



QUANTUM COMPUTING: A NEW ERA FOR STUDENTS IN EDUCATION AND RESEARCH

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Abstract

Modern technologies and innovations are making an impact on all areas of our lives. Among them, quantum computing stands out as one of the most advanced and promising fields. While traditional computers have certain limitations, quantum computing offers the ability to reach new heights. Quantum computers can solve complex problems quickly and efficiently. The ability to perform multiple calculations simultaneously using qubits is increasing the demand for quantum technologies. Today's students have the opportunity to become future specialists who will develop and manage these technologies. For students studying English, mathematics, computer science, and physics, learning quantum computing technologies will not be difficult and will further enhance and deepen their understanding of these subjects.

This article discusses the basic concepts of quantum computing, the opportunities it offers students in education and research, and its impact on society.

Keywords: Superposition, quantum entanglement, interference, qubit, Qiskit, Cirq, Q#, cryptography.

Introduction

KVANT HISOBLASH: TALABALAR UCHUN O‘QISH VA TADQIQOTDA YANGI DAVR

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Annotatsiya

Zamonaviy texnologiyalar va innovatsiyalar hayotimizning barcha sohalariga o'z ta'sirini ko'rsatmoqda. Shular qatorida kvant hisoblash ham eng ilg'or va istiqbolli yo'nalishlardan biri hisoblanadi. Oddiy kompyuterlarning imkoniyatlari ma'lum darajada cheklangan bo'lsa, kvant hisoblash yangi marralarni zabt etish imkonini beradi. Kvant kompyuterlar murakkab masalalarni tez va samarali hal qilishga yordam beradi. Kubitlar yordamida bir vaqtning o'zida bir necha hisob-kitoblarni bajarish imkoniyati kvant texnologiyalariga bo'lgan talabni oshirmoqda. Bugungi talabalar kelajakda ushbu texnologiyalarni rivojlantiruvchi va boshqaruvchi mutaxassislariga aylanish imkoniyatiga egadirlar. Ingliz tili, matematika, informatika va fizika fanini o'rganayotgan o'quvchilar uchun kvant hisoblash texnologiyalarini o'rganish qiyinchilik tug'dirmaydi va bu fanlarni yana ham chuqurroq o'rganishga, rivojlantirishga ko'mak beradi. Ushbu maqolada kvant hisoblashning asosiy tushunchalari, talabalarning ta'lim va tadqiqotdagi imkoniyatlari hamda uning jamiyatga ta'siri haqida so'z yuritiladi.

Kalit so'zlar: Superpozitsiya, kvant bog'lanishi, interferensiya, kubit, qiskit, cirq, Q#, kriptografiya

Introduction

With the development of modern technologies, the field of quantum computing is also growing at a rapid pace. Quantum computing is a brand-new approach that utilizes the fundamental principles of quantum mechanics in computational processes. While classical computers encode information using bits that represent only "0" and "1," quantum computers operate with qubits, which can exist simultaneously in the "0," "1," or a superposition of both states.

Unlike traditional computing technologies, quantum computing leverages the quantum-mechanical properties of qubits to efficiently solve complex problems that current computers cannot address. This rapidly evolving field holds revolutionary potential in areas such as artificial intelligence, cryptography, chemical simulations, and many others.

This article discusses the fundamentals of quantum computing, the opportunities it offers to students, and its future significance. The aim of the article is to provide



students with insights into the basic concepts of quantum computing, the opportunities for learning, and future prospects in the field.

METHODOLOGY

This research was conducted based on five main methodological approaches:

- Analysis of literature, including more than 50 scientific articles, books, and educational resources on quantum computing;
- Systematic exploration of platforms and resources such as IBM Quantum Experience, Google Quantum AI, and Microsoft Quantum, including testing their real-time experimental capabilities;
- Review of over 25 quantum computing educational programs from leading universities such as MIT, Harvard, Stanford, as well as platforms like Coursera and edX;
- Collection and structured analysis of opinions from 30 experts and specialists through structured interviews;
- Practical study of quantum programming languages and libraries such as Qiskit, Cirq, and Q#, involving the creation and evaluation of more than 10 sample quantum programs, algorithms, and simulations.

The data collected during the research was systematically analyzed through content analysis and comparative methods, and the results were synthesized to form a comprehensive understanding of the current state and development of the modern quantum computing field.

RESULTS

According to the research findings, three fundamental principles of quantum computing have been identified. The first is superposition, where qubits can exist in multiple states simultaneously, enabling quantum computers to perform numerous calculations in parallel. The second is quantum entanglement, where two or more qubits are linked such that the state of one affects the other, even across large distances, thereby improving data processing efficiency. The third is interference and error correction, which allows quantum computers to eliminate unwanted computation paths and select only the correct results.

Several important opportunities for learning quantum computing have been identified: the IBM Quantum Experience platform (free interactive courses, Qiskit



library, online experiments on real quantum computers); Google Quantum AI and Cirq (the Cirq programming library and "Quantum Supremacy" research); courses from leading universities such as MIT, Harvard, and Stanford; online platforms like edX and Coursera; and Microsoft's Q# programming language and Azure Quantum platform. Research in quantum computing is currently concentrated in four main areas: quantum cryptography (ensuring absolutely secure communication), artificial intelligence (quantum neural networks and machine learning), optimization problems (solving complex problems in logistics, energy, and finance), and molecular simulation (modeling molecular systems to create new drugs and materials).

The research findings show that mastering four core subjects is essential for learning quantum computing: mathematics (algebra, complex numbers, trigonometry, probability theory), physics (fundamentals of quantum mechanics), computer science (algorithms, programming, computer architecture), and English language proficiency. Students have wide-ranging opportunities in quantum computing, including:

- Education through specialized courses at universities and online platforms;
- Learning modern quantum programming languages such as Qiskit, Cirq, and Q#;
- Participating in scientific research projects to create quantum algorithms and programs;
- Professional development opportunities, as quantum computing specialists are expected to be in high demand in the future.

DISCUSSION

The research results highlighted several key advantages of quantum computing. First, it offers extreme computational speed, enabling quantum computers to solve problems in seconds or minutes that would take traditional computers hours, days, or even years. For example, Google's Sycamore processor completed a calculation in 200 seconds that would have taken the world's most powerful supercomputers approximately 10,000 years. Second, due to their parallel processing capability, qubits in superposition can perform a massive number of calculations simultaneously — a quantum computer with N qubits can work on 2^N different possibilities at once. Third, quantum computing opens new scientific frontiers, allowing precise simulations of chemical reactions, biological processes, and



material properties at the atomic level, potentially revolutionizing fields like pharmaceuticals, materials science, and energy.

Although the field currently faces technological challenges such as maintaining qubit stability, error correction, and operating at extremely low temperatures, it is expected to have a significant impact in the future:

- Creating new cryptographic standards and breaking existing encryptions;
- Simplifying the process of developing new drugs and modeling protein structures in medicine;
- Optimizing transportation and supply chains in logistics;
- Designing advanced AI systems capable of solving complex problems;
- Modeling complex systems related to climate change.

Students aspiring to succeed in quantum computing are provided with a clear roadmap.

First, it is essential to acquire fundamental knowledge — mastering mathematics (matrix algebra, complex numbers, linear algebra), basic quantum mechanics (the principle of superposition, Schrödinger's equation, theories of quantum measurements), and quantum computing principles. This foundational knowledge is critical for understanding quantum algorithms deeply.

Second, developing programming skills is necessary — learning to work with modern quantum programming tools such as Qiskit (IBM), Cirq (Google), and Q# (Microsoft), being proficient in Python, using quantum programming libraries, and gaining experience in independently writing quantum algorithms. Students can test quantum programs using simulators and conduct real-time experiments on cloud platforms like IBM Quantum Experience.

Third, active participation in research and practical projects is vital — reading and analyzing scientific articles, participating in competitions and hackathons, joining organizations like the Quantum Open Source Foundation, building a personal portfolio in quantum programming, participating in competitions on platforms like Kaggle and Qiskit Community, and doing internships at research institutions.

Fourth, building professional networks — connecting with leading universities, companies, and scientific centers in the field, attending quantum computing conferences, joining quantum communities, networking with professionals, and actively participating in scientific seminars and webinars, while developing a personal brand on platforms like GitHub and LinkedIn.



Finally, continuous learning is critical — because quantum computing is rapidly evolving, students must regularly follow scientific journals, learn new quantum algorithms and methods, pursue specialized studies at the graduate level, and continuously update their skills.

CONCLUSION

Quantum computing is one of the most promising areas in science and technology, with its computational power and capabilities expected to create revolutionary changes across many fields — from cryptography and medicine to logistics and artificial intelligence. For students, this field offers new knowledge, scientific discoveries, and professional development opportunities, especially as major technology companies like IBM, Google, and Microsoft, along with leading universities worldwide, are increasingly offering educational programs and research opportunities in quantum computing.

In conclusion, quantum computing provides students with a pathway to becoming leading specialists of the future and contributing to solving global challenges. Therefore, students who begin studying this field early will gain a significant competitive advantage in the future — the earlier one starts, the greater the achievements they can reach!

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