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Driving Quantum Literacy: Multi-Stakeholder Collaborative Efforts in Philippine Education

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***Abstract*— Recent advancements in quantum computing have sparked tremendous interest among students, professors, and enthusiasts, driving a surge in exploration and inquiry. To harness this momentum effectively, collaboration between research institutions, universities, and enthusiast communities is imperative. Furthermore, there's a pressing need to enhance quantum literacy among students and experts from allied fields such as engineering and computer science, which necessitates the development of educational programs specifically tailored to their needs.**

This paper delves into the collaborative initiatives orchestrated between the Department of Science and Technology-Advanced Science and Technology Institute (DOST-ASTI), universities, and enthusiast communities to bolster quantum education and awareness in the Philippines. Through presentations delivered to five universities, a hackathon co-hosted with OneQuantum Philippines, and a lecture series in alliance with the Polytechnic University of the Philippines (PUP) engineering faculty, these initiatives aim to ignite interest, offer hands-on experience, and foster a sustainable ecosystem for quantum education and research. By emphasizing the pivotal role of multi-stakeholder engagement, this paper underscores the transformative potential of collective efforts in propelling quantum science and engineering education not only within the Philippine context but also on a broader global scale.

Keywords—Quantum Computing, Education, Hackathon

I. INTRODUCTION

Since its inception in the 1970s [1] and early 1980s [2], research on the application of quantum mechanics in information processing and computing has been driven by various motivations. Scholars have delved into the nature of information when encoded using physical units that adhere to quantum mechanical principles [2]. Theoretical models of computing systems exhibiting quantum mechanical properties have emerged to elucidate the behavior and constraints of quantum computers during computations. Notably, the quantum circuit model [3] [4] has gained prominence as a primary interface for end-users in contemporary quantum computing platforms [5] [6].

In recent years, global tech giants such as Google, Microsoft, and IBM, in collaboration with leading engineering universities worldwide, alongside specialized technology startups like D-Wave [7], IonQ [8], and Rigetti [9], have released their proprietary Noisy Intermediate-Scale Quantum (NISQ) processing units, along with corresponding quantum programming frameworks and software libraries, freely accessible. While these prototype quantum processors currently support only small-scale quantum information bits, independent startups abroad have begun integrating their quantum processor hardware into larger corporate infrastructures. These companies offer access to their quantum computing infrastructure through cloud-based computing services, enabling researchers to submit computer programs to the cloud-based service's user interface for execution. Requests are queued alongside those of researchers worldwide.

In 2022, the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI), a Philippine government agency dedicated to research and development in emerging technologies, initiated its flagship quantum computing research project, the Quantum Circuit Simulator (QCS) Project. This endeavor aims to lay the groundwork for subsequent projects within the institution's quantum computing domain. The project is centered on optimizing quantum circuit simulators for execution within DOST-ASTI's high-performance computing (HPC) facility. The project's outcomes will enable local researchers to conduct few-qubit simulations of quantum algorithms for algorithm verification, necessitating capacity building for future users of the project.

To accomplish its goals, the QCS project actively pursued partnerships with both academia and industry. Over a two-year period, the project team delivered introductory presentations at various universities and private companies, with a specific focus on extending outreach beyond the central hub of Metro Manila. By engaging a wide array of stakeholders, including educational institutions and industry entities, the project aimed to facilitate collaboration and knowledge-sharing, ultimately bolstering quantum literacy and research capabilities nationwide. In 2023, as a result of these efforts, the QCS project successfully established partnerships with the Polytechnic University of the Philippines and OneQuantum Philippines.

In collaboration with OneQuantum Philippines, the team co-organized the inaugural quantum computing hackathon in the country, which attracted participation from 21 undergraduate students in Cebu City. This event provided participants with a hands-on opportunity to engage with quantum computing concepts and technologies, fostering interest and skill development in this emerging field. Additionally, partnering with the Polytechnic University of the Philippines (PUP), the team collaborated with the university's Research Institute for Strategic Foresight and Innovation to organize a lecture series on quantum computing tailored for the faculty of the College of Engineering. This series aimed to provide faculty members with comprehensive insights into quantum computing, equipping them with the

knowledge necessary to integrate quantum concepts into their teaching and research endeavors.

The QCS project signifies a significant leap forward in advancing quantum computing research and development in the Philippines. Through strategic alliances with academia and industry, the project endeavors to enhance quantum literacy and research prowess across the nation. Collaborations with pivotal institutions and the vibrant local community underscore the collective impetus driving quantum computing initiatives in the country. These partnerships have catalyzed landmark events such as the inaugural quantum computing hackathon and specialized lecture series, nurturing interest, fostering skill development, and catalyzing the integration of quantum concepts across academic and research realms. Such initiatives position the Philippines as an emerging hub for quantum computing innovation and expertise on the global stage.

II. University Collaborations and Engagements

The team diligently networked to establish contacts with various universities, resulting in fruitful collaborations. This effort led to several introductory presentations aimed at inspiring young researchers to pursue careers in quantum computing research and engineering.

On March 23, 2023, during the 23rd Philippine Computing Science Congress at the University of San Jose-Recoletos in Cebu City, the QCS team delivered two introductory lectures [10]. The first lecture focused on quantum computing fundamentals, employing a linear algebra approach, while the second discussed tensor networks and their applications for quantum circuit simulation. The audience comprised students, academics, and industry researchers, fostering a diverse and engaging discussion.

Subsequently, on June 8, 2023, at the 2nd International Conference of Computing and Information Sciences held at Caraga State University in Butuan City, a QCS project researcher delivered a presentation on the burgeoning field of quantum computing [11]. The presentation provided an overview of potential applications of quantum computing across various fields, offering insights into its rapid development and emerging significance in the technological landscape.

At the event "Emerging Horizons: Futures Thinking in the Age of Disruption," held on December 4, 2023, at the Polytechnic University of the Philippines (PUP), the team introduced electronics engineering students to the field of quantum computing [12]. Additionally, they highlighted potential research areas where their expertise is highly sought after and can be effectively applied. Following this event, the Department of Science and Technology - Advanced Science and Technology Institute (DOST-ASTI) and the Polytechnic University of the Philippines (PUP) have formalized their collaborative engagement in a Memorandum of Understanding (MoU), solidifying their commitment to future collaboration. This includes plans for a lecture series for PUP's engineering faculty, further enhancing collaboration and knowledge exchange between the two institutions.

On March 16, 2024, the team, in collaboration with OneQuantum Philippines and the Department of Computer Science of the University of the Philippines Diliman, organized a lecture series on Quantum Computing at Mindanao State University - Iligan Institute of Technology [13]. The series covered a wide array of topics, from the marvels of computer science to quantum circuit simulation and quantum machine learning. The aim was to provide computing students with motivation and inspiration by showcasing how their skills as computer scientists can be effectively utilized in the field of quantum computing.

In this series of presentations primarily attended by engineering students and educators, we adopted an approach to quantum computing that prioritized practical applications and motivations for research, rather than delving deeply into the underlying physics. Recognizing the engineering backgrounds of the audience, we focused on distilling essential principles of quantum mechanics to what is absolutely necessary for understanding quantum computing concepts. This approach allowed us to provide targeted insights and foster interest among participants, highlighting the relevance and potential of quantum computing in engineering fields.

III. First Quantum Computing Hackathon in the Philippines

The Quantum Hackathon 2023, hosted at the Cebu Institute of Technology-University (CIT-U), marked a significant milestone in the Philippines' journey into quantum computing. Co-organized by DOST-ASTI, OneQuantum Philippines, CIT-U, University of San Carlos (USC), and supported by IBM Quantum, this pioneering event aimed to foster innovation and collaboration in quantum computing. Preceding the hackathon was a lecture series designed to prepare participants. The series covered essential topics:

1. Quantum Computing Unveiled - Introduction to the fundamentals of quantum computing.
2. Crunching the Numbers - Mathematical essentials for quantum computing.
3. Algorithms and Complexity - Understanding algorithms and computational complexity in the context of quantum computing.
4. Unlocking the Gates to Quantum Mysteries - Basics of quantum computing such as qubits and gates.
5. Elegant Exploration of Quantum Algorithms and Circuitry - Exploring advanced quantum algorithms and circuit design.
6. Quantum Cryptography, Key Distribution Algorithms, and Optimization - Overview of quantum cryptography and its applications in security and optimization.

Keynote speakers provided valuable insights into the latest developments and future trends in quantum computing, setting the stage for a day of intense competition and knowledge exchange. The hackathon, based on the QISKit Blocks game, challenged participants from prestigious universities to apply their skills in solving quantum computing problems. Additionally, the event showcased the QCS Project, an initiative led by DOST-ASTI, aimed at optimizing quantum circuit simulators and fostering research and knowledge-sharing activities in the field of quantum computing among local researchers.

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exchange. The hackathon, based on the QISKit Blocks game, challenged participants from prestigious universities to apply their skills in solving quantum computing problems. The event saw the participation of seven teams, each composed of three undergraduate students and one coach (instructor/professor). Participating institutions included CIT-U (BS Computer Science and BS Computer Engineering), University of San Carlos, University of the Philippines Cebu, and University of San Jose Recoletos (BS Computer Science and BS Computer Engineering). The hackathon ran for two hours, during which all teams successfully answered problems related to foundational concepts, fulfilling the objectives of the preparatory lecture series. Additionally, the event showcased the QCS Project, an initiative led by DOST-ASTI, aimed at optimizing quantum circuit simulators and fostering research and knowledge-sharing activities in the field of quantum computing among local researchers.

IV. Quantum Computing Lecture Series with the College of Engineering Faculty of the Polytechnic University of the Philippines

The Quantum Computing Lecture Series conducted with the College of Engineering Faculty of the Polytechnic University of the Philippines (PUP) aimed to introduce faculty members to the foundational concepts and emerging trends in quantum computing. This series was structured to provide comprehensive insights into quantum computing, catering to the engineering background of the faculty members. Drawing from a diverse range of topics covered in the syllabus, including quantum mechanics principles, mathematical foundations, quantum algorithms, and software programming, the lectures aimed to equip the faculty with the knowledge and understanding necessary to integrate quantum concepts into their teaching and research endeavors effectively.

The series commenced with an introductory session on the current use cases for quantum computing in the noisy intermediate-scale quantum era, providing faculty members with real-world examples of quantum computing applications across various industries. Subsequent sessions delved into the basics of classical computing, mathematical foundations of quantum computing, and the principles of quantum mechanics underlying quantum computing. These sessions aimed to bridge the gap between classical and quantum computing paradigms, ensuring faculty members gained a holistic understanding of the subject matter.

Furthermore, the lecture series included sessions focusing on quantum algorithms and their advantages over classical counterparts, software programming for quantum computation, and an introduction to high-performance computing (HPC) through DOST-ASTI's Quantum Circuit Simulation Project. These sessions provided faculty members with insights into the practical aspects of quantum computing, including programming techniques, simulation methodologies, and utilization of HPC resources for quantum circuit simulations.

Throughout the lecture series, interactive lectures, hands-on programming assignments, and group discussions were employed as teaching methods, ensuring active engagement and participation from the faculty members. Mediums such as Jupyter Notebooks, Presentation Slides, and Google Classroom were utilized for content delivery and assessment purposes, with continuous assessment comprising assignments, quizzes, and a final examination.

The lecture series served as a platform for faculty members to deepen their understanding of quantum computing and its applications, empowering them to incorporate quantum concepts into their curriculum and research activities at the Polytechnic University of the Philippines. With reference materials including textbooks, research papers, and online resources provided, faculty members were equipped with the necessary resources to further explore and engage with quantum computing beyond the scope of the lecture series.

V. Conclusion

In conclusion, the collaborative efforts between the Department of Science and Technology - Advanced Science and Technology Institute (DOST-ASTI), academic institutions, and industry partners have propelled quantum computing research and development forward in the Philippines. The Quantum Circuit Simulator (QCS) Project, in particular, has been instrumental in enhancing quantum literacy and research capabilities nationwide. This was demonstrated through successful events like the Quantum Hackathon 2023 at the Cebu Institute of Technology-University (CIT-U), which brought together students, researchers, and industry professionals for a day of collaborative problem-solving and innovation.

Additionally, the Quantum Computing Lecture Series conducted in collaboration with the College of Engineering Faculty of the Polytechnic University of the Philippines (PUP) has been pivotal in enriching the quantum computing ecosystem locally. By equipping faculty members with foundational knowledge and practical insights into quantum computing, the lecture series has laid the groundwork for integrating quantum concepts into teaching and research activities at PUP. This comprehensive approach, covering topics from quantum mechanics principles to software programming for quantum computation, empowers faculty members to explore the emerging field and leverage its potential in advancing engineering education and research.

Overall, these initiatives position the Philippines as an emerging hub for quantum computing innovation and expertise. As momentum in quantum computing research continues to grow, fueled by initiatives like the QCS Project, the nation is well-positioned to contribute significantly to the advancement of quantum technologies and their applications across various sectors. Through continued collaboration and knowledge exchange, the Philippines can harness the transformative power of quantum computing to address complex challenges and drive innovation in the digital age.

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2. Polytechnic University of the Philippines

3. University of San Jose Recoletos

Their engagement and commitment to promoting quantum literacy and research excellence have played a crucial role in shaping the success of our collaborative initiatives.

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