Self-Guided Learning in Quantum Technologies: Unveiling the Role of Grassroots Organizations in Education and Outreach

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Abstract. This study explores the intersection of goals and values in grassroot organisations for quantum technologies (QT) education, emphasizing the distinction between providing education and democratizing learning with inclusivity and accessibility. It analyses how these organisations navigate the early stages, balancing core values with sustainable growth in the specialised QT field. Strategic approaches, including creating educational ecosystems and fostering community engagement, are uncovered. The research highlights potential vulnerabilities, particularly as members transition into professional roles. The paper contributes to the understanding of how emerging QT educational organisations balance ideological commitments with growth considerations, highlighting critical factors influencing their trajectory and impact.

Introduction

The rapid development of QT in recent years has led to remarkable progress in quantum sensors, communications and the scaling up of quantum computing. To sustain this momentum, the establishment of effective ecosystems and the training of a skilled workforce are critical [1]. In recognition of this need, QT degree programmes and workforce training initiatives have emerged, but limitations remain. Traditional pathways often neglect groups such as high school students and individuals from countries with underdeveloped QT landscapes, such as the Global South [2].

In response to these gaps, informal education and training programmes have emerged, facilitated by grassroots organisations. These initiatives offer accessible entry points to QT and potentially provide demand-driven training. Given their nimble nature with small teams, these grassroots efforts address current shortcomings in the conventional training system [2]. However, an understanding of the landscape of such organisations, their operational mechanisms and the motivations behind their establishment is essential. To fill this knowledge gap, our study explores the goals and values of these grassroots QT initiatives.

Theory

Second-generation QT exploit the manipulation of individual quantum states to enable improved measurements, secure communications and the solution of previously intractable problems. Despite the diverse nature of these sub-technologies, they share common quantum mechanical principles such as superposition or entanglement, and are therefore collectively referred to as QT. As QT is still in its infancy and the fundamental processes are still being optimised, research in this field typically requires a fundamental understanding of physics [1]. Traditional physics-related degree courses provide such knowledge, but their accessibility and adaptability to a rapidly evolving technology are limited. Recognising this gap, various grassroots organisations (or initiatives), have emerged to provide alternative approaches to QT education [2].

A previous internal study identified notable differences in the direction of grassroot organisations, highlighting the need to explore the motivations, goals and guiding values of grassroots organisations in QT education. In response, our research aims to address three key questions: (1) What motivates grassroots organisations in QT? What goals do they pursue and what values shape their actions? (2) Do grassroots organisations play a significant role in QT

education or are they emerging as key contributors? (3) How do grassroots organisations operate and what is their impact on the QT ecosystem?

Methods and Findings

To address our research questions, a mixed-methods study was conducted using interviews and a questionnaire. This facilitated the collection of quantitative data on the development of grassroots organisations and revealed unexpected motivations of the founders. The selection of these organisations was based on a previous project using a convenience sample. Interviews with founders were conducted in two rounds - first focusing on established organisations and then analysing a more geographically diverse group to cover global regions.

Sixty-minute online interviews with a total of 22 organisations, of which 17 were qualitatively interviewed, revealed geographical diversity: Africa (6), Asia (5), Europe (3), North America (7) and South America (1). Predominantly small in size (25% with <10 staff, 60% with 10-20, and <20% with >20), these organisations often had youthful leadership, with members of school or university age. Initial goals were predominantly educational, with an emphasis on material development and opportunity creation, addressing gaps in beginner-friendly learning resources and workforce diversity. Grassroots initiatives aimed to engage marginalised groups and unreached societies, promote collaborative learning, raise awareness and influence QT stakeholders.

Underlying values align with these aims, with inclusivity, accessibility and diversity at the forefront. There is an emphasis on breaking down barriers, particularly language barriers, and developing leadership skills. Notably, while training is valued, democratising QT ranks higher. Teaching and learning methods prioritise accessible learning materials, comprehensibility, sharing platforms and events such as journal clubs. By challenging the perception of QT as a "secret code", these methods help to break down barriers.

These grassroots efforts have a significant impact on the QT ecosystem by fostering community building and integrating neglected voices, potentially influencing technology development and QT adoption. Regional differences are evident, with grassroots from Africa and Asia focusing on outreach and opportunity creation, while European and North American organisations emphasise ecosystem and community building. Challenges include a lack of attention from key stakeholders, funding issues and a reliance on educational programmes.

Conclusion

In conclusion, our mixed-methods study looks at grassroots QT organisations around the world. These nimble initiatives, predominantly led by young members, aim to democratise QT education by emphasising inclusivity, accessibility and breaking down barriers. By addressing global inequalities and including marginalised voices, these organisations are having a significant impact on the QT ecosystem. However, challenges such as funding and stakeholder attention persist, highlighting the need for continued support to bridge educational gaps and foster diverse contributions to the evolving quantum landscape.

References

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