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Review/ Derleme

Perspectives on Quantum Science and Technology of the Future

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Abstract:

Quantum science and technology are increasingly recognised as critical areas of research and development with profound implications for various scientific fields and practical applications. Quantum science explains experimental observations of subatomic phenomena, thereby enhancing our fundamental understanding of the entire system of concepts based on the principles of quantum theory. Quantum computing has the potential to bring about a radical transformation in computational methods. The development of fundamental tools such as quantum chemistry, quantum cryptography, and quantum machine learning, along with advanced applications like quantum biology, quantum finance, quantum sensing, weather forecasting, and quantum space science, is expected to exert a significant global impact. This review provides a broad overview of developments and highlights the importance of research with diverse possible applications in the field, offering solutions across sectors.

Keywords: Quantum science, quantum technology, quantum computing, quantum sensors

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INTRODUCTION

The United Nations has declared 2025 as the International Year of Quantum Science and Technology (IYQ). It is a global initiative designed to celebrate the past (100th anniversary), increase public awareness of the importance of quantum science and its applications, and plan for the future of quantum technology for the benefit of mankind (IUPAC, 2025). Quantum mechanics, quantum computing, materials science (including superconductors and quantum dots), and quantum communications are the major branches of study. The primary reactions in photosynthesis (light-harvesting), enzymecatalysed processes, brain function, olfaction, and avian magnetoreception can be explained using the principles of quantum theory. Quantum theory, as an emergent framework, explains semiconductor electronics, superconductors, lasers, spectral lines, the photoelectric effect, and blackbody radiation (Bongaarts, 2015; Schleich et al., 2016; Wang et al., 2020;). The molecular dynamics, chemical kinetics, ultra-fast molecular transitions, and molecular orbitals can be described by quantum mechanics. It is essential to rebuild trust in science, encourage quantum science education and training opportunities, and promote investment in quantum research activities to boost research and development in the emerging field. The objective of this paper is to present an overview of an emerging field of quantum science and technology based on conventional knowledge and a qualitative survey of recent advancements and workforce requirements. The scope of the manuscript encompasses perspectives on a wide range of multidisciplinary topics and is expected to have a lasting impact on various technologies and industries. This paper is organised in the following sections: introductory inputs, activating the archives, quantum science in everyday life, future technological developments, public awareness and education, quantum progress perspectives, rewiring the quantum workforce, establishing a quantum ecosystem, and concluding comments.

Activating the Archives

In this section, we examine the early development of quantum science, which contributed significantly to the evolution of our understanding of the quantum world. Quantum mechanics deals with microscopic entities such as atoms, molecules, ions, solids, nuclei, and electrons (particles) and can explain the photoelectric effect, blackbody radiation, atomic spectra, and the Compton effect (Le Bellac, 2011; Levine, et.al, 2009). The method consists of finding the wave function of a particle or a system with discrete states on a microscopic scale. The absorption, emission, and stimulated emission of photons occur when their quantum energy matches the energy gap between the initial and final states. The energy of oscillating particles in matter is quantised. Quantum is the smallest discrete unit of a phenomenon, such as a photon for light or an electron for electricity. Light is always absorbed or emitted in discrete amounts of energy, and only the probability of physically observable events is predictable. Quantum physics studies particles at the atomic or subatomic levels, explaining their wave-particle duality and the unique interactions of photons and matter. The timeline of major milestones in quantum science is shown in Table 1.

Table 1

Timelines of significant developments in quantum science (Peacock 2007)

Year	Description
1900	Concept of quantized energy to explain blackbody radiation
1905	Photoelectric effect explanation (wave-particle duality)
1909	Single-photon interference demonstration
1913	Atomic model
1924	Wave nature of matter
1925	Matrix mechanics formulations
1926	Wave mechanics development
1927	Uncertainty principle
1927	Wave-like behaviour of electrons
1950	Quantum electrodynamics
1982	The idea of quantum computing
1994	Algorithm to revolutionise cryptography
2001	Shor's algorithm on a 7-qubit quantum computer
2019	Quantum computer performing complex calculations
2025	Research and developmental activities

The quantum numbers specify the properties of atomic orbitals and electrons in orbitals (Piela, 2013). Four quantum numbers, principal (n), azimuthal (angular) (l), magnetic (m), and spin (s) quantum numbers, are used to differentiate between electrons in an atom. The principal quantum number gives the size of the electron orbital, and the azimuthal quantum number provides the shape of the electron orbital. The orientation/disposition of an electron orbital is given by the quantum number, while the spin quantum number gives the electron spin. The principal quantum number labels the electron energy level or shell number, and possible values are n = 1, 2, 3…The azimuthal quantum number indicates the orbital type, such as s, p, d, f, depending on l = 0, 1, 2...n-1. The magnetic quantum number m suggests the orbital subtype and can have values between +l, …-1, 0, 1, and − l (integers). The spin quantum number indicates the electron spin values of +/-1/2 (up or down). These quantum numbers can describe the energy, angular momentum, and spin of an electron and explain atomic structure and properties.

The energy of a molecule consists of translational, rotational, vibrational, and electronic energy (Di Lauro, 2020; Yardley, 2012). Translational energy is a small amount of energy stored as kinetic energy. In theory, it is quantised, but the quantum effects are so small that they are not observable in practice. The rotational (kinetic energy associated with the tumbling motion of molecules), vibrational (oscillatory motion of atoms or groups within a molecule), and electronic (energy associated with electronic transitions - absorption/emission) energy are quantised and have definite rotational/vibrational/electronic energy levels. The spacing between the quanta of the energy level for different motions is different. Molecular energy has broad implications, and it can affect material properties, chemical reactions, the structure of molecules, and the behaviour of organic devices. Molecular kinetic energy (MKE) directly impacts phases (solid/liquid/gas) and phase transitions involving their movement and interactions. Molecular energy levels play a crucial role in the electrical conductivity and electronic properties of semiconductor and thin film materials. The energy absorbed/emitted by molecules during electronic transitions determines their optical properties and color.

Molecular potential energy (MPE) with specific bonds and a particular geometric structure determines its stability. The activation energy required to break and make bonds dictates the reaction rates. The energy landscape of a reaction determines the possible reaction trajectories and final products. Molecular energy is fundamental to understanding the thermodynamics of chemical processes, including entropy, enthalpy, and Gibbs free energy. The MPE determines the stability of different conformations and isomers. Molecular rotations and vibrations can only exist at specific energy levels (quantised). Studying molecular energy levels through ultraviolet-visible, infrared, and Raman spectroscopy provides scientifically meaningful information about molecular structure and dynamics. Molecular energy levels (ionisation energy and electron affinity) are essential for optimising charge transfer in organic solar cells. They are crucial for designing charge-transport and emission layers in organic light-emitting diodes (OLEDs). Molecular orientations in thin films can significantly impact energy levels and electronic device performance.

Quantum Science in Everyday Life

Quantum science is deeply intertwined with the fabric of everyday life (Carroll, 2022; Grandy, 2010; Vedral, 2011). We can explain how plants capture sunlight to convert it into energy through photosynthesis. Even the color of the sky is explained by a quantum mechanical effect of the scattering of sunlight by air molecules, which causes the sky to appear blue. The glow of hot objects, such as a toaster or light bulb filament, is due to the quantum mechanical effect of electrons emitting light at certain wavelengths. The quantum tunnelling effect is believed to play a role in some enzymatic reactions. Superconductivity and superfluidity phenomena are macroscopic manifestations of quantum mechanics. Quantum processes in birds' brains might contribute to their ability to navigate long distances. Quantum mechanics provides a deeper understanding of the universe, revealing the underlying principles that govern the behaviour of matter and energy at the smallest scales. Insights on how the universe works at the tiniest level help us understand the natural world.

Quantum science plays a crucial role in modern electronics, medical imaging, and lasers. The operation of everyday electronics such as transistors and microchips relies on the quantum mechanical behaviour of electrons in semiconductors. Light-emitting diodes (LEDs), found in devices from screens to lighting bulbs, emit light based on quantum electronic transitions within the material. Microprocessors, crucial components in computers, rely on the quantum mechanical properties of materials to function. Magnetic Resonance Imaging (MRI) machines use the quantum phenomenon of nuclear magnetic resonance (proton NMR) to generate detailed images of internal organs, aiding in medical diagnosis. Medical lasers used in various procedures, including surgery and vision correction, utilise the quantum principle of stimulated emission. Electron microscopy utilises quantum mechanics to understand the structure of materials at the atomic level, which is crucial in materials research. Lasers, which are used in everything from barcode scanners to laser pointers, are a direct application of quantum mechanics. It is fundamental to the operation of fiber optic cables, enabling high-speed data transmission. Highly accurate atomic clocks used in Global Positioning Systems (GPS) systems rely on the atomic quantum properties to maintain their precise timekeeping. Quantum cryptography offers the potential for unbreakable encryption methods where the key information is sent using polarised photons. Semiconductor chips in smartphones rely on quantum mechanics to control the flow of electrons, enabling data processing and storage. In essence, quantum science provides the underlying principles that make these technologies possible and efficient.

Future Technological Developments

Quantum science is poised to revolutionise numerous industries through advancements in computing, sensing, and communication (Coccia, 2022; García de Arquer et al., 2021; Hossain, 2023; Möller & Vuik, 2017). Quantum computers faster than classical ones could solve complex numerical problems, impacting fields like drug discovery and materials science. Quantum simulations can model molecular interactions with unprecedented accuracy, accelerating the development of new drugs and therapies. Quantum computing can aid in the design of new materials with tailored structure and properties, potentially leading to breakthroughs in energy storage and catalysis. Quantum sensors promise breakthroughs in medical imaging, navigation, and environmental monitoring. Highly detailed images of the brain and body structures can revolutionise the diagnostics and treatment of complex neurological disorders. A more accurate and robust navigation system can overcome the limitations of GPS. Secure communication channels based on quantum entanglement, unbreakable encryption through quantum key distribution (QKD), could become a reality, enhancing cybersecurity. Quantum sensors can be used for precise measurement of diverse environmental parameters, contributing to precise weather forecasting, climate monitoring, and precision agriculture. Quantum computing as a service will allow businesses to access quantum processing power without large upfront investments. Building a quantum internet would allow for secure and instantaneous communication between quantum computers and other devices. Military applications include developing advanced military hardware, such as autonomous systems and sensors. These examples of anticipated future breakthroughs, including quantum-enhanced AI and advanced quantum sensing, indicate the potentially powerful impacts of quantum science in various fields. Research continues in quantum computing, quantum cryptography, communication, sensing, and other quantum technologies, with significant investments and developments in hardware and algorithms.

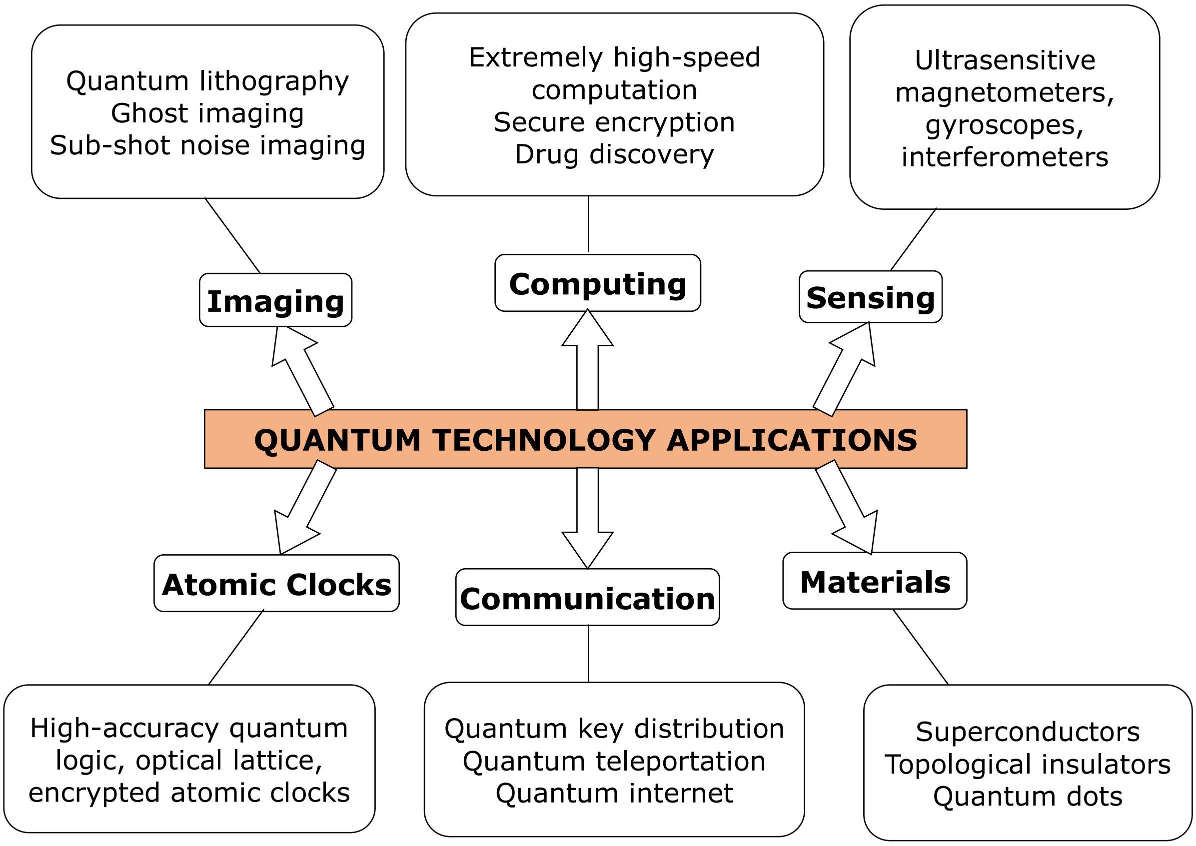
Quantum computers, which utilise qubits that can exist as one, zero, or both simultaneously (superposition), enable fast parallel calculations. Quantum communication uses these qubits and the special properties of quantum systems, like superposition and entanglement, to transmit information securely and enhance communication protocols like QKD, quantum dense coding, and teleportation (Singh et al., 2020; Luo et al., 2023). It is useful in modern unbreakable encryption, digital healthcare, data security, and cybersecurity. Research is underway on quantum repeater protocols to enable long-distance quantum communication and their application to improve 6G mobile networks. Quantum science and technology have many applications including electronics (transistors), medical imaging (MRI scanners), quantum computing in financial modeling, drug development, weather forecasting, quantum sensing technologies, disaster management (tsunamis, droughts, earthquakes, floods), climate change data collection, quantum simulators, ultra-precise measuring devices (magnetometers, gyroscopes, interferometers), and squeezed light to detect gravitational waves (Oi et al., 2017; Schleich et al., 2016; Wang & Song, 2020). In summary, quantum technology has applications in research in fundamental physics, secure communications, disaster management, aerospace engineering, pharmaceuticals, cybersecurity, advanced manufacturing, and weather prediction (Acín et al., 2018). Applications of quantum mechanics in various modern sciences include quantum materials, quantum optics, quantum sensors, quantum computing, next-generation AI, and quantum cryptography.

Quantum dots, wires, and wells are nanostructures that exhibit quantum confinement in all three dimensions (0D system), in two dimensions (1D system), and in one dimension (2D system), respectively (Harrison & Valavanis, 2016). Quantum confinement is the trapping of particles and restricting their motion [confinement: 3 (x, y, z)]. Quantum dots contain electrons and holes confined within a limited volume and exhibit semiconducting behaviour because of their small size. Quantum wires act as a potential well, confining electrons and holes in two dimensions [confinement: 2 (x, y)]. Quantum wells transmit electrons of any energy above a certain level [confinement: 1 (z)]. The drastic changes in properties in such ultrasmall structures are observed because of the quantum-mechanical nature compared to the corresponding bulk structure (3D system) [confinement 0]. The extreme case of the size reduction process in which all three dimensions reach the nanometer range (1-100 nm) is called a quantum dot. If only two dimensions are so reduced while one remains large, the resulting structure is called a quantum wire. Suppose one dimension is reduced to a nanosize, a quantum well structure results. Based on the spatial distribution of preformed nanoparticles, we can have 0 (clusters), 1(nanotubes, fibers, rods), 2 (thin films, coats), and 3 (polycrystals) dimensional nanomaterials that exhibit remarkable properties due to inherent nanostructures (Paras et al., 2022; Ross et al., 2016; Yang et al., 2021). Examples of nanomaterials in products include automobiles, clothes, textiles, electronics, toys, cosmetics, sports items, food additives, pharmaceuticals, and household products. The remarkable difference in the properties of nanomaterials compared to corresponding bulk materials is due to the size effect. For instance, opaque to transparent in copper, inert to catalysts in platinum, stable to combustible in aluminum, solid to liquid in gold, and insulator to conductor in silicon is because of their nano-size.

A quantum state of matter is an arrangement of particles describing their interactions with each other. Superconductivity and Bose-Einstein condensate are some examples of this state of matter. They can be exotic and extreme, including room-temperature superconductors, diamonds, and novel semiconductors that can reveal more about the phenomena in the multiverse. Quantum sensing technology using quantum systems to collect motion data, electric/magnetic fields, and imaging has many applications in healthcare, civil, and military areas. Two molecules, photons, or electrons can become entangled to remain connected even when separated by large distances (quantum entanglement). The use of 'magic wavelength optical tweezers' to create a highly stable environment that supports long-lasting quantum entanglement of molecules paves the way for next-generation quantum technology. The modern states of matter include quantum spin liquid, a disordered state that preserves its disorder even at very low temperatures, supersolid state in which a solid can move without friction but retains a fixed shape, string-net fluid state in which atoms have an unstable arrangement like a liquid but have a pattern of solid, and heavy Fermion material state of a specific state of the intermetallic compound, containing elements with 4f electrons in vacant orbitals. The advancements in quantum biology may play a role in DNA mutations and can lead to groundbreaking research in biomedical sciences. Further research on colloidal quantum dots, quantum information technologies, quantum encryption, and quantum beam science could lead to major breakthroughs and disruptive innovations soon. Major application areas of quantum technology are summarised in Figure 1.

Figure 1

Major application areas of quantum technology



Public Awareness and Education

Public awareness and education initiatives are crucial for fostering a deeper understanding and relevance of quantum science and technology (Gutorov et al., 2025; Holincheck et al., 2024; Seskir et al., 2024). The IYQ-2025 aims to increase public awareness of its importance through various events and activities worldwide. The IYQ will include the setting up of four thematic hubs in academic and national research and development institutes on quantum computation, quantum communication, quantum sensing and metrology, and quantum materials and devices, with broad support from the international scientific community and national governments. These efforts involve making quantum science more accessible and understandable to a wider audience, including those outside the scientific community. Emphasising the impact of quantum science on everyday technologies like smartphones, computers, and magnetic resonance imaging (MRI) can make it more relatable. Encouraging participation from diverse groups, including women and those from developing countries, is essential for building a more inclusive quantum future. Social media events, conducting quizzes/puzzle games on quantum concepts, faculty development programs, research collaborations, developing quantum curricula, developing online/offline educational resource materials, faculty exchange programs, public lectures and talks, global education fair/expo, and workshops on quantum-related fields are all essential for advancing quantum education. Public awareness and quantum literacy campaigns, technical exhibitions, and outreach activities in quantum technologies can spark curiosity and encourage individuals to learn more about quantum technologies. Higher education initiatives like incorporating quantum science courses in various science/engineering disciplines can help build a skilled quantum workforce for the future. Introducing learners to different perspectives and diverse experiences enhances intellectual capabilities, leadership qualities, and critical thinking processes in higher education institutions. Quantum knowledge initiative with the best policies, overall quality education process, and the right trajectory could be the game changer of the future. Understanding quantum science can lead to a greater appreciation for its potential in addressing global challenges like healthcare and climate change.

Quantum Progress Perspectives

Quantum mechanics (QM) reveals that matter and energy exist in discrete packets called quanta (Kramers, 2018). Subatomic particles exhibit wave-particle duality. There is uncertainty in the precise determination of position and momentum simultaneously. Two or more particles can become entangled and share the same fate, though they are far apart. Quantum technologies include lasers, transistors, medical imaging, quantum computing, quantum optics, quantum condensed matter physics, quantum information theory, device engineering, quantum simulation, and quantum sensors. They have applications in fields like communication, manufacturing, medicine, modern electronics, MRI, computation, and precise and sensitive sensors for measuring various physical parameters (Schleich et al., 2016). Quantum field theory combines quantum mechanics with special relativity to describe the fundamental forces and particles of nature (Peskin, 2018). Modern perspectives explore its profound implications for understanding the multiverse.

Modern research areas include quantum chemistry, quantum gravity, topological insulators and superconductors, quantum materials, quantum dynamics, simulating molecular systems, and quantum information. Quantum technologies include quantum sensors, quantum metrology, quantum imaging, and quantum gravity. Further research on high-temperature quantum superconducting materials and exploring their unique properties deepens the understanding of underlying mechanisms and paves the way for synthesising a broader class of such special materials with practical applications in modern electronics and energy-efficient technologies (Yao & Ma, 2021). Recent advances include new quantum particles (fractional excitons), progress in quantum entanglement, logical qubits (– 0, 1, or a mixture of both at the same time), quantum computing with advancements in qubit technology and quantum algorithms, quantum testing, cryptography, secure and reliable communications, quantum statistics, and quantum sensors. New advancements in microelectronics, quantum computing, and quantum communication are paving the way for a deeper understanding of the quantum world. These advancements include energy-efficient microelectronic devices, quantum computer operating systems, and quantum machine clusters for high-end computation. Additionally, techniques like redox gating, intracellular sensing and mapping, sophisticated error mitigation, quantum satellite links, quantum magnetism, and quantum spin models from nanographene are also contributing to this progress (Mohseni et al., 2017).

The role of water in supporting life involves its role as a universal solvent to dissolve a wide range of substances essential for biochemical reactions, temperature regulation with its high specific heat capacity, and important nutrient transport in cells to thrive (Thimmappa, 2023). Water is also present in various forms in subsurface oceans and exoplanets, suggesting the possibility of extraterrestrial life. At the quantum level, molecules of water exhibit phenomena such as superposition, where they exist in multiple rotational and vibrational states simultaneously, and quantum entanglement occurs between water molecules through hydrogen bonds. Superconductors and quantum dots can be joined to make hybrid devices for quantum simulation in the solid state, quantum computing, and electrical power generation. They can also create transistors, tunable couplings, spin-photon couplings, and electrical qubit driving (De Franceschi et al., 2010; Van Dam, et.al., 2006). Quantum time travel breakthrough research enables scientists to reverse the flow of time, and it is possible to control (speed up, slow down, or reverse) tiny particles (photon/electron) within quantum systems (qubit) in real time (Baumeler et al., 2019; Phillips, 2025). A rewind protocol in quantum processors can be used to reverse unwanted errors, saving time and energy. The application of quantum computing principles and techniques to improve the performance and capabilities of AI algorithms, using superposition and entanglement properties, is an emerging field to solve complex numerical problems. Recent research reveals that compact metasurfaces can act as powerful building blocks for scalable quantum optical networks and could offer 'lab-on-a-chip' capabilities for basic science (Yousef et al., 2025). Gold nanoclusters can mimic gaseous trapped atoms in quantum performance, offering scalable and tunable building blocks for next generation quantum computers and a variety of quantum applications using spin polarisation property (Foxley et al. 2025; Smith et al., 2025).

Establishing a Quantum Ecosystem

Building a coherent and robust quantum ecosystem based on the firm foundations of the evolution of quantum science, its present trajectory, and its applications in strategic sectors such as healthcare, hardware, electronics, defence, computing, advanced manufacturing, nanotechnology, cognitive technology, and biotechnology has the potential for startups in quantum technologies. Building portable cardiac scanners, cellular-level cancer simulation/drug lifecycle modeling, molecular understanding of drug pathways, 3D heart mapping, ultra-sensitive cardiac quantum sensors, and other portable diagnostic tools leads to a new era of predictive, curative, and safer healthcare. Quantum roadmap must include talent hunt and quantum skill development, research and development infrastructure, cross-sector collaboration, nurturing quantum/deep-tech startups, industry-institute partnerships, and strong policy support. Quantum skilling educational programs (quantum education) in higher education institutions/universities to build a technical future workforce in software, hardware, and applied research. Teachers must be trained in quantum content teaching methods and a dedicated quantum teaching center to give a flavour of the quantum system should be established across the world. Access to a variety of tools, diverse pedagogical practices, 21st-century learning materials, proactive learner engagement, and contextually relevant education policy would pave the way for quantum knowledge production. Initiatives aimed at public awareness and promoting quantum literacy, including educational programs, exhibitions, and outreach activities, would add value, and the global quantum calendar can extract tangible gains in decoding the language of the quantum world. Private-public partnerships in quantum research and a uniform quantum education framework for all nations can eventually bring dreams into reality. Breakthrough innovations in this strategic frontier field and quantum solutions fundamentally transform the way the global industries solve their most complex challenges. Key enablers include single window regulatory clearances, allocation of land and licenses for industrial activities, stamp duty concession/exemption, continuous power supply, skilled manpower, physical infrastructure, good connectivity, and tax holiday for formative years.

Rewiring Quantum Workforce

The driving force for the quantum workforce is the increasing relevance and latest technological advancements in the emerging field of quantum technologies and changing demands (Aiello et al., 2021; Hughes et al., 2022; Gerke et al., 2022; Greinert et al., 2023; Kaur & Venegas-Gomez, 2022). It requires a well-educated and skilled workforce trained in quantum hardware and software, and other relevant quantum topics, as it moves from research laboratories to industrial applications. Quantum computing, with a projected market size of 8.6 billion USD by 2027, will experience rapid growth and a big economic impact in diverse sectors. Corporations are investing billions of dollars to develop and commercialise quantum technologies fully. Higher education must be geared up to provide quantum literacy education through structured learning programs, more interactive and engaging content, and specialised skills with an interdisciplinary approach involving physics, computer science, mathematics, and engineering. Building and nurturing a quantum workforce for a quantum computing revolution requires a national and global strategic plan fast enough to avoid severe shortages or quantum winter in the quantum workplace.

Interdisciplinary collaboration of communicators, business developers, policymakers, technicians, physicists, and engineers, and continuous learning will be crucial to bridge the knowledge gap between different disciplines. Quantum researchers, engineers, technicians, software developers, business developers, communicators, and policymakers - all require a strong foundation in quantum mechanics to make a meaningful difference. Addressing the multi-faceted ethical and societal implications of quantum technology is vital in powering sustainable progress (Aboy et al., 2025). Thus, theoretical background, practical applications, and soft skills are essential for the future of the quantum workforce. Investment in setting up a practical computing laboratory and a 'national mission on quantum technologies and applications is needed to tap the vast potential unfolding beyond the limits of classical computers. Outcome-focused incentives to attract research talent from across the globe are required to thrive in quality quantum research outputs. Further financial support and contributions/advancements in this emerging field of the quantum world will shape the future of strategic applications and human resources. It is essential to leverage advanced technologies to provide actionable insights to power businesses in real-time and create an ecosystem where individual interests are aligned with the best-in-class and tailor-made solutions for larger projects. It is important to stay updated on the latest technological advancements and shape young minds for a sustainable quantum future, reflecting a commitment to creating a positive and enduring impact on society.

CONCLUSIONS

A qualitative study on the impact of quantum science and technology involving adoption, challenges, and strategic applications will provide more valuable insights into the emerging field. Answering the W's, including quantum science explanation (what), history and future of quantum science (when), applications to nanomolecules/nanomaterials (where), advantages of using it in molecular design (why), enabling quantum technologies including products, processes, and systems (how) will provide deeper insights into quantum science and technology. Quantum mechanics successfully explains the properties of microscopic particles, and we have witnessed spectacular advances in chemistry, physics, biology, and medicine to transform our world. The rapidly advancing quantum science and technology have the potential to redefine the industrial landscape, lead to innovations in materials science, and improve quality of life. The ability to assemble large atom arrays quickly (milliseconds), free of any defects, and reliably opens up new trajectories toward building a sustainably faster and scalable modern quantum computer. In the context of education, a constructive global strategic perspective that emphasises the role of quantum education in balancing human experience and development, particularly in the context of the changing dimensions of research, is essential.

Quantum computing can lead to a paradigmal shift in data analysis faster than classical computers and threat detection via more secure quantum encryption techniques. Quantum technologies can provide solutions to sustainable energy, faster information transmission, medical diagnostics, climate change monitoring, and geological exploration. Recently, prominent technology firms have started investing in the applications of quantum technologies. There is a gap between research advancements and commercial applications, and academia and industry. It is challenging to create an innovative ecosystem in quantum technology, fostering collaboration between academic institutions and industries, and advanced training to generate human power for teaching and research in this modern age of quantum mechanics. Recent developments in the field include quantum-centric computers to simulate quantum chemistry, the use of artificial intelligence to solve challenges in quantum chemistry, setting the stage for quantum chemistry in space, and using high-performance quantum computing to advance drug discovery.

Conflict of Interest Declaration

The author has not declared a potential conflict of interest during the research, authorship, and publishing of this article.

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Ethical Committee Decision / Permission

Not Applicable

Kuantum Bilimi ve Teknolojisinin Geleceğine Yönelik Perspektifler

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Özet:
Kuantum bilimi ve teknolojisi, çeşitli bilimsel alanlar ve pratik uygulamalar üzerinde derin etkileri olan kritik bir araştırma ve geliştirme alanı olarak giderek daha fazla önem kazanmaktadır. Kuantum bilimi, atom altı olgulara ilişkin deneysel gözlemleri açıklayarak kuantum teorisinin ilkelerine dayalı kavramsal sistemin tamamına dair temel anlayışımızı geliştirmektedir. Kuantum hesaplama, hesaplama yöntemlerinde köklü bir dönüşüm yaratma potansiyeline sahiptir. Kuantum kimyası, kuantum kriptografisi ve kuantum makine öğrenimi gibi temel araçların geliştirilmesi; kuantum biyolojisi, kuantum finansı, kuantum algılama, hava tahmini ve kuantum uzay bilimi gibi ileri uygulamalarla birlikte, önemli bir küresel etki yaratması beklenmektedir. Bu kısa derleme, alandaki gelişmelere geniş bir bakış sunmakta ve çeşitli olası uygulamalarla araştırmaların önemini vurgulayarak farklı sektörlerde çözümler üretme potansiyelini ortaya koymaktadır.

Anahtar kelimeler: Kuantum bilimi, kuantum teknolojisi, kuantum hesaplama, kuantum sensörler

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