collaborative and Multinational Research Ecosystems

The European Union has adopted a collaborative approach through large-scale programs such as the Quantum Flagship initiative. These efforts emphasise cross-border research collaboration, interdisciplinary education and mobility of researchers across member states. European universities actively integrate quantum science into curricula while promoting open-access resources and shared research infrastructures, fostering a highly connected and inclusive innovation ecosystem.

China: Strategic National Investment and Long-Term Vision

China has made substantial investments in quantum communication, computing and applied research as part of its long-term national strategy. The integration of quantum studies into university programs and national laboratories reflects a strong alignment between education, research and industrial objectives. Through sustained funding and centralised planning, China has positioned itself as a global leader in quantum innovation and technological self-reliance.

India: Emerging Ecosystem and Policy-Driven Growth

India has taken significant steps toward strengthening its quantum education and research ecosystem through initiatives such as the National Quantum Mission (NQM). The focus on capacity building, research infrastructure and skill development has encouraged universities to establish centers of excellence and interdisciplinary programs. While progress is evident, challenges remain in scaling infrastructure, training specialised faculty and ensuring widespread access to advanced quantum education.

Industry–academia Collaboration as a Global Trend

Across regions, strong collaboration between academia and industry has emerged as a defining feature of successful quantum ecosystems. Partnerships enable knowledge transfer, applied research, workforce development and commercialization of innovations. Joint research labs, internship programs and co-developed curricula ensure that academic training remains aligned with industry needs.

Emphasis on Talent Development and Workforce Readiness

Countries leading in quantum technologies prioritise human capital development through specialised training, fellowships and interdisciplinary education. Programs focus on building a skilled workforce capable of advancing research, innovation and commercialisation. This emphasis on talent development ensures long-term sustainability and global competitiveness.

Global Collaboration and Knowledge Sharing

International collaboration plays a crucial role in accelerating progress in quantum science. Cross-border research partnerships, academic exchanges and shared research infrastructure promote knowledge exchange and reduce duplication of efforts. Global cooperation enhances innovation while fostering shared ethical and governance standards in the development of quantum technologies.

Together, these global trends demonstrate that sustained investment, collaborative governance and integrated education–research frameworks are essential for building a robust and competitive quantum ecosystem.

Implications for Higher Education Transformation

The rapid advancement of quantum technologies has profound implications for the future of higher education. As knowledge systems evolve and technological complexity increases, universities must reorient their academic structures, pedagogical practices and governance frameworks to remain relevant and impactful. The transformation required is not merely technological but also conceptual, demanding a shift in how learning, research and institutional responsibility are understood. The key implications presented below highlight how higher education must adapt to meet emerging global demands.

Curriculum Redesign Toward Competency-Based Learning

Higher education institutions must move beyond content-heavy curricula toward competency-driven frameworks that emphasise critical thinking, problem-solving, creativity and interdisciplinary understanding. Integrating quantum concepts and emerging technologies across disciplines prepares learners to address complex real-world challenges and fosters intellectual adaptability.

Strengthening Faculty Capacity and Professional Development

Faculty development is central to effective educational transformation. Continuous training programs are essential to equip educators with expertise in emerging technologies, innovative pedagogies and interdisciplinary research methods. Empowered faculty members can more effectively design learning experiences that reflect contemporary scientific and technological realities.

Enhanced Industry–Academia Collaboration

Strong partnerships between universities, industry and research organisations are vital for translating theoretical knowledge into practical applications. Such collaborations support curriculum relevance, provide experiential learning opportunities and facilitate technology transfer, thereby enhancing graduate employability and innovation outcomes.

Integration of Research and Teaching

Research must become an integral component of teaching and learning processes. Encouraging inquiry-based learning, undergraduate research and project-based engagement foster analytical thinking and innovation. This integration bridges the gap between knowledge creation and dissemination, strengthening academic ecosystems.

Institutional Agility and Governance Reform

Universities must adopt flexible governance structures that support innovation, interdisciplinary collaboration and rapid adaptation to technological change. Streamlined decision-making, autonomy and accountability are essential for responding effectively to emerging educational and research needs.

Emphasis on Ethical and Social Responsibility

As quantum and digital technologies reshape society, higher education institutions have a responsibility to promote ethical awareness, social responsibility and inclusivity. Embedding ethical reasoning and social impact considerations within curricula ensures that technological progress aligns with human values and societal well-being.

Global Engagement and Knowledge Exchange

Active participation in international academic networks enables institutions to share knowledge, adopt best practices and contribute to global scientific advancement. Cross-border collaboration enhances research quality, promotes cultural understanding and positions institutions within the global knowledge ecosystem.

Transforming Teaching–Learning Processes

The rapid advancement of digital and quantum technologies is fundamentally reshaping the nature of teaching and learning in higher education. Traditional content-driven instructional models are gradually giving way to learner-centred, technology-enabled and competency-oriented approaches. This transformation emphasises critical thinking, creativity, adaptability and lifelong learning as essential outcomes of education. The seven key dimensions discussed below highlight how teaching–learning processes are being redefined in the contemporary academic landscape.

Shift from Teacher-centred to Learner-Centred Pedagogy

Modern education emphasises active learner participation rather than passive reception of knowledge. Students are encouraged to engage in inquiry, collaboration, and self-directed learning, fostering autonomy and deeper cognitive engagement. This shift redefines the teacher's role from knowledge transmitter to facilitator of learning.

Personalised and Adaptive Learning Approaches

The use of digital platforms and learning analytics enables personalised learning experiences tailored to individual needs, learning styles, and pace. Adaptive systems adjust content and instructional pathways, supporting diverse learners and enhancing engagement and learning effectiveness.

Project-based and Experiential Learning Models

Project-based and inquiry-driven learning approaches encourage students to solve real-world problems through collaboration and experimentation. These methods promote critical thinking, creativity and practical skill development by linking theoretical knowledge with authentic contexts.

Integration of Artificial Intelligence in Teaching and Assessment

Artificial intelligence plays a transformative role by enabling intelligent tutoring systems, personalised feedback and continuous assessment. AI-driven analytics support informed instructional decisions, facilitate early identification of learning gaps and enhance overall learning outcomes.

Application of Quantum Technologies in Learning Environments

Quantum technologies enable advanced simulations and modelling of complex phenomena, particularly in science and engineering disciplines. These tools allow learners to visualise abstract concepts and conduct virtual experiments, thereby strengthening conceptual understanding and experiential learning.

Interdisciplinary Curriculum Design and Integration

Contemporary education emphasises interdisciplinary learning that connects science, technology, humanities and social sciences. Such integration fosters holistic understanding, encourages innovation and prepares learners to address complex societal challenges from multiple perspectives.

Redefining the Role of Educators and Professional Development

Educators increasingly serve as facilitators, mentors, and co-learners in dynamic learning environments. Continuous professional development in digital pedagogy, instructional design and emerging technologies is essential for equipping educators to support transformative teaching and learning practices.

These dimensions collectively illustrate how teaching–learning processes are evolving to meet the demands of a rapidly changing, technology-driven world, ensuring relevance, inclusivity and educational excellence.

Institutional Transformation and Governance

The transformation of higher education in the contemporary knowledge economy requires strong institutional frameworks, responsive governance structures and forward-looking policy alignment. As universities adapt to rapid technological, social, and economic changes, effective governance becomes central to ensuring innovation, accountability, and sustainability. The following key dimensions highlight how institutional transformation can be strategically achieved:

Alignment with National Policy Frameworks

National initiatives such as the National Education Policy (NEP) 2020, the National Quantum Mission (NQM) and Digital India provide a strategic foundation for higher education reform. These policies promote multidisciplinary education, research excellence, technological integration and global competitiveness. Aligning institutional goals with national priorities enables coherent and future-oriented development.

Strengthening Institutional Infrastructure and Digital Readiness

Modern higher education institutions require robust digital and physical infrastructure to support teaching, research and innovation. Smart campuses, digital libraries, learning management systems and virtual laboratories enhance accessibility and academic efficiency. Infrastructure readiness is essential for implementing blended and technology-driven learning models.

Promoting Research, Innovation and Industry Collaboration

Institutional transformation depends on vibrant research ecosystems that encourage interdisciplinary collaboration and industry engagement. Establishing research centers, incubation hubs and innovation cells facilitates knowledge transfer, entrepreneurship and applied research. Partnerships with industry and research organisations strengthen relevance and societal impact.

Effective Governance and Leadership Structures

Strong governance frameworks are crucial for institutional autonomy, accountability and strategic decision-making. Visionary leadership enables institutions to respond proactively to change, foster innovation and align academic goals with national and global priorities. Transparent governance mechanisms support efficient management and institutional resilience.

Sustainable Funding and Resource Management

Sustainable financial models are essential for long-term institutional development. A balanced mix of public funding, private investment and collaborative partnerships ensures adequate resources for infrastructure, research and human capital development. Transparent financial governance enhances accountability and optimal resource utilisation.

Ethical Governance and Data Protection

As institutions increasingly adopt digital technologies, ethical considerations related to data privacy, cybersecurity and responsible use of technology become critical. Establishing clear governance frameworks for data protection, academic integrity and ethical conduct ensures trust, inclusivity and long-term sustainability in the digital transformation of higher education.

Challenges and Ethical Considerations

The integration of advanced digital and quantum technologies into higher education holds immense transformative potential; however, it also introduces complex challenges that must be addressed thoughtfully. While technological advancements promise innovation, efficiency and expanded access, they simultaneously raise concerns related to equity, ethics, institutional preparedness and cultural sensitivity. A balanced and responsible approach is therefore essential to ensure that technological progress contributes to inclusive, sustainable and value-driven educational development. The major challenges and ethical considerations associated with this transformation are discussed below.

Digital Divide and Accessibility

One of the most critical challenges in the digital transformation of higher education is the persistent digital divide between urban and rural regions. Unequal access to reliable internet connectivity, digital infrastructure and technological devices limits participation for students from economically disadvantaged and geographically remote areas. This disparity risks deepening existing educational inequalities rather than reducing them.

Socioeconomic Inequalities in Access to Technology

Access to digital education is closely tied to socioeconomic status. Students from marginalised backgrounds often lack personal devices, stable internet connectivity and conducive learning environments. Such inequalities became particularly evident during periods of remote learning, highlighting the urgent need for inclusive digital policies and targeted support mechanisms.

Shortage of Technologically Skilled Faculty

A major institutional challenge lies in the limited availability of faculty members trained in digital pedagogy, data analytics and emerging technologies such as artificial intelligence and quantum computing. Without adequate professional development, educators may struggle to effectively integrate technology into teaching and research, reducing the impact of digital transformation.

Ethical Concerns Related to Data and Artificial Intelligence

The growing reliance on digital platforms raises serious ethical issues related to data privacy, surveillance and algorithmic bias. Educational technologies often collect extensive personal and behavioural data, which, if mismanaged, can compromise privacy and trust. Algorithmic decision-making systems may also perpetuate bias, affecting assessment, admissions and academic support.

Cultural and Epistemic Challenges

Technology-driven education systems risk marginalising indigenous knowledge systems, local languages and culturally rooted pedagogies. Standardised digital content may overlook contextual diversity, leading to cultural homogenization. Preserving epistemic diversity requires conscious efforts to integrate local knowledge and cultural perspectives into digital learning environments.

Institutional Resistance and Structural Constraints

Resistance to change among faculty and administrators remains a significant barrier. Concerns related to increased workload, lack of technical competence and uncertainty about pedagogical outcomes often hinder adoption. Additionally, rigid institutional structures, limited incentives and bureaucratic processes slow innovation and reform.

Need for Ethical and Inclusive Governance

Addressing these challenges requires comprehensive policy frameworks that prioritise equity, transparency and accountability. Ethical governance mechanisms must guide the responsible use of technology, while inclusive strategies should ensure that digital transformation benefits all learners. Strengthening institutional capacity, fostering professional development and promoting a culture of ethical innovation are essential for sustainable educational transformation.

Together, these challenges highlight the importance of balancing technological advancement with ethical responsibility, inclusivity and human-centred values to ensure that the future of education remains equitable, accessible and socially responsive.

Future Directions and Strategic Recommendations

As higher education systems worldwide respond to rapid technological change, particularly the emergence of quantum technologies, there is an increasing need for a coherent, forward-looking and integrated strategic framework. The transformation of higher education cannot be limited to technological adoption alone; it must encompass curriculum reform, institutional governance, capacity building and ethical stewardship. A holistic and inclusive approach is essential to ensure that technological advancement contributes meaningfully to national development, social equity and global competitiveness. The key directions that outline a comprehensive pathway for strengthening higher education in the era of quantum and advanced digital technologies are discussed here.

Developing a Quantum-Ready Educational Ecosystem

A foundational priority is the creation of an education ecosystem that embeds quantum literacy across disciplines. Rather than confining quantum studies to specialised scientific domains, basic quantum concepts should be integrated into science, engineering, and interdisciplinary curricula. Such an approach will prepare learners to engage with emerging technologies and foster a workforce capable of navigating complex, technology-driven environments.

Curriculum Reform and Modular Learning Frameworks

Curriculum redesign is essential to ensure flexibility, relevance, and adaptability. Modular and competency-based frameworks enable learners to acquire interdisciplinary knowledge and update skills in response to technological change. These flexible structures support lifelong learning and allow institutions to align academic offerings with evolving industry and societal needs.

Strengthening Research and Innovation Ecosystems

Robust research ecosystems are critical for advancing quantum science and technology. Universities must promote interdisciplinary collaboration, industry partnerships and translational research that bridges theory and application. Dedicated funding mechanisms, shared research infrastructure and innovation hubs can accelerate knowledge creation and technological advancement.

Capacity Building and Faculty Development

Faculty development is central to sustainable transformation. Continuous professional training in emerging technologies, digital pedagogy and interdisciplinary research equips educators to deliver high-quality instruction and mentor future innovators. National and institutional programs should support faculty upskilling through fellowships, workshops and international collaborations.

National and International Academic Collaboration

Strategic partnerships with global universities, research institutions and industry leaders enhance knowledge exchange and strengthen research capacity. International collaboration facilitates access to advanced infrastructure, promotes joint research initiatives, and positions institutions within global academic networks.

Establishment of Centres of Excellence in Quantum and Advanced Technologies

Dedicated centres of excellence can serve as focal points for research, innovation and talent development. These centres enable concentrated investment in advanced facilities, foster interdisciplinary collaboration and act as hubs for national and international engagement in quantum science and related fields.

Policy Alignment and Sustainable Funding Mechanisms

Effective transformation requires coherent policy frameworks and long-term financial commitment. Policies must support innovation, institutional autonomy and accountability while ensuring equitable resource distribution. Sustainable funding models involving government, industry and international partners are essential for long-term impact.

Promotion of Inclusive and Ethical Educational Practices

Equity and ethics must underpin all technological advancements in higher education. Ensuring access for marginalised communities, safeguarding data privacy and promoting responsible innovation are critical for building trust and social legitimacy. Inclusive policies help ensure that the benefits of technological progress are widely shared.

Conclusion

The transformation of Indian higher education is at a critical juncture, shaped by rapid technological advancement, evolving societal expectations and the growing influence of quantum and digital innovations. This paper has examined the shifting educational landscape through the lens of pedagogical transformation, technological integration, institutional reform and policy evolution. It has highlighted how traditional models of teaching and learning, while foundational to India's academic legacy, must now evolve to remain relevant in an increasingly complex and interconnected world.

The discussion has underscored that quantum technologies, artificial intelligence and digital infrastructures are not merely tools of efficiency but catalysts for reimagining knowledge creation, dissemination and application. The movement from teacher-centred instruction to learner-oriented and inquiry-driven pedagogies represents a significant shift in educational philosophy. Similarly, the integration of data-driven learning systems, virtual environments and interdisciplinary curricula reflects a broader commitment to fostering critical thinking, creativity and adaptability among learners. These changes signal a transition from rote learning to meaningful engagement with real-world challenges.

At the institutional level, the paper has emphasised the importance of governance reforms, infrastructure development and research capacity building. Effective implementation of national initiatives such as the National Education Policy (NEP) and the National Quantum Mission (NQM) depends on institutional readiness, visionary leadership and sustained investment. The success of these reforms also relies on strengthening collaboration between academia, industry and government to ensure that education remains relevant to societal and economic needs.

Equally important is the recognition of ethical, social and cultural dimensions in the adoption of advanced technologies. Ensuring equitable access, safeguarding data privacy and preserving cultural diversity are essential to building a humane and inclusive education system. The transformative potential of quantum technologies must therefore be guided by ethical responsibility and social accountability, ensuring that technological progress serves the broader public good.

Looking ahead, the future of Indian higher education lies in its ability to balance innovation with inclusivity, global competitiveness with local relevance and technological advancement with human values. A coordinated and collaborative approach involving policymakers, educators, researchers and industry leaders is essential for realising this vision. By embracing reform, investing in human capital and fostering a culture of continuous learning, India can position itself as a global leader in knowledge creation and educational innovation.

In conclusion, the transition toward a quantum-enabled educational ecosystem represents not merely a technological shift but a profound transformation of educational philosophy and practice. Through strategic planning, ethical governance and collective commitment, Indian higher education can evolve into a dynamic, inclusive and future-ready system that empowers learners and contributes meaningfully to national and global development.

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Artificial Intelligence in Higher Education: Present Scenario and Future Possibilities

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Artificial Intelligence (AI) is rapidly transforming the landscape of higher education across the globe, and India is no exception. This article explores the current integration of AI within Indian universities and colleges, from personalized learning and smart classrooms to research innovation and administrative automation. It examines how AI is reshaping teaching methodologies, enabling interdisciplinary curriculum development, and creating new career and entrepreneurial opportunities for students. The article also highlights major government initiatives, such as NEP 2020, NITI Aayog's National Strategy for Artificial Intelligence, and national skilling programs that support AI adoption in education. While the progress is promising, challenges such as faculty readiness, infrastructure disparities, and ethical concerns persist. The article concludes by emphasizing the need for a holistic, inclusive, and future-ready ecosystem that equips learners not just with AI skills but also with the ability to innovate responsibly in a technology-driven world (Abstract).

Introduction: AI and the Changing Face of Higher Education

Artificial Intelligence (AI) is no longer a futuristic concept confined to science fiction or high-tech laboratories, it has become a transformative force reshaping industry, societies, and increasingly, education systems. In the context of higher education, AI is redefining how institutions operate, how educators teach, and how students learn. From intelligent tutoring systems and AI-powered assessments to personalized learning environments and administrative automation, AI is being deployed to enhance efficiency, accessibility, and academic outcomes.

Globally, universities are adopting AI to improve decision-making, support research, enable remote learning, and provide predictive analytics for student success. In India, this transformation is gathering momentum. With the push from the National Education Policy (NEP) 2020 and initiatives like the National Programme on AI (NPAI), Indian higher education institutions are beginning to embed AI in teaching, research, and institutional governance.

However, this integration is not without its challenges, including the need for skilled faculty, updated curricula, ethical considerations, and equitable access to technology. As we stand at this inflection point, it becomes imperative to explore the present status, future opportunities, and strategic pathways for embedding AI meaningfully into India's higher education ecosystem.

Current Landscape: AI Integration in Indian Higher Education

The integration of Artificial Intelligence in Indian higher education is steadily gaining traction, with several pioneering institutions leading the way in adopting AI-based tools and practices. While the adoption is still at a nascent stage compared to global benchmarks, significant strides have been made in key areas such as teaching, learning, administration, and research.

Smart Classrooms and Digital Campuses

Indian Institutes of Technology (IITs), Indian Institutes of Information Technology (IIITs), and Universities are implementing smart classroom technologies that use AI for facial recognition-based attendance, interactive content delivery, and real-time feedback mechanisms. Private institutions are also investing in AI-enabled learning management systems (LMS) that facilitate hybrid and online learning.

Adaptive Learning Platforms

AI-powered EdTech platforms such as NPTEL, SWAYAM, and those developed by private players are being increasingly integrated into the curriculum. These platforms use machine learning algorithms to adapt content to individual learning styles and pace, helping students master concepts more efficiently.

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Administrative Automation

Several universities are adopting AI to streamline administrative tasks such as admissions processing, fee management, student record maintenance, and examination evaluation. Chatbots and virtual assistants are being used for handling student queries, thereby improving responsiveness and efficiency.

AI in Assessment and Feedback

Automated proctoring, AI-driven grading systems, and plagiarism detection tools are being deployed to ensure academic integrity and improve assessment quality. These tools not only save time but also provide deeper insights into student performance patterns.

Research and Data Analytics

AI is empowering researchers with tools to analyse large datasets, conduct simulations, and model complex systems. Institutions are setting up dedicated AI and Data Science centres to support interdisciplinary research across domains like healthcare, agriculture, finance, and climate science.

While these developments are promising, their implementation remains uneven across institutions due to infrastructural, financial, and skill-related constraints. Bridging this digital divide will be essential to ensure that the benefits of AI are equitably distributed across the higher education spectrum in India.

AI in Teaching and Learning: Opportunities and Challenges

Artificial Intelligence is beginning to redefine the very nature of teaching and learning in higher education. With its ability to process vast amounts of data and recognize patterns, AI offers unprecedented opportunities to personalize education, enhance student engagement, and support educators in delivering more effective instruction.

Opportunities for Personalized Learning

One of the most significant contributions of AI in education is its capacity to tailor learning experiences to individual needs. Adaptive learning systems analyse students' progress and behaviour to recommend customised content, practice exercises, and remedial interventions. This personalised approach enables learners to grasp concepts at their own pace, leading to improved learning outcomes.

Support for Educators

AI tools can assist teachers in several ways, from automating grading and managing class materials to providing insights into student performance and learning gaps. AI-driven dashboards can alert instructors to students at risk of falling behind, enabling timely interventions. Moreover, virtual teaching assistants and intelligent tutoring systems can help manage large classrooms by offering 24/7 support to students.

Enhanced Learning Through AI-Powered Tools

Natural Language Processing (NLP) tools such as AI-based language tutors, automated essay evaluators, and speech recognition applications are becoming more common. They help students improve their communication skills and allow instructors to assess assignments more objectively. Augmented reality (AR) and virtual reality (VR) platforms powered by AI further enhance immersive learning, particularly in disciplines like medicine, engineering, and architecture.

Challenges and Concerns

Despite these benefits, the integration of AI in teaching comes with challenges. A major concern is the digital divide, where students from under-resourced institutions may not have access to AI-enhanced tools and infrastructure. Moreover, there are ethical issues related to data privacy, algorithmic bias, and the potential over-reliance on machine decisions.

Another pressing issue is faculty preparedness. Many educators lack the necessary training to effectively use AI tools, highlighting the need for continuous professional development and institutional support.

AI holds the potential to transform pedagogy by shifting the focus from traditional lecture-based methods to more learner-centric models. However, realizing this potential will require a balanced approach, combining technology with human insight, and innovation with inclusivity.

AI in Research and Innovation: A New Frontier

Artificial Intelligence is revolutionizing academic research by accelerating the pace of discovery, enabling complex data analysis, and fostering interdisciplinary collaboration. For researchers in higher education, AI is not just a tool; it is becoming a research partner that augments human capabilities and opens up new frontiers of inquiry.

Accelerated Data Analysis and Pattern Recognition

AI algorithms can sift through vast datasets, from genomic sequences to climate models, at speeds and scales far beyond human capacity. Machine learning techniques help identify patterns, correlations, and anomalies that might otherwise go unnoticed. This has significantly impacted fields such as biotechnology, environmental science, linguistics, and social sciences.

Simulations and Modelling Complex Systems

AI-powered simulations are being used to model phenomena ranging from protein folding to economic behaviour. In engineering and physics, neural networks are used to simulate experiments and design prototypes, reducing the need for costly physical testing. Similarly, in medicine and drug discovery, AI helps predict molecular behaviour and treatment efficacy.

Knowledge Discovery and Literature Mining

Natural Language Processing (NLP) enables researchers to mine vast scientific literature and databases, summarize findings, and identify emerging trends. Tools like semantic search engines and AI-driven citation analysis are enhancing literature reviews and helping scholars stay current in their fields.

Interdisciplinary Research and Collaboration

AI is inherently interdisciplinary, encouraging collaboration between computer scientists, domain experts, and policymakers. In Indian academia, AI is being integrated into research across agriculture, healthcare, law, linguistics, and public policy. Institutions such as IITs, IISc, and several central universities are establishing AI research labs and Centres of Excellence with a focus on solving real-world problems.

Challenges in Ethical AI Research

While the potential is immense, researchers must also grapple with challenges related to data quality, transparency, and ethical use of AI. Issues like algorithmic bias, explainability, and misuse of AI-generated content need to be addressed through responsible research practices and regulatory frameworks.

AI is reshaping the research ecosystem in higher education by making inquiry more data-driven, agile, and collaborative. With the right investments in infrastructure, training, and ethics, Indian institutions can position themselves as global leaders in AI-led innovation.

Training the Next Generation: AI Education and Curriculum Development

Preparing students for an AI-driven future requires reimagining higher education curricula to equip them with the knowledge, skills, and mindset necessary to thrive in a rapidly evolving technological landscape. Indian universities have begun responding to this need by introducing AI-focused academic programs, upgrading existing syllabi, and fostering interdisciplinary learning.

AI in Engineering and Computer Science Curricula

AI has been incorporated into the undergraduate and postgraduate curricula of many engineering colleges, particularly in branches like Computer Science, Information Technology, and Electronics. Courses in machine learning, neural networks, natural language processing, computer vision, and data science are increasingly being offered as core or elective subjects. Institutions like the IITs, IIITs, NITs, and other premier technical universities are at the forefront of this shift, often in collaboration with industry partners.

Emergence of Dedicated Degree Programs

Several universities have launched specialized programs such as B.Tech in Artificial Intelligence and Data Science, M.Tech in AI, and postgraduate diplomas in Machine Learning. These programs combine foundational computer science with mathematics, statistics, ethics, and domain-specific applications, ensuring that students receive both theoretical and applied training.

Interdisciplinary AI Education

Recognising the cross-cutting nature of AI, many institutions are promoting interdisciplinary programs where AI is applied to domains like biology (bioinformatics), finance (fintech), linguistics (language technologies), and agriculture (precision farming). This approach is helping non-engineering students engage with AI tools and methods relevant to their fields.

Online and Hybrid Learning Platforms

To widen access, AI courses are also being delivered through national platforms like SWAYAM, NPTEL, and AICTE's NEAT initiative. These MOOCs (Massive Open Online Courses) offer flexibility to students across disciplines and geographies and often feature content from leading Indian and global universities.

Faculty Development and Capacity Building

A major challenge is the shortage of qualified faculty who can teach cutting-edge AI topics. Government schemes and institutional programs are encouraging upskilling through Faculty Development Programs (FDPs), workshops, and international collaborations to address this gap.

AI for All: Beyond Technical Education

In line with the NEP 2020 vision of holistic and multidisciplinary education, there is growing emphasis on AI literacy for students in humanities, commerce, law, and social sciences. The goal is to create not only AI developers but also informed citizens and professionals who understand the ethical, social, and economic implications of AI.

To effectively train the next generation, Indian higher education must continue evolving its curricula, strengthen industry-academia links, and ensure inclusive access to quality AI education.

Employment and Careers in AI: Trends and Projections

As Artificial Intelligence continues to permeate diverse sectors, the demand for skilled professionals in AI and related fields is surging. For graduates in India, AI is no longer confined to niche roles in tech companies; it has become a central pillar in industries ranging from healthcare and finance to agriculture, logistics, and governance.

Rising Demand for AI Talent

India is projected to be one of the largest global markets for AI talent. According to NASSCOM, the demand-supply gap in AI and data science roles is significant, with thousands of positions going unfilled due to a shortage of qualified professionals. Roles such as AI/ML engineers, data scientists, natural language processing experts, computer vision specialists, and AI ethics officers are in high demand.

Career Pathways in AI

Students trained in AI can explore a wide range of careers:

Technical Roles: ML Engineer, Data Analyst, Research Scientist, AI Architect

Applied Roles: AI Product Manager, Business Intelligence Analyst, AI in Healthcare, AgriTech, EdTech, etc.

Policy and Ethics: AI Policy Analyst, Ethics Consultant, Regulatory Affairs

Many of these roles require a strong foundation in mathematics, programming, and domain knowledge, underscoring the importance of multidisciplinary education and project-based learning.

AI in the Public and Development Sector

Government departments and public sector units are increasingly deploying AI for applications such as predictive governance, traffic management, public health surveillance, and citizen services. This opens career opportunities in policy labs, research organizations, and social impact start-ups working at the intersection of AI and public welfare.

Skill-based Certifications and Industry Alignment

In addition to formal degree programs, employers value hands-on skills and certifications from recognized platforms like Coursera, edX, Udacity, and Skill India's AI tracks. Hackathons, internships, and open-source contributions further enhance employability. Companies like TCS, Infosys, Wipro, and start-ups alike seek professionals who can demonstrate problem-solving with real-world AI applications.

Challenges for Employability

Despite growing opportunities, many graduates face challenges due to outdated curricula, limited exposure to live projects, and lack of soft skills. Bridging this gap requires stronger academia-industry collaboration, structured internships, mentorship programs, and emphasis on innovation ecosystems within universities.

As AI continues to transform the job market, Indian higher education institutions must not only teach the technology but also guide students to adapt to evolving roles, embrace lifelong learning, and cultivate ethical and human-centered thinking.

Entrepreneurship and Start-ups in the AI Ecosystem

Artificial Intelligence is catalysing a vibrant start-up ecosystem in India, where young innovators are leveraging AI to solve pressing societal and business challenges. Encouraged by a supportive policy environment, availability of open-source tools, and access to a growing digital market, student entrepreneurs and researchers are increasingly exploring AI as a foundation for their ventures.

Rise of AI-Driven Start-ups

India is now home to over 1,500 AI start-ups spanning sectors such as healthcare (e.g., SigTuple, Qure.ai), agritech (e.g., CropIn, Fasal), fintech (e.g., ZestMoney, Cred), and EdTech (e.g., Embibe, AI-powered learning platforms). Many of these companies have emerged from university incubation centres or alumni networks and are focused on scalable, impact-driven innovation.

Student Innovation and Campus Incubation

Higher education institutions are actively fostering entrepreneurial mindsets through AI-focused hackathons, innovation cells, start-up weekends, and incubators. Institutes like IIT Madras (with its AI and Data Sciences Research Park), IIIT Hyderabad, and several central and private universities have established Centres of Excellence that support ideation, prototyping, and commercialization of AI solutions.

Access to Funding and Mentorship

Early-stage AI ventures are attracting investments from venture capital firms, government seed funds, and corporate accelerators. Initiatives like the Start-up India Seed Fund Scheme (SISFS), Atal Incubation Centres (AICs), and DST's NIDHI program offer financial support and mentorship to AI start-ups emerging from university ecosystems.

Entrepreneurial Opportunities in Social Sectors

AI-based entrepreneurship is not limited to profit-driven ventures. Social enterprises are using AI for rural education, language translation, disease detection, and disaster response. This aligns with India's developmental goals and opens new pathways for purpose-driven entrepreneurship among youth.

Challenges and the Way Forward

Despite the momentum, student entrepreneurs often face hurdles in scaling their AI ideas, including limited compute infrastructure, access to large datasets, lack of IP literacy, and regulatory uncertainty. Addressing these challenges will require stronger linkages between academia, industry, and government, along with policies that facilitate safe experimentation and responsible innovation.

To harness the full potential of AI entrepreneurship, India must embed innovation into the academic DNA by promoting cross-disciplinary collaboration, incentivising risk-taking, and building a culture of experimentation from the undergraduate level onwards.

Government Initiatives and Policy Support for AI in Education

The Government of India has recognised Artificial Intelligence as a strategic technology critical to the nation's growth and competitiveness. A series of policy frameworks, mission-mode programs, and institutional initiatives have been launched to integrate AI into education, skill development, research, and innovation.

National Strategy for Artificial Intelligence– #AIforAll

Released by NITI Aayog in 2018, this landmark document outlines India's vision for leveraging AI across five sectors: healthcare, agriculture, education, smart mobility, and smart cities. The strategy emphasizes inclusive growth, ethical AI, and capacity building, setting the tone for future government initiatives.

National Education Policy (NEP) 2020

NEP–2020 envisions the integration of emerging technologies, including AI, across all levels of education. It advocates for:

- Introducing coding and computational thinking from early grades.
- Offering AI as an elective subject in higher education.
- Promoting multidisciplinary and flexible curricula.
- Establishing National Educational Technology Forum (NETF) to foster EdTech innovation.

Skill Development Initiatives

To address the growing demand for AI talent, several skilling programs have been introduced:

FutureSkills Prime (by NASSCOM & MeitY): Offers AI and data science courses with industry certifications.

AICTE Training and Learning (ATAL) Academy: Conducts Faculty Development Programs (FDPs) in AI and machine learning.

National Skill Development Corporation (NSDC): Partners with academic institutions and

EdTech companies to provide AI training modules aligned with job roles.

AI Centres of Excellence and Research Hubs

The Ministry of Education, Ministry of Electronics and Information Technology (MeitY), and the Department of Science and Technology (DST) have supported the establishment of AI Centres of Excellence in select universities and technical institutions. These hubs promote interdisciplinary research, collaboration with industry, and innovation through hackathons and competitions.

SWAYAM and NEAT Platforms

SWAYAM offers MOOCs on AI, ML, and data science from top Indian institutions.

NEAT (National Educational Alliance for Technology) identifies and brings EdTech solutions, including AI-powered learning tools, to students through public-private partnerships.

Policy and Regulatory Support

Initiatives like the Digital India programme, Data Governance Framework, and draft AI Regulation Guidelines aim to provide a structured environment for AI deployment while addressing concerns related to ethics, bias, and data protection.

Together, these efforts represent a robust ecosystem being built by the government to empower institutions, educators, and students to embrace AI. The challenge now is to ensure effective implementation, especially in under-resourced institutions, to make AI education truly inclusive and impactful.

AI Tools Enhancing Teaching and Learning

AI tools in education are reshaping both teaching and learning by making them more personalized, interactive, and data-informed. Globally, platforms like Duolingo adapt language lessons to each learner's pace and proficiency, while Khan Academy and Coursera use AI to provide tailored learning paths, real-time feedback, and content recommendations that enhance student engagement and retention. For educators, tools like Gradescope automate grading, reducing time and bias, and platforms such as Nearpod and Socrative offer interactive assessments that support real-time classroom engagement. Learning Management Systems (LMS) like Google Classroom and Moodle leverage AI to track student performance, streamline content delivery, and improve administrative efficiency. Additionally, AI models like ChatGPT are increasingly used as virtual teaching assistants, helping explain complex concepts, create lesson plans, and generate practice questions.

In the Indian context, AI-powered edtech solutions are gaining momentum. Byju's uses AI to customize learning experiences based on individual student progress and understanding. Embibe, supported by Reliance, applies deep learning analytics to diagnose learning gaps and suggest personalized study strategies. ConveGenius provides AI-enabled chatbots and assessments in regional languages, improving accessibility in low-resource areas. iDream Education integrates AI into tablets and mobile apps to support inclusive learning for rural and government school students. Teachers are also adopting platforms like Teachmint, which uses AI for classroom management, student engagement tracking, and automation of routine tasks. These innovations are not only improving educational quality but also fostering equity by making personalized learning accessible to a broader, more diverse student population across India.

The Indian government has introduced several AI-powered educational tools and platforms to enhance access, personalization, and efficiency in learning. Platforms like DIKSHA use AI to recommend personalized resources and track student progress, supporting school education across the country. Swayam and Swayam Prabha integrate AI for adaptive learning and course recommendations in higher education. NDEAR (National Digital Education Architecture) provides the backbone for AI-based analytics and interoperable digital tools across education systems. Initiatives like PM eVIDYA and Aatmanirbhar AI for Education aim to promote inclusive digital learning through automated assessments and regional content creation. Additionally, the Bhashini platform uses AI for real-time translation, making learning resources accessible in multiple Indian languages. These efforts reflect the government's commitment to leveraging AI for equitable, scalable, and multilingual education across India.

AI in Different Industries: Key AI Applications in Major Sectors

Artificial Intelligence (AI) is revolutionising major industries by automating processes, enhancing decision-making, and delivering personalised experiences. In healthcare, AI aids in diagnostics, personalised medicine, and drug discovery. In retail and e-commerce, it powers recommendation engines, inventory management, and chatbots. The banking and finance sector leverages AI for fraud detection, algorithmic trading, and personalised services, while logistics and supply chains benefit from predictive maintenance and route optimisation. AI also enhances travel, real estate, and media by offering personalised recommendations, dynamic pricing, virtual tours, and content creation. In manufacturing, AI improves predictive maintenance, quality control, and efficiency. Automotive companies use AI for autonomous driving and production automation. In education, AI enables personalised learning and automates administrative tasks. Fashion uses AI for trend forecasting and supply chain optimisation, and in hospitality, AI supports guest personalisation, pricing strategies, and operational efficiency. Across these sectors, companies like Amazon, Tesla, Netflix, Duolingo, and IBM Watson are showcasing AI's transformative impact, helping businesses reduce costs, improve services, and boost productivity.

Conclusion

Artificial Intelligence is not just a technological revolution, it is a transformational force reshaping how we teach, learn, research, innovate, and prepare for the future of work. For Indian higher education, the AI era brings immense possibilities, but also a pressing responsibility to evolve, adapt, and lead. The present scenario reveals a growing momentum, from smart classrooms and AI-enabled learning platforms to emerging degree programs, research centres, and start-ups. Government policies, institutional initiatives, and industry collaborations are laying the groundwork for a more agile, inclusive, and innovation-driven education system. However, significant challenges remain: disparities in access to technology, shortage of trained faculty, curriculum inertia, and ethical concerns around AI usage. To overcome these, a coordinated and sustained effort is essential. This includes: Embedding AI literacy across disciplines and educational levels; Investing in infrastructure and teacher training for AI adoption; Encouraging interdisciplinary and ethical thinking in AI application; Fostering an ecosystem that values creativity, entrepreneurship, and responsible innovation. Ultimately, an AI-ready higher education system must not only produce skilled professionals but also critical thinkers, compassionate innovators, and responsible citizens. With the right vision and execution, India has the potential to emerge as a global leader in harnessing AI for equitable and sustainable educational transformation.

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Simulative Epistemologies in Higher Education Science under NEP 2020: Physics Education Technology and the Digital Pedagogical Frontier

Kushagri Singh*

Science education at the university level is undergoing a significant transformation, primarily due to the integration of digital resources, including virtual laboratories and interactive simulations. These novel technologies have emerged as valuable pedagogical instruments that mitigate the challenges associated with conventional science instruction. Conventional laboratory sessions and lectures frequently encounter issues such as accessibility challenges, safety risks, elevated operational expenses, and varying levels of student engagement. Interactive simulations and virtual laboratories are gaining popularity as they provide engaging, adaptable, and secure environments for learning that transcend the constraints of the physical world. Physics Education Technology (PhET) Interactive Simulations, developed by the University of Colorado Boulder, is a prominent platform in this domain. PhET offers numerous subject-specific simulations for physics, chemistry, biology, and earth sciences as well.

These simulations let students change the settings of an experiment and see the results right away, which is a fun and hands-on way to learn about complicated scientific ideas. This kind of learning encourages students to be active and think critically, letting them learn about ideas at their own pace and deepen their understanding through trial and error.

Empirical research validates the efficacy of PhET simulations in higher education contexts. Banda et al. (2022) did an experimental study with physics undergraduates and found that using PhET simulations greatly increased students' motivation, understanding of concepts, and academic performance in topics like oscillations and waves. Because simulations are interactive, they helped students understand ideas that are hard to understand in other ways. In the same way, Alsalhi et al. (2021) used a quasi-experimental design to look at how PhET affected university-level physics labs. Their results showed that adding PhET to the curriculum led to a big rise in post-test scores and academic success, showing how it can help students learn better.

In addition, the benefits of virtual labs go beyond specific subjects to include broader educational problems. According to Bazie et al. (2024), virtual labs in undergraduate chemistry classes yielded much better learning outcomes than those in classes with only lectures. Physical labs are still important for some hands-on skills, but virtual labs are a flexible and scalable option that can supplement or even replace some of these experiences, especially in institutions with limited resources. These labs also provide a safe space for students to do experiments repeatedly, which helps them learn without having to worry about the cost of materials or safety issues.

Virtual labs and simulations help students learn how to ask scientific questions, make hypotheses, design experiments, and make decisions (Abdelmoneim et al., 2022). Pranata et al. (2024) also talked about how adding game-like features to PhET simulations can motivate students. This makes science education more fun and interactive, which helps students learn more deeply.

The crux of the matter is, adding interactive simulations and virtual labs to higher education science teaching and learning is a significant step forward. These digital tools not only make science easier to understand and more interesting, but they also help different types of learners and improve learning outcomes. As colleges and universities keep using these technologies, they will probably become more useful and integrated into science classes around the world through more research and new ways of doing things (Table 1).

Interactive Simulations in Science Education

PhET Interactive Simulations, developed by the University of Colorado Boulder, cover a broad spectrum of subjects, including physics, chemistry, biology, and earth sciences. These simulations allow students to manipulate parameters and

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Table 1: Summary of Key Research Studies on the Effectiveness of PhET Simulations and Virtual Labs in Higher Education Science Learning

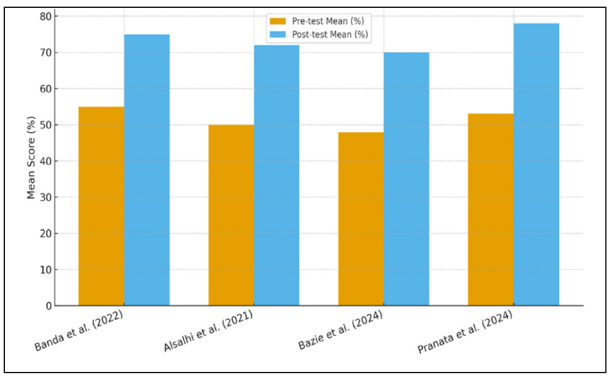
Study Focus	Methodology	Key Findings	Reference
Impact of PhET on learning oscillations and waves in physics undergraduates	Experimental	Significant improvement in student achievement, motivation, and conceptual understanding using PhET simulations.	(Banda, et al., 2022)
Effect of PhET on academic achievement in university physics labs	Quasi-experimental	Significant positive effect on post-test scores and academic performance in physics.	(Alsalhi, et al., 2021)
Effect of virtual labs on undergraduate chemistry achievement	Comparative experimental	Virtual labs enhance learning outcomes; real labs still have highest impact; virtual labs superior to lecture-only.	(Bazie, et al., 2024)
PhET as game-based learning tool in physics	Experimental	Integration of PhET with game-based methods improves understanding and engagement.	(Pranata, et al., 2024)
Virtual labs' impact on expert thinking and decision-making in science	Experimental	Virtual labs positively affect scientific reasoning and decision-making skills.	(Abdelmoneim, et al., 2022)
Systematic review of virtual experiments in physics education	Systematic review	Virtual experiments effectively support physics learning and skill development.	(Wang, et al., 2025)
Comparison of Virtual Lab Simulations (VLS) and in-person labs for foundational microbiology skill development	Experimental study with quizzes and focus groups comparing virtual and in-person lab performance	No significant difference in student performance between virtual and in-person labs; students positively perceived virtual labs for detailed explanations, repetition, and time management; virtual labs effective as pre-lab or supplemental learning tools	(Ayer Miller, et al., 2025)

visualise processes that would be time-consuming or impossible in physical labs (PhET, 2024). For example, in physics courses, PhET simulations enable virtual explorations of oscillations and wave mechanics, helping students comprehend abstract theories through experiential interaction (Banda, et al., 2022).

By integrating such simulations, educators move beyond passive lectures to interactive, student-centred learning. Students become active participants, which fosters critical thinking and problem-solving (Figure 1). The real-time feedback from simulations allows immediate testing of hypotheses and adjustment of experiments, enhancing the learning cycle (Alsalhi, et al., 2021 and Pranata, et al., 2024).

The figure juxtaposes pre-test and post-test mean scores from four studies (2021–2024) examining the effects of interactive simulations, such as PhET,

Figure 1: Learning Gains from Interactive Simulations (PhET Studies, 2021-2024)



on science education. It demonstrates a constant enhancement of 20–25% across all investigations, with post-test scores markedly exceeding pre-test values. This indicates that students who participated in interactive simulations attained a more profound conceptual comprehension and enhanced academic achievement relative to conventional training. The image demonstrates that simulation-based learning improves engagement, critical thinking, and problem-solving abilities, rendering it an excellent approach for fostering active, student-centred learning in higher education science courses.

Virtual Labs Benefits for Universities

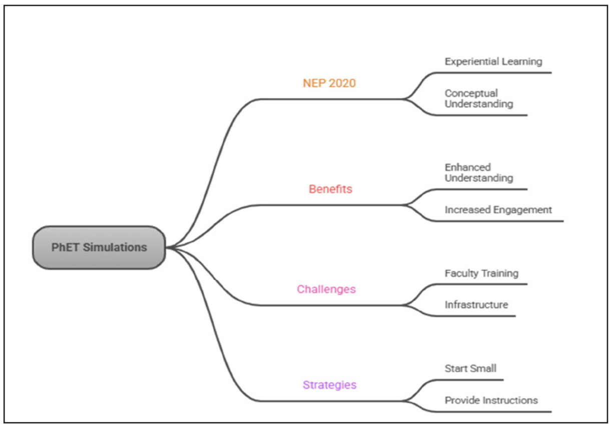
Virtual laboratories supplement or replace traditional labs, overcoming resource constraints, safety issues, and logistical barriers in higher education institutions. These labs provide flexible learning schedules and access to remote or under-resourced facilities (Bazie, et al., 2024). They also enable repeated experimentation without material costs or risk exposure (Figure 2).

Research comparing virtual and physical labs indicates hands-on labs yield the highest learning gains; however, virtual labs consistently outperform lecture-only approaches in knowledge retention and application (Bazie et al., 2024). For example, chemistry students using virtual labs demonstrated significant improvements in both theoretical understanding and practical skills (Bazie et al., 2024). Virtual labs also nurture decision-making and expert thinking, critical for scientific inquiry and research (Abdelmoneim et al., 2022).

Emerging technologies such as gamified virtual experiments further enrich engagement. Gamification elements embedded in platforms like PhET serve as motivating factors, offering challenges and rewards that sustain student interest and deepen their conceptual understanding (Pranata, et al., 2024).

Figure 2 illustrates the role of PhET simulations in higher education science, highlighting their alignment with NEP–2020, associated benefits, implementation challenges, and recommended pedagogical strategies.

Figure 2: PhET Simulations in Higher Education Science



Case Examples and Impact

The body of research on PhET simulations consistently reports benefits in academic achievement, motivation, and student attitudes. Banda et al. (2022) found that physics undergraduates exposed to PhET improved notably in tests involving oscillations and wave concepts because of enhanced visualisation and interactive learning experiences.

Alsalhi et al. (2021) reported significant gains in examination scores when PhET simulations were integrated into university physics labs, highlighting the tool's effectiveness in fostering understanding and confidence.

Virtual labs have similarly been validated as instruments that significantly improve undergraduate student outcomes in chemistry and related sciences, while also providing scalable and accessible solutions, especially pertinent in the post-pandemic educational landscape (Bazie, et al., 2024). Systematic reviews by Wang et al. (2025) substantiate these findings across physics curricula, affirming virtual experiments' role in skill development and engagement.

Conclusion

The incorporation of interactive simulations and virtual laboratories signifies a revolutionary progression in the pedagogy of science within higher education. PhET and other tools not only help with learning concepts, but they also work for diverse types of learners and settings. Some experiential learning still needs to happen in physical labs, but virtual labs make scientific experimentation more accessible and help it become more common in university courses. Teachers should try to connect these technologies to the goals of their courses and use their interactive character to promote relevant, contextualised, and student-driven science education. More research and money spent on virtual and immersive labs will lead to more new ways to teach and better science literacy among college students.

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(contd. on pg.109)

Towards Responsible AI Integration in Education: Ethical Perspectives and Accountability Frameworks

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Artificial Intelligence (AI) has emerged in the education sector at a fast pace, facilitating personalisation, efficiency, and innovative learning and teaching approaches, but its implementation generates urgent ethical challenges. This research seeks to investigate how education's framing of AI is constituted in contemporary literature, determine dominant ethical issues, uncover potential for ethical use, and suggest guiding frameworks. Employing thematic analysis of peer-reviewed articles, policy reports, and institutional publications, the study mapped out on a systematic basis the dominating narratives regarding AI ethics. Five overarching themes appeared: academic honesty, data privacy and surveillance, bias and fairness in algorithms, tension between innovation and ethics, and the function of governance and policy structures. The results uncover that AI is invariably imagined as a two-edged sword, promising efficiency and scalability while at the same time posing the threats of bias, inequity, and loss of human values. The argument draws attention to the point that narratives that are efficiency-focused normally dominate ideas of justice, equity, and accountability, suggesting the necessity of imagining AI as a socio-technical system and not as a neutral technology. The research concludes that it is necessary to integrate ethical guarantees, governance frameworks, and human-based values into AI implementation to ensure that technology operates in favor of equity and integrity instead of destroying the ethical foundations of education. (Abstract)

The twenty-first century has seen the widespread diffusion of Artificial Intelligence (AI) across a wide range of fields, and education is no exception. AI now supports intelligent tutoring systems, adaptive learning software, plagiarism detection software, automated grading systems, and generative writing aids. AI has the potential to mimic human-level decision-making. It can scan enormous data sets, forecast student performance, tailor content presentation, and offer feedback in real time. For example, intelligent tutoring systems such as Carnegie Learning can adjust pace and style to accommodate each learner, whereas generative models like ChatGPT can generate essays, solutions to problems, or even computer program code in an instant.

Although these opportunities are groundbreaking, they have very serious ethical implications. The application of AI in learning raises concerns regarding academic integrity (when students use AI to produce work without accreditation), data protection and privacy (since AI needs enormous amounts of data from students), algorithmic bias and fairness (since AI systems tend to carry over biases from their training data), and the educator–student relationship (since AI takes over roles traditionally played by instructors). In addition, there exists a challenge across the globe to make sure that AI technologies never increase the digital divide between technology-rich and technologically poor areas.

Academics and policymakers alike increasingly emphasise the importance of incorporating ethical values into AI integration. UNESCO advocates for a human-centric approach in which technology must complement human capacities instead of substituting them. Likewise, fairness, accountability, transparency, and inclusivity as necessary principles for AI in the education sector are also emphasized. Nevertheless, despite such appeals, there is no agreement on what responsible AI use in schools looks like.

Nofirman et al., (2025) sought to empirically examine and contrast teachers' and high school students' attitudes toward the ethical issues and proper application of AI in education. The results showed that there was a broad split in attitudes, with teachers showing more concern over academic integrity and data privacy, whereas students

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were more concerned over AI as an instrument of efficiency. Both groups nonetheless showed a common interest in having straightforward, explicit ethical rules. There is a glaring disconnect between student and teacher views on AI ethics education.

Mhlanga (2023) was thriving on objectives such as providing a comprehensive analysis of the ethical and responsible use of ChatGPT in education, and to prompt additional research and discourse on the significant topic. The chapter established that using ChatGPT in learning necessitates respect for privacy, fairness and absence of discrimination, transparency of the utilisation of ChatGPT, and several other aspects.

A comprehensive study discusses the complex ethical implications of AI in contemporary education, which seeks to balance innovation and responsibility. Ethical concerns in education involving AI cover a broad spectrum of issues, among others, such as data privacy and protection, bias and fairness in algorithms, learner autonomy and agency, transparency and accountability, and the fair allocation of AI-facilitated resources and opportunities (Abbas, 2023).

Kathala et al. (2024) throw light on the essential role of ethical and responsible AI in creating the inventors of tomorrow who will drive technological progress. Based on cross-disciplinary insights, this paper proposes an all-encompassing framework prioritising collaboration, ethical literacy, inclusive design, governance arrangements, and ongoing assessment. Strategies to integrate AI ethics into STEM education are highlighted to develop key decision-making skills among students. We also offer policy suggestions to enable the ethical adoption of AI within the education sector

Tubella (2024) makes a contribution to dealing with some of the challenges to bring AI ethical progress to the public discussion, education and hands-on learning by examining the strategies from the literature and by conducting in-depth interviews of 11 experts in five countries to assist in formulating educational approaches, competencies and necessary resources for the successful implementation of Trustworthy AI in higher education and to reach students across all fields. The results are framed in the format of recommendations both for teachers and policy incentives, bringing the guidelines to higher education teaching and practice, so that Europe's future generation of youth can deliver an ethical, secure and pioneering AI made in Europe. Therefore, in this article, the researchers explore the recent trends in the arena of ethical and responsible AI in education by performing a thematic analysis of academic literature on AI ethics in education. Through systematic analysis, it flags both the benefits and challenges of AI, providing some direction for ethical incorporation.

Objectives

In this research on the responsible and ethical application of Artificial Intelligence (AI) in education, these objectives were carefully structured to both seize the challenges and opportunities inherent in the adoption of AI:

- To conduct thematic analysis of what exists currently in the literature regarding AI ethics in education
- To identify the prevailing ethical concerns raised in schools
- To explore promising AI prospects that are harmonious with responsible and ethical practices.
- To consider the way in which thematic patterns reflect the tension between innovation and ethics
- To propose models and guidelines for responsible AI implementation in education.
- Together, these objectives constitute an equally weighted agenda by examining challenges critically while also envisioning directions for ethical and responsible AI application in education.

Methodology

Research Design

The study used thematic analysis as its exclusive methodological approach. Thematic analysis is especially well adapted to combine disparate qualitative data and to uncover repeated patterns of meaning from different sources. As the objective of the study was to map ethical arguments and proposals on responsible practice regarding AI in education, the method enabled systematic, open, and reproducible questioning of policy briefs, empirical research, and practitioner recommendations.

Data Selection and Collection Process

The critical corpus included publications between 2018 and 2025, encompassing the recent surge in AI uses in education. An initial search was conducted on four leading academic and professional databases: Google Scholar, Scopus and Web of Science. The search terms utilized words like "AI ethics in education," "responsible AI learning," "academic integrity AI," "privacy AI classrooms" and "algorithmic bias education."

Sources Consulted: Peer-reviewed journals, educational technology-related papers, and institutional reports.

Search Databases: Google Scholar, Scopus, Web of Science.

Inclusion Criteria: Publications focusing on ethical implications of AI use in school, higher education, and lifelong learning are included.

Exclusion Criteria: Articles on purely technical AI models without reference to education or ethics are excluded.

Data Analytical Process

- *Familiarization*: The researchers read and re-read each complete text, taking analytical memos to record repeated ideas, conceptual framings, and illustrative examples.
- *Coding Initial Codes*: Text passages describing ethical issues, advantages, proposals for governance, and pedagogical consequences were coded. Codes varied from semantic markers (e.g., "risk of plagiarism," "consent to data") to more interpretive labels (e.g., "culture of surveillance," "teacher agency").
- *Identification of Themes*: Connected codes were grouped into potential themes through repeated comparison; codes for monitoring, proctoring, and data storage, for instance, merged into a larger "Privacy & Surveillance" theme.
- *Reviewing Themes*: Candidate themes were checked against the whole dataset to confirm internal consistency and uniqueness. Overlapping themes were merged or redefined; marginal codes were re-examined or absorbed into richer categories.
- *Defining and Naming Themes*: Each final theme was assigned a clear operational definition and boundary conditions, and exemplar references from the corpus were given.
- *Producing the Report*: The thematic map and interpretive commentary were prepared with cross-referencing to source material and with attention to how themes mapped onto the study objectives.

Findings

The thematic analysis produced five core themes that summarise the ethical and responsible application of AI in education. Each theme is expanded below with literature-based supporting evidence.

Academic Integrity and Authenticity of Learning

Another of the most significant ethical issues revealed was the compromise of academic honesty (Sharma, 2023; Nwozor, 2025; and Elom, 2025). Student use of generative AI tools like ChatGPT, Jasper, or Writesonic means that they can produce essays, reports, and even research papers with hardly any effort involved. Likewise, problem-solving software like Photomath offers quick solutions without engaging the mind. But over-reliance on AI can make education a transactional activity instead of a developmental experience. And plagiarism checkers are usually not able to detect AI-generated work, posing challenges to assessment integrity.

But on the other hand, AI can provide scaffolding for learners, such as grammar correction, brainstorming, or guiding initial problem-solving steps. Thus, the challenge lies not in banning AI outright but in designing assessments that reward creativity, reasoning, and higher-order thinking - areas where AI assistance is limited.

Data Privacy and Surveillance Concerns

EdTech relies heavily on big data analytics. Learning management systems monitor log-in time, completion rate, keystrokes, and even gaze in certain proctoring tools. While they are helpful for measuring engagement, they have fundamental issues with student autonomy and privacy (Huang, 2023). Ethical integration necessitates informed consent, data minimisation, and transparency in data use (Patel, 2024). Students and parents must have a clear understanding of how data is gathered, why, and for what duration it will be kept. Responsible AI design necessitates conformance to international standards like the General Data Protection Regulation.

Algorithmic Bias, Fairness, and Equity in Access

A common thread throughout the literature was algorithmic bias (Boateng & Boateng, 2025; Khan, 2023). AI platforms are only as impartial as their training data. Whenever datasets are biased towards specific languages, regions, or cultural environments, the results perpetuate systemic inequalities. For example, voice recognition AI tends to perform poorly on regional accents, putting learners from rural or minority linguistic backgrounds at a disadvantage. Adaptive learning systems may actually classify marginalised group students as "low-performing" based on biased measures. Equity also applies to access to AI technologies. Children from under-resourced schools or low-income nations might not have stable internet connectivity, hence left behind in the AI revolution. This creates a digital divide, increasing the disparity between affluent and disadvantaged learners. Responsible AI should thus prioritise fairness, inclusivity, and accessibility. Multilingual platforms, culturally representative datasets, and low-bandwidth solutions are essential to make AI available to all learners.

Contradiction between Innovation and Ethics

The results suggest that AI in education is always framed by an essential contradiction between technological innovation and moral responsibility (Tabish, 2023; Ray & Ray, 2024). Throughout the literature under examination, innovation is often seen to be a double-edged sword holding out the promise of efficiency, personalisation, and enhanced learning, while also creating threats of bias, inequality, and the loss of human-centric values. Thematic analysis indicates that this tension is frequently expressed as a balancing act between responsibility and progress. On the one hand, the impulse for efficiency and scale identifies the transformative power of AI-driven systems in educational contexts. On the other hand, worries about fairness, justice, and the protection of ethical standards expose the social and moral challenges inherent within AI adoption.

Policy, Governance, and Ethical Frameworks

Lastly, the literature again referred to the lack of strong regulatory frameworks for AI in education (Chan, 2023 and Kaliisa et al., 2025). While there are institutions experimenting with local policies, there is no one solution that is universally agreed upon. UNESCO (2023) calls for a human-centric AI strategy based on fairness, accountability, transparency, and explainability. Policy frameworks ensuring AI is aligned with democratic and educational values are also emphasised. Institutional implementation remains patchy, however.

Discussion

Thematic analysis conducted in this research emphasises a fundamental contradiction, even though Artificial Intelligence has immense potential to revolutionise education, it also presents equally compelling ethical issues:

Academic Integrity: Redesigning Learning and Evaluation

The academic integrity theme highlights the most apparent disruption that AI has had on education. Essay-writing, math problem-solving, and coding assistance tools call into question the validity of traditional exams and assignments. Teachers worry that the use of AI can undermine students' own critical thinking abilities and encourage academic cheating. But the findings also underscore that AI necessitates a revisit of old-fashioned pedagogical models. Old-fashioned memorisation-type or recall-based assessment processes are most susceptible to exploitation, while project-based, inquiry-type, and problem-focused ones are more suited to realistic learning. Accordingly, instead of projecting AI as a threat to intellectual integrity, this issue indicates that it can serve as an incentive for pedagogical transformation. AI identifies loopholes in existing systems of evaluation and provides a chance to re-design tests that test creativity, critical thinking, and application of knowledge in real life.

Privacy: Balancing the Surveillance-Education Scale

Privacy is one of the most delicate ethics issues associated with the use of AI in education. Intelligent tutoring environments, learning analytics tools, and proctoring tools tend to need access to students' individual information from demographics to patterns of behavior. While such information can facilitate robust insight into learning requirements, performance deficits, and individualised support, the same process threatens to turn students into objects of monitoring. There are concerns about secretive data-handling processes, without informed consent, and commoditizing learner data. This conflict is most apparent in online education platforms, where remote proctoring has triggered international controversy regarding student autonomy and dignity. The discourse proposes that the future is in open policies with a focus on the rights of students, informed consent procedures, and data use boundaries. Privacy cannot be an add-on; it must be incorporated as a principle to shape the design and deployment of AI systems in the education sector.

Equity: AI as a Divider or Equaliser

Equity is both the hope and risk of AI adoption. On the one hand, AI systems have vast possibilities of tailoring learning, aiding disabled learners, and overcoming resource disparities by ensuring high-quality learning materials reach individuals at scale. On the other hand, differences in infrastructure, digital device access, and bias in AI models have the potential to widen the digital divide. For example, if AI systems are optimised for English or dominant cultural settings alone, students belonging to marginalised or non-dominant linguistic communities might be subjected to systemic disadvantage. The analysis directs attention to the necessity of multilingual, bias-mitigated, and culturally adaptive AI systems. Equity does not come from offering AI tools but through the inclusive design of them and making sure that any learner, irrespective of socio-economic background or place of origin, is able to access and avail benefits from them. This involves focused investment, ethical design, and continuous tracking of bias and exclusion.

Tension between Innovation and Ethics

The findings demonstrate that AI in learning is perceived comprehensively from the perspective of competition between technological advancement and ethical responsibility. Innovation proves to be a two-faced phenomenon, increasing efficiency, customisation, and scalability while, at the same time, generating risks like bias, inequality, and loss of human values. This ambivalence indicates that the implementation of AI must be evaluated not only based on technical merit but also in terms of its social and ethical implications. There is a common thread in the literature that speaks to the imbalance between efficiency and justice, and the drive for speedy progress can ignore considerations of fairness, inclusion, and transparency. The results underscore that AI in education must be conceptualised as a socio-technical system, not a value-free tool. In order to progress toward accountable and ethical AI, there needs to be continuous conversation to harmonise technological innovation with accountability systems that protect equity and maintain human-centric values.

Governance: Policies as Ethical Anchors

Lack of explicit, enforceable policies is still a key obstacle to ethical use of AI in education. Without governance, potential risks like data misuse, algorithmic bias, and unequal access are likely to remain unchecked. The discussion shows that most institutions and countries are in the nascent stages of formulating guidelines, sometimes catching up with the fast rate of technology uptake. Governance calls for synergy at local, national, and global levels. Institutions need to formulate their own practice codes alongside integration into general frameworks, e.g., those suggested by UNESCO. Governance cannot be restricted to reactive regulation but needs to actively foresee upcoming dangers while protecting innovation. Moral violations in education have wide-ranging implications, not merely for individual students but also for public trust in education systems. Strong institutional direction, cross-sector collaboration, and open accountability mechanisms are necessary.

Combined, these themes confirm that accountable AI integration in education should always be human-centred, equity-oriented, and policy-supported. AI in education cannot leave the future to market forces or technical efficiencies. Rather, teachers, policymakers, developers, and learners must collectively co-design spaces where innovation is shaped by ethics, accountability, and inclusivity. AI should augment, not diminish, the fundamental values of education—justice, equity, respect, and human development.

Conclusion

The use of AI in learning is inevitable and revolutionary. However, as this thematic analysis indicates, ethical application cannot be taken for granted; it needs to be purposely designed. Academic integrity, privacy, fairness, teacher autonomy, and governance models constitute the five pillars of sound AI uptake. The future of AI in education lies not in its technological potential alone but in the ethical imagination of educators, policymakers, and learners. By embedding responsibility at every stage, design, deployment, and usage, education can harness AI's power while safeguarding its moral core. In this way, AI will not replace teachers or diminish human learning, but instead become a partner in building inclusive, fair, and human-centred education systems for the future.

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Role of Artificial Intelligence in Addressing Global Teacher Shortages: A Conceptual Framework

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The Global Education System is very challenging, as it is facing a critical shortage of teachers, which threatens the achievement of universal quality education. (UNESCO, 2023) global report on the shortage of teachers, which focuses on Sustainable Development Goal 4, i.e., "ensure inclusive and equitable quality education and also promote the whole life of everyone".

If we talk about the Indian Education System, which evolved from Gurukul Shiksha to the Artificial Intelligence world. The persistent shortage of teachers at both primary and secondary levels has highlighted critical gaps in the education sector. This article explains how artificial intelligence can be a supplement, rather than a replacement, for teachers. Through a focused analysis of AI-enabled solutions—such as Personalized Learning, Administrative Automation, and Data-Driven Policy—this article evaluates the transformative potential of these technologies for modern education.

The article shows that using AI in education can change the learning results and help address the global teacher shortage. It also discusses the challenges faced during AI use in practice in the school campus, and it offers policy recommendations that will support the AI adaptation at worldwide. (Abstract)

Teacher shortages have become a global crisis for many reasons, including problems with the quality and accessibility of education. The UNESCO (2021) report estimates a major shortage of teachers in many countries. According to the report of OECD (2020), it mentions that the dropping of teachers is happening very speedily, because of their salary concerns, heavy workloads, and job satisfaction.

Further, (UNESCO, 2023) global report on the shortage of teachers which will help to hold the data and case studies to shed light on the progress towards target 4 of SDGs (Sustainable Development Goals), which aims that "By 2030, it says that it is essential to increase the supply of teachers through various international cooperation maintain for teacher training in developing countries, especially least developed countries and small island developing states".

The main aim of global progress towards SDGs Goal 4.c, mentioned above, is comparable worldwide. Indicators were identified to measure both the quality and quantity of teachers and teaching, governments are called to indicators of different categories, such as an increase the quantity of teachers with the minimum required qualifications by education system, the number of teachers who already done the in-service training by different types of training institutions, and also includes the salary of teachers relative to those of other professionals requiring a indifferent level of qualifications.

According to the 'UNESCO Institute for Statistics (UIS 2009)', increasing the workforce of teachers all over the world shows the progress of recruiting the required many teachers to achieve universal primary and secondary education. Here, 44 million teacher shortage is expected by 2030, down from 69 million in 2016 (according to the report of UIS, 2016). A huge number of teachers are needed in Sub-Saharan Africa, South Asia, Europe, and North America (Table 1).

Primary Level

The table 1 shows the requirements of teachers of various countries, and it discusses the number of teachers working in 2022 at primary schools, particularly in Eastern Asia (7417) and less in Oceania Countries (199). On the other hand, the total additional requirement of teachers is more (3050) and less in Central Asia (96).

At the secondary level, it is greater in Southern Asia (8554) and less in Central Asia (904), and in the Secondary level total additional teachers' requirement is more in Sub-Saharan Africa, less in Oceania (152).

Teachers Shortages in India

According to the report of UDISE+ (2023-24), the Indian Education System faces a significant

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Table 1. Total Number of Primary and Secondary Level Additional Teachers Required for Different Regions by 2030 (in thousands)

Primary Education Teachers required by various Regions

REGIONS	TEACHERS 2022	REPLACING STAFF ATTRITION	NEW TEACHING POSTS	TOTAL ADDITIONAL RECRUITEMENT NEEDED BY 2030
CENTRAL ASIA	302	42	54	96
EASTERN ASIA	7417	163	17	179
EUROPE AND NORTHEN AMERICA	4862	1689	25	1714
LATIN AMERICA AND THE CARIBBEAN	3071	979	30	1009
NORTHEN AFRICA AND WESTERN ASIA	2849	868	365	1233
OCEANIA	199	114	10	123
SOUTH-EASTERN ASIA	3682	2945	104	3050
SOUTHERN ASIA	6428	664	397	1061
SUB-SAHARAN AFRICA	4931	2447	1944	4391
TOTAL	33741	9911	2946	12857

Secondary Level

Secondary Education Teachers required by various Regions

REGIONS	TEACHERS 2022	REPLACING STAFF ATTRITION	NEW TEACHING POSTS	TOTAL ADDITIONAL RECRUITEMENT NEEDED BY 2030
CENTRAL ASIA	904	362	289	651
EASTERN ASIA	8082	2089	1011	3101
EUROPE AND NORTHEN AMERICA	7775	2830	285	3115
LATIN AMERICA AND THE CARIBBEAN	4126	1867	331	2198
NORTHEN AFRICA AND WESTERN ASIA	3348	1638	1386	3024
OCEANIA	M	82	69	152
SOUTH-EASTERN ASIA	3075	1070	420	1490
SOUTHERN ASIA	8554	2399	4317	6716
SUB-SAHARAN AFRICA	3528	3191	7467	10658
TOTAL	39392	15531	15574	31105

Source: *UIS, 2023c, and UNESCO and Teacher Task Force, 2023a.Adapted from Ramfrez et.al., forthcoming.*
Created by a Researcher using Canva. Note: m stands for missing data.

shortage of teachers, particularly in rural and underserved areas.

The UDISE+ report indicates the total number of teachers in the school education system (from classes 1 to 12) is approximately 9.5 million, with a pupil-teacher ratio (PTR) of 26:1 at the primary level, 19:1 at the upper primary level, and 17:1 at the secondary level. However, these national reports mask the regional disparities, such as states like Bihar, Jharkhand, and Uttar Pradesh.

The report also highlighted that 1.1 lakh schools are run through single-teacher schools (approximately 7%), mainly in rural areas, which affects over 10 million students. Furthermore, some of the shortage of subject-specific teacher shortages (approximately 15%) are in mathematics and science.

Now, 'India's education system' has gone through a significant transformation over the last few years, particularly in the teaching and learning system. As education is an essential part of our lives, technology is playing a major role in the education system.

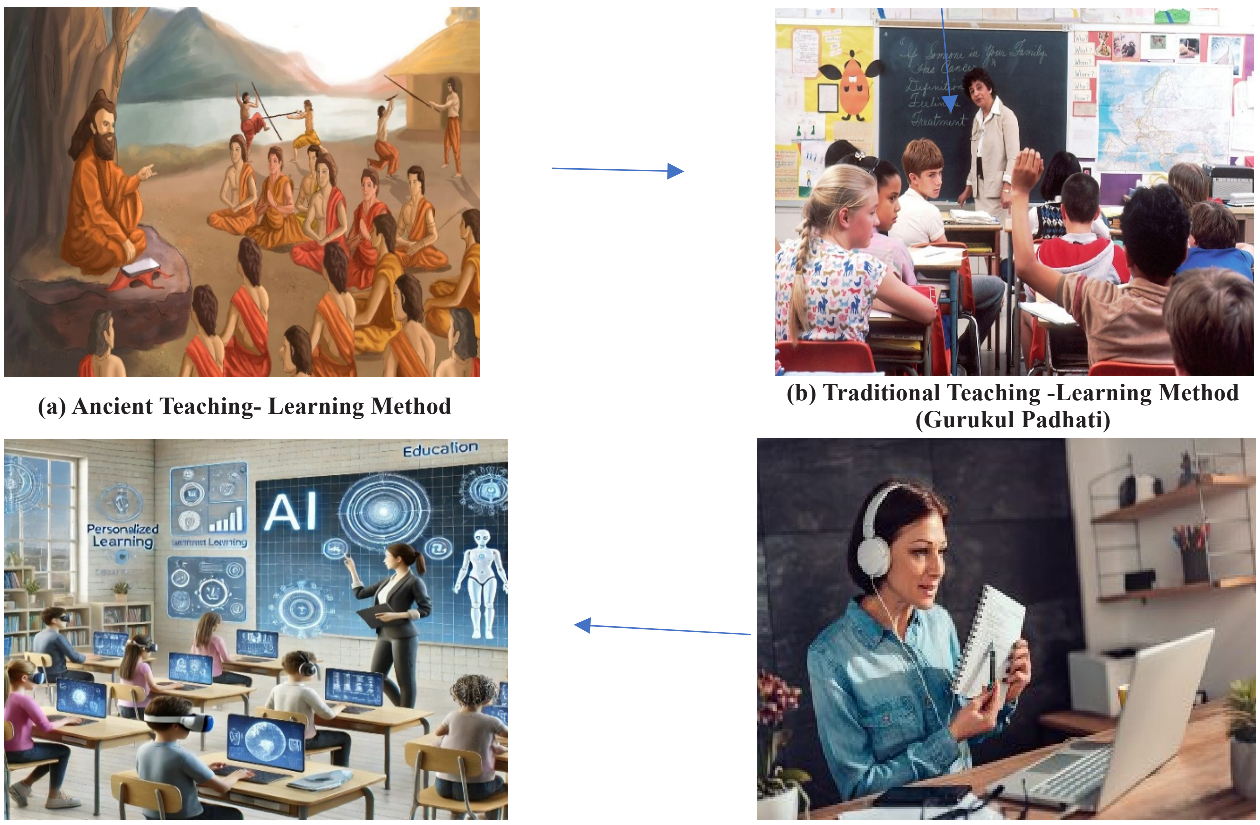
Unfortunately, several institutions, schools, and universities do not work with the latest technologies in place of traditional educational methods.

As Artificial Intelligence (AI) is making a change in the education system all over the world through adaptive learning platforms, automated grading assessment systems, and intelligent tutoring (Holmes, Bialik, & Fadel, 2019), making it possible for the education system to run very smoothly.

Figure 1 illustrates that the progress of different divisions of learning is moving from traditional to AI in education. ICT information and communication-based technology has spread very fast, and striking the students' knowledge about systems will make it possible to meet the needs of the modern era.

Through this transformation, the future will be an intellectual world, which will ensure suitable

Figure 1: Transformation of the Teaching-Learning Process with New Technologies



(a) Ancient Teaching- Learning Method

(b) Traditional Teaching -Learning Method (Gurukul Padhati)

(d) AI-based Teaching-Learning Method

(c) e- Teaching -Learning Method

Sources:(a)*https://share.google/Wt8FiKIMnSjsY8xuB,(b)https://share.google/j2U1Tpgr3IvNvnAHI,(c)https://share.google/images/c9iAA50GTxlUBZZES,(d)https://share.google/images/ MdXeuCNEG5CfjyGKy* educational opportunities for students in the upcoming generation. As we are very familiar with the old method of teaching that totally depends on oral transformation of thoughts, because knowledge was delivered through autocratically by the teacher to students. After that, traditional teaching practices were totally based on chalk and blackboard. In the alternative case, e-learning is the new educational technology with the help of the internet and computer application, anybody can do their work from anywhere, so it is not wrong to say that today's education system is totally different from the traditional one.

AI learning apps have various properties of intelligence-based tools that will provide the best environment for the students for their better learning, and faculty can also use them to improve course content, and they can also take the help of AI for assessment. Therefore, by going through these technologies by implementing them, we will see various changes in the upcoming years in the teaching and learning system.

Definition of Artificial Intelligence

Artificial Intelligence can be defined as a machine that performs various tasks of humans carry out through their thinking (Dorfler, 2022). The usage of artificial intelligence is growing at an unprecedented rate and rapidly changing the aspects of human life. (Xue and Wang, 2022a)

"The main purpose of developing Artificial Intelligence is to make computers combined with mechanical equipment skilful for some difficult work which often fulfils the needs of human minds and also reduces the curriculum-based burden of human beings" (Xue and Wang, 2022).

Artificial Intelligence in Education

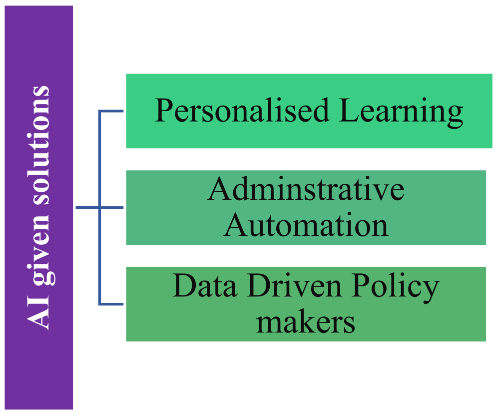
Artificial intelligence plays an essential role in transforming India's education system, addressing critical challenges like teacher shortages, data management in schools, and equitable access to quality education.

With 1.5 million schools, 250 students, and a shortage of teachers of approximately 1 million (by the global report on teachers: UNESCO,2024), the report reveals that around 44 million teachers are required for primary and secondary level worldwide by 2030. keeping in mind AI can offer some best practices through different methods such as Personalised learning, administrative automation, and data-driven policymakers.

"Artificial Intelligence in Education is the first internationally comprehensive attempt to help policy makers and educators to read through the lines of artificial intelligence and find what is in there for them. Readers will certainly welcome the analytical perspectives and, even more, the value propositions that reaffirm the value of education in a world where many spheres of daily life, from work to culture and social life, could be dramatically challenged by artificial intelligence."

—Francesc Pedró, Chief, Education Policy, UNESCO

Figure 2: Solutions through Artificial Intelligence



In figure2 Artificial Intelligence gives solutions based on Personalised Learning, Administrative Automation, and Data-Driven Policy makers.

Personalised Learning: Personalised Learning is used to measure the ability of learners through Adaptive learning opportunities. For achieving these AI AI-based platforms provide to learners. So, they can measure the patterns of learning of students, strengths, and weaknesses, to provide them with customised, appropriate content and exercises.

Administrative Automation: Administrative Automation is basically used to help with administrative tasks, through which automation can reduce manual errors and free up valuable resources for critical tasks. Automation in Administration is a game-changer (Berglind et al., 2022).

Data-driven Policymakers: It is used to extend the conceptual and practical boundaries of AI research in the public sector to governmental decision-making and governance.

UNESCO Report on Artificial Intelligence is Essential for Education

UNESCO, the United Nations Educational, Scientific and Cultural Organisation, which gives main concern on AI, role in the education system, from which we got a clear picture of the necessities of AI in different aspects of education. So, it will promote inclusion and rectify the issues related to diversity that will help various digital devices, which require the skill for the use of their applications and technology.

With the help of AI in education, inclusivity and the quality of education seem to be changing day by day. It will also improve the outcomes of the teaching and learning process and make it accessible for all students, as well as teachers and non-teaching staff. Due to the use of AI in the education system, teachers can raise their professional growth through taking different training in AI-related tools and techniques.

It also focuses on the collaboration of stakeholders and policymakers to enhance their capability to use various tools, which will help in addressing the educational challenges, like the limited accessibility of AI Tools provided to enhance the quality of education, shortages of teachers due to different reasons, and Learning disparities.

Challenges Faced During the Implementation of Artificial Intelligence in the Education System

Many challenges come during the implementation of AI in the Education System, as discussed below:

- ***Data Privacy and Security***

  The major reasons are data privacy and the security of students' data. It will be checked whether AI is integrated into the education system. It often requires running a vast amount of personal data, including performance metrics, behavioural data, and demographic data. Therefore, we can say that this is a question of concern about data security and the misuse of sensitive information of a person.

- ***Lack of Infrastructure***

  In various areas of the country, particularly in developing countries, there is still a lack of basic needs for providing the proper infrastructure that will support AI implementation in education. It is very difficult to find reliable internet access, computers, and electricity pose significant barriers in the adoption of AI in education.

- ***Resistance from Teacher in Adopting AI***

  Many teachers have fears that AI could replace their jobs, while others may struggle with the technical aspect of incorporating an AI tool into their teaching methods. It is very tough to train all teachers to keep it in mind; this will necessitate adopting new AI technologies which will meet resistance.

- ***Cost of AI Implementation***

  AI offers numerous benefits, but it is still problematic due to the high cost of implementing an AI system in education. Developing AI tools, maintaining infrastructure, and ensuring ongoing software updates can strain budgets, especially in public schools.

Major Initiatives to Empower Teachers in AI

- ***National Education Policy 2020***

  NEP 2020 has the main concern of AI integration, with various initiatives like CBSE's initiative AI-based curriculum for classes 9^{th} and 11^{th} standards. Secondly, it also promotes the AI for all program, like AI-based literacy run from 2020. Other famous pathways that are working for school education, like DIKSHA and SWAYAM, that use AI to deliver multilingual content and lectures, must increase accessibility across India's diverse regions.

- ***AI in School Education***

  In School Education, AI can play a transformative role by giving personalised learning experiences for students. The policy says about the individual learning needs through AI-based educational content, keeping in mind students' strengths and weaknesses. It can also assess the students' understanding of the concept in real time and provide instant feedback to teachers, so that they can enhance and modify in teaching methods accordingly.

- ***AI Used for Teachers' Training and their Professional Growth***

  Teachers are the main concern for the success of NEP 2020, and AI has the potential to revolutionize teacher training and their professional development. Various AI tools will be provided to teachers; therefore, they will get real-time feedback on their teaching methods and suggestions which is required for their improvement.

- ***Continuous Professional Development***

  AI-based platforms can recommend teacher training programs and resources that adapt according to individual teachers' needs. This will enable the teachers to keep up to date with the latest teaching technology and subject content.

- ***AI as Teaching Assistant***

  AI can work as a virtual assistant for teachers by handling non-teaching work, such as grading and attendance, allowing teachers to focus on their main concern, of their core responsibility of teaching. The NEP 2020 also promotes AI-based platforms like DIKSHA to deliver NISTHA (Teacher Training) programs integrated with AI components. (The Hindu Report).

- ***SOAR Programme- Skilling Teachers for AI Readiness***

  Ministry of Skill Development and Entrepreneurship (MSME) has initiated the SOAR Programme (Skilling for AI readiness) to equip Indian school students from class 6 to class 12, and teachers within the school system, with the main concern of making teachers and students knowledgeable persons for taking practical skilling of AI.

- ***AI-based Lesson Plan for Schools Launched by NITI Aayog***

  According to NEP 2020, the main concern of the policy is that students are well-prepared for emerging technologies. As NITI Aayog has launched various programmes, one of them is "Atal Tinkering Labs" and the Introduction of AI in the school classroom and outside the classroom, which will help teachers for more clarity about the practical usages of the concept.

  "Atal Innovation Mission", along with CBSE, has launched several AI-based lesson Plans for integrating AI into the school curriculum. This plan is expected to give a proper 360-degree view of Artificial Intelligence of Things (AIoT) that can enhance teaching and learning in a classroom situation (NITI Aayog, 2023).

- ***Vidya Samiksha Kendra***

  Vidya Samiksha Kendra (VSK) is an initiative taken by the "Ministry of Education", Govt. of India, whose aim is to enable integrated and shared 'seeing' for amplifying data-driven decision making and action taken by stakeholders for academic as well as administrative activities, thereby improving learning outcomes.

The VSK was conceived it optimally utilize" modern technologies to provide insights into different educational programs, and facilitate integrated functioning towards a common goal.

The objective of VSK includes observing the real-time status of various projects/ activities under the scheme of Samagra Shiksha, improving the academic performance of students, and enhancing the accountability of teachers in schools. To attain these objectives, VSK encompasses features such as administrative reforms, digital education, tracking and monitoring, and a data-driven approach towards enrolment.

Conclusion

Teacher shortages are a major issue all over the world, as the UNESCO report provides data from different countries. This issue behaves like a barrier for not achieving the goal of SDG 4. As discussed above, according to Deloitte's YeSSE 2023 report, different reasons are defined for shortages of teachers, like less qualified teachers, the salary of teachers, and the facilities of teachers.

AI, integrated in education, can provide crucial support to teachers in instruction, administration, professional development, and access to education. Rather than replacing the teachers, AI can help the teachers as a helping hand, train teachers for more skillful, provide content mastery, rather than replacing them, AI can enhance the quantity as well as quality of teachers, also improve the teaching-learning quality.

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AI-Driven Indigenous Research and Innovation in Indian Universities: Opportunities and Institutional Challenges

Bindu Dua*, Bharti Tandon and Arpana Koul*****

Artificial Intelligence is increasingly reshaping research practices and knowledge production in higher education institutions worldwide. In the Indian context, its integration with indigenous knowledge systems offers new possibilities for revitalising community-based research, strengthening innovation, and enhancing the global visibility of locally rooted knowledge traditions. Indian universities, positioned at the intersection of policy, technology, and society, play a crucial role in mediating this transformation. This study examines the opportunities and institutional challenges associated with AI-driven indigenous research and innovation in Indian universities. Adopting a conceptual and policy-oriented approach, the paper analyses national frameworks such as the National Education Policy 2020, the National Research Foundation, the India AI Mission, and Indian Knowledge Systems initiatives to understand their implications for university-based research. The study highlights key opportunities, including improved documentation and analysis of indigenous knowledge, interdisciplinary collaboration, community participation, and indigenous product innovation. At the same time, it identifies major constraints related to infrastructure gaps, limited human resource capacity, governance fragmentation, ethical concerns, intellectual property protection, and digital inequalities. The paper argues that AI-driven indigenous research must be guided by inclusive institutional design, ethical governance, and strong community partnerships. It concludes that AI has the potential to transform indigenous research into a socially responsible and innovation-oriented academic domain, provided that technological advancement is balanced with cultural sensitivity and policy commitment (Abstract).

The rapid advancement of Artificial Intelligence (AI) is reshaping the nature of knowledge production, research methodologies, and innovation systems across the globe. In higher education, AI has evolved from a supportive digital tool into a strategic driver of data-intensive research, interdisciplinary inquiry, and evidence-based decision-making (Dwivedi, et al., 2021 and UNESCO, 2023). For developing knowledge societies such as India, the adoption of AI within universities holds particular significance, as it offers new pathways to enhance indigenous research and locally grounded innovation while maintaining global academic relevance.

Indigenous research in the Indian context encompasses traditional knowledge systems, community-based practices, regional technologies, vernacular sciences, and culturally embedded problem-solving approaches (Bharati, 2019 and NITI Aayog, 2021). Despite their richness, many of these knowledge systems have historically remained under-represented within formal academic research due to limitations in documentation, standardisation, and institutional validation. AI technologies—such as machine learning, natural language processing, digital archiving, and data analytics—provide powerful mechanisms to document, analyse, and reinterpret indigenous knowledge in ways that preserve authenticity while enabling contemporary scientific engagement (Singh & Mishra, 2022).

Indian universities occupy a central position in this transformation. As hubs of research, innovation, and policy implementation, universities possess the institutional capacity to integrate AI with indigenous knowledge systems through interdisciplinary curricula, research centres, innovation cells, and community partnerships. The National Education Policy (NEP) 2020 explicitly advocates the promotion of Indian knowledge systems, technology integration, multidisciplinary research, and innovation-driven higher education (Government of India, 2020). Similarly, the establishment of the National Research Foundation (NRF) further reinforces the role of universities in strengthening research ecosystems and indigenous innovation capabilities (UGC, 2022).

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Within this evolving policy environment, AI-driven indigenous research aligns closely with national priorities such as *Atmanirbhar Bharat*, Digital India, sustainable development, and inclusive growth. AI enables universities to convert local knowledge into scalable research outputs, socially relevant innovations, and market-oriented products, thereby strengthening the linkage between academia, industry, and society (Kumar & Gupta, 2023). It also enhances global visibility for indigenous research by facilitating international collaboration, open-access dissemination, and cross-cultural knowledge exchange.

However, the institutional realisation of these opportunities remains uneven. Indian universities continue to face challenges related to infrastructural inadequacies, shortage of AI-trained faculty, limited funding for advanced research, fragmented governance structures, and ethical concerns regarding data ownership and intellectual property rights of indigenous communities (Chatterjee & Bhattacharya, 2021 and UNESCO, 2023). Moreover, the digital divide among institutions risks creating unequal access to AI-enabled research opportunities, potentially marginalising smaller and rural universities.

Additionally, the application of AI to indigenous knowledge raises critical ethical and cultural questions. Issues of misrepresentation, commercial exploitation, cultural appropriation, and loss of community control over knowledge require strong regulatory and institutional safeguards (Nayak, 2022). Without appropriate governance frameworks, AI-driven research may unintentionally undermine the very knowledge systems it seeks to promote.

Against this backdrop, this paper critically examines the opportunities and institutional challenges associated with AI-driven indigenous research and innovation in Indian universities. It explores how AI can strengthen research capacity, foster indigenous innovation, and enhance university-community engagement, while also identifying the structural, ethical, and policy constraints that limit effective adoption. By adopting a conceptual and policy-oriented approach, the study seeks to contribute to contemporary debates on AI-enabled higher education and provide strategic insights for academic leaders, policymakers, and researchers.

The paper ultimately argues that AI-driven indigenous research is not merely a technological intervention but a transformative academic project that demands inclusive institutional design, ethical governance, and sustained policy commitment to ensure that innovation remains locally rooted, socially responsible, and globally relevant.

Rationale for Focusing on Universities as Key AI Innovation Hubs

Universities occupy a central position in national innovation systems due to their dual mandate of knowledge generation and human resource development. In the context of artificial intelligence, universities serve not only as sites of technological research but also as spaces where ethical, social, cultural, and policy dimensions of AI are critically examined (Dwivedi et al., 2021). This multidimensional role makes universities uniquely suited to function as key AI innovation hubs within the higher education ecosystem.

Indian universities possess structural advantages that enable them to support AI-driven innovation. Their multidisciplinary academic environments facilitate collaboration among engineering, social sciences, humanities, management, and natural sciences, which is essential for responsible and context-sensitive AI development (Kumar & Gupta, 2023). Such interdisciplinary integration allows AI applications to move beyond technical efficiency toward socially relevant and culturally grounded solutions, particularly in areas such as indigenous research, sustainability, health, education, and rural development.

Universities also play a crucial role in capacity building by producing skilled human capital in AI, data science, and allied fields. Through teaching, research supervision, and training programmes, universities prepare future researchers, innovators, and policymakers who will shape India's AI ecosystem (UNESCO, 2023). This educational function ensures the long-term sustainability of AI innovation rather than limiting it to short-term technological experimentation.

Furthermore, universities act as institutional bridges connecting government, industry, and society. Innovation cells, incubation centres, technology transfer offices, and start-up ecosystems within universities promote the translation of research into practical applications and marketable products (Chatterjee & Bhattacharya, 2021). In the Indian context, such platforms are particularly important for transforming indigenous research into socially useful innovations while maintaining academic integrity and community engagement.

Policy frameworks in India further strengthen the role of universities as AI innovation hubs. The National Education Policy (NEP) 2020 emphasises research, innovation, technology integration, and multidisciplinary learning as core functions of higher education institutions (Government of India, 2020). The establishment of the National Research Foundation (NRF) also underscores the expectation that universities will become centres of high-quality research, knowledge creation, and innovation leadership (UGC, 2022). These policy initiatives position universities as primary institutional actors in India's AI-driven knowledge transformation.

Equally important is the ethical responsibility of universities in guiding AI development. Unlike corporate or purely commercial entities, universities are expected to uphold principles of academic freedom, social responsibility, and public accountability. This makes them appropriate spaces for developing ethical frameworks, regulatory awareness, and culturally sensitive AI practices, particularly when dealing with indigenous knowledge systems (Nayak, 2022).

Moreover, universities ensure inclusivity in AI innovation by extending opportunities to diverse regions, disciplines, and social groups. While private sector AI development is often concentrated in urban and elite institutions, universities across different regions can democratise access to AI education and research, thereby reducing digital and regional inequalities (UNESCO, 2023).

In light of these academic, institutional, and policy functions, universities emerge as the most appropriate and strategic sites for nurturing AI-driven research and innovation in India. Their ability to integrate technology with ethics, culture, policy, and social responsibility makes them indispensable for ensuring that AI-driven innovation remains inclusive, sustainable, and nationally relevant.

The present paper aims to critically examine the emerging role of artificial intelligence in strengthening indigenous research and innovation within Indian universities. The specific objectives of the study are to:

- To analyse the relevance of AI in revitalising and systematising indigenous research and innovation practices in the Indian higher education context.
- To analyse the policy context of AI, Indigenous Knowledge Systems, and higher education in India with reference to NEP 2020, the National Research Foundation, the IndiaAI Mission, and Indian Knowledge Systems Centres, and to examine their implications for university-based indigenous research and innovation.
- To identify key opportunities offered by AI for enhancing research capacity, community engagement, and indigenous product innovation in Indian universities.
- To explore institutional challenges related to infrastructure, governance, human resources, ethics, and equity in implementing AI-driven indigenous research.
- To suggest strategic directions for strengthening AI-driven indigenous research in a manner that is inclusive, ethical, and socially responsible.

This paper is primarily conceptual and policy-oriented. It does not attempt to provide a technical or computational analysis of artificial intelligence systems. Instead, the study focuses on the institutional, academic, cultural, and governance dimensions of AI-driven indigenous research within Indian universities.

Geographically, the paper is limited to the Indian higher education context, while drawing selectively from global literature to support theoretical understanding and comparative insight. Institutionally, the study concentrates on universities and higher education institutions as primary sites of research, innovation, and policy implementation. Thematically, the paper covers:

- Indigenous knowledge systems and innovation traditions in India
- AI as an enabler of research and innovation
- University-based research ecosystems
- Policy frameworks influencing AI and indigenous research
- Ethical, cultural, and governance concerns
- Institutional opportunities and constraints

Methodologically, the paper adopts a descriptive and analytical approach based on secondary sources, including policy documents, scholarly literature, and institutional reports (Dwivedi, et al., 2021; Government of India, 2020 and UNESCO, 2023). Empirical fieldwork is beyond the scope of the present study; however, the analysis aims to provide a strong conceptual foundation for future empirical research.

By clearly defining its objectives and scope, the paper seeks to maintain analytical focus while offering meaningful insights into the evolving relationship between artificial intelligence, indigenous research, and higher education institutions in India.

Conceptual Framework: AI and Indigenous Knowledge Systems

The conceptual framework of this study is grounded in the intersection of three interrelated domains: artificial intelligence, indigenous knowledge systems, and university-based research ecosystems. This framework views AI not merely as a technological instrument but as a socio-technical enabler that can transform the processes of knowledge documentation, analysis, validation, and innovation when applied within culturally grounded research contexts (Dwivedi, et al., 2021 and OECD, 2019).

Indigenous knowledge systems represent community-based, experience-driven, and culturally embedded forms of knowledge that evolve through long-term interaction with local environments and social realities (Bharati, 2019 and Smith, 2012). These systems are holistic in nature, integrating ecological, medicinal, technological, and social dimensions. However, due to their oral traditions, contextual specificity, and non-standardised formats, indigenous knowledge has often remained outside mainstream scientific research frameworks (Gupta, 2016). The conceptual challenge, therefore, lies in enabling indigenous knowledge to engage with modern research systems without losing its cultural authenticity and community ownership.

Artificial intelligence offers conceptual possibilities to address this challenge. Technologies such as machine learning, natural language processing, pattern recognition, and digital archiving can support the systematic documentation, classification, and analysis of indigenous knowledge while preserving linguistic diversity and contextual richness (Singh & Mishra, 2022). From a conceptual standpoint, AI functions as a bridge between tacit community knowledge and formal academic research, enabling the transformation of experiential wisdom into analysable and shareable knowledge forms.

Within this framework, universities operate as mediating institutions that connect AI technologies with indigenous knowledge systems. Universities provide methodological rigour, ethical governance, interdisciplinary expertise, and institutional legitimacy to indigenous research processes (Etzkowitz & Leydesdorff, 2000 and Salmi, 2009). The Triple Helix model of university–industry–government relations further strengthens this role by positioning universities as central actors in national innovation ecosystems (Etzkowitz & Leydesdorff, 2000). In the Indian context, this mediation is particularly significant because universities are expected to balance global scientific standards with local cultural responsibilities.

The framework also draws from decolonial and participatory research perspectives, which argue that indigenous communities must be recognised as knowledge producers rather than passive research subjects (Smith, 2012). AI-driven indigenous research, therefore, must adopt participatory, ethical, and community-centred approaches to ensure that technological advancement does not reproduce historical patterns of epistemic domination. In this sense, AI is conceptually positioned as a supportive tool that enhances community knowledge visibility rather than replacing indigenous epistemologies.

Another important dimension of the conceptual framework is innovation. Indigenous innovation is understood as locally rooted problem-solving that emerges from cultural practices, ecological understanding, and community needs (Gupta, 2016). When supported by AI, such innovation can be scaled, validated, and integrated into formal research and development systems. Thus, innovation in this framework is not restricted to high-tech laboratories but extends to grassroots creativity and contextual solutions. Conceptually, the framework establishes a dynamic relationship among:

- AI as an enabling technology,
- Indigenous knowledge as a foundational epistemic resource, and

- Universities as institutional integrators and ethical guardians.

This triadic relationship allows AI-driven indigenous research to move beyond mere digitisation toward meaningful innovation, social relevance, and policy impact. Furthermore, the framework recognises that this integration is shaped by institutional capacities, governance structures, ethical norms, and policy environments. Therefore, AI-driven indigenous research is conceptualised as an ecosystem process rather than a linear technological intervention. It involves continuous interaction among technology, culture, institutions, and society.

By adopting this conceptual framework, the study positions AI-driven indigenous research as a transformative academic approach that redefines how knowledge is produced, validated, and applied within Indian universities. It provides the theoretical foundation for analysing opportunities, challenges, and strategic directions in subsequent sections of the paper

Relevance of Indigenous Research and Innovation in the Indian Knowledge Ecosystem

India possesses one of the world's richest and most diverse indigenous knowledge traditions, encompassing fields such as agriculture, medicine, architecture, ecology, metallurgy, astronomy, linguistics, and social organisation. These knowledge systems, developed through centuries of empirical observation and community-based practice, have contributed significantly to sustainable living, environmental conservation, and socio-cultural resilience (Bharati, 2019; Sen, 2020). Indigenous research and innovation, therefore, represent not merely historical legacies but dynamic and evolving intellectual resources within the Indian knowledge ecosystem.

Despite their intrinsic value, indigenous knowledge systems have long remained marginalised within formal academic and research frameworks, primarily due to colonial epistemological dominance and the privileging of Western scientific paradigms (Nayak, 2022). As a result, many indigenous practices were either dismissed as non-scientific or relegated to cultural studies, rather than being recognised as legitimate sources of scientific inquiry and innovation. This epistemic imbalance has limited the integration of indigenous perspectives into mainstream research, policy formulation, and technological development.

In recent years, however, there has been a renewed recognition of the importance of indigenous research for sustainable development, inclusive growth, and knowledge sovereignty. Indigenous innovations in areas such as organic farming, water conservation, herbal medicine, disaster management, and local craftsmanship offer context-specific solutions to contemporary challenges such as climate change, food security, and public health (UNESCO, 2017 and Sen, 2020). These innovations reflect a holistic understanding of the relationship between humans, nature, and society, which is often absent in purely technocratic approaches.

Within the Indian knowledge ecosystem, indigenous research also plays a crucial role in strengthening cultural identity, linguistic diversity, and community participation in knowledge production. It enables the democratisation of research by recognising local communities as knowledge holders rather than merely as subjects of study (Bharati, 2019). This shift from extractive to participatory research models enhances ethical accountability and promotes socially responsible innovation.

The National Education Policy (NEP) 2020 has explicitly acknowledged the significance of Indian Knowledge Systems (IKS) and emphasised their integration into higher education curricula, research agendas, and institutional practices (Government of India, 2020). By encouraging multidisciplinary approaches and contextual learning, the policy seeks to reposition indigenous research as a central component of India's academic and innovation ecosystem. Similarly, initiatives such as the establishment of IKS Centres in universities highlight a growing institutional commitment to reviving and systematising indigenous knowledge.

Moreover, indigenous research and innovation contribute directly to India's broader development goals by fostering self-reliance, sustainability, and social inclusion. Indigenous technologies often rely on locally available resources, low-cost methods, and community expertise, making them particularly relevant for rural development and marginalised populations (Sen, 2020). When supported by institutional research frameworks, these innovations can be scaled, validated, and integrated into national development strategies.

However, the relevance of indigenous research in the contemporary knowledge ecosystem depends largely on its effective documentation, validation, and ethical utilisation. Without institutional mechanisms for protection, many indigenous innovations remain vulnerable to misappropriation and commercial exploitation. Therefore, strengthening the academic legitimacy, legal protection, and policy recognition of indigenous research is essential for ensuring that these knowledge systems continue to contribute meaningfully to India's intellectual and developmental future.

In this context, indigenous research and innovation must be understood not as remnants of the past but as living knowledge systems that can actively shape India's response to modern challenges. Their integration with emerging technologies such as artificial intelligence offers new possibilities for preservation, analysis, and innovation, thereby reinforcing their relevance within India's evolving knowledge ecosystem.

Policy Context: AI, Indigenous Knowledge and Higher Education in India

India's higher education and research landscape is currently undergoing a significant policy-driven transformation aimed at integrating technology, innovation, and indigenous knowledge systems into mainstream academic practices. The convergence of artificial intelligence, indigenous knowledge, and university-based research is strongly supported by recent national policy frameworks, which collectively position higher education institutions as central actors in India's knowledge and innovation ecosystem.

National Education Policy (NEP) 2020

The National Education Policy (NEP) 2020 provides the foundational policy framework for integrating technology, research, and Indian knowledge systems in higher education. The policy explicitly emphasises the promotion of Indian Knowledge Systems (IKS), multidisciplinary education, critical thinking, and innovation-oriented research (Government of India, 2020). NEP 2020 calls for the systematic inclusion of indigenous knowledge traditions in curricula, research agendas, and pedagogical practices, thereby recognising their academic and societal value.

At the same time, NEP–2020 strongly advocates the use of digital technologies, including artificial intelligence, to enhance teaching, learning, assessment, and research processes. By encouraging technology-enabled education and research, the policy creates a strategic space where AI can be applied to preserve, analyse, and innovate upon indigenous knowledge systems. This dual emphasis makes NEP 2020 a crucial policy instrument for legitimising AI-driven indigenous research within universities.

National Research Foundation (NRF)

The establishment of the National Research Foundation (NRF) further strengthens India's research ecosystem by promoting high-quality, interdisciplinary, and socially relevant research across universities and research institutions (UGC, 2022). The NRF is designed to address long-standing challenges related to research funding, coordination, and capacity building in Indian higher education.

Within the context of AI-driven indigenous research, the NRF plays a vital role by encouraging:

- Interdisciplinary research collaborations
- University-based innovation projects
- Integration of traditional knowledge with modern scientific methods
- Institutional research capacity enhancement

By prioritising inclusivity and research excellence, the NRF provides a policy mechanism through which indigenous knowledge systems can be formally integrated into national research priorities using advanced technological tools such as AI.

India AI Mission

The IndiaAI Mission represents the government's strategic commitment to positioning India as a global leader in artificial intelligence. The mission focuses on building AI infrastructure, promoting research and innovation, developing human capital, and ensuring ethical and responsible AI deployment (NITI Aayog, 2021). Importantly, the mission emphasises the use of AI for social good, inclusive development, and context-specific problem solving.

This policy orientation aligns closely with the goals of indigenous research, which is inherently rooted in local contexts, community needs, and sustainable practices. Through the IndiaAI Mission, universities are encouraged to develop AI applications that address agriculture, healthcare, education, environment, and rural development—areas where indigenous knowledge offers valuable insights. Thus, the mission provides an enabling policy environment for integrating AI with indigenous research and innovation.

Indian Knowledge Systems (IKS) Centres

The establishment of Indian Knowledge Systems (IKS) Centres in universities marks a significant institutional effort to revive, document, and promote indigenous knowledge traditions. These centres focus on areas such as Ayurveda, yoga, classical arts, architecture, mathematics, philosophy, ecology, and traditional technologies. Their mandate includes research, curriculum development, faculty training, and community engagement (Government of India, 2020).

IKS Centres provide an institutional platform where indigenous knowledge can interact with contemporary research methodologies and emerging technologies. When supported by AI tools for digitisation, translation, data analysis, and knowledge mapping, these centres can significantly enhance the accessibility, visibility, and innovation potential of indigenous research. They also play a crucial role in ensuring ethical documentation and protection of community knowledge.

Policy Convergence and Institutional Implications

Collectively, NEP 2020, the NRF, the IndiaAI Mission, and IKS Centres create a coherent policy ecosystem that supports the integration of artificial intelligence with indigenous research in higher education. This convergence reflects a shift from viewing indigenous knowledge as purely cultural heritage to recognising it as a dynamic resource for innovation, sustainability, and national development.

However, the effectiveness of these policies depends on institutional readiness, governance capacity, and sustained academic engagement. Universities are expected not only to implement these policy directives but also to reinterpret them within their local contexts, ensuring that technological advancement does not compromise cultural integrity and ethical responsibility.

In this policy environment, Indian universities are strategically positioned to emerge as centres of AI-driven indigenous research and innovation. The policy context thus provides both legitimacy and direction for the transformative integration of artificial intelligence, indigenous knowledge systems, and higher education in India.

Opportunities for AI-Driven Indigenous Research in Indian Universities

Artificial intelligence offers significant opportunities for strengthening indigenous research and innovation in Indian universities by enhancing research capacity, promoting community engagement, and enabling socially relevant innovation. When applied thoughtfully, AI can transform indigenous knowledge from largely descriptive and fragmented traditions into systematic, analysable, and innovation-oriented research domains.

Enhancing Research Capacity

AI substantially improves research efficiency and depth through advanced data processing, pattern recognition, and predictive analysis. Indigenous knowledge, which often exists in diverse languages, oral traditions, and non-standard formats, can be digitised, translated, and organised using AI-based tools such as natural language processing and machine learning algorithms (Singh & Mishra, 2022). This enables universities to build structured digital repositories of indigenous knowledge that are accessible for interdisciplinary research.

AI also supports comparative and longitudinal analysis of indigenous practices across regions and communities, allowing researchers to identify common patterns, variations, and applications. Such capabilities enhance the academic legitimacy of indigenous research and integrate it more effectively into mainstream scientific inquiry.

Strengthening Community Engagement

AI-driven platforms provide new opportunities for participatory research by enabling indigenous communities to contribute directly to knowledge documentation and validation. Digital interfaces, mobile applications, and community databases allow local knowledge holders to share practices, narratives, and innovations in their own languages and cultural contexts. This strengthens trust between universities and communities and promotes ethical, inclusive research practices.

Moreover, AI-supported translation and voice-recognition tools help overcome linguistic barriers, ensuring that indigenous knowledge is not restricted to dominant languages. This enhances cultural preservation while encouraging wider academic engagement.

Promoting Indigenous Product Innovation

One of the most significant opportunities lies in transforming indigenous practices into innovative and socially useful products. AI can assist in analysing traditional medicinal formulations, agricultural techniques, architectural designs, and ecological practices to identify scalable and sustainable applications (Patwardhan & Mashelkar, 2009). Universities, through AI-supported research, can facilitate the development of herbal products, eco-friendly materials, sustainable farming technologies, and traditional design-based innovations.

Such innovation strengthens the linkage between research and entrepreneurship, enabling indigenous knowledge to contribute to local economies while maintaining cultural authenticity. University incubation centres and start-up ecosystems further support this transformation by providing institutional and technical assistance.

Fostering Interdisciplinary Collaboration

AI-driven indigenous research naturally encourages interdisciplinary collaboration among departments such as computer science, sociology, anthropology, environmental studies, medicine, and management. This interdisciplinary engagement enriches research perspectives and allows indigenous knowledge to be examined from scientific, social, cultural, and economic dimensions simultaneously.

Universities, as multidisciplinary institutions, are ideally positioned to facilitate such collaboration, thereby strengthening the overall research ecosystem.

Enhancing Global Visibility

AI enables indigenous research to gain global visibility through digital platforms, open-access repositories, and international collaboration networks. By making indigenous knowledge more accessible and systematically organised, AI allows Indian universities to contribute meaningfully to global debates on sustainability, biodiversity, traditional medicine, and cultural heritage (UNESCO, 2023). This visibility enhances both academic recognition and policy relevance of indigenous research.

Integrative Insight

Overall, AI offers Indian universities a powerful opportunity to revitalise indigenous research by enhancing methodological rigour, ethical participation, innovation potential, and global engagement. However, the realisation of these opportunities depends on institutional readiness, ethical governance, and inclusive policy support, which are discussed in the following section on institutional challenges.

Institutional Challenges in Implementing AI-Driven Indigenous Research in Indian Universities

Despite the significant opportunities offered by artificial intelligence, the effective implementation of AI-driven indigenous research in Indian universities is constrained by multiple institutional challenges. These challenges are not merely technological in nature but are deeply embedded in infrastructural, human, governance, ethical, and equity-related dimensions of higher education.

Infrastructure and Resource Constraints

One of the most pressing challenges is the inadequate availability of digital infrastructure across many Indian universities. Advanced AI applications require high-performance computing systems, reliable internet connectivity, secure data storage facilities, and specialised software platforms. However, disparities between centrally funded institutions and state or rural universities create uneven access to these essential resources. As a result, the adoption of AI-driven research practices remains concentrated in a limited number of elite institutions, thereby reinforcing existing institutional inequalities (UNESCO, 2023).

Financial constraints further limit the ability of universities to invest in AI research infrastructure. Funding for interdisciplinary and indigenous research projects is often insufficient, short-term, or project-specific, which restricts long-term research planning and sustainability.

Human Resource and Capacity Challenges

The shortage of faculty members trained in AI and interdisciplinary research constitutes another major challenge. Many faculty members lack exposure to AI methodologies, while AI specialists may not possess an adequate understanding of indigenous knowledge systems. This disciplinary gap hinders meaningful integration between technology and indigenous research.

Additionally, limited opportunities for continuous professional development, training programmes, and collaborative research restrict the capacity of faculty and researchers to engage effectively with AI-driven indigenous research. Without sustained capacity-building initiatives, universities risk treating AI as a technical add-on rather than as an integral research tool.

Governance and Institutional Coordination

Institutional governance structures in many universities are not yet adequately equipped to support AI-driven interdisciplinary research. Fragmented departmental silos, rigid administrative procedures, and a lack of coordinated research strategies impede collaborative initiatives. Indigenous research often requires collaboration across departments such as anthropology, computer science, environmental studies, and medicine, which existing governance frameworks may not easily facilitate.

Furthermore, the absence of clear institutional policies on AI use, data management, and indigenous knowledge protection creates uncertainty and discourages innovation. Effective implementation requires integrated governance mechanisms that can align technological, academic, and ethical considerations.

Ethical and Legal Challenges

Ethical concerns constitute one of the most sensitive challenges in AI-driven indigenous research. Issues related to informed consent, data ownership, intellectual property rights, cultural misrepresentation, and commercial exploitation of indigenous knowledge demand careful institutional oversight (Nayak, 2022; Smith, 2012). Without strong ethical guidelines, AI-driven documentation and analysis may unintentionally violate community rights and cultural integrity.

Legal frameworks for protecting indigenous intellectual property in digital and AI-based contexts remain inadequate and fragmented. This creates risks of misappropriation by external agencies and commercial actors, thereby undermining community trust and participation.

Equity and Access Concerns

AI-driven indigenous research also raises serious equity concerns. Digital divides among universities, regions, and social groups limit equal participation in AI-enabled research opportunities. Marginalised communities and smaller institutions may remain excluded from AI innovation ecosystems, further widening knowledge and resource gaps.

Moreover, gender and socio-economic disparities affect access to AI training and research opportunities within universities. Without targeted inclusion strategies, AI-driven research may reproduce existing inequalities rather than reduce them.

Integrative Insight

These institutional challenges indicate that AI-driven indigenous research cannot be achieved through technological adoption alone. It requires systemic transformation in infrastructure development, human resource training, governance reform, ethical regulation, and equity-oriented policy interventions. Addressing these challenges is essential for ensuring that AI-driven indigenous research in Indian universities becomes inclusive, sustainable, and socially responsible.

Strategic Directions / Way Forward

For AI-driven indigenous research and innovation to realise its full potential in Indian universities, a comprehensive and coordinated institutional strategy is required. This strategy must balance technological advancement with ethical responsibility, cultural sensitivity, and social inclusion. The following strategic directions outline a sustainable and responsible pathway for strengthening AI-enabled indigenous research ecosystems.

Strengthening Institutional Infrastructure

Universities must prioritise the development of AI research infrastructure through dedicated funding, shared digital laboratories, and regional research hubs. Collaborative platforms among universities can help optimise resource use and reduce institutional disparities. Public funding agencies and the National Research Foundation should support long-term, interdisciplinary research projects that integrate AI with indigenous knowledge systems.

Capacity Building and Faculty Development

Continuous professional development programmes should be introduced to equip faculty and researchers with interdisciplinary competencies in AI, data science, and indigenous research methodologies. Joint training initiatives involving technologists, social scientists, and community experts can foster meaningful knowledge integration. Doctoral and post-doctoral fellowships in AI-driven indigenous research should be encouraged to build future academic leadership.

Ethical Governance and Community Protection

Universities must establish institutional ethical frameworks specifically designed for AI-driven indigenous research. These frameworks should ensure informed consent, community participation, transparency, and protection of intellectual property rights. Indigenous communities should be recognised as knowledge partners rather than research subjects, and benefit-sharing mechanisms must be institutionalised.

Policy Integration and Institutional Alignment

National policies such as NEP 2020, NRF guidelines, and the IndiaAI Mission should be translated into clear institutional action plans. Universities must create internal policy units or task forces to monitor alignment between institutional research practices and national policy objectives. This will ensure that AI-driven indigenous research is not implemented in isolation but as part of a broader national knowledge strategy.

Promoting Inclusive and Decentralised Innovation

Special support must be extended to state universities, rural institutions, and marginalised regions to ensure equitable participation in AI research ecosystems. Digital platforms, open-access repositories, and inter-university collaborations can democratise access to AI tools and research outputs. Gender and social inclusion should be explicitly addressed in AI training and research funding policies.

Strengthening University–Community–Industry Linkages

Universities should strengthen partnerships with indigenous communities, civil society organisations, and ethical industry partners. Such collaborations can ensure that indigenous innovations are transformed into socially beneficial products without compromising cultural integrity. Community-based innovation models must be prioritised over purely commercial approaches.

Encouraging Student Engagement and Curriculum Integration

AI-driven indigenous research should be integrated into undergraduate and postgraduate curricula through project-based learning, internships, and field-based research modules. This will cultivate early academic interest in indigenous knowledge and responsible AI practices, ensuring long-term sustainability of the research ecosystem.

Integrative Insight

The strategic directions outlined above highlight that the future of AI-driven indigenous research in Indian universities depends not only on technological readiness but also on institutional vision, ethical governance, and inclusive policy implementation. By adopting these strategic pathways, universities can transform AI into a powerful tool for cultural preservation, social innovation, and sustainable national development.

Conclusion

This paper examined the emerging role of artificial intelligence in strengthening indigenous research and innovation within Indian universities. By analysing conceptual foundations, policy frameworks, institutional opportunities, and structural challenges, the study highlighted the transformative potential of AI when applied to culturally grounded and socially relevant knowledge systems.

The analysis demonstrated that universities occupy a strategic position in mediating AI technologies with indigenous knowledge traditions through interdisciplinary research, ethical governance, and institutional legitimacy. While AI offers significant opportunities for research enhancement, community engagement, innovation, and global visibility, its effective implementation remains constrained by infrastructural, human resource, governance, ethical, and equity-related challenges.

The paper further showed that national policy frameworks such as NEP 2020, the National Research Foundation, the IndiaAI Mission, and Indian Knowledge Systems Centres provide a supportive institutional environment for AI-driven indigenous research. However, policy success ultimately depends on institutional readiness, sustained funding, and ethical accountability.

The strategic directions proposed in the study emphasise that AI-driven indigenous research must be guided by inclusivity, community participation, cultural sensitivity, and social responsibility. When supported by strong institutional commitment and ethical governance, AI can become a powerful tool for revitalising indigenous knowledge, promoting sustainable innovation, and strengthening India's knowledge sovereignty.

The study concludes that AI-driven indigenous research is not merely a technological advancement but a transformative academic and social endeavour that can redefine the future of higher education in India.

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Integrating Artificial Intelligence and Indian Knowledge Systems for 21st Century Skills Development

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The rapid advancement of Artificial Intelligence (AI) is transforming education, work, and skill requirements globally. At the same time, India has witnessed a renewed policy and academic emphasis on Indian Knowledge Systems (IKS) as a means of culturally grounded and holistic education, particularly under the National Education Policy (NEP) 2020. This paper argues that the integration of Artificial Intelligence and Indian Knowledge Systems offers a unique and contextually relevant framework for fostering 21st century skills in Indian learners. While AI enables personalised learning, data-driven feedback, and digital literacy, Indian Knowledge Systems contribute ethical reasoning, experiential learning, holistic development, and culturally rooted pedagogies. Drawing on interdisciplinary literature from education, AI studies, and IKS scholarship, this paper develops a conceptual framework for AI–IKS integration and examines its potential to enhance critical thinking, creativity, collaboration, ethical reasoning, and lifelong learning skills. The study also discusses policy alignment, pedagogical strategies, and challenges such as digital divides, epistemic imbalance, and cultural tokenism. The paper concludes that a synergistic integration of AI and IKS can promote future-ready yet culturally grounded learners, contributing to inclusive, ethical, and sustainable skill development in 21st century India.(Abstract)

The 21st century is characterised by rapid technological change, digital transformation, and shifting labour market demands. Artificial Intelligence (AI), automation, and data-driven technologies are increasingly shaping how individuals learn, work, and interact with knowledge systems. In this context, education systems across the world are being reoriented to focus not only on content mastery but also on the development of so-called '21st century skills', including critical thinking, creativity, collaboration, communication, digital literacy, adaptability, and ethical reasoning.

In India, this global technological shift coincides with a renewed emphasis on Indian Knowledge Systems (IKS) as a foundational element of culturally rooted and holistic education. The National Education Policy (NEP) 2020 explicitly recognizes the importance of integrating indigenous knowledge traditions, local contexts, ethical values, and experiential learning into mainstream education. This policy direction reflects a broader intellectual movement to reclaim, revitalize, and mainstream Indian epistemologies that were marginalized during colonial and postcolonial educational frameworks.

Traditionally, Artificial Intelligence and Indian Knowledge Systems have been viewed as belonging to distinct epistemic domains: AI representing modern, Western, data-driven, and computational paradigms, and IKS representing ancient, indigenous, holistic, and experiential traditions. However, this binary framing overlooks the possibility of productive synergy between the two. Rather than treating AI and IKS as oppositional, this paper argues that their integration can create a powerful pedagogical and epistemic framework for developing 21st century skills in a culturally meaningful and ethically grounded manner.

This paper seeks to explore the following core questions: How can Artificial Intelligence be meaningfully integrated with Indian Knowledge Systems in educational contexts? In what ways can this integration contribute to the development of 21st century skills? What are the pedagogical, ethical, and policy implications of such an integration? By addressing these questions, the paper aims to contribute to interdisciplinary debates on educational innovation, decolonisation of knowledge, and culturally responsive AI.

Conceptualising 21st Century Skills

The concept of 21st century skills has emerged from global educational reform movements seeking to align education with the demands of

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knowledge economies and rapidly changing work environments. International organizations such as UNESCO, OECD, and the World Economic Forum have emphasized skills such as critical thinking, problem-solving, creativity, collaboration, communication, digital literacy, emotional intelligence, and lifelong learning. These skills represent a shift from rote memorisation and content-centric education toward learner-centred, competency-based models. In the Indian context, NEP 2020 similarly emphasises critical thinking, experiential learning, multidisciplinary education, and ethical reasoning. However, the implementation of these skills often remains framed within Western pedagogical paradigms, potentially limiting their cultural relevance and accessibility.

From an Indian Knowledge Systems perspective, many of these so-called '21st century skills' are not entirely new. Traditional Indian pedagogical models, such as the *Guru–Shishya parampara,* emphasized personalized mentorship, critical inquiry, debate *(shastrartha),* experiential learning, and moral-ethical formation. Concepts such as *anubhava* (lived experience), *viveka* (discernment), and *dharma* (ethical duty) align closely with contemporary notions of reflective thinking, ethical reasoning, and responsible citizenship.

Thus, rather than importing 21st century skills as external constructs, there is significant potential to reinterpret and contextualise them through IKS frameworks. This contextualization can enhance learner engagement, cultural relevance, and ethical depth, while also aligning with global competency standards.

Overview of Artificial Intelligence in Education

Artificial Intelligence in Education (AIED) refers to the use of machine learning, natural language processing, learning analytics, and intelligent systems to support teaching and learning processes. Common applications of AI in education include adaptive learning platforms, intelligent tutoring systems, automated assessment, learning management system analytics, and personalised feedback mechanisms.

AI promises several pedagogical benefits. First, it enables personalisation by adapting content and pacing to individual learner needs. Second, it provides data-driven insights into learner performance, enabling early identification of learning gaps. Third, it can support scalability by extending educational access to large and diverse populations. Fourth, AI can enhance digital literacy and prepare learners for technologically mediated work environments.

However, AI in education also raises significant concerns, including data privacy, algorithmic bias, digital divides, and the risk of reducing learning to measurable, standardised outputs. In the Indian context, these concerns are compounded by socio-economic inequalities, linguistic diversity, and uneven digital infrastructure.

The AI systems are typically designed based on Western educational assumptions and datasets, which may not align with Indian pedagogical traditions, cultural contexts, or epistemic priorities. This creates a risk of epistemic homogenization, where diverse ways of knowing are subsumed under standardised, data-driven models of learning.

Indian Knowledge Systems: Philosophical and Pedagogical Foundations

Indian Knowledge Systems represent a vast and diverse body of philosophical, scientific, cultural, and pedagogical traditions developed over millennia. These systems encompass fields such as philosophy, mathematics, astronomy, medicine (Ayurveda), ecology, linguistics, aesthetics, ethics, and education. Importantly, IKS are not monolithic but plural, encompassing diverse regional, linguistic, and community-based traditions.

Pedagogically, IKS emphasize holistic development, integrating cognitive, ethical, emotional, and spiritual dimensions of learning. The Guru–Shishya tradition highlights personalised mentorship, dialogic learning, and character formation. Methods such as *shravana* (listening), *manana* (reflection), and *nididhyasana* (deep contemplation) emphasise layered learning processes that go beyond surface-level knowledge acquisition.

Ethics and values are central to IKS pedagogy. Concepts such as *dharma, karma, lokasangraha* (social welfare), and ahimsa (non-violence) frame learning as a moral and social responsibility, not merely an individual achievement. This ethical grounding is particularly relevant in an era of powerful technologies, where technical competence must be balanced with social responsibility and ethical judgment.

From a contemporary perspective, IKS also emphasize experiential and community-based

Table 1: Select Literature Browses on AI--IKS Integration

S. No.	Author & Year	Focus Area	Summary
1	Kathavate, P. N., & Maheshwari, D. D. (2025)	AI, NEP 2020, IKS & innovative pedagogy	This review analyses NEP 2020 as a paradigm shift in Indian education, emphasising innovative pedagogy, AI integration, and the role of Indian Knowledge Systems. It argues that blending technology with indigenous knowledge can modernize teaching–learning while preserving cultural continuity and fostering higher-order thinking skills.
2	Majhi, R. (2025)	AI–IKS integration for sustainability & innovation	This qualitative study explicitly explores how Artificial Intelligence can be integrated with Indian Knowledge Systems to address contemporary challenges. Although focused on sustainability, it provides one of the few direct discussions of AI–IKS integration and argues for interdisciplinary frameworks that combine traditional wisdom with modern AI for innovation and skill development.
3	Somaiya University Proceedings (2024)	Harmonizing AI and IKS in education	This institutional proceeding discusses Ministry of Education–supported initiatives to harmonise Indian Knowledge Systems with Artificial Intelligence. It scaffolds AI–IKS integration as a holistic educational paradigm and emphasises its potential for developing future-ready competencies, innovation capacity, and culturally grounded learning models.
4	Holmes, W., Bialik, M., & Fadel, C. (2019)	AI for 21st century skills	This widely cited book examines how AI can support personalized learning, critical thinking, creativity, and collaboration. It provides a strong theoretical foundation for using AI to develop 21st century skills and is frequently used in educational technology research to justify AI-enabled skill-based learning models.
5	Luckin, R., et al. (2016)	AI in education & skill development	This foundational report explores how AI can transform education through personalisation, feedback, and adaptive systems. It links AI applications to the development of problem-solving, metacognition, and lifelong learning skills, supporting the role of AI as a tool for enhancing future-oriented competencies.
6	Ministry of Education, Government of India (2020)	IKS, holistic education & skills (NEP 2020)	The National Education Policy 2020 formally mandates the integration of Indian Knowledge Systems and emphasises holistic development, critical thinking, ethical reasoning, and experiential learning. It provides the strongest policy justification for using IKS to support 21st century skill development in Indian education.
7	Ministry of Education, Government of India (2023)	IKS institutional framework	The MoE IKS framework document defines the scope of Indian Knowledge Systems and their role in education, research, and innovation. It emphasises experiential learning, ethics, and interdisciplinary knowledge, which align closely with global 21st century skill frameworks such as critical thinking, creativity, and cultural competence.
8	Sambasivan, N., et al. (2021)	Contextual AI for Global South	This ACM paper demonstrates that AI systems designed in Western contexts often fail in India due to social and cultural complexity. It argues for context-sensitive AI design, indirectly supporting the need to integrate local and indigenous knowledge systems to make AI more educationally and socially relevant.
9	Selwyn, N. (2019)	Critical perspectives on AI in education	Selwyn provides a critical analysis of AI in education, emphasising that technology must be socially, culturally, and pedagogically grounded. The work supports arguments for integrating culturally rooted knowledge systems, such as IKS, to avoid technocratic and reductionist models of skill development.
10	Puri, J. (2025)	IKS for educational innovation	This qualitative review analyses how Indian Knowledge Systems can support academic innovation and cultural continuity under NEP 2020. It argues that IKS can enhance creativity, ethical reasoning, and contextual intelligence, which are core components of 21st century skills, even though AI is not its central focus.
11	Singh, T. P. (2024)	IKS & problem-solving skills	This peer-reviewed teacher education paper examines how integrating Indian Knowledge Systems into pedagogy can enhance problem-solving, innovative thinking, and experiential learning. It directly links IKS-based pedagogies to higher-order cognitive skills associated with 21st century competencies.
12	Bardia, A., & Agrawal, A. (2025)	AI for personalized learning & skills (India)	This arXiv paper presents an AI-powered personalized learning platform for rural India. It highlights how AI can support adaptive learning, mentorship, and digital skill development, providing applied evidence for AI's role in enhancing future-ready skills in the Indian educational context.

learning, where knowledge is embedded in lived practices, crafts, agriculture, medicine, and ecological stewardship. These dimensions resonate strongly with modern educational emphases on project-based learning, sustainability, and contextual problem-solving. Select literature on AI and IKS is presented in Table 1.

Rationale for Integrating AI and IKS

The integration of Artificial Intelligence and Indian Knowledge Systems is not merely a technical exercise but a philosophical and pedagogical project. It seeks to bridge modern technological capabilities with indigenous epistemologies to create a culturally responsive and future-oriented education system. One key reason behind this is the alignment between AI-driven personalisation and the Guru–Shishya model. AI-based adaptive learning systems can, in principle, emulate aspects of personalised mentorship by tailoring content, pacing, and feedback to individual learners. When guided by IKS pedagogical principles, such systems can move beyond standardised personalisation toward culturally informed and ethically grounded learning pathways.

While AI can support cognitive skill development, IKS can provide ethical frameworks that guide the responsible use of technology. Integrating dharmic ethics, social responsibility, and holistic values into AI-mediated learning can help cultivate not only technically skilled but also morally grounded learners.

Integrating IKS content and perspectives into AI systems can help counter epistemic marginalisation and promote knowledge diversity. This is particularly important in a postcolonial context, where indigenous knowledge traditions have historically been undervalued or excluded from formal education.

Research Questions

1. How can Artificial Intelligence and Indian Knowledge Systems be conceptually and pedagogically integrated to support the development of 21st century skills in Indian higher education?
2. What are the perceived opportunities and challenges associated with implementing AI–IKS integrated approaches for 21st century skills development among educators and learners?

Research Objectives

1. To explore the existing theoretical, policy, and pedagogical literature on Artificial Intelligence, Indian Knowledge Systems, and 21st century skills in order to identify points of conceptual and practical convergence.
2. To conceptualise a framework for integrating Artificial Intelligence and Indian Knowledge Systems to support 21st century skills development in Indian educational contexts.
3. To identify the opportunities, and challenges of AI–IKS integration in developing 21st century skills.

Methodology

This study is a conceptual paper based on a literature review to explore the potential for integrating Artificial Intelligence (AI) and Indian Knowledge Systems (IKS) for the development of 21st century skills. As a conceptual paper, the study does not involve primary data collection, it synthesises existing theoretical, empirical, and policy-oriented literature to develop a new integrative framework.

Conceptual Framework for AI–IKS Integration

This paper proposes a conceptual framework that positions AI and IKS as complementary rather than competing systems. The framework consists of four interrelated components: technological infrastructure, pedagogical integration, epistemic grounding, and skill outcomes.

First, technological infrastructure includes AI tools such as adaptive learning platforms, intelligent tutoring systems, and learning analytics. These tools provide the technical capacity for personalization, feedback, and scalability. Second, pedagogical integration involves embedding IKS-based teaching methods within AI-supported learning environments. This may include dialogic learning, reflective exercises, experiential projects, and mentorship-oriented designs. Third, epistemic grounding ensures that content and learning processes are informed by Indian philosophical, ethical, and cultural frameworks. This includes integrating indigenous case studies, ethical discussions, and community-based knowledge practices. Fourth, skill outcomes focus on the development of 21st century competencies, including critical thinking, creativity, collaboration, digital literacy, ethical reasoning, and lifelong learning. Together, these components form a cyclical and dynamic model in which AI enhances access and personalisation, while IKS ensures cultural relevance, ethical grounding, and holistic development.

AI–IKS Integration and Key 21st Century Skills

Critical Thinking and Problem-Solving

AI systems can support critical thinking by presenting adaptive problem sets, simulations, and real-time feedback. When combined with IKS traditions of debate (*shastrartha)* and reflective inquiry, learners can engage in deeper analytical processes. For example, AI-supported platforms can facilitate structured debates on ethical or philosophical questions drawn from Indian texts and contemporary social issues.

Creativity and Innovation

Indian Knowledge Systems emphasise creativity through arts, crafts, music, and storytelling traditions. AI tools for content creation, design, and simulation can be integrated with these traditions to foster culturally rooted innovation. Learners can use AI to explore new forms of artistic expression while grounding their creativity in indigenous aesthetics and narratives.

Collaboration and Communication

Traditional Indian learning environments often emphasised collective learning and community engagement. AI-based collaborative platforms can support group projects, peer feedback, and virtual learning communities. Integrating IKS values of cooperation and social harmony can strengthen collaborative skill development in digital environments.

Digital and AI Literacy

Digital literacy is a core 21st century skill. AI–IKS integration can promote not only technical competence but also critical awareness of technology's social and ethical implications. Learners can be taught to understand AI systems while also reflecting on their societal impacts through IKS ethical frameworks.

Ethical Reasoning and Values-Based Decision-Making

Perhaps the most distinctive contribution of IKS lies in ethical reasoning. Integrating dharmic ethics, social responsibility, and holistic values into AI-mediated education can help learners develop strong moral judgment. This is particularly important in contexts involving data use, automation, and algorithmic decision-making.

NEP–2020: Opportunities for Integrating AI and Indian Knowledge Systems for 21st Century Skills

The National Education Policy (NEP) 2020 provides a comprehensive and forward-looking policy framework that explicitly supports the integration of technology, Indian Knowledge Systems (IKS), experiential learning, and holistic skill development. Several sections of the policy directly envision educational reforms that can be strategically aligned with Artificial Intelligence (AI) and IKS to foster 21st century skills such as critical thinking, creativity, collaboration, ethical reasoning, and digital literacy.

Holistic Development and 21st Century Skills

NEP 2020 strongly emphasises a shift from rote learning to holistic and competency-based education aimed at developing higher-order skills. "The aim of education will not only be cognitive development, but also building character and creating holistic and well-rounded individuals equipped with the key 21st century skills (NEP 2020, Page 12, Paragraph 4.4).

This clause directly legitimises skill-based education and provides a foundation for integrating AI-driven personalised learning with IKS-based holistic pedagogy. AI can support cognitive skill development through adaptive systems, while IKS contributes to character-building and ethical grounding.

Experiential and Inquiry-Based Learning

The policy repeatedly emphasises experiential, discovery-based, and inquiry-driven pedagogies, which align closely with both AI-enabled simulations and traditional IKS pedagogical practices. "Experiential learning will be adopted, including hands-on learning, arts-integrated and sports-integrated education, story-telling-based pedagogy, among others, as standard pedagogy within each subject" (NEP 2020, Page 13, Paragraph 4.6). This creates a strong policy basis for integrating AI-based simulations, virtual labs, and project-based learning with IKS traditions of experiential learning (anubhava), storytelling (katha), and applied knowledge practices.

Multidisciplinary and Integrative Education

NEP–2020 promotes multidisciplinary education as a core strategy to develop creativity, problem-solving, and integrative thinking. "A holistic and multidisciplinary education would help develop well-rounded individuals who possess critical 21st century capacities in fields across the arts, humanities, languages, sciences, social sciences, and professional, technical, and vocational fields (NEP 2020, Page 38, Paragraph 11.1). This provision supports combining AI (as a technological domain) with IKS (as a cultural and philosophical domain) within multidisciplinary curricula to foster integrative thinking and innovation skills.

Promotion of Indian Knowledge Systems (IKS)

NEP–2020 explicitly mandates the integration of Indian Knowledge Systems into mainstream education. "Indian Knowledge Systems, including knowledge from ancient India and its contributions to modern India and its successes and challenges, will be integrated into the school and higher education curricula in a comprehensive manner (NEP 2020, Page 45, Paragraph 13.4).

This is one of the strongest policy justifications for embedding IKS content and pedagogical principles into AI-supported learning systems, ensuring that technological innovation remains culturally grounded.

Ethical and Constitutional Values

The policy emphasises ethics, constitutional values, and character education as integral to education. "Education must develop not only cognitive capacities, but also social, ethical, and emotional capacities and dispositions" (NEP 2020, Page 12, Paragraph 4.5).This clause directly supports the integration of IKS ethical frameworks (dharma, lokasangraha, social responsibility) with AI education to promote values-based decision-making and ethical technology use.

Integration of Technology and Digital Education

NEP–2020 strongly advocates for technology integration, including digital platforms, personalised learning, and educational technology ecosystems."Appropriate integration of technology into all levels of education will be done to improve classroom processes, support teacher professional development, enhance educational access for disadvantaged groups, and streamline educational planning, administration and management (NEP 2020, Page 56, Paragraph 23.1). This provides explicit policy support for using AI systems for personalised learning, learning analytics, and adaptive instruction — which can be designed to incorporate IKS-based content and pedagogy.

National Educational Technology Forum (NETF)

The policy establishes an institutional mechanism to guide technology integration."The National Educational Technology Forum (NETF) will be created as a platform for free exchange of ideas on the use of technology to enhance learning, assessment, planning, and administration (NEP 2020 56, Paragraph 23.4).NETF provides a structural space for developing AI platforms that are aligned with IKS principles and culturally responsive pedagogies.

Vocational Education and Real-World Skills

NEP–2020 emphasises vocational education and real-world skill development. states: "By 2025, at least 50% of learners through the school and higher education system shall have exposure to vocational education." (NEP 2020, Page 21, Paragraph 4.26) This supports the use of AI-based skill platforms combined with traditional crafts, indigenous technologies, and IKS-based vocational knowledge to develop practical, employability-oriented 21st century skills.

Teacher Professional Development and Capacity Building

Teachers are positioned as key agents of reform. "Continuous professional development will be driven by the needs of the teachers and will be provided in multiple modes, including online and blended learning (NEP 2020, Page 59, Paragraph 24.1). This allows for AI-supported teacher training programs that integrate IKS pedagogical principles, enabling educators to effectively deliver culturally grounded, technology-enabled education.

Challenges and Limitations in Integrating Artificial Intelligence and Indian Knowledge Systems for 21st Century Skills Development

Even after the significant potential of integrating Artificial Intelligence (AI) and Indian Knowledge Systems (IKS) for enhancing 21st century skills, several structural, pedagogical, technological, and epistemic challenges constrain effective implementation which are as follows:

Digital Divide and Infrastructure Inequalities

One of the most significant challenges is the persistent digital divide across regions, socio-economic groups, and educational institutions in India. Access to reliable internet connectivity, digital devices, and electricity remains uneven, particularly in rural, tribal, and economically marginalized areas. While AI-enabled education platforms presume continuous access to digital infrastructure, many learners and institutions lack the necessary technological capacity to participate fully in such initiatives.

This infrastructural inequality risks reinforcing existing educational and social disparities, whereby urban and well-resourced institutions disproportionately benefit from AI-based learning, while marginalized communities remain excluded. In such contexts, AI–IKS integration may inadvertently exacerbate educational stratification rather than promote inclusive skill development. The localized IKS knowledge, often concentrated in rural and indigenous communities, may remain disconnected from AI-enabled platforms due to limited digitization and access barriers.

Risk of Cultural Tokenism and Superficial Integration of IKS

A major epistemic challenge is the risk of reducing Indian Knowledge Systems to symbolic or superficial content additions rather than embedding them meaningfully within pedagogical and technological design. There is a tendency in policy and curriculum reforms to include selective references to IKS—such as isolated texts, practices, or cultural symbols—without engaging with the deeper philosophical, pedagogical, and ethical frameworks that define these traditions.

Such tokenistic integration may result in the appropriation of IKS as cultural artifacts rather than living knowledge systems. When IKS is treated merely as supplementary content within AI-driven platforms, its transformative pedagogical potential is undermined. This risks reinforcing hierarchical knowledge structures, where modern technological knowledge remains dominant and indigenous epistemologies are marginalised or aestheticised.

Epistemic Imbalances and Knowledge Hierarchies

AI systems are predominantly trained on large, digitized datasets that reflect dominant languages, institutional knowledge, and globally mainstream epistemologies. Indian Knowledge Systems—particularly regional, oral, indigenous, and community-based traditions—are often underrepresented or absent from such datasets. This creates an epistemic imbalance in which AI systems structurally privilege certain forms of knowledge while excluding others.

As a result, AI-mediated education may reproduce historical patterns of epistemic marginalisation, where indigenous and non-Western ways of knowing are systematically undervalued. This raises concerns regarding epistemic justice and knowledge sovereignty. Without deliberate efforts to digitise, curate, and ethically integrate IKS knowledge, AI platforms may continue to reflect colonial and elite biases in knowledge representation.

Language Barriers and Linguistic Inequality

India's linguistic diversity presents both an opportunity and a challenge for AI–IKS integration. While IKS knowledge is embedded in a wide range of regional and classical languages, many AI systems perform optimally in English and a limited set of major Indian languages. This linguistic asymmetry limits the accessibility of AI-enabled learning for large sections of the population and constrains the meaningful inclusion of IKS knowledge expressed in local and indigenous languages.

The marginalisation of non-dominant languages in AI systems contributes to linguistic epistemic injustice, whereby certain linguistic communities are excluded from full participation in digital learning ecosystems. This not only affects access but also shapes which knowledge traditions are algorithmically visible and valued.

Teacher Preparedness and Capacity Constraints

The successful integration of AI and IKS depends critically on teacher competence and pedagogical capacity. Many educators may lack training in AI tools, digital pedagogy, and data literacy. Simultaneously, there may be limited institutional support for developing deep engagement with IKS pedagogical principles, especially in modern teacher education programmes.

This dual capacity gap creates a significant barrier. Teachers may be proficient in either technology or traditional knowledge domains but lack the interdisciplinary expertise required to integrate both meaningfully. Without sustained professional development, AI–IKS integration risks becoming either technologically driven without cultural grounding or culturally rich but technologically underutilised.

Ethical, Privacy, and Data Governance Concerns

AI-based educational systems rely on extensive data collection, including student performance data, behavioural patterns, and personal information. This raises serious concerns regarding data privacy, surveillance, consent, and data governance. In the absence of robust regulatory frameworks and institutional safeguards, learners may be exposed to data misuse, profiling, or algorithmic decision-making without transparency.

From an IKS and ethical perspective, such practices may conflict with indigenous values related to dignity, community autonomy, and relational ethics. Integrating IKS ethical frameworks into AI governance remains conceptually appealing but practically underdeveloped. This gap limits the ethical coherence of AI–IKS integration initiatives.

Standardisation versus Contextualization Tensions

AI systems often rely on standardisation to scale learning across large populations. However, Indian Knowledge Systems emphasise contextual, localised, and community-specific knowledge practices. This creates a structural tension between the scalability logic of AI and the contextual specificity of IKS.

Standardised AI platforms may struggle to accommodate diverse regional practices, localized curricula, and community-based knowledge transmission models. This tension raises questions about whether AI–IKS integration can preserve the contextual richness of indigenous knowledge while achieving the efficiency and scale associated with digital technologies.

Institutional and Policy–Practice Gaps

Although NEP–2020 provides strong policy support for technology integration and IKS inclusion, there is often a significant gap between policy intent and institutional implementation. Constraints related to funding, administrative capacity, curriculum redesign, and interdepartmental coordination may limit the realization of integrated AI–IKS models. Furthermore, institutional silos between technology departments, humanities, IKS centers, and teacher education programs can impede interdisciplinary collaboration. Without coherent institutional strategies, AI and IKS initiatives may remain fragmented, limiting their collective impact on skill development.

Limited Empirical Evidence and Evaluation Frameworks

As an emerging interdisciplinary area, there is limited empirical research evaluating the learning outcomes of AI–IKS integrated pedagogies. Most existing literature remains conceptual, policy-oriented, or focused on either AI or IKS in isolation. The lack of robust evaluation frameworks makes it difficult to assess the effectiveness, scalability, and long-term impacts of integrated models on 21st century skill development. This empirical gap represents both a limitation and an opportunity. While it constrains evidence-based policy and practice, it also underscores the originality and necessity of further research in this area.

Conclusion

This paper has provided the argument that integrating Artificial Intelligence (AI) and Indian Knowledge Systems (IKS) offers a culturally grounded and future-oriented framework for developing 21st century skills in Indian education. In the context of rapid technological change and evolving workforce demands, education must cultivate not only digital and technical competencies but also critical thinking, creativity, ethical reasoning, collaboration, and lifelong learning. By combining AI's capacities for personalisation, adaptive learning, and scalable access with the holistic, experiential, and ethical foundations of IKS, this study proposes a synergistic model of skill development that is both technologically robust and culturally responsive.

The content analysis of the National Education Policy (NEP) 2020 demonstrates strong policy alignment with this integrative approach. NEP 2020 emphasises holistic education, experiential and inquiry-based learning, multidisciplinary curricula, promotion of Indian Knowledge Systems, and strategic use of educational technologies. These provisions collectively provide an enabling institutional and normative framework for embedding IKS-informed pedagogies within AI-enabled learning environments.

At the same time, the paper has highlighted critical challenges, including digital divides, epistemic and linguistic inequalities, risks of superficial or tokenistic inclusion of IKS, teacher capacity constraints, and ethical and data governance concerns. These limitations underscore that AI–IKS integration is not merely a technical exercise but a socio-cultural and institutional transformation requiring sustained capacity-building, participatory design, and ethical oversight.

By addressing a significant gap, this study tries to provide a conceptual framework linking AI, IKS, and 21st century skills. Overall, integrating AI and IKS offers a promising pathway toward developing 21st century in learners.

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Artificial Intelligence in Education: Applications, Challenges, and Future Directions

Vaishali S Patil*

Artificial Intelligence (AI) is emerging as a transformative force in education, reshaping administrative processes, teaching practices, and learning experiences. Its applications include intelligent tutoring systems, adaptive learning platforms, plagiarism detection, and immersive technologies such as virtual reality and gamified environments. Through machine learning (ML), learning analytics, and educational data mining, AI enables automation, personalised instruction, and data-driven decision-making for educators. Recent studies, including the work of Ahmed et al., demonstrate the effectiveness of ML models such as Random Forest, Decision Trees, and Support Vector Machines (SVM) in predicting student performance and identifying at-risk learners. While AI substantially improves efficiency and personalisation, concerns related to ethics, equity, academic integrity, and responsible use remain. This review examines the expanding role of AI in education, its impact on student learning outcomes, and the need for balanced, sustainable, and inclusive implementation strategies (Abstract).

The improvement of computing technologies has empowered the integration of AI into education, resulting in substantial progress in learning and teaching results. AI is no longer limited to computers but comprises embedded systems, robots, and intelligent web-based platforms [1-3]. AI is commonly defined as the capacity of machines to initiate human cognition, flexibility, and problem-solving skills. In the context of education, AI empowers automation, customisation, and improved student engagement. Current studies have highlighted the usage of ML to forecast student academic performance, which is a crucial application of AI in education. Ahmed et al. (2024) studied multiple ML algorithms, including Random Forest, Decision Trees, K-Nearest Neighbours (KNN), Naïve Bayes, and SVM for predicting student outcomes based on demographic, academic, and behavioural data [4].

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Nature and Scope of AI and ML in Education

Artificial Intelligence (AI) in education encompasses a broad interdisciplinary field that integrates computer science, cognitive science, psychology, linguistics, and data analytics to enhance teaching, learning, and administrative decision-making. Its scope extends across three major domains: administration, instruction, and learning as defined by Chassignol et al. These domains form the foundation of contemporary AI-driven educational ecosystems.

Machine Learning (ML), learning analytics, and educational data mining serve as the core technical pillars supporting AI-enabled educational systems. These technologies enable predictive modelling, personalised learning pathways, automated evaluation, and continuous monitoring of student performance. ML algorithms such as Random Forest, Artificial Neural Networks (ANN), Support Vector Machines (SVM), Decision Trees, and K-Nearest Neighbours (KNN) are widely employed for tasks including classification, regression, dropout prediction, and performance forecasting.

A systematic review by Munir, Vogel, and Jacobsson (2022) identified six dominant AI/ML themes in digital education: intelligent tutoring systems, automation of academic tasks, student performance prediction, adaptive and predictive learning, dropout detection, and learning analytics. Random Forest consistently demonstrated strong accuracy and resilience across diverse educational datasets, highlighting its value for early identification of at-risk learners. The effectiveness of these models is strongly influenced by data preprocessing, feature selection, and the integration of meaningful variables such as prior performance, study habits, and parental involvement [5-7].

Learning analytics further enhances instructional design by identifying behavioral patterns, supporting tailored interventions, and guiding evidence-based decision-making. Meanwhile, educational data mining discovers hidden relationships in student data, enabling adaptive content delivery and personalized instruction grounded in learner profiles and performance trends [8]. In summary, the nature and scope of AI in education are deeply intertwined with its technical foundations. Together, they enable the development of intelligent, adaptive, and data-informed educational environments that support student success, improve resource allocation, and strengthen institutional effectiveness.

Applications of AI in Education

Artificial intelligence (AI) has found substantial uses in education in three areas: administration, instruction, and learning. Automated systems for administration, such as Turnitin, Grammarly, and Knewton, expedite grading, plagiarism detection, and feedback delivery, lowering teacher effort and increasing efficiency. AI-driven technologies in teaching, such as simulation environments, virtual reality, cobots, and chatbots, offer immersive, interactive, and adaptable pedagogical support, hence boosting instructional quality and student engagement. AI in learning promotes customization and adaptation via platforms such as Knewton, Cerego, and CALL, whilst intelligent tutoring systems enhance deeper cognitive processing. Furthermore, AI-enabled web-based platforms provide inclusive and equal educational possibilities to a worldwide audience, highlighting AI's transformational significance in modern education [9-13].

Table 1 summarises how AI enhances education by applying advanced techniques from personalised learning and automated assessment to immersive smart classrooms and mobile education support. Together, these approaches improve efficiency, adaptability, and accessibility in modern learning environments.

Technical Foundations of AI in Education

Data mining, learning analytics, and machine learning are all used in AI-enabled education.

Predictive analysis of student performance, recommendation systems, and automated grading are all made possible by machine learning [14]. Using learning analytics, at-risk kids may be identified, and interventions can be customised to meet their specific learning requirements [15]. Finding latent patterns in student data allows educational data mining to personalise learning routes [16]. These technologies guarantee that AI systems offer evidence-based, tailored, and adaptable learning experiences.

Impact of AI in Education

On Administration

AI has meaningfully enhanced the effectiveness of administrative procedures, reduced paperwork and allowed teachers to focus more on education. Computerised platforms help with plagiarism detection, response delivery, and presentation monitoring.

On Instruction

Instructional quality and efficiency are improved through AI-driven tools. Adaptive systems and ITS align content delivery with learners' needs, while VR and gamification offer immersive skills [17]. AI also adopts academic integrity through plagiarism checkers and proctoring technologies [18].

On Learning

AI promotes personalised learning, ensuring curriculum and content are custom-made to individual learners' strengths and weaknesses. It also encourages deep learning through simulations and ITS, grooming students for industry-relevant tasks. However, concerns remain regarding potential misuse, such as academic dishonesty facilitated by AI-enabled services [19-22].

Table:1 Applications of AI in Education and Associated Techniques

Educational Scenario	AI-Driven Techniques
Evaluation of students and institutions	Personalized learning approaches, adaptive models, academic performance analytics
Exam and assignment assessment	Computer vision, image recognition, automated scoring, predictive modeling
Customized and intelligent instruction	Data mining, Bayesian inference, adaptive tutoring systems, learning analytics
Smart learning environments (smart schools)	Speech and facial recognition, sensor-based technologies, AR/VR-enabled labs, virtual labs
Remote and mobile digital education	Edge computing, real-time monitoring, AI-based virtual assistants, personalized feedback

Table.2 Mapping Educational Functions, AI Technologies, and Input Components in Adaptive Learning Systems [23,24]

Top-Level Educational Functions	Core AI Technologies	Underlying Input Components
Course Evaluation	Knowledge Inference	Learning Objectives
Adaptive Learning	Machine Learning	Student Profile
Learning Analytics	Reinforcement Learning	Content Map
Personalized Instruction	Computer Vision	Instructor Insights
Knowledge Acquisition	Natural Language Processing	Knowledge Metadata

Table 2 shows that the AI-driven educational ecosystem integrates input components such as learning objectives, student profiles, content maps, instructor insights, and knowledge metadata with core AI technologies like machine learning, NLP, and computer vision to deliver advanced educational functions, including evaluation, adaptive learning, analytics, personalised instruction, and knowledge acquisition. This layered structure highlights how data and AI methods work together to enhance teaching, learning, and decision-making in education [23,24].

Challenges and Future Directions

While AI has demonstrated positive impacts, challenges persist in ensuring ethical use, fairness, and academic integrity. Over-reliance on robotic systems risks withdrawing critical thinking and creativity. Future AI systems are estimated to advance toward higher intelligence levels, analysing learners' emotions, creativity, and styles to foster holistic education [25-36]. A balanced adoption strategy is desired to maximise benefits while justifying risks.

Limitations

Although AI offers significant benefits for education, several limitations must be acknowledged. AI models may inherit algorithmic bias from unbalanced datasets, leading to unfair predictions or unequal treatment of students. Data privacy and security remain critical concerns, as AI platforms collect sensitive academic and behavioural information that requires strict protection. Many models function as "black boxes," reducing transparency and interpretability for educators who need to understand algorithmic decisions. The generalizability of AI systems is also limited, as models trained in specific contexts often perform poorly in different institutions or cultural settings. Finally, excessive reliance on automation risks weakening human judgment, creativity, and critical thinking in the learning process. Addressing these limitations is essential for responsible, equitable, and trustworthy AI integration in education.

Conclusion

This paper provides an integrated analysis of how artificial intelligence is transforming education by linking its technical foundations with practical applications and ethical considerations. Unlike narrower reviews, this study offers a holistic framework that unifies AI's administrative, instructional, and learning functions while emphasising the unique value of machine learning techniques such as Random Forest, SVM, and ANN in predicting student performance and enabling early intervention. The paper clarifies the interplay between learning analytics, educational data mining, and ML models in creating adaptive, student-centred environments, while also identifying major challenges related to bias, transparency, data privacy, and generalizability. These insights highlight the need for responsible, human-centred implementation.

Overall, the findings show that AI offers substantial opportunities to enhance learning outcomes and institutional efficiency, but its success relies on ethical governance, high-quality data, and equitable access. Future research should prioritise interpretable, bias-aware models and hybrid humans. AI systems focused on supporting educators and strengthening their teaching practices.

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Artificial Intelligence Revolution in Higher Education

Deepak Mistry*

Artificial Intelligence (AI) in this article refers to digital tools and technologies that utilise AI to support the educational process. AI boost student learning experience and academic performance - makes education more engaging, and improves teaching effectiveness. Different AI academic support tools are used by institutes of Higher Education Institutions (HEIs) for problem-solving activities, examination preparation, paraphrasing, summarizing content, detailed explanations, report writing, presentations, preparing speeches, translate documents instantly, assisting in coding, identifying errors in the coding, preparation of professional CV, debate material from different perspectives, word document to power point bullets, to turn the lecture notes to flash cards and interactive quizzes, personalised assessments and feedback of students, lecture preparation, making of stimulating assignments, timetable arrangements, etc.

One of the most promising contributions of AI lies in its ability to enhance accessibility and inclusivity in education. AI can bridge gaps in access to education by providing remote learning opportunities and personalised learning experiences. In higher education, AI has introduced socio-technical transformations. These changes have the potential to reshape teaching methodologies and internal dynamics within educational settings. Additionally, the integration of AI is shifting traditional roles and responsibilities, redistributing decision-making power among institutions, educators, and students, which may lead to both opportunities and challenges across various levels of the academic system. An automated personalised feedback system was evaluated to provide tailored feedback to students based on their specific demographics, attributes, and academic status. AI-driven feedback mechanisms can positively influence learning outcomes by offering customised support to students. AI-based writing tool, (adaptive learning technology) designed to support English as a Foreign Language learners. was particularly effective for learners with lower proficiency, enabling them to approach the level of more advanced peers. Generative AI is reshaping how students engage with learning on an individual level. Tools such as ChatGPT and similar platforms have added new dimensions to how students approach their work, enabling the creation of written content, visual materials, and other digital resources. It has immense potential to advance educational equity, mainly for students with disabilities and those from underrepresented backgrounds.

AI is also being applied at the institutional level. The use of neural network-based models to optimise faculty subject allocation by assessing factors such as academic background, teaching experience, and administrative responsibilities. This approach supports more structured and outcome-based teaching. Together, these findings suggest that while the integration of AI into education offers substantial benefits, its effective implementation is contingent upon broader educational reforms, such as universities needing to revise teaching models, establish new academic disciplines, address ethical considerations in AI, and strategically align educational outcomes with the growing demand for AI expertise in the workforce. Alongside these systemic changes, it is equally important to consider the skills and competencies individuals need to participate meaningfully in an AI-enhanced environment. As AI becomes deeply embedded in digital systems, AI literacy is emerging as a fundamental skill. Given AI's growing role in global education, it is increasingly important for both educators and learners to develop strong literacy and competency in using AI tools across academic, professional, and personal contexts. The integration of AI and digital literacy into higher education is not only vital for improving employability but also for addressing systemic issues like digital inequality and curriculum relevance.

However, for a successful AI implementation, a unified regional vision, student empowerment, alignment with cultural values, and promotion of a knowledge-based economy are needed. One can take a systematic approach by evaluating the tool's features and functionalities to determine if it could support the course objectives. Once deemed suitable, it can be tested it with a small group of students to gather feedback, identify issues, and

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make necessary adjustments to better fit the learning environment and student needs — "Check tool capabilities, align with course objectives, create a way to utilise, test with a limited audience, adjust to fit, and then launch to all students. Evaluate whether the tool can adapt to different learning styles, paces, and preferences. The integration of AI tools, improved learning, lesson preparation, management of teaching resources, preparation of assignments and exams, customising lessons to meet different learning styles, increased student engagement, increased accuracy and efficiency of grade aggregation, increased efficiency in obtaining grade analysis and better insights on students' progress and performance, efficiency in allocating and managing tasks.

Learners' Experiences (Both Good & Bad) about AI.

1) For me, I believe that using AI has improved my thinking abilities. It helps me to generate new ideas and view things from different angles, so I can expand my knowledge of different topics. I feel that AI has helped increase my class participation. For instance, there are times when I want to share my opinion but struggle to articulate my ideas clearly. But by using AI, I can formulate my thoughts more effectively. I feel more confident to share my ideas in class and to engage more actively in class discussions.

2) This semester, I'm studying a math subject that I find difficult. I often can't go to the instructor because the office hours don't fit my schedule. So, I use AI to help me understand the problems, and it has been very useful. Because of this, I started using AI for most of my other subjects. AI can answer any question and simplify difficult concepts, making it easier for me to understand complex information. As a result, I talk less with my instructor because I don't need to.

3) In the past, I used to visit them during office hours to ask questions or get help understanding lecture materials. These interactions helped me understand difficult concepts and, of course, build a personal connection with my instructors. But now, I mostly rely on AI to help me understand things better. So, I believe that my use of AI has changed how I learn and how I interact with my instructors. I use AI to find a simple description with examples and everything I need. I don't have to talk to the instructor. But of course, this does not mean that AI is better or can replace instructors. AI will never be as accurate as an instructor.

4) Some students experienced that the use of AI results in limited communication and interaction with the juniors, peers and seniors. They noted that AI tools resulted in a decline in study groups. Thus, the source of real knowledge, collaboration, to have different perspectives on the same topics, suffers. The only benefit they see is that it saves time. In their opinion, all other aspects are negative for education. They feel that using AI might make them lose the ability to learn, to do research, to manage their time and to solve problems. A very common thing we find is that some students have shut down their brains and rely completely on AI. This has even led to an increase in academic cheating, in writing reports and solving exam papers. Using artificial intelligence has made them lazier. Before, they worked hard to get the information they wanted, but now they rely more on technology. AI has restricted human thinking and creativity.

5) One of the downsides of AI is that it creates a gap in human capability. For whenever someone faces a challenging question/ task they turn off their brain and run towards AI. They don't bother to think on their own and can't be creative. Why should I bother, when there is an existing tool that can solve them for me? Why should I spend time creating a presentation when AI can do it for me? Why put in much effort when I can relax and let AI complete my tasks? They might act like robots, not thinking but just doing what AI tells them to do. In the long run, heavy reliance on AI will results into learners missing out on essential study skills.

Learners Should be Careful

Learners should know the limitations and harmful effects of AI. They should know that the job of the learners is to enquire, research, and deep dive into the problems. That is why they have joined the universities. Whatever they learn, they have to apply in the practical world. They should know particularly that:

1) In ready-made material provided by AI, sometimes some information may be wrong. Using AI in scientific research, for example, to

write reports, can be challenging. The answers from AI often lack reliable sources, such as journal articles and scientific books. To know and evaluate whether the answers provided are correct or not, the student should have a clear background about the topic. AI is perceived as less reliable for challenging academic tasks that require deep understanding and critical thinking skills. AI is only useful for asking straightforward questions. But for anything that needs analysis and critical thinking, it will not work.

2) One of the biggest challenges in using AI is the ability to formulate questions, because there is a specific way to ask AI. If you ask a question normally, as you would talk to any person, the AI might not understand your question, or you might not get a useful answer. For example, when we use AI for the same purpose but write the question in two different ways, so the answers could be correct sometimes and wrong other times, depending on how the question is written. The problem with AI is that the answer you get depends on your input. For example, if you input incorrect data in your question, the answer will be wrong. Dealing with AI is not like dealing with humans; AI cannot fully understand exactly what you mean."

Instructors / Professors Should Be Careful

It will become difficult for instructors to differentiate between hardworking and negligent students because most students use AI to complete their assignments. And this makes their performance levels look similar. And we can't only rely on class participation to assess the level of students, as some successful students may not always prefer to participate in the class. When students rely on AI a lot, they might receive grades they don't deserve. This is because they haven't made an effort or depended on themselves to solve the problems or to find the answers.

Indian Scenario

The higher education landscape in India has undergone a tremendous transition in the last decade. Exponential growth in the number of universities (over 1200) and number of colleges and standalone institutions (over 57000), and the number of enrolments of students in higher education (over 4 crores) is unprecedented. We have the world' second largest education system, after China. Factors like technological advancements, increased globalisation, gaps in employability and skills, and increasing student expectations have contributed to such growth. In educational institutions, digital tools and platforms have revolutionised data management, streamlined administrative processes, and enhanced communication between educators and students. The next significant leap in this digital evolution lies in the integration of Generative Artificial Intelligence (GAI). GAI stands out as one of the most promising and impactful technologies of our time. Its applications for higher education are diverse and hold the potential to revolutionise the area in profound ways.

Thus, as AI evolves and matures, so will its role in higher education, providing new opportunities and solutions to age-old educational difficulties. By embracing this technological revolution with a balanced and forward-thinking approach, higher education institutions can empower their students to reach their full potential, contribute to a brighter, more innovative future, and flourish in an increasingly complicated and interconnected world.

Integration of GAI in the Education System

AI integration into higher education holds immense promise for reshaping the future of learning and administrative processes. Various studies undertaken on the subject " AI (GAI) in Higher Education "imply that GAI tools have become a necessity and essential, and therefore should be integrated in teaching, learning, assessment, research and administration functions of the institutions of HE. Students, faculty and administrators should get acquainted with GAI to maintain competitiveness in their respective fields.

The adoption of generative AI (GAI) in higher education has the potential to transform various educational practices in learning, teaching, and assessment. GAI's diverse capabilities, including providing comprehensive feedback, exceeding the performance on reflective writing of the average student, enhancing multimedia learning and pioneering the development of adaptive educational content, are well recognised.

Integrating generative AI (GAI) into higher education is crucial for preparing a future generation of GAI-literate students. On the world stage, it is still in a native stage. The universities are exploring the characteristics of GAI innovation, including compatibility, trialability, and observability. They are proactively addressing GAI integration by developing policies and guidelines, opening up communication channels and defining the roles and responsibilities of different stakeholders. They have to craft inclusive, transparent, and adaptive strategies for integrating GAI into higher education. To navigate the challenges and ensure a positive integration of GAI, for Educational Institutions across the world, it is crucial:

(i) to create GAI literacy and awareness;

(ii) to propagate interdisciplinary studies and projects, industry collaboration, and to establish clear policies and guidelines.

(iii) take proactive steps in addressing any resistance to GAI usage.

Need to Create GAI Literacy and Awareness

Educational institutions should focus on building AI/GAI literacy and awareness by organising knowledge-sharing sessions that educate both faculty and students on the following:

a) how to critically evaluate the reliability and accuracy of AI- generated content;

b) how to use AI tools effectively while staying actively engaged to prevent skill decay;

c) how to ethically utilise AI in teaching and learning, focusing on responsible usage and proper acknowledgement of AI contributions in academic work;

d) What measures are taken to safeguard personal data and to prevent data privacy concerns?

Where AI Can Be Used in HE Institutions

1. Personalised learning platforms, / adaptive learning systems,
2. Curriculum development, break-up, and scheduling
3. Automated assessment tools, performance monitoring systems,
4. Generative content creators
5. Intelligent tutoring systems,
6. Feedback systems
7. Faculty collaboration and partnership - faculty professional development
8. Research assistance
9. Automating repetitive tasks such as grading, scheduling, and attendance tracking.
10. Predictive analytics,
11. Educational robotics,
12. Support for distance learning
13. Embedding AI literacy within the curriculum.
14. Cyber Security and Data Privacy.
15. Automating admission, enrolment, management and Financial work.

AI Tools in HE

- For enhancing teaching, learning, and professional tasks, office applications tools like ChatGPT are useful as their primary AI tools as they indicate a strong preference and active student participation due to their accessibility and ease of use.
- Tools like Grammarly for editing and to detect plagiarism, and AI Tools are available.
- For Coding Tools like W3Schools, Blackbox AI, Bubble diagramming tools (e.g., draw.io, Lucidchart), and LMS (e.g., MindTap, MyLab, Nearpod). Quill bot, Grammarly Chatsmith, SlidesGo, Blackbox and Shaguf Bites
- For designing purposes, tools like Canva and Beautiful.AI are used to format presentations and proposals
- More Advanced Applications Tools, like Virtual Reality Modelling Language (VRML), ML models for AI integration are used.
- Most of the Software These days has AI built in that for increasing its functionality and users' convenience.

Task Cut Out for the Institutions

Every institution of HE has to work on Building AI confidence across staff and students, embedding AI into teaching, processes, & leadership and turning global insights into local strategies that work. And for this, they have to:

1. To emphasise the significance of communication channels requiring a two-way flow of information. This approach facilitates the active participation of all key stakeholders, including faculty, students, and administrators,

in the decision-making process, thus increasing the chances of successful innovation adoption

2. To implement regular, comprehensive professional development programs (workshops, conferences, or online learning platforms) focusing on AI advancements and practical applications, ensuring that faculty and students stay updated on AI technologies and integrate them effectively into their teaching and learning.
3. To foster collaborative learning by promoting interdepartmental cooperation among faculty;
4. To incorporate interdisciplinary hands-on projects and collaborative assignments that link academic learning with industry practices, giving students and faculty practical experience and a deeper understanding of AI's real-world applications;
5. To initiate training programs for faculty and students, sponsored by the corporate sector, to help them gain industry-specific skills and knowledge related to AI utilisation;
6. To encourage continuous learning and interdisciplinary approaches to help faculty to better prepare students for careers shaped by AI technologies;
7. To build external partnerships with experts in new technologies, AI tools developing tech companies, industry leaders and others to introduce new perspectives and opportunities for practical AI applications in education.
8. To establish clear policy and procedures:

a) on the extent of the AI use in academic work;

b) on the appropriate usage of AI in academic programs, with special reference to ethical issues;

c) on the personal responsibilities of academic staff regarding data usage and storage, while ensuring alignment with laws and regulations.

9. Every stakeholder has certain roles and responsibilities towards AI. The roles and responsibilities of various Stakeholders in Higher Education towards AI are depicted in Table-1

Major Challenges in Integrating AI in HE

Major challenges are weak infrastructure, limited/inadequate teachers' training (skilled work force), institutional resistance, cultural concerns, cost implications and the absence of clear policies and resources. Students must demonstrate ethical awareness, digital responsibility, and the skills needed to use these tools confidently and competently.

Table -1: Roles and Responsibilities of various Stakeholders in Higher Education towards AI

Stakeholders	**Roles & Responsibilities**
Faculties	(1) Integrating GAI into Curriculum and Assessment
	(2) Enhancing Teaching and Learning
	(3) Communication and Education on GAI Use
	(4) Setting Guidelines and Policies Enhancing Critical Thinking
	(5) Enhancing Critical Thinking
Students	(1) Reviewing Ethical and Security Concerns
	(2) Ethical Use and Academic Integrity
	(3) Understanding the capabilities and limitations of GAI
	(4) Engagement and Communication
	(5) Learning Enhancement
Administrators	(1) Policy Development and Implementation
	(2) Support and Resources
	(3) Integrity and Ethical Use
	(4) Supervision in the Procurement Process of GAI Services
	(5) Support for Diverse Educational Needs and Equity

The main problem is that we don't know much about the different AI applications; we don't have a clear understanding.

Currently, everyone is experimenting with these different available applications to see "how effective they are." AI at present is at an 'experimental stage' and the broader impacts of AI, both positive and negative, are still largely unknown. This suggests that there is a widespread ambiguity about AI tools and their potential outcomes.

Overcoming Resistance to AI Integration

In addition to creating awareness about AI and carrying out various tasks by the HE institutions to integrate AI (as said earlier above) following steps will also be helpful to overcome initial resistance to integrating AI tools in Teaching & Learning.

1. Identify and address technical and institutional barriers that hinder the effective use of AI tools, including providing support for faculty less familiar with technology.
2. inspire and motivate faculty to embrace AI technologies and to adopt innovative practices in their own teaching by highlighting successful examples of AI integration from leading institutions;
3. continuously monitor and evaluate the impact of AI tools on teaching effectiveness, student engagement, and academic outcomes, and in turn identify strengths and areas for improvement in AI integration.

Conclusion

Higher education institutions are adopting certain strategic and proactive measures towards the integration of GAI, guided by a commitment to academic integrity, teaching, learning enhancement, and equity. All institutions of HE shall emphasise GAI's compatibility with educational values, its potential for fostering innovation and critical thinking, and the importance of trial ability and observability in its adoption. Significant gaps found in comprehensive policy development, communication strategies, and the equitable distribution of resources for GAI integration should be addressed effectively. There should be a collaborative and inclusive model that navigates the complexities of GAI adoption in education, ensuring its alignment with institutional values and the broader educational mission.

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ATTENTION READERS

The government is commemorating the 150th birth anniversary of Sardar Vallabhbhai Patel with a two-year-long nationwide programme from 2024 to 2026 to honour his monumental contribution to the country. University News also invites articles on the 'Contributions of Sardar Vallabhbhai Patel to the Nation' . Authors can submit manuscripts throughout the year till September 30, 2026 to Dr Sistla Rama Devi Pani, Editor, University News, via Email: ramapani.universitynews@gmail.com, and also send a copy to: universitynews@aiu.ac.in.

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Editor

Artificial Intelligence : Reshaping Higher Education in India

Saraswati Rachayya Ratkalle*

Need for AI in Higher Education in India

In an increasingly interconnected world, digital inclusion has emerged as a cornerstone of development strategies. Digital India's goal is to transform the nation into a digitally empowered society and knowledge economy. The India AI Mission comes with a very comprehensive vision, and together, these initiatives aim to develop India's global leadership in AI, foster technological self-reliance, and ensure ethical and responsible AI deployment. The goal of initiatives like the AI for All programme and the National AI Strategy is to promote the adoption, development, and research of AI technology across a variety of industries and higher education. Some of the popular definitions include:

"Artificial Intelligence (AI) is technology enabling computers to perform tasks needing human intelligence, like learning, problem-solving, decision-making, and understanding language, by analysing vast data to find patterns, make predictions, and act autonomously, seen in virtual assistants, self-driving cars, and medical diagnostics.

"Artificial intelligence is the simulation of human intelligence processes by machines, such as computer systems. AI powers many technology-driven industries, such as educational institutions, health care, finance, transportation and much more".

"Artificial intelligence offers benefits like boosting productivity, enhancing decision-making, improving customer experiences, and automating repetitive tasks, leading to increased efficiency and reduced costs across industries, while also revolutionizing healthcare, education, and cybersecurity through personalized solutions, predictive analytics, and advanced pattern recognition. It enables innovation, strengthens security, and creates new capabilities, ultimately improving daily life and solving complex global challenges"

"Artificial intelligence (AI) is the theory and development of computer systems capable of performing tasks that historically required human intelligence, such as recognizing speech, making decisions, and identifying patterns. AI is an umbrella term that encompasses a wide variety of technologies including machine learning.

Implementing Artificial Intelligence and artificial neural networks in education in India includes many kinds of intelligent instructional and evaluation techniques, such as intelligent tutoring systems, intelligent assessment of student performance, intelligent virtual agents, talking robots, humanised chatbots, and any other educational technique based on Artificial Intelligence. Artificial Intelligence is one of the disruptive techniques to customise the experience of different learning groups, teachers, and tutors.

Generative Artificial Intelligence

Generative AI is becoming increasingly common in everyday life, powering tools such as ChatGPT, Google Gemini, and Microsoft Copilot. While other kinds of machine learning models are well suited for performing narrow, repetitive tasks, generative AI is capable of responding to user inputs with unique outputs that allow it to respond dynamically in real-time.

Generative AI is a kind of artificial intelligence capable of producing original content , such as written text or images, in response to user inputs or prompts.

Use of AI in Higher Education

AI in higher education personalizes learning with adaptive paths, automates grading ability to quickly generate new content such as text or images and offers student support via chatbots, while also providing data analysis to predict at-risk students and guide interventions, though ethical concerns around bias, privacy, and academic integrity require careful management. It empowers both students (research, writing help, concept explanation) and educators (lesson planning, feedback, efficiency) by streamlining workflows and enhancing engagement.

Use of AI for Students

Homework assistance, adaptive review systems, virtual tutoring, assistance in research,

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writing enhancement, language learning, coding, study planning, concept visualization, audio/video learning.

- ***Personalized Learning*:** AI is used for personalised learning as content, pace, and resources to individual needs.
- ***Support*:** Chatbots and virtual tutors answer questions and explain complex topics.
- ***Writing & Research*:** Assists with grammar, summaries, first drafts, idea generation, and finding information.
- ***Skill Development*:** Helps apply knowledge and explore concepts from different perspectives.

Use of AI for Educators and Institutions

Grading and assessment, content creation, resource curation, course structuring, personalized learning analytics, administrative tasks, real-time teaching and interaction with students.

- ***Content Creation*:** Generates lesson plans, quizzes, study materials, and course outlines.
- ***Automated Tasks*:** Grades assignments, manages scheduling, and handles data entry.
- ***Data Analytics:*** Identifies at-risk students for early intervention and tracks performance.
- **Curriculum Design:** Analyses data to suggest updates and fill learning gaps.

How AI Works

1. **Data Input:** Raw data (text, images, numbers) is fed into the system.
2. **Data Processing:** Data is cleaned and converted into formats (vectors) AI models can use.
3. **Model Training:** Algorithms, like neural networks, learn patterns from this data.
4. **Prediction/Action:** The trained model makes decisions or predictions, such as identifying a cat in a photo or understanding a voice command.

AI Used in Various Fields

Navigation Apps

Google Maps uses real-time data to find the fastest routes and avoid traffic.

- **Transportation**

AI powers safety features in cars and is developing autonomous driving.

- Shopping & E-Commerce

AI offers product recommendations and manages inventory.

- **Banking :** Detects fraudulent transactions in real-time.
- **Search engines:** Google uses AI to provide relevant results.
- **Language tools :** Translation apps (Google Translate) and autocorrect use AI.

Benefits of AI

- **Boosts Productivity and Efficiency**

Automates mundane tasks, allowing humans to focus on more complex work, speeding up operations across sectors.

- **Enhances Decision-Making**

  Analyses vast datasets rapidly to provide insights, leading to smarter, data-driven decisions in real-time.

- **Improves Customer Experience**

  Delivers personalized service, faster responses, and tailored recommendations through chatbots and virtual assistants.

- **Reduces Human Error**

  Minimises mistakes in data processing, manufacturing, and critical applications, increasing accuracy.

- **Drives Innovation**

  Unlocks new capabilities, fosters creativity, and accelerates research and development in fields like medicine and technology.

- **Strengthens Cybersecurity**

  Detects and prevents threats in real-time, protecting systems and data from sophisticated attacks.

- **Revolutionises Healthcare**

  Aids in early disease detection, personalised treatment plans, drug discovery, and efficient patient monitoring.

- **Personalises Education**

  Creates adaptive learning platforms that tailor lessons to individual student needs and progress.

- **Optimizes Operations & Logistics**

  Streamlines supply chains, predicts equipment failures (predictive maintenance), and manages resources better.

- **Increases Accessibility**
  - Makes services and information more accessible to broader audiences through features like real-time translation and digital assistants.
  - Greater accuracy for certain repeatable tasks, such as assembling vehicles or computers.
  - Decreased operational costs due to the greater efficiency of machines.
  - Increased personalisation within digital services and products.
  - Ability to quickly generate new content, such as text or images.

Personalised Learning Experience

AI in higher education enables professors to create personalised learning experiences with ease, enhancing student engagement. As higher education is a place where research, innovation, problem-solving, and the use of the latest technologies are sought to be leveraged by excellence, AI offers, in this context, an opportunity to support students in their offering personalised learning processes, intelligent tutoring systems or helping students in the analysis of their path and performance. At the same time, it also helps students and teachers by allowing them to be active. In this field, advances in artificial intelligence open up new possibilities and challenges for teaching and learning in higher education, with the potential to fundamentally change governance and the internal architecture of institutions of higher education.

Higher education institutes are playing an important role in the development of the nation. Economic and social development of an individual depends upon two important factors, viz. Knowledge and learning.

Artificial Intelligence (AI) is rapidly transforming how we live, work and interact by powering smarter systems, automating complex tasks and extracting insights from vast amounts of data. AI is accelerating innovation, improving efficiency and opening new possibilities across sectors worldwide, from powering fraud detection in finance to enhancing diagnostics in healthcare. As this technology continues to evolve, it is also changing the landscape of education, making learning more personalised, improving access and engagement, and equipping learners and institutions to thrive in an AI-driven future.

AI has rapidly moved from a niche technology to a mainstream tool in higher education, with the widespread availability of free generative AI tools such as ChatGPT, DeepSeek and conversational AI engines like Perplexity. These technologies have democratized access to AI-powered assistance, and brought AI adoption to the forefront of academic discourse and practice, enabling students and educators alike to access powerful capabilities for learning, research and administration.

However, the rapid rise of AI often outpaces the development of national and institutional policies, leaving many universities struggling to integrate it responsibly and effectively. The technology encompasses machine learning algorithms, natural language processing, computer vision, predictive analytics and automated decision-making systems that increasingly permeate educational infrastructure. This broader AI ecosystem demands a nuanced understanding that goes beyond surface-level interaction with chatbots and content generators.

Transformation of Higher Education Using AI

AI is transforming education by improving learning experiences, optimising administrative processes and expanding accessibility. In Higher Education Institutions (HEIs), AI benefits both students and educators. It enables personalised learning based on individual student needs, making education more effective, while automated grading and scheduling systems reduce educators' workload, allowing them to focus more on teaching. However, the global impact of AI on HEIs is more substantial than in India due to higher adoption rates, greater readiness, and a more advanced policy framework. Several countries, including the US, China, the UK and Australia, have developed AI policies to govern the use of AI in education. Education-related AI applications in areas such as admissions, decisions, grading systems and proctoring systems.

- The global higher education landscape is swiftly embracing AI's transformative potential, reshaping how institutions teach, assess and support students.
- The landscape of higher education in India and globally is undergoing a profound transformation driven by artificial intelligence. AI-powered tools are now embedded not only in classrooms but also in the administrative functions that keep universities running smoothly.

- AI across teaching, employability and academic services, exploring how universities are leveraging these technologies to build institutional capacity and enhance educational outcomes.
- While AI is being applied across a wide range of areas in higher education, personalised learning pathways that adapt to individual student needs, and the enhancement of educator effectiveness through intelligent tools and analytics.
- AI-powered career services that bridge the gap between education and employment and sophisticated assessment tools that provide more accurate and efficient evaluation methods. These applications are reshaping not only how knowledge is delivered and consumed but also how institutions operate and scale their educational services as Homework assistance, adaptive review systems, virtual tutoring, assistance in research, writing enhancement, language learning, coding, study planning, concept visualization, audio/video learning Grading and assessment, content creation, resource curation, course structuring, personalized learning analytics, administrative tasks, real-time teaching and interaction with students. Career path discovery, interview preparation, behavioural and cognitive assessment, resume support, career development skills such as salary negotiations, prioritisation, time management and networking.

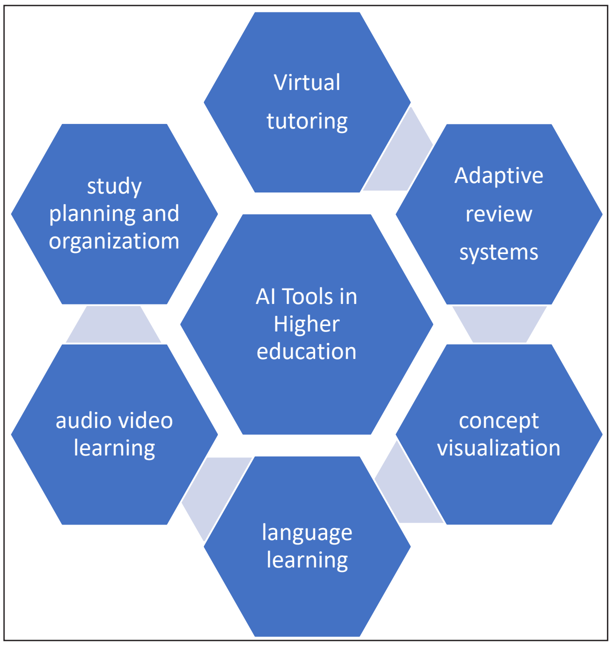
Some of the Most Common Examples of GAI Tools

- **ChatGPT:- Uses** Large Language Models (LLMs) to generate text in response to questions or comments posed to it.
- **Google Translate:** Uses deep learning algorithms to translate text from one language to another.
- **Netflix:** Uses machine learning algorithms to create personalized recommendation engines for users based on their previous viewing history.
- **Apple's Siri:** Apple’s voice-activated personal assistant, Siri, is powered by Deep Neural Networks (DNNs) to interact with users and complete their requests.

Use of AI Tools in Higher Education

HEIs in India have already embraced a wide range of AI tools and applications, and are actively considering their adoption. This clearly indicates that the integration of AI into the Indian education landscape is well underway.Some of the common AI tools used by HEIs are as follows

Fig:-AI Tools in Higher Education



- Personalised or adaptive learning platforms are tools that tailor educational content and experiences to each learner’s individual needs, pace and preferences using AI.
- AI-powered tutoring or chatbots are virtual assistants that use AI to provide instant, personalised academic support, answer student queries and guide learning in real-time.
- Predictive analytics for student success and retention refers to the use of data and AI to identify students at risk of dropping out or underperforming, helping institutions take timely actions to support them.
- Automated grading and feedback systems are AI-driven tools that evaluate student assignments and provide instant, personalised feedback to help improve learning outcomes.
- Mental health and wellbeing support tools are AI-powered applications that help students manage stress, anxiety and emotional wellbeing through resources like self-help content, mood tracking and virtual counselling.
- GenAI tools for creating teaching materials are AI-powered tools that produce educational

content such as quizzes, presentations and lesson plans based on input from educators.

- Academic counselling uses AI to help students make informed decisions about their educational goals, course selections and career paths through personalised guidance and planning.

Conclusion

The landscape of higher education is undergoing a paradigm shift from traditional approaches to AI-driven personalised learning experiences. A thriving AI-enabled future in Higher Education depends on a strong collaborative ecosystem, with the government serving as a key facilitator. Strengthening global networks, enabling infrastructure sharing, and forging strategic partnerships with industry, Advancing AI in education requires providing support to a wide network of institutions. Centres of Excellence are an important first step, but their reach must extend to support faculty and researchers from diverse HEIs in contributing to global knowledge on AI-enabled education. Faculty development requires structured and continuous programs that build skills needed to integrate AI into teaching and research. As AI continues to transform higher education, the government must play a pivotal role in shaping a national vision that guides its responsible and effective integration. This includes establishing comprehensive frameworks for teaching and ethical AI use, ensuring data privacy and security, and promoting equitable access to AI-powered learning.

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The Quantum Leap: Exploring Tomorrow's Technologies

V Narayanan, Distinguished Scientist, Secretary, Department of Space and Chairman, Indian Space Research Organization delivered the Convocation Address at the 21st Convocation Ceremony at the National Institute of Technology Tiruchirappalli, Tamil Nadu on July 26, 2025. He said, *"The success, both personal and professional, depends on how we think, how we act and what we believe in. Develop inner strength of character. You should always be honest & trustworthy."* Excerpts

I feel really happy to be with you and to share this significant moment and the happiness of students receiving their degrees here today. I am so excited to be in the best and most sought-after NIT of the country. NIT, Trichy has a great history and legacy of 61 long years, right from its inception in 1964 as REC. Renamed as NIT from 2003, this institute is a real marvel in engineering education in the country.

I am a native of this state, Tamil Nadu and right from my student days, I have heard the name of this Institute and it was anybody's dream to get admission and study in this great institute. You are the privileged set of students who could get admission and study in this institute through your sheer merit and hard work and let me wholeheartedly congratulate each and every one of you. I had the opportunity of working few months in BHEL, Trichy, before I joined ISRO in 1984 and hence I am very much aware of the capabilities and the talent pool of NIT, Trichy. The very fact that it has the Distinction of *'Best Industry Linked NIT in India'* by Confederation of Indian Industry is a really great compliment.

I am happy to note that students receiving degrees here today belong to undergraduate and Postgraduate programmes of various Engineering and allied disciplines. I am sure the Management & Faculty here have contributed in a big way in leading the students towards providing true education. The education that ensures absorption of knowledge, accumulation of wisdom and appreciation of the experience.

I have always been a person who believed that all the good qualities of a student, be it behaviour, character, ethics, compassion, empathy and so on, are brought in mainly by the teachers.

The stars of today's function are the students receiving their degrees. Let me take this opportunity to greet each and every one of you. More than anything else, I have felt that Convocation is a function for you to look back to remember and thank all those good souls who have helped you to reach this level.

Apart from your hard work and dedication, you owe the degree you are receiving today to your parents, who have educated you to see your bright future. Let me salute each of the parents present here today.

Convocation is one of the happiest occasions in one's life. You all are entering into a new phase of your life with great maturity, knowledge and a good degree from a great institution. On this occasion, I wish to reiterate the message of Swami Vivekananda *'Arise, Awake and Stop not till the goal is achieved'*.

We are all in a very high mood right now as our own Astronaut, Shubanshu Shukla has just become the first Indian to reach the International Space Station and land back in Earth safely. I had the great privilege of associating with this Axiom mission in a big way. All of us had a busy time last month in US at the Kennedy Space centre and we were happy to contribute in our own way in ensuring the safe launch of Shukla and 3 other astronauts to ISS. It is a big stepping stone as we move towards our own human space program – *Gaganyaan* quite shortly.

Since the time I have taken over as Chairman, ISRO, i.e., beginning of this year, we have achieved some key successes within a short time. India has become the 4th country to successfully achieve Docking and Undocking in Space with the success of SPADEX mission, in which we demonstrated precise docking and undocking of the Chaser and Target. In January this year, we had the successful 100th launch of the GSLV F15/ NVS-02 mission from Sriharikota. I am also so happy to get the final approval for the Third launch pad, catering to the launch of our future generation of launch vehicles, which will take Indians to the Moon.

Dear friends, with the knowledge you have gained till now, you are starting to serve our country, which has completed 77 years of independence and the progress we have made during this period is phenomenal. One has to understand that at the time of independence, 97.5% of our people were below the poverty line with an average life expectancy of 32 years. From that state of affairs today we have grown in every sector. In the agriculture sector, we had the green revolution and became self-sufficient in food production. In health sector, we have world-class hospitals & doctors and have increased the average life span of Indians from 32 years to 72 years.

- India as a nation has grown by leaps and bounds in Science and Technology since its independence.
- In India over the years, we have made significant progress in various sectors through movements like the Green Revolution, White Revolution, Grey Revolution and Blue Revolution
- Literacy level which was alarmingly low, pegged at around 12% soared to 79.7% as of date. Number of primary schools which numbered around 2825 at Independence, has soared to about 8.40 lakhs. We could create world class Institutions of National importance like IITs, IISc, IIMs, AIMS, NITs, IISERs, etc. wherefrom the pass-outs are accepted and respected worldwide. We could also establish a number of other schools and colleges of international repute. At present, we have 742 medical colleges and 4351 Engineering colleges in India, rolling out trained men and women to add value-added services to our country. The average enrolment of students in colleges in India is the largest in the world (30.6 million).
- From receiving food aid in the 1950s and 1960s to becoming a net exporter, India has seen a turnaround in food production. Aided by the Green Revolution, total food production, which stood at 54.92 million tonnes in 1950, has risen to 305.44 million tonnes. In agriculture, we have made 5 fold increase in production since independence. The green revolution has taken us to this growth today. We too had the white revolution for dairy products and the blue revolution for fisheries.
- Only 3,061 villages had access to electricity in 1950. Currently, all of India's villages 5,97,464 in total, have been electrified. The total power generating capacity has increased from meagre 1362 MW in 1947 to 403 GW. The per capita electricity consumption, which can be directly equated as an index of development, was a mere 16.3 kWh and has increased to 1208 KWh. The country has achieved total self-reliance adopting a threefold combination of hydroelectric, Thermal and nuclear power stations along with tapping others like tidal, wind, solar, etc. Nuclear power plants have been set up at a fast pace ever since Homi Jahangir Bhabha started the research activities at BARC.
- India's GDP stood at Rs 2.7 lakh crore at Independence. Now it has reached Rs 135.13 lakh Crore. India is now the 4th largest economy in the world, overtaking UK itself. We have the potential of becoming the third-largest economy by 2031, as per Bank of America. Our vision is to have an economy of 300 lakh crores by the end of this decade.
- Indian Railway, the longest railway system in the world, expanded by over 14,000 kilometres, reaching 67,956 kilometres in route length by end of 2021. We have added a host of metros in most major cities and fast moving Bullet trains.
- Roads have expanded exponentially in the last 75 years. In 1950, India only had 0.4 million kilometres of roadways, which has grown to 6.4 million kilometres. This is a 16-fold rise in the total length of roadways, making India’s road network the second largest in the world. We have an extensive network of waterways, too, spread across states and intercontinental water passages. Our national highways and expressways are rated among the best in the world, connecting the length and breadth of this vast country.

Our unique programmes like “Make In India” have revolutionised the engineering sector in the country. Hence, it is imperative that there are plenty of opportunities for all of you to contribute to making India a developed country when we celebrate Azadi ka Amrit Mahotsav, 100 years of independence in 2047.

Our country has built world-class institutions over the years and achievements have been plenty.

Take the case of DRDO, over the years, they have developed large range of weapons like the

Arjun battle tank, Zarovar light tank, Brahmos long range supersonic missile system, Agni & Prithvi series of missiles, Tejas light combat aircraft, Pinaka, a multi barrel rocket launcher, Akash, a comprehensive air defence system and so on leading India to become a defence power.

In Atomic energy too, we have made a mark and at present, we have 23 nuclear reactors across 8 major nuclear plants, starting from Tarapur and including the Bhabha Atomic Research Centre (BARC). At present, we have the capability to generate 8180 Mega Watts power but we are still a long way to go.

We have world-class CSIR Labs under the Department of the Council of Scientific and Industrial Research.

Our country has built world-class institutions over the years and achievements have been plenty - DST, DRDO, IGCAR, Tata Institute of Fundamental Research, Kalpakam and Kudamkulam Nuclear plants, Medical Technological Institutes like AIIMS - Eradication of fatal diseases like Smallpox, Diphtheria, Malaria, etc., Commissioning of hundreds of roads, bridges and railway lines, National Educational Institutions like IITs, IISc, IIMs, RGIPT, Metro trains, World's biggest Statue - Statue of Unity, High Speed Rail Corridor, etc.

Dear friends, on this important day of your life, let me share a few of my thoughts

Give Back to Society

Dear Graduates, education is a privilege that you enjoy for which you are deeply indebted to the society of which you are a member. For the degree you are receiving today, so many have contributed,

1) Your parents who have sacrificed their comfort to educate you and see you as great leaders in future.
2) Your school teachers who have taught you and given you a good foundation.
3) Your college teachers and staff members who have given high-quality education and shaped & molded your career.
4) The fellow citizens who have provided you good ambience for your education.
5) The common man, the taxpayers and the society of our country, who have funded for your education indirectly.

Is it not your responsibility to give back something to society?

Noble leaders like the father of our nation, Mahatma Gandhi, Pandit Jawaharlal Nehru, Sardar Patel and so many others have sacrificed their entire lives for our country. As a valuable and responsible citizen, you also have to work for the welfare & development of the institutes where you have studied, care for the citizens of our country and build up the nation.

- **Learning is a Continuous Process**

  To update your knowledge, excel in your profession and reach greater heights in life and to contribute to the betterment of society, you should learn continuously. Dr. Radhakrishnan, the great scholar & our former President, once said, "The habit of reading is one of the greatest resources of mankind".

- **Work Hard and Earn Your Happiness**

  Dear Graduates, you all know that there is 'No substitute for Hard & Smart work.

  I have learned from *'Wings of Fire'*, the Autobiography of our former president, Dr AP.J. Abdul Kalam, "Total commitment is a pivotal quality for those who want to reach the very top of their profession". It is true. I myself have experienced.

- **Develop Inner Strength of Character**

  The intellectual education influences the mind, whereas the value-based education influences the heart. A person with a high academic record with intellectual education and bankrupt value-based education is of no use to society. The success, both personal and professional, depends on how we think, how we act and what we believe in. Develop inner strength of character. You should always be honest & trustworthy.

  - "Dream & Aim for greater things, Set high targets and work for it. Dreams are internal monitors. Dreams are powerful tools of an individual to achieve his goals.
  - Be imaginative, Innovative & Creative. A person who uses his imagination and creativity will overpower the one who has more resources.

- Self-confidence and Self Motivation is another important requirements for success "Can-do approach is an essential requirement for the one for reaching greater height you should be persistent in achieving your goals.
- Teamwork with a win-win approach and calculated risk-taking ability is another important requirement for success.
- You should develop a noble leadership quality. Above all, you should become a good human being.

Accomplishments and Future Plan of the Indian Space Programme

I am today standing before you in the capacity of Secretary, Department of Space/Chairman, ISRO. When India started its space programme in 1962, and ISRO was formed on August 15th, 1969, one should keep in mind that Yuri Gagarin had gone to outer space and came back safely in 1961 itself. We also had Neil Armstrong landing on the moon in 1969. Hence, we were something like 60 years behind the advanced nations in space technology. But over the years we could more or less bridge this gap and also come out with flying colours in many areas.

- From the first launch of the tiny rocket from Indian soil on 21st November 1963, till today we have launched more than 4000 sounding rockets from India.
- The First launch vehicle – SLV3 was launched successfully in 1980. To our credit, we have so far developed 6 generations of launch vehicles (SLV3, ASLV, PSLV, GSLV, LVM3 & SSLV) and launched 101 launch vehicle missions.
- As far as satellites are concerned, in 1975, we had the launch of our first spacecraft, Aryabhatta. From that humble beginning, till today, we have developed and realised a total of 132 satellites serving us in various applications. Over the years, the designed life of satellites has increased from 7 to 15 years and the power handling ability has increased from 6 kW at 42V to 20 kW at 70V. We have also launched 433 satellites of 34 foreign countries and other student satellites.
- Chandrayaan 1 mission was a great success and became the first mission in the world to find presence of water on the moon. We all are all aware that our Chandrayaan – 2 mission had placed an orbiter with the best OHRC camera, which is still functioning but we narrowly missed the soft landing in the last 2.10 km. I had the privilege to be the Expert Committee Chairman to identify possible anomalies and make suitable recommendations for the next mission. My team did extensive analysis and came out with more than 100 recommendations, all of which were effectively implemented in the Chandrayaan 3 mission, ensuring 100% success, making India proud and made history of becoming the first country in the world to soft land near the south pole of the moon.
- The Mars Orbiter Mission (MOM) was also a well-acclaimed mission, which our honourable PM has described as the expense per kilometre travel was less than Auto fare and also total expenditure less than many Hollywood movies. We were the first country successfully accomplish this mission on the first attempt.
- India holds the world record of placing in orbit 104 satellites in a single launch, for the first time. We also had a successful re-entry of the spacecraft capsule in SRE-1 in first attempt.
- Indigenous cryogenic development after technology denials is another proved development. I was so proud to be the Project Director of C25 cryogenic stage, where we have three world records during the development.
- We also placed One Web 1 & 2, putting 72 commercial satellites in precise orbits last year using our LVM3 vehicle.
- We have also successfully placed our Adithya spacecraft in the Legrangian point L1 of the sun thus becoming only the 4th country to have a satellite to study the sun.
- India became the fourth country in the world to achieve Docking of spacecraft in space just less than 4 months ago.
- Over the years, our satellites have provided applications ranging from Communication, Meteorology, Cartography, Disaster Warning, Television broadcasting, Telemedicine, Tele education, Village Resource Centres, Remote Sensing, Oceanography, Mineral/Resource mapping just to name a few. India has gifted a satellite for the benefit of all SAARC countries. The Indian NAVIC system has a constellation of

spacecrafts which is also serving the country in various domains. Real Time Tracking system is also introduced for 8700 trains. The satellites have played a major role in disaster warning, giving early warning, saving thousands of lives.

- For the fishermen, we have developed applications for getting information about their location.
- Potential fishing zones monitoring and informing is yet another success story.
- Bhuvan portal, equivalent to Google is also developed and deployed.
- At present, we are in the advanced development stages of our Gaganyaan, our human space mission, wherein we shall be for the first time taking Indians to space and return them safely using our own launcher. Towards this program, the first unmanned mission is planned very shortly. This is a national program which involves meticulous mission planning and the development of cutting-edge technologies.
- Our Prime Minister has recently rolled out the broad envelope of where our space programme has to reach in the coming years. The Chandrayaan-4 programme is already approved and this mission shall be planned as a sample return mission. The Bharathiya Anthariksh station (BAS) shall be a reality by 2035 for which the initial modules in space shall start as early as 2027. An Indian has to land in moon and return safely by a fully indigenous moon mission by 2040. A Venus Orbiter Mission (VOM) has also been approved where we shall be sending a spacecraft to study planet Venus. A heavy lift Next Generation Launch Vehicle (NGLV) with a recoverable first stage has also been approved by Govt of India. You can imagine the complexity involved in these missions and the degree of quality consciousness and levels to be displayed in each and every subsystem we are going to roll out.

When we look at ISRO, the organisation is built by generations of leaders and each of them has played their role very well. It had a visionary leader, Dr. Vikram Sarabhai, Institution builder Prof. M G K Menon & Dr. Satish Dhawan, Dedicated first Launch Vehicle PD, Dr. APJ Abdul Kalam, a risk taking, first spacecraft PD and former Chairman Prof. UR Rao, a multifaceted personality – Dr. Kasturirangan, a great visionary and humanitarian leader - Dr Madhavan Nair, the Task Masters – Dr. Radhakrishnan, Shri. Kirankumar, Dr. Sivan and Dr S Somanath.

The Government of India has also rolled out the Space Sector Reform to bring out a vibrant space ecosystem in the country. The success of the Indian Space Programme is due to the organisation's open working culture, teamwork, risk-taking ability and above all the outstanding human resource.

Summary

Dear graduates, as Dr. APJ Abdul Kalam used to say, you should always be righteous in the heart, which leads to beauty in the character, beauty in the character brings harmony in the home, harmony in the home leads to order in the nation, and the order in the nation leads to peace in the world. As you pass out, you have plenty of opportunities, effectively utilise them and contribute to making *Bharat* a developed nation and also contribute to the peaceful and happy life of the global community.

Once again, let me congratulate all the graduating students. My best wishes to the NIT team for developing good quality human resources required for transforming India into a developed nation. Let me once again thank the NIT, Trichy, for giving me the opportunity to be with you today.

May GOD bless you. Thank you, Jai Hind! ❑

CAMPUS NEWS

Faculty Development Programme on AI and MOOCs in the Evolution of Digital Pedagogy

A six-day Faculty Development Programme on 'AI and MOOCs in the Evolution of Digital Pedagogy for *Viksit Bharat*@2047' was organised by the Faculty Development Centre, Sri Dev Suman Uttarakhand University, recently. The programme brought together distinguished resource persons from leading universities, central institutions, and research organisations across India. The event witnessed enthusiastic participation from faculty members, research scholars, and academic practitioners across disciplines and regions, making it a vibrant platform for the exchange of ideas and collaborative learning.

The Chief Guest, Prof. N K Joshi, Vice Chancellor, Sri Dev Suman Uttarakhand University, delivered the keynote address. He underscored that technological innovation, coupled with academic excellence, is the cornerstone for India's future in higher education. He pointed out that Artificial Intelligence and MOOCs are not merely supporting tools but critical enablers in shaping an inclusive, globally competitive, and learner-centric academic ecosystem. His words set the vision and tone for the entire programme.

Prof. Anita Tomar, Director, Faculty Development Centre, extended a warm welcome to all participants and speakers. She stressed that Indian higher education stands at a transformative crossroads, where the convergence of innovation, technology, and pedagogy will determine the future of academic excellence. She described the Faculty Development Programme as a comprehensive academic experience designed to equip teachers with AI-powered teaching and research tools, strategies for integrating MOOCs into the curriculum, and an understanding of how generative AI and deep learning can redefine digital pedagogy. She highlighted that the event would enable teachers to design inclusive and future-ready learning environments in line with NEP-2020.

The programme structure was introduced by the Coordinator, Dr. Atal Bihari Tripathi, who explained the sequence of expert-led sessions, while Dr. Seema Baniwal, Co-coordinator, proposed the vote of thanks. The inaugural ceremony concluded with the National Anthem, marking the beginning of a rich academic journey.

Prof. Pushpender Kumar, University of Delhi, delivered the inaugural lecture on 'AI Tools for Research and Teaching'. He introduced participants to practical AI applications for research assistance, data analysis, academic writing, and the development of learner-centric content. The focus was on tools that could directly enhance both teaching quality and research productivity.

Dr. Deivam, Hemvati Nandan Bahuguna Garhwal University, Srinagar, Uttarakhand, spoke on 'Digital Pedagogy and AI in Education'. He emphasised the capacity of AI to support adaptive learning models, personalised teaching, and flexible classroom strategies. He demonstrated real-world examples where AI-driven analytics help educators tailor teaching to diverse student needs.

The session on 'Natural Language Processing in Education' was handled by Prof. Mamta Rani, Central University of Rajasthan. She offered participants a glimpse into the world of NLP applications, ranging from automated essay scoring and intelligent tutoring systems to advanced language learning tools. The session illustrated how language technologies are bridging communication gaps and making education more interactive.

During his session, Dr. Atal Bihari Tripathi, Sri Dev Suman Uttarakhand University, spoke on the theme 'MOOCs Integration Strategies'. He discussed how online platforms can complement classroom teaching by ensuring flexibility, inclusivity, and scalability. He emphasised how MOOCs can bring world-class resources to local classrooms and enable blended learning. This was followed by an in-depth lecture on 'Neural Networks and Deep Learning' by Dr. Ajay, Central University of Rajasthan, who explained the working of deep learning algorithms and their applications in image processing, speech recognition, and education technology. Participants gained clarity on how machine learning underpins many of today's AI-driven tools. The next session, 'Foundations of the Internet and AI in Teaching' by Dr. Krishna Kumar Mihbey, Central University of Rajasthan, explained the architecture of the internet, web browsers, and connectivity frameworks that enable MOOCs and AI tools to function effectively. The final session, 'AI Meets MOOCs' by Dr. Divya Srivastava, AIRDL, Ajmer, presented case studies on how the integration of AI into MOOCs can personalise content, enhance learner engagement, and support adaptive delivery.

The next day of the event was more hands-on and application-driven. Dr. G Jaculine Priya, LIBA, Chennai, delivered the session on 'AI Tools and Prompt Engineering'. The session provided participants with practical skills in designing effective prompts for generative AI systems. She showed how carefully crafted inputs can yield precise, useful, and context-specific outputs in teaching and research. The next session on 'Internet of Things (IoT*)'* was delivered by Dr. Gaurav Meena, Central University of Rajasthan. He highlighted how IoT-enabled campuses can create smart learning environments with connected classrooms, real-time data monitoring, and intelligent learning systems. Another session on 'AI Innovations in Academia and Research' by Prof. Shikha Gupta, Chandigarh University, showcased examples of how AI is being deployed in institutional decision-making, plagiarism detection, research analytics, and smart libraries. Finally, the session by Dr Divya Srivastava, titled 'Craft, Curate, Captivate: AI Tools Every Educator Should Know', presented a toolkit of everyday AI applications, including lesson planning aids, automated assessments, and interactive teaching platforms.

The session by Dr. Niradhar, Indira Gandhi National Open University on 'NEP-2020 in Digital Education and SWAYAM and its Framework' mapped how government initiatives are promoting inclusive education. He elaborated on the structure of SWAYAM as India's flagship MOOCs platform and the role of educators in developing high-quality online courses. This was followed by the session on 'AI and MOOCs: Redefining Digital Pedagogy for the Future' by Prof. Praveen Kumar Shukla, Babu Banarasi Das University, Lucknow, who stressed how AI can act as a bridge between traditional pedagogy and digital delivery. The last session, 'Generative AI Tools and Techniques' by Prof. Sumathi S., St. Joseph's College, Chennai, highlighted the creative power of generative AI in content development, curriculum design, and learner engagement.

Dr. K Thiyagu, Central University of Karnataka, delivered the session on 'AI Tools for Education and Learner-Centred Content Development' and encouraged participants to adopt learner-centric approaches and use AI tools to make content more engaging. It was followed by two practical sessions by Dr. Niradhar, IGNOU, on 'Structuring Online Modules for MOOCs and Exploring MOOCs Design through SWAYAM*'*. Those provided participants with a hands-on roadmap for designing, structuring, and implementing MOOCs effectively.

The Programme concluded with the event report presentation and valedictory session, where participants expressed how the sessions had broadened their horizons. In her concluding remarks, Prof. Anita Tomar, Director of the Programme, emphasised that the Faculty Development Programme not only strengthened teaching and research skills but also encouraged educators to reimagine their role in a technology-driven academic landscape. It provided participants with a rare combination of theoretical insights, practical training, and policy direction. The sessions inspired educators to integrate AI and MOOCs into their teaching, research, and institutional practices, making them active contributors to the national mission of transforming Indian higher education by 2047.

International Conference on Excellence in Research and Education

A three-day International Conference on 'Excellence in Research and Education' is being organised by the Indian Institute of Management Indore (IIM Indore), Madhya Pradesh from May 01-03, 2026. The theme of the event is 'Business Excellence Reimagined: Competing in the Age of AI'. A key focus of the event will be on providing emerging scholars with a platform to present their research and receive constructive feedback, fostering the next generation of academic leaders. By facilitating networking opportunities and promoting discussions on emerging trends, the event seeks to stimulate innovative thinking and contribute to the advancement of knowledge. The Research Areas of the event are:

- ***Accounting and Finance***

  From core financial management and accounting principles, the field has expanded into areas such as fintech, algorithmic trading, risk analytics, and forensic accounting. Research now focuses on sustainable finance, blockchain applications, and financial resilience in dynamic markets.

- ***Economics and Public Policy***

  Traditionally centred on market structures and policy-making, economic research now delves into behavioural economics, sustainability, digital economies, and financial inclusion. It aims to understand how evolving global and technological landscapes influence decision-making and resource allocation.

- ***Business Policy and Strategic Management***

  Strategic management research originated from military strategy and economic theories, initially focusing on competitive advantage and resource allocation. It has evolved to integrate innovation, sustainability, and dynamic capabilities, emphasising long-term value creation and adaptability in the rapidly changing knowledge-driven economy.

- ***Communication***

  Initially focused on traditional corporate and interpersonal communication, this area has evolved with the rise of digital platforms and AI-driven messaging. Research now explores media strategies, virtual collaboration, persuasive communication, and the impact of technology on human interaction.

- ***Marketing***

  While originally centred on consumer behaviour and brand management, marketing research now explores neuromarketing, digital consumer engagement, AI-powered analytics, and the psychological impact of social media on purchasing decisions.

- ***Humanities and Social Sciences***

  Initially grounded in classical theories of human behaviour and ethics, this area now integrates interdisciplinary research on workplace culture, social transformation, and the ethical implications of AI and automation in business and society.

- ***Operations Management and Quantitative Techniques***

  Moving beyond traditional process optimisation and supply chain efficiency, research now focuses on AI-driven logistics, predictive modelling, sustainability in operations, and decision sciences for complex, data-heavy environments.

- ***Organisational Behaviour and Human Resource Management***

  Initially focused on workplace motivation and leadership, OBHR now examines agile work environments, employee well-being, diversity and inclusion, gig economy dynamics, and the impact of remote work on organisational culture.

- ***Information Systems in Management***

  Evolving from fundamental IT systems and database management, research now emphasises digital transformation, cybersecurity, AI-driven decision-making, and the role of big data in business intelligence and innovation.

For further details, contact the Organising Secretary, Indian Institute of Management Indore, Madhya Pradesh-453 556. E-mail: *cere@iimidr.ac.in.* For updates, log on to*: www. iimidr.ac.in/research-publications/conference/*

National Workshop on Modern Deep Learning Architectures

A five-day National Workshop on 'Modern Deep Learning Architectures in Computer Vision: Concepts, Design, and Research Trends' is being organised by the Department of Information Technology, NIT Raipur, Chhattisgarh from March 16-20, 2026. The faculty members, research scholars and M. Tech / MS in Computer Science, AI, Data Science, and related disciplines, and industry professionals involved in vision-based AI systems may participate in the event.

The event is a focused academic workshop that bridges foundational theory with current research practice in computer vision. The workshop examines how modern deep learning architectures are designed, why they work, and where the field is heading. Rather than treating models as black boxes, the sessions unpack architectural choices, training strategies, and evaluation practices that drive real-world performance in vision tasks. Emphasis is placed on understanding research trends, reading recent literature critically, and translating ideas into implementable solutions. The Topics of the event are:

- Foundations and Evolution.
- Convolutional Architectures.
- Attention and Transformer-based Models.
- Advanced Architectural Concepts.
- Research Trends and Open Challenges.

For further details, contact the Convenor, Dr. Sudhakar Pandey, Head, Department of Information Technology, National Institute of Technology, Raipur, Chhattisgarh-492010. Contact on: 09853125354 / 07389233152. For updates, log on to: *www.nitrr.ac.in/events/*

World Conference on Shaping the Future with Computational Intelligence and AI Innovations

A two-day World Conference on 'Shaping the Future with Computational Intelligence and AI Innovations' is being organised by the Department of Computer Science and Engineering, Chandigarh University, Punjab from March 26-27, 2026. The event is a landmark global event celebrating the transformative power of computational intelligence, Artificial Intelligence (AI), and cutting-edge technologies across diverse domains. It serves as a dynamic platform where visionaries, researchers, industry leaders, and academics come together to share groundbreaking innovations, inspire ideas, and forge partnerships that may shape the future. The conference highlights the fusion of technology and human ingenuity, showcasing interdisciplinary approaches and real-world applications that are driving innovation in diagnostics, personalised patient care, and system optimisation. The Tracks of the event are:

Track-1*: Artificial Intelligence and Machine Learning*

- Neural Networks.
- Deep Learning.
- Expert Systems.
- Data Mining.
- Fuzzy Logic.
- Natural Language Processing.
- AI in Cybersecurity.

Track-2: ***Computing Paradigms and Technologies***

- Quantum Computing.
- Cloud Computing.
- High-Performance Computing.
- Cognitive Computing.
- Grid Computing.
- Embedded Computing.
- Mobile Computing.
- Green and Sustainable Computing.

Track-3: ***Machine Vision, Perception, and Bioinformatics***

- Computer Vision.
- Image Processing.
- Medical Diagnostics.
- Human-Computer Interaction.
- Video Analysis.
- Augmented Reality (AR) and Virtual Reality (VR).
- AI in Drug Discovery.
- Disease Modeling and Prediction.

Track-4: ***Emerging Trends and Applications in Computing***

- Big Data and Data Analytics.
- Internet of Things (IoT).
- Blockchain Technologies.
- Cyber-Physical Systems.
- Smart Cities and Machine-to-Machine (M2M) Communication.
- Social Computing.
- Digital Transformation.
- Industry 4.0 and Digital Twins.

For further details, contact Organising Chair, Prof. Meenu Gupta, Professor, Department of Computer Science Engineering, Chandigarh University, Punjab-140413, Mobile No: 8708951544, E-mail : *WcCST@cumail.in.* For updaters, log on to : *www. cuchd.in/conference/ WcCST-26/* ❑

Book Review

A Strong Teaching Resource

Suresh Sharma*

Narayana, D., Ranjan, Sharad and Tyagi, Nupur (2023). ***Basic Computational Techniques for Data Analysis:*** **An Exploration in MS Excel, Routledge, Second Edition, Paperback, PP 300, Rs 725/.**

'Basic Computational Techniques for Data Analysis: An Exploration in MS Excel' presents a structured and application-oriented introduction to data analysis using spreadsheet technology. The book addresses a persistent gap in higher education, particularly in the social sciences, commerce, and management disciplines, where statistical theory is often taught without adequate emphasis on computational implementation. By integrating statistical reasoning, financial analysis, and spreadsheet-based procedures, the authors aim to equip learners with practical analytical skills that align with academic research and professional requirements. The text positions Excel not merely as a data-entry tool but as a comprehensive platform for quantitative analysis.

The book follows a carefully sequenced three-phase structure that reflects a progressive learning model.

Phase I focuses on foundational Excel operations, including worksheet structure, data entry, formatting, sorting, filtering, visualisation, and pivot tables. While these topics may appear introductory, their inclusion is pedagogically significant, particularly for learners with a limited digital or computational background. The authors correctly emphasise that sound data management practices form the basis of reliable analysis. By ensuring operational fluency in spreadsheet handling, this section prepares readers for more advanced quantitative tasks.

Phase II transitions into statistical analysis, covering measures of central tendency, dispersion, skewness, kurtosis, correlation, regression, and hypothesis testing. The distinctive feature of this section is the integration of conceptual explanation with step-by-step Excel procedures. Rather than treating statistics as an abstract mathematical discipline, the text demonstrates how built-in spreadsheet tools can be used to compute and interpret results. The treatment of regression analysis is particularly noteworthy, as it introduces inferential reasoning within a practical computational framework, mirroring real-world research practices.

Phase III extends the discussion into financial and growth-related computations, including growth rates, compounding, future value, Net Present Value (NPV), Internal Rate of Return (IRR), and loan amortisation. This section broadens the book's relevance to economics, finance, and management education. The presentation of financial decision-making tools within the same computational environment reinforces the interdisciplinary applicability of spreadsheet analysis. The chapters on growth estimation, including regression-based growth techniques, are particularly relevant for policy analysis and development studies.

The book adopts a highly instructional and learner-centred approach. Concepts are presented through a consistent pattern of definition, explanation, numerical illustration, and Excel-based execution. Numerous figures, screenshots, and practice exercises support experiential learning. The language remains clear and accessible without oversimplifying key ideas, making the text suitable for students with only basic mathematical preparation. The inclusion of exercises encourages independent practice and reinforces computational confidence.

Another significant pedagogical contribution is the emphasis on real-world data sources. The authors introduce readers to publicly available national and international datasets, thereby

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promoting research readiness and data literacy. This practical orientation encourages learners to engage with authentic data rather than relying solely on hypothetical examples.

The primary strength of the book lies in its ability to bridge the gap between statistical theory and computational practice. By situating quantitative techniques within a familiar and widely accessible software environment, the text enhances both learning outcomes and professional relevance. Its interdisciplinary coverage of statistics and finance further increases its utility across multiple academic domains. The structured progression, visual support, and hands-on orientation make it especially effective for applied learning contexts

The book's Excel-centric focus, while beneficial for accessibility, also constitutes a limitation. It does not introduce readers to statistical programming environments such as R or Python, which are increasingly important in advanced data science and econometric applications. Additionally, the treatment of regression and hypothesis testing remains at an introductory to intermediate level and does not extend to advanced econometric modelling. However, these limitations reflect the defined scope of the text as a foundational and skill-building resource rather than a specialised advanced manual.

The book is particularly well-suited for undergraduate and postgraduate students in economics, commerce, management, and social sciences. It also serves as a practical teaching resource for instructors and a reference guide for early-stage researchers and professionals requiring routine statistical and financial computations. Its emphasis on spreadsheet-based analysis aligns well with the growing demand for digital data literacy across disciplines

Overall, Basic Computational Techniques for Data Analysis is a valuable contribution to applied quantitative education. It successfully transforms Excel into an instructional laboratory for statistics and financial analysis, enabling learners to translate theoretical knowledge into practical competence. While not a substitute for advanced statistical software training, the book fulfils an essential role by making data analysis accessible, structured, and professionally relevant. Its integration of conceptual clarity, computational guidance, and real-world applicability makes it a strong resource for foundational quantitative learning.

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COMMUNICATION

Nurturing India's Academic Excellence and Research Innovation Amid AI

Chaitali Moitra*

As artificial intelligence continues to impact higher education and research worldwide, India's institutions are navigating what this shift means for originality, trust, and scholarly success. These themes were at the heart of *Anveshan 2025,* hosted by the Association of Indian Universities (AIU), where Turnitin joined academic leaders, educators, and researchers to strategise on the future of academia in the AI era.

Across the North, East, and South zonal events in 2025, one message resonated clearly: AI presents a significant opportunity for India, but only if institutions can uphold the principles that underpin academic excellence. Attendees spoke candidly about both the promise of generative AI and the challenges it places on academic quality, honesty and research practice.

Throughout the discussions, several key themes emerged:

Upholding originality in academic and research work, with recognition that a strong culture of academic integrity provides a foundation for responsible and effective AI use.

- **Concern about research paper retractions** resulting from undisclosed AI use or flawed AI output, and the importance of promoting research best practices.
- **Avoiding over-reliance on generative AI**, with a priority on humans' critical thinking, scholarly voice, and disciplinary expertise remaining central to education and research.
- **Rising expectations for transparency in academic writing**, including clearer identification of AI use and establishing greater trust between writers and evaluators.
- **A shared concern about AI skill gaps** alongside an ambition to adapt confidently and remain globally competitive in research and innovation.

Some institutions in India rely on traditional, compliance-focused approaches to deter misconduct; however, there is growing awareness of the value in promoting a more formative approach to integrity. This is especially relevant for institutions that are not seeking to restrict AI innovation but to guide it responsibly—ensuring that AI enhances, rather than diminishes, the quality and credibility of academic work.

With changes afoot in India's higher education system and while AI policy is taking shape, institutions still need confidence in the academic and research decisions they make today. In response, Turnitin is bringing clarity, consistency, and peace of mind to academic and research workflows as governance and AI guidelines continue to evolve.

Turnitin's AI writing indicator helps institutions understand when and how generative AI has been used in academic work—including the use of 'AI bypasser' tools designed to evade detection. Our solutions also go beyond detection to support students and researchers in adopting ethical habits in the academic writing process. The award-winning Turnitin Clarity enables faculty to assess how work was developed over time, not just the final submission, with insights to guide constructive use of AI and deliver targeted feedback.

The discussions at Anveshan 2025 helped illuminate a path forward for Indian higher education. The question is no longer whether AI will be part of academic and research practice, but how responsibly it is integrated. With strong partnerships, shared understanding, and the right integrity frameworks in place, Indian institutions are well-positioned to lead with confidence in this new era of AI-enabled scholarship.

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**Regional Director, Turnitin. E-mail:cmoitra@turnitin.com*

THESES OF THE MONTH

HUMANITIES

A List of doctoral theses accepted by Indian Universities

(Notifications received in AIU during the month of Dec 2025-Jan 2026)

Cultural Studies

1. Maithreyee, K G. **To evaluate the fundamental principles and construction techniques of Vesara or Hoysala Temple architecture in Karnataka between 11th and 14th century AD**. (Dr. Rajani Jairam), Department of Humanities & Social Sciences, Jain (Deemed-to-be University), Bangalore.

History

1. Mandal, Kuldeep. **British Bharat ke prashasnik parivartan: Ek saiddhantik vishleshnatamak adhyayan 1858 isvi-1935 isvi tak**. (Dr. Vibhanshu Mandal), Department of History, T M Bhagalpur University, Bhagalpur.
2. Singh, Ashish Kumar. **Vaidik kaal mein paryavarniye chintan aur vartman samey mein iski prasangikta: Ek adhyayan**. (Dr. Himanshu Shekhar), Department of History, T M Bhagalpur University, Bhagalpur.
3. Sudarshan, H S. **Study of comets and related celestial phenomena as depicted in ancient Sanskrit texts**. (Dr. R N Iyengar), Department of Humanities & Social Sciences, Jain (Deemed-to-be University), Bangalore.

LANGUAGES & LITERATURE

English

1. Ambhore, Madhavrao Bhagwanrao. **Civilization, human nature, good and evil in Sir William Golding's novels Lord of the Flies, The Inheritors, Rites of Passage and The Paper Men**. (Dr. Sachin L Patki), Department of English, Swami Ramanand Teerth Marathwada University, Nanded.
2. Benny, Ann Treessa. **Shades of ex-centricity: An analysis of madness in select postcolonial Indian English fiction**. (Dr. Abilash Chandran R), Department of English and Cultural Studies, Christ (Deemed to be University), Bengaluru.
3. Dhengle, Pramod Mahadeorao. **Exploration of the indigenous culture and tradition among the Angami Nagas in the works of Easterine Kire**. (Dr. R D Mundhe), Department of English, Swami Ramanand Teerth Marathwada University, Nanded.
4. Dogra, Akanksha. **Identity, culture and nation in the works of Amitav Ghosh, Rohinton Mistry, Salman Rushdie and Bapsi Sidhwa**. (Dr. Abhilasha Singh and Dr. Nipun Chaudhary), Amity School of Liberal Arts, Amity University, Gurugram.
5. Hasargunde, Chetna Omprakash. **Trauma of identify crisis of women in the fictional world of Bapsi Sidhwa**. (Dr. Smita R Nagori), Department of English, Swami Ramanand Teerth Marathwada University, Nanded.
6. Joseph, Gifty. **Contextualising text worlds: A cognitive stylistic study of select poems of Charles Tomlinson**. (Dr. John Joseph Kennedy P), Department of English and Cultural Studies, Christ (Deemed to be University), Bengaluru.
7. Joshi, Kishankumar Dalpatray. **Translation of the selected oral narratives of Dungari Bhils collected by Bhagwandas Patel with a critical introduction**. (Dr. Nila Shah), Department of English, Saurashtra University, Rajkot.
8. Kamble, Prakash Dashrathrao. **Decoding social inequality: A study of Dr B R Ambedkar's select prose writings**. (Dr. Arvind M Nawale), Department of English, Swami Ramanand Teerth Marathwada University, Nanded.
9. Paramar, Bhavesh Giga. **A critical study on human and animal's coexistence in the selected works of Damien Lewis, Jack London and Yann Martel**. (Dr. Vipul Kapoor), Department of English, Saurashtra University, Rajkot.
10. Ramesh, Gopika L. **Negotiating personhood in postcolonial Trinidad: Reading public spaces in select novels of Earl Lovelace**. (Dr. Sharon J), Department of English and Cultural Studies, Christ (Deemed to be University), Bengaluru.
11. Raviya, Riddhi Mukeshbhai. **Alice Munro and Himanshi Shelat: A thematological study**. (Dr. Pramodsingh R Chauhan), Department of English, Saurashtra University, Rajkot.
12. Rellan, Vandana. **Discourse analysis of English language in advertising for online education in India**. (Prof. Hitesh Raviya), Department of English, Maharaja Sayajirao University of Baroda,Vadodara.

13. Roy, Abhipriya. **The impact of integrating web based storytelling in high school English language education: An experimental study**. (Dr. Bhavani S), Department of English and Cultural Studies, Christ (Deemed to be University), Bengaluru.

14. Sabu, Melba. **Situating waste in the works of Janice Pariat, Kamila Shamsie and Shubhangi Swarup: An ecocritical study**. (Dr. Ajay Kumar), Department of English and Cultural Studies, Christ (Deemed to be University), Bengaluru.

15. Samuel, Christine Elizabeth. **An ecocritical analysis of the original folk and fairy tales of the Brothers Grimm**. (Dr. Richa), Department of English and Cultural Studies, Christ (Deemed to be University), Bengaluru.

16. Sarkar, Soumita. **The role of error analysis in teaching and learning of English as a second language: A case study in Jawahar Navodaya Vidhyalaya**. (Dr. Bharti Dave), Department of English, Gujarat University, Ahmedabad.

Hindi

1. Durga Prasad. **Hindi Sufi sahitya ka soundaryabodh: Ek aalochanatmak adhyayan**. (Prof. M P Pandey), Department of Hindi, North Eastern Hill University, Shillong.

2. Kendre, Dhondiba Baburao. **Hariram Meena ke yatra vritanttoh mein vyakt adivashi jeevan-sangarsh**. (Dr. Ramesh Sambhaji Kure), Department of Hindi, Swami Ramanand Teerth Marathwada University, Nanded.

3. Lute, Rupali Arun. **Sanjeev ke katha sahitye mein adivashi vimarsh**. (Dr. Jogendra Singh Bisen), Department of Hindi, Swami Ramanand Teerth Marathwada University, Nanded.

Nepali

1. Sharma, Shiben. **Samaya tattwaka aadharma Indrabahadur Raika Kathaharuko vishlesanaatmak adhyayan**. (Dr. Pushkar Parajuli), Department of Nepali, University of North Bengal, Darjeeling.

Sanskrit

1. Adhikari, Puran. **Narayana Bhattakrtasya prayogaratnasya sampadanam samiksananca**. (Prof. Gopal Prasad Sharma), Department of Veda, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

2. Awasthi, Taruna. **Shrimadbhagavadgitoktadharmashastriyatattvanamanushilanam**. (Prof. Yashveer Singh), Department of Dharmashastra, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

3. Dash, Soumya Ranjan. **A comparative study of doctrines of Vijnaneswara and Jimutavahana's thought of the subject of sonless men's property**. (Prof. Sudhanshu Bhusan Panda), Department of Dharmashastra, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

4. Dash, Subrat Kumar. **A deontological review of the duties relating to the King mentioned in Shanti-parva of Mahabharat**. (Prof. Sudhanshu Bhusan Panda), Department of Dharmashastra, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

5. Hegde, Ganesh. **Narayanatirthaviracitasya advaitaratnakarasya pathasampadanam samiksatmakamadhyayananca**. (Dr. Janakisharana Acharya), Department of Darshana, Shree Somnath Sanskrit University,Veraval.

6. Jadav, Ajaykumar Jerambhai. **The nature of dance in natyasastra of Bharata and Nrtyadhyaya of Asokamalla**. (Dr. M K Moliya), Department of Sanskrit, Saurashtra University, Rajkot.

7. Jani, Prakashbhai Pravinbhai. **Srimadbhagavadgitaya upabrmhakam Srimadbhagavatamahapuranam ekamadhyayanam**. (Dr. Pankajkumar Rawal), Department of Purana, Shree Somnath Sanskrit University, Veraval.

8. Jha, Siddhinath. **Shikshnadhigamdrishtya Sandheyrnusheelanam**. (Dr. Sureshwar Jha), Department of Vyakaran, Kameshwara Singh Darbhanga Sanskrit University, Darbhanga.

9. Maharshi, Narendra. **Sidhantkomudayah karakprakaranseya prormanoramalaghushabdeyendusheykharteekyoaha: Aaloke sameekshatamakmadhyayanam**. (Dr. Mayuriben Bhatia), Department of Sanskrit, Gujarat University, Ahmedabad.

10. Manoj Kumar. **Comparative study of Yogataravali and Hathayogapradipika**. (Prof. Jawaharlal), Department of Sarva Darshan, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

11. Mishra, Anupam. **A critical study of the Samskaratattva written by Mahamahopadhyaya Shri Raghunandanabhattacharya**. (Prof. Sudhanshu Bhusan Panda), Department of Dharmashastra, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

12. Niraula, Dharmaraj. **Paninyastakasutresvanyacaryamatanam Samiksanam**. (Prof. Ramsalhai Dwivedi), Department of Vyakarana, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

13. Pal, Subhas. **Yogsutrasadhanapadasya Shattikanam samikshanam**. (Prof. Markandey Nath Tiwari), Department of Sankhya Yoga, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

14. Semwal, Vishnu Prasad. **Sanskritsahitye Rashtrabodhvimarshas**. (Prof. Murlimanohar Pathak), Department of Sahitya, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

15. Shuchi. **An analytical study of Dattaka Chandrika made by Kubera Bhatta**. (Prof. Sudhanshu Bhusan Panda), Department of Dharmashastra, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

16. Suraj Kumar. **Jyotishashastradrushtya Grahajanyarogshamanopayanam prayogikam samikshanam**. (Prof. Vinod Kumar Sharma), Department of Phalit Jyotisha, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

17. Tripathi, Ashutosh Mani. **MuraariMisrakrtparaskaragrhyasutrabhasyasya sampadanam Samiiksananch**. (Prof. Gopal Prasad Sharma), Department of Veda, Shri Lal Bahadur Shastri National Sanskrit University, New Delhi.

18. Trivedi, Rahul Ravindrabhai. **LaghukamaYajurvedagruhyasutraprakashah: sampadanam samikshatmakam adhyayanam ch**. (Dr. Ravindrakumar V Khandwala), Department of Sanskrit, Gujarat University, Ahmedabad.

Urdu

1. Shaikh, Maola Ismaeel Sab. **Hafeez Jalandhari ki Nazm Nigari ka tanqeedi mutala: Shahbama-e-Islam ke Khususi hawale se**. (Dr. Mohd Maqbool Ahmed), Department of Urdu, Swami Ramanand Teerth Marathwada University, Nanded.

PERFORMING ARTS

Music

1. Parmar, Pritesh Mahendrabhai. **Supportive instrument Tanpura in North Indian classical music: A study**. (Dr. Jay Sevak), Faculty of Performing Arts, Saurashtra University, Rajkot.

2. Vaishampayan, Arpita. **Chhota Gandharva: An epitome of creativity in Indian music**. (Prof. Sheetal More), Department of Music, S.N.D.T. Women's University, Mumbai.

Philosophy

1. Bhattacharjee, Gobinda. **Post-metaphysical critique and theory of knowledge: A study on Jurgen Habermas**. (Dr. Anup Jyoti Sarma), Department of Philosophy, Tripura University, Suryamaninagar.

RELIGION

Buddhism

1. Arnandar. **Gratitude to parents in Buddhism: A blueprint for mindful parenting**. (Dr. Arvind Kumar Singh and Dr. Bhuwan Kumar Jha), Department of Buddhist Studies and Civilization, Gautam Buddha University, Greater Noida.

2. Chinh, Nguyen Minh. **Development of Mahayana Buddhism in China: A survey from 1st to 6th century CE**. (Dr. Arvind Kumar Singh), Department of Buddhist Studies and Civilization, Gautam Buddha University, Greater Noida.

3. Diem, Mai Thi. **Modern Sakyadhitas: A study of the struggles and accomplishments of engaged Buddhist women of Asia**. (Dr. Arvind Kumar Singh), Department of Buddhist Studies and Civilization, Gautam Buddha University, Greater Noida.

4. Lappermsap, Suttisa. **Development of the conception of Buddhanussati in Theravada philosophy: An approach to doctrinal analysis**. (Dr. Arvind Kumar Singh), Department of Buddhist Studies and Civilization, Gautam Buddha University, Greater Noida.

Jainism

1. Vijay, Muni Puranchandra. **Jain darshan mein jeev ki avadhaaranaa aur uski purna vikas yatra**. (Dr. Trapti Jain), Department of Humanities & Social Sciences, Jain (Deemed-to-be University), Bangalore.

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To Our Readers

Knowledgeable and perceptive as they are, our contributors must not necessarily be allowed to have the last word. It is for you, the readers, to join issues with them. Our columns are as much open to you as to our contributors. Your communications should, however, be brief and to the point.

Dr Sistla Rama Devi Pani, Editor

BHAKTA KAVI NARSINH MEHTA UNIVERSITY - JUNAGADH

Employment Notification

Bhakta Kavi Narsinh Mehta University invites Online Applications (Second Attempt) for Recruitment for the following PwD Teaching Posts. Candidates are advised to visit university **website www.bknmu.edu.in** for details of posts, minimum qualifications, category, experience, pay scale, general terms & conditions and other details before applying online on website. Applications received after due date will not be considered.

Sr. No.	Advt. No.	No. of Post	Posts
01	01/2026	01	PwD (B,LV) Associate Professor, Commerce
02	01/2026	01	PwD (B,LV) Assistant Professor, Chemistry (Organic)

Date of commencement of online application	31/01/2026
Last date of online application	20/02/2026
Last date of receipt of hardcopy of online application form along with enclosures	24/02/2026

Date:31/01/2026 **Registrar**

Junagadh

Senapati Prataprao Gujar Shikshan Sanstha, Kanadewadi's

RAJA SHIVCHHATRAPATI ARTS & COMMERCE COLLEGE, MAHAGAON

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(Affiliated to Shivaji University, Kolhapur)

(Permanently Granted)

WANTED

Applications are invited from eligible candidates for the following posts:

Sr. No.	Name of the Posts	Vacant Posts	Reservation
1	Principal	01	Open to All - 01
2	Director of Physical Education	01	OBC - 01

Place:

Date:

President/Secretary

Senapati Prataprao Gujar Shikshan Sanstha, Kanadewadi,
Tal- Gadhinglaj, Dist- Kolhapur – 416504

Latthe Education Society, Sangli (Jain Minority Institution)

Wood House Road, Rajnemi Campus, Sangli,
Tal. Miraj, Dist. Sangli – 416 416 (Maharashtra)
(Affiliated to Shivaji University, Kolhapur)

(Permanently Granted)

WANTED

Applications are invited from eligible candidates for the following posts:

Sr. No.	Name of College	Name of Posts	Vacant Posts	Total Vacant Posts	Total Unreserved (Open) Posts
1	Smt. Gangabai Khivaraj Ghodawat Kanya Mahavidyalaya, Jaysingpur	Principal	01	Total 04 Posts	04 Posts Open to all
		Librarian	01		
2	Smt. Kasturbai Walchand College of Arts & Science, Sangli	Librarian	01		
3	Ganpatrao Arwade College of Commerce, Sangli	Director of Physical Education	01		

NOTE :-
1) **For detailed information about posts, qualifications and other terms and conditions please visit University website : www.unishivaji.ac.in**
2) **Applications should be in prescribed format, available on the Institute Website : www.lattheeducation.in**

Place: Sangli
Date : 12/02/2026

Chairman
Latthe Education Society, Sangli

Satara Maratha Vidya Prasarak Samaj Satara
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NAAC Reaccredited 'B+ Grade' 2024 (CGPA - 2.53)
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Applications are invited from eligible candidates for the following post :

Sr. No.	Name of Post	Vacant post	Reservation
1.	Principal	01	Post – 01 (Open)

Note: For detailed information about post, qualifications and other terms and Conditions please visit University **website : www.unishivaji.ac.in.**

Place Satara
Date

President
Satara Maratha Vidya Prasarak Samaj, Satara

Secretary
Satara Maratha Vidya Prasarak Samaj, Satara

Shikshan Prasarak Mandal's

College of Pharmacy, Akluj

Sangola Road, Malewadi-Akluj, Tal.Malshiras Dist. Solapur 413101
Phone No. (02185) 224243, 226433,
Email: copakluj@gmail.com

(Affiliated to Punyashlok Ahilyadevi Holkar Solapur University, Solapur)

UNAIDED (NON-MINORITY, PERMANANTALY NON GRANTABLE)

Applications are invited for the Post of PRINCIPAL from the Academic Year 2025-26:

Sr. No.	Designation	Total Vacant Posts
1	Principal	01

Note:

1. Apply giving the full particulars **within 30 days** from the date of publication of this advertisement to the undersigned.
2. For detailed information for above post, qualifications and other terms and conditions, please visit University **website : www.sus.ac.in.**

Place : Akluj
Date : 12.02.2026

President / Secretary
Shikshan Prasarak Mandal, Akluj
Tal.Malshiras, Dist.Solapur
Pin Code: 413101, Maharashtra State.

Shikshan Prasarak Mandal's

College of Pharmacy, Akluj

Sangola Road, Malewadi-Akluj, Tal.Malshiras Dist. Solapur 413101
Phone No. (02185) 224243, 226433,
Email: copakluj@gmail.com

(Affiliated to Punyashlok Ahilyadevi Holkar Solapur University, Solapur)

UNAIDED (NON-MINORITY, PERMANANTALY NON GRANTABLE)

Applications are invited from eligible candidates for the following Post of Professor/Associate Professor, Assistant Professor/Lecturer Academic Year–2025-26:

Sr. No.	Designation	Subject	Vacant Posts	Posts Reservation
01	Professor/ Associate Professor	Pharmacology	01	SC- 01 VJ-A- 01
		Pharmacognosy	01	
02	Assistant Professor/ Lecturer	Pharmaceutical Chemistry	03	SC- 01 ST- 01 VJ-A - 01 NT-B - 01 OBC – 02 (Female-1) EWS - 01 SEBC - 01 OPEN -02(Female-1)
		Pharmaceutics	02	
		Pharmacognosy	02	
		Pharmacology	03	

Note:

1. Apply giving the full particulars **within 30 days** from the date of publication of this advertisement to the undersigned.
2. For detailed information for above post, qualifications and other terms and conditions, please visit University **website : www.sus.ac.in.**

Place : Akluj
Date : 12.02.2026

President / Secretary
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Tal.Malshiras, Dist.Solapur
Pin Code: 413101, Maharashtra State.

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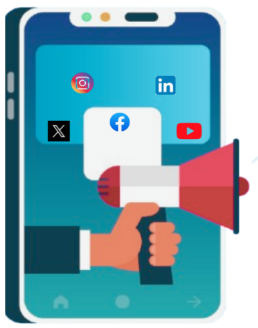

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Website: https://adslawcollege.com ● Email ID. ashokdadasablelawcollege@gmail.com ● Contact: 919511641944

APPLICATIONS ARE INVITED FOR THE FOLLOWING POSTS FROM THE ACADEMIC **YEAR 2025-26:**

UN-AIDED

Sr. No.	Cadre	Subject	Total No. of Posts	Reservation for Posts
01	Principal	LL.M. NET/SET/Ph.D	01	01- OPEN
02	Assistant Professor	Law LL.M. NET/SET/Ph.D	08	SC-01, ST- 01, DT(A) -01, OBC-01, OPEN-02, SEBC-01, EWS - 01
03	Librarian	M.Lib/NET/SET/Ph.D	01	Open -01

For Assistant Professor (Horizontal Reservation)

Persons with Disability Total Posts – 01 (A Group – B./LV- 01 Post), Sportsmen - 01

The Posts for the reserved category candidates will be filled in by the same category Candidates (Domicile of State of Maharashtra) belong to that particular category only.

Reservation for women will be as per **University Circular No. BCC/16/74/1998 dated 10th March, 1998. 4% reservation shall be for the persons with disability as per university Circular No. Special Cell/ICC/2019-20/05 dated 05th July, 2019.**

Candidates having knowledge of Marathi will be preferred.

"Qualifications, Pay Scale and other requirement are as prescribed by the UGC Notification dated 18th July, 2018, Government of Maharashtra Resolution No. Misc- 2018/C.R.56/18/UNI- 1, dated 26th March, 2019 and revised from time to time."

The Government Resolution & Circular are available on the website: mu.ac.in.

Applicants who are already employed must send their application through proper channel

Applicants are required to account for breaks, if any, in their academic career.

Application with full details should reach to the PRESIDENT, MANGAON SHIKSHAN PRASARAK MANDAL's ASHOKDADA SABLE LAW COLLEGE, At Post Mangaon Tal Mangaon District Raigad, **within 15 days** from the date of publication of this advertisement. This is University approved advertisement.

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Mail: sainursinginstitute@gmail.com ● Contact No.:- 9011214289

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Applications are invited from eligible candidates for filling up the below mentioned Regular posts:

Sr. No.	Name of Post	No. of Posts	Category of Post	Essential Educational Qualification & Working Experience
1	**Assistant Professor in Nursing**	03	UR – 03	**Essential Qualifications:** M.Sc. (Nursing) with minimum 3 years teaching experience.Desirable: Ph.D. (Nursing)

For all the above posts:

1. Applicants should compulsorily produce valid 15 years Residence Certificate of Goa.
2. Knowledge of Konkani is essential. Knowledge of Marathi is desirable.
3. Age limit shall not exceed 45 years (Relaxation as per rules of Govt. of Goa).
4. Candidates should possess a valid Employment Registration Certificate.
5. Applications with full biodata stating full name, address, age with date of birth, educational qualifications, experience, along with self-attested copies of relevant certificates, should reach Sai Nursing Institute, Housing Board Colony, Harvalem, Sankhali – Goa, **within 15 days** from the date of publication of this advertisement.

Place :
Date :

Officiating Principal
Sai Nursing Institute, Sankhali-Goa

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Shri Sevadas Shikshan Prasarak Mandal's Vasantrao Naik

(Arts, Comm. & Science) Mahavidyalaya, Vasarni, Nanded. Tq. & Dist. Nanded (M.S.)

WANTED

Applications are invited from the eligible candidates for the post of Principal to be filled in Shri Sevadas Shikshan Prasarak Mandal's Vasantrao Naik (Arts,Comm.& Science) Mahavidyalaya,Vasarni,Nanded.Tq. & Dist.Nanded (M.S.) (Granted Eligible candidates should submit their applications along with all necessary documents **within 15 days** from the date of publication of the advertisement by Registered Post Only.

Sr. No.	Subject	No. of Posts	Reservation
01	**Principal**	01	Unreserved

Permission as per NOC No.JDHE Nanded/NOC/2026/56 Dated 20.01.2026

A) Educational Qualification: -

1) A Master's Degree with at least 55% of the marks (or an equivalent grade in a point scale whenever grading system in followed) by recognized University.
2) A Ph.D.Degree in concerned/allied/relevant discipline(s) in the institution concerned with evidence of published work and research guidance.
3) Professor/Associate Professor with a total experience of fifteen years of teaching/research in administration in University/College and other institutions of higher education.
4) A minimum of 10 research publication in peer reviewed or UGC listed Journals.
5) A minimum of 110 research score as per Appendix II, Table 2 of UGC Regulation 2018 .
6) Academic Eligibility and other Rules Regulations as per UGC Regulation 18 July 2018 and Govt .Resolution No. Misc-2018/C.R.56/UNI-I Date 8 March-2019

B) Tenure:-

A College Principal shall be appointed for the period of five years extendable for another term of five years on the basis of performance based assessment, a committee appointed by the University constituted as per rules of UGC and Govt. of Maharashtra.

Salary & Allowances :-

Pay scale as per the UGC, State Government of Maharashtra & Swami Ramanand Teerth Marathwada University, Nanded form time to time.

Note :-

1) Prescribed application form is available on the University website **(www.srtmun.ac.in)**
2) No.T.A./D.A. will be paid for attending the interview.
3) Eligible candidates those who are already in service should submit their application through the proper channel.
4) All Attested Xerox copies of certificates and other relevant documents should be attached with the Application form
5) The Original certificates must be produced at the time of Interview.
6) The vacant post is being filled under the decision of Hon. High Court, Aurangabad Bench petition no.12051/2015

Address for correspondence :-
The Secretary, Shri Sevadas Shikshan Prasarak Mandal's Nanded C/O Mahatma Gandi B.Ed College CIDCO, New Nanded-431603 Tq. & Dist.Nanded.

BHARATI VIDYAPEETH, PUNE

Bharati Vidyapeeth Bhavan, Lal Bahadur Shastri Marg, Pune - 411 030 (Maharashtra)

WANTED

Applications are invited from eligible candidates for the following post:

Sr. No.	Name of the Posts/Subject	Subject Wise Vacant Posts	Name of Colleges	Total Vacant Number of Posts	Total Reservation
A)	**Assistant Professor**				
1.	Logic	01	Dr. Patangrao Kadam Mahavidyalaya, Sangli (Permanently Granted) (Affiliated to Shivaji University, Kolhapur)	Total 07 Posts	SC – 01, OBC – 02, EWS – 01, SEBC-01, Open to all - 02
2.	Chemistry	01	Matoshri Bayabai Shripatrao Kadam Mahavidyalaya, Kadegaon, Sangli (Permanently Granted) (Affiliated to Shivaji University, Kolhapur)		
3.	English	01			
4.	Economics	01	Yashwantrao Mohite College, Pune (Permanently Granted) (Constituent Unit of Bharati Vidyapeeth (Deemed to be University), Pune)		
5.	Microbiology	01			
6.	Zoology	01			
B)	**Director of Physical Education**	01	Yashwantrao Mohite College, Pune (Permanently Granted) (Constituent Unit of Bharati Vidyapeeth (Deemed to be University), Pune)		

Note: For detailed information about posts, qualifications and other terms and conditions please visit University **website : www.unishivaji.ac.in** and **bvp.bharatividyapeeth.edu/index.php/careers**

Place :
Date :

Secretary,
Bharati Vidyapeeth, Pune
Bharati Vidyapeeth Bhavan,
Lal Bahadur Shastri Marg, Pune

Chhatrapati Shahu Institute of Business Education and Research Trust's

Chhatrapati Shahu Institute of Business Education and Research (CSIBER), Kolhapur

University Road, Kolhapur (Affiliated to Shivaji University, Kolhapur)

(Permanently Non Grant)

WANTED

Applications are invited from eligible candidates for the following posts:

Sr No.	Name of Posts	No. of Posts	Reservation	Sr No.	Name of Posts	No. of Posts	Reservation
Mater of Business Administration (MBA)							
A.	**Professor**						
1.	General Management	1	1 – Open				
B.	**Associate Professor**						
1.	General Management	1	1 – Open	2.	Human Resource Management	1	1 – Open
3.	Marketing Management	1	1 – Open	4.	Financial Management	1	1 – Open
C.	**Assistant Professor**						
1.	General Management	2	1 SC 1 – Open	2.	Human Resource Management	2	1 SC 1 – Open
3.	Marketing Management	2	1 SC 1 – Open	4.	Financial Management	02	1 - SC 1 – Open
5.	Production Management	1	1 – Open	6	System Management	02	01 – SC 01 – Open
7	Agribusiness Management	1	1 – Open				
Master of Computer Application (MCA)							
A.	**Professor**			**B.**	**Associate Professor**		
1.	Computer Science	01	01 – Open to all	1.	Computer Science	01	01 – Open to all
C.	**Assistant Professor**						
1.	Computer Science	03	01-SC, 01-VJA, 01-OBC				
D	**Librarian**	01	01 – Open to all	**E**	**Physical Education Director**	01	01 – Open to all

SECRETARY
Chhatrapati Shahu Institute of Business
Education and Research Trust (CSIBER), Kolhapur

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Applications with full Bio-data are invited from Indian citizens for the post of **PRINCIPAL** (unreserved category) to be filled in the above Government aided college.

The required minimum qualifications for the post of Principal are as follows:

A) Eligibility:

i) Ph.D. degree

ii) Professor/Associate Professor with a total service/experience of at least 15 years of teaching/research in Universities, Colleges and other institutions of higher education.

iii) a minimum of 10 research publications in peer reviewed journals as approved by Goa University from time to time or UGC listed journals out of which at least two should be in scopus/web of science journals.

iv) a minimum of 110 research papers score as per appendix II, table 2 of Goia University Statute SC-16.

B) TENURE:

College Principal shall be appointed for a period of five years, extendable for another term of five years on the basis of performance assessment by a committee appointed by the university, constituted as per the statute of Goa University.

Essential Requirements:

a) Knowledge of Konkani Language

b) 15 years of residence certificate in Goa issued by competent authority.

Desirable Requirement: knowledge of Marathi language

Scale of pay:- As prescribed by UGC, Goa University and Directorate of Higher Education, Government of Goa from time to time.

Service Conditions: As prescribed by the UGC, Goa university, Directorate of Higher Education, Government of Goa and other competent authorities.

Applicants who are already employed shall send their applications through proper channel.

Applications completed in all respect along with self certified photo copies of statement of marks of all public examinations from SSC onwards, API score sheet and other certificate should reach the undersigned at the above address **within 21 days** from the date of publication of this advertisement.

Appointment is subject to the approval of Govt. of Goa and Goa University.

No TD/DA will be paid for attending an interview.

Place: Mandre – Goa.
Date: 09/02/2026.

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VP's Mandre College of Commerce,
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S.R.D.S.P. Mandal's

SHRI PANCHAM KHEMRAJ LAW COLLEGE, SWANTWADI

At & Post Sawantwadi, Dist. Sindhudurg 416510.

APPLICATIONS ARE INVITED FOR THE FOLLOWING POSTS FROM THE ACADEMIC YEAR 2025-26:

UN-AIDED

Sr. No.	Cadre	Subject	Total No. of Posts	Post Reserved for
1.	**Principal**	-	01	01-OPEN
2.	**Assistant Professor**	Law	06	01-SC/ST, 01-DT(A), 01-OBC, 01-SEBC/EWS, 02-OPEN
3.	**Librarian**	-	01	01-OPEN

The posts for the reserved category candidates will be filled in by the same category candidates (Domicile of State of Maharashtra) belonging to that particular category only.

Reservation for women will be as per University Circular No. BCC/16/74/1998 dated 10th March, 1998. 4% reservation shall be for the persons with disability as per University Circular No. Special Cell/ICC/2019-20/05 dated 05th July, 2019.

Candidates having knowledge of Marathi will be preferred.

"Qualifications, Pay Scales and other requirement are as prescribed by the UGC Notification dated 18th July, 2018, Government of Maharashtra Resolution No. Misc-2018/C.R.56/18/UNI-1, dated 8th March, 2019 and University circular No. TAAS/(CT)/ICD/2018-19/1241, dated 26th March, 2019 and revised from time to time" The Government Resolution & Circular are available on the **website : mu.ac.in.**

Applicants who are already employed must send their application through proper channel. Applicants are required to account for breaks, if any in their academic career.

Applications with full details should reach to the CHAIRMAN, S.R.D.S.P. Mandal's SHRI PANCHAM KHEMRAJ LAW COLLEGE, SWANTWADI, At & Post Sawantwadi, Dist. Sindhudurg 416510 **within 15 days** from the date of publication of this advertisement. This is University approved advertisement.

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CHAIRMAN

Association of Indian Universities

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Postal Regd. No. DL (C)-05/1241/2024-26
UNIVERSITY NEWS 64 (07) February 16-22, 2026
Regd. No. RNI-7180/1963
Published on Monday: 16-02-2026 No. of Pages 184 including Covers
Posted at LPC Delhi RMS, Delhi-6 on Tuesday/Wednesday every week

Edited, Printed and Published by Dr Sistla Rama Devi Pani, on behalf of the Association of Indian Universities, AIU House, 16 Comrade Indrajit Gupta Marg (Kotla Marg), New Delhi-110 002. Phones: 23230059 (6 Lines). Fax: 011-23232131, E-Mail : aiu89@gmail.com, ramapani.universitynews@gmail.com, universitynews@aiu.ac.in, advtun@aiu.ac.in, publicationsales@aiu.ac.in, subsun@aiu.ac.in (for subscription), sgoffice@aiu.ac.in, Website: http://www.aiu.ac.in
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