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Quantum for All: Using Social Media to Raise Public Awareness of Quantum Technologies

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Abstract: Quantum technology has significantly progressed over the last decade. While initially of interest to a narrow circle of professionals and technology enthusiasts, the general public's knowledge of the developments in this domain, as well as the pitfalls and benefits, is currently considered low. As quantum innovations are being integrated into strategic agendas on national and supranational levels, initiatives should be undertaken to raise public awareness about these technologies. The present paper examines the current trends of the implementation of social media, and, in particular, Instagram, by supranational organizations and initiatives to raise public awareness of quantum technology advancements. This research conducts an analysis of topical messages from the Instagram accounts of the International Year of Quantum Science and Technology (IYQ), the United Nations Educational, Scientific and Cultural Organization (UNESCO), and the European Commission account for Digital EU. The study highlights the patterns of social media communication by supranational organizations and initiatives on quantum technologies' properties and provides reflections on the future research avenues to explore public awareness of this disruptive technology. The findings serve as the basis for further research on various aspects of public outreach to inform about the quantum evolution and its potential impact on society, economy, and future digital transformation developments.

Keywords: quantum technologies; quantum computing; emerging technologies; technological awareness; digital transformation

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1. Introduction

Over the past decade, quantum technologies, and, in particular, the quantum computing (QC) domain, have garnered remarkable interest in academic and industrial circles [1] due to their outstanding characteristics. Enhanced efficiency, upskilling, and the desire to achieve market leadership are among the main drivers for QC exploration in industry [2]. The quantum technology market is expected to grow in the coming years, with the maximum expected revenue reaching USD 106 billion by the year 2040, and QC showing the highest revenue growth expectations [3]. The disruptive potential of quantum technologies is recognized at the governmental level, with China, the European Union (EU), and the United States leading in the public funding of this technology [4]. The European Union's Digital Decade strategy aims to launch its first supercomputer with quantum acceleration by 2025, positioning the EU to lead in quantum technologies by 2030 [5]. Quantum advancements attract attention on national and supranational levels—the United Nations (UN) declared 2025 the International Year of Quantum Science and Technology (IYQ) [6] with the aim of spreading awareness of the properties of these technologies and the opportunities they provide to society.

Today, the applications of QC go beyond solving theoretical research. They are increasingly moving into solving applied problems in biochemistry and pharmaceuticals, optimizing financial and logistics problems, and several other domains. However, today, there is a prominent trait of QC in that it is perceived as a highly scientific product, far from being accepted even into certain areas of human activity on an ongoing basis. It is of interest to a narrow circle of people—scientists, engineers, top managers of large corporations, and government officials. Many articles in the research literature databases provide technical, highly specialized information on solving specific theoretical or applied tasks in QC technology. There is comparatively little research concerned with the economic and social components of quantum technology that could motivate interest in wider audiences and, therefore, could provide a higher level of awareness among various audiences.

How well people understand the meaning of quantum technologies will determine further progress in its study, dissemination pace, fields of application, coverage rates, and readiness for technological transformation. Therefore, the current issue is to understand how society can gain a general understanding of quantum technologies, the advancements they bring to the world, and the hurdles that society may face in adopting these disruptive technologies. There are a number of ways to raise social awareness about key societal concerns. For example, The Transparency, Accountability and Participation (TAP) Network stands for the public outreach of the UN Sustainable Development Goals by adopting a range of methods: the development of educational materials for non-experts; media production; organization and engaging in the events, both online and offline; radio and mobile communications; mass media outreach; and online engagement by means of employment of social media [7]. Indeed, social media has recently become an important medium for public outreach by governments and supranational organizations [8–11]. In the present article, we explore the dynamics of awareness-raising on the benefits and pitfalls of quantum technologies in social media, particularly on Instagram, through the accounts of the IYQ, the United Nations Educational, Scientific and Cultural Organization (UNESCO), and the European Commission account for Digital EU, and how this information is communicated to the public.

The paper is organized as follows: the Methodology Section describes the research method applied to the study; the Literature Review Section provides evidence of the recent developments in the academic discourse on the possible applications of quantum solutions and the ways to raise awareness on the topic reflected in the literature; the Results and Discussion Section provides findings from the conducted research; and the main outcomes of the research are summarized in the Conclusions Section.

2. Literature Review

2.1. Quantum Computing Applications: Opportunities and Challenges

QC "is an emerging branch of computer technology that uses principles of quantum mechanics to perform computations" [12], increasing its speed and accuracy. Many existing studies mainly consider the technical aspects of QC, which have some applications in social and business spheres. QC is greatly gravitating to becoming commercialized, and primarily, this is a merit of the pharmaceutical, fintech, gaming, insurance, and chemical industries, automotive production, bank arbitrage, advertising, the IoT and IoV; therefore, adverse consequences for the economy would appear in the case of security breaches in these industries [13–17].

The e-commerce sector is first driven by complex algorithms that determine pricing and recommendations and enable the processing of large amounts of data. In this regard, QC can significantly help and even revolutionize e-commerce [18]. QC would also affect marketing activities: it would greatly help elaborate and embed efficient and

target-driven recommender systems [19] and facilitate advertisements in reaching high conversion rates [17].

Studies have revealed that QC also shows transformational effects on the financial services sector; this is most evident in credit risk evaluation activities; it is better and faster than Monte Carlo simulations made on classical computers [20]. Credit portfolio risk measurement was performed in another study by Kaneko et al. 2021 [21]. A combination of quantum amplitude estimation (QAE) has been applied by researchers together with pseudorandom numbers; the operations performed in the aforementioned study are implied to make financial institutions capable of leveraging QC for the efficient management of credit portfolios comprising different customer categories [21].

QC is expected to significantly impact renewable energy through applications in simulation, scheduling, dispatch, and reliability analysis; future challenges in this sector, mainly related to the scalability of existing methods, could be effectively addressed by QC [22].

The immense power of QC has the potential to greatly benefit the pharmaceutical and medicine fields; this capability could enable the development of vaccines and drugs several times faster than current methods; however, this potential has yet to be proven, as achieving the necessary computational capabilities will require years of rigorous engineering and scientific effort [23].

Quantum chemical simulation, a newly proposed method, provides a more efficient, faster, and more cost-effective means of understanding the properties of pharmaceutically relevant molecules, often without the need for expensive laboratory experiments; moreover, computational techniques can help explore novel classes of therapeutics and help push the boundaries of medical treatment [24].

Despite the potential opportunities and use cases of QC, the technology's significant challenge is the high cost of integrating QC into everyday life [25]. Along with that, attendant security presents a significant challenge, and transitioning to QC would still require significant research to mitigate these attendant security challenges [26]. Security matters come out on top, as QC could break encryption mechanisms and lead to accompanying harmful consequences. There is still a lack of standardized measures to protect data, though QC is already in use and strives to become a supreme computing technology [27].

2.2. Ways to Raise People's Quantum Computing Awareness

The studied papers generally admit that people's awareness of QC technologies is still low. Various information sources can also cause people to have misconceptions about this technology. However, quantum technologies as a broad concept, QC in particular, are most likely becoming the basis for the Industrial Revolution 4.0, and society should be ready to accept this and, moreover, prepare specialists of various levels to work in this area [28]. An important part of these actions should also be increasing people's awareness about QC, development prospects, and tasks that could be solved with QC's implementation. When the level of information awareness increases, it affects the intensification of people's interest in finding, studying, and learning these technologies, which will ultimately lead to the intensification of the development of quantum technologies and the pathway to technological transformation.

There is a pressing workforce gap in QC education and skills, while the post-quantum era is getting closer; therefore, a systematic, transversal approach to quantum education is needed, and both public and private stakeholders have started to actively enhance the efforts to advance quantum education [29]. Universities can be the primary source of QC awareness; QC education could be integrated into cybersecurity and software engineering curricula to heighten students' quantum awareness and curiosity; the authors of [30] observe the increase in student eagerness to further explore QC.

Pasin et al. (2024) [30] present an international lab called QuantumCLEF, focused on using Quantum Annealing, a paradigm designed to tackle optimization problems. The value of the lab was not only to use real QC technologies to develop and evaluate QC algorithms, but given that QC technologies are currently not widely accessible to the general public, the lab also aims to raise awareness about the potential of QC and its likely future impact. Lab participants acquired the skills to solve diverse problems within their research domains, applying QC technology skills beyond the lab environment [30]. Such labs can disseminate a specific range of knowledge in QC among students and other researchers and are likely to contribute to upgrading their skills. Such information sources are designed for a narrow range of people, primarily those engaged in university and already familiar with QC basics.

Boateng and Liu (2014) [31] raise the security aspect of QC in the context of people's and organizations' awareness of QC; organizations and individuals should be aware of QC to know how to resist future potential breaches of cryptography mechanisms and how to secure data with the emergence of more powerful computing technologies.

Exhibitions render the particular effect of raising public awareness of quantum technologies, in particular, the interactive ones [32]. Scholars presented the findings of an interactive art exhibition on the theme of quantum physics in Davos, Switzerland, in January 2020 during the World Economic Forum; the goal of the exhibition was to raise awareness amongst the general public as well as policy and government officials toward QC and to inspire the visitors to learn more about how quantum phenomena work. Such events, like the interactive exhibition described above, specifically impact the general public and serve as enablers and contributors to people's awareness of QC. More such exhibitions should be held on regional and global levels, aiming to attract more related visitors.

The topic of the society-wide adoption of the QC is an important issue. The following questions are still obscure: When will QC become available for general public use? What benefits are promised for the individuals? The use of QC might be limited for the general public due to the intrinsic characteristic of solving rather specialized tasks. Despite this, the situation might change in the future when the technology demonstrates broader utility and comfort of use. Society's optimistic expectations for QC (formed and nurtured by governments and corporations, at least) could act as a catalyst for this. In this sense, it is important to form a positive perceived benefit of QC for everybody, even if QC can solve highly specialized tasks for now [27].

3. Methodology

In this article, we explore social media communications of supranational organizations and initiatives regarding the properties of quantum technologies to raise public awareness on the topic. We decided to analyze the Instagram activities of the recently launched IYQ initiative, UNESCO and the EU as major supranational organization involved in the "quantum" discourse and one of the leaders in quantum technology funding. In order to retrieve more topical data, we agreed to investigate the following Instagram accounts:

1. @quantumyear2025_—An account of the IYQ initiative [33]. The IYQ opening ceremony was held on 4 February 2025, and by the time this article is finalized, not all events and approaches to raise public awareness on quantum technologies may have been launched. For the same reasons, social media communication from this account is still in its initial stages. Nonetheless, there is already evidence of its emerging communication pattern and the evolving public discourse on quantum technologies.
2. @unesco—The official account of the United Nations Educational, Scientific and Cultural Organization (UNESCO) [34], which proposed the launch of the IYQ initiative with the support of the representatives of professional circles and at the request of

several states, and coordinates its activities together with the American Physical Society (APS).

3. @DigitalEU—The official account of the European Commission to promote the EU's pursuits on digital technologies [35]. This account informs the followers on a wide range of digital innovations employed or developing in the EU, it raises awareness on various digital issues society may face, and quantum technology discourse falls in this domain.

After the authors reached an agreement on the Instagram accounts, the criteria for including posts in the study were identified. It was decided to retrieve the posts, including both descriptions and any messages in the post galleries (collections of multiple photos or videos shared in a single post), that discuss the properties of quantum technologies, explain their potential applications, highlight benefits and challenges for society, and simplify the technical aspects. This approach aims to provide a comprehensive understanding of how quantum technologies are communicated to the public through social media.

Table 1 shows the number of posts published on the selected accounts as of 14 March 2025, as well as the posts chosen for analysis.

Table 1. Posts gathered for further analysis.

Instagram Accounts	Total Number of Posts	Number of Posts Chosen
@quantumyear2025_	14	6
@unesco	3495	1
@DigitalEU	2370	17
Total	**5879**	**24**

After carefully reviewing 5879 Instagram posts, we identified 24 posts falling within the predefined parameters. We combined the @quantumyear2025_ and @unesco posts into a single group under the code name "UN", as UNESCO is a key UN organization for this initiative; however, it is important to note that management and supervision activities of the IYQ involve the joint efforts and participation of international partners, including representatives from governments, academia, and industries. @DigitalEU posts are united in the EU group. The posts were analyzed using principal component analysis (PCA), and a term co-occurrence map was created to visualize the relationships between key terms, thereby providing deeper insights into the content and themes related to quantum technologies.

4. Results and Discussion

4.1. UN Quantum Initiatives

The IYQ is a global initiative, that "began as a grassroots movement" [36] designed to enhance public understanding of the significance and influence of advancements in quantum technologies and their applications across various domains. On 7 June 2024, the UN proclaimed 2025 as the IYQ to celebrate the centenary of quantum research with UNESCO as a "lead agency and focal point" [6] of this initiative. In the proposal for this initiative presented by UNESCO in April 2023 [37], among the outcomes of the IYQ are the following:

> *"Improved appreciation by the general public of the importance of quantum science and technology in research and development in scientific areas relevant to achieving the SDGs."*

and

> *"An improved appreciation by all citizens of the world of the achievements of science in shaping the modern world, particularly the nature of the scientific method which is an essential tool against scientific misinformation."*

The initiative claims that quantum research is not proprietary and ought to be accessible to everyone. The IYQ encourages all individuals to share their perspectives with those less acquainted with quantum concepts, acknowledging the advantages, pitfalls, and eventual uncertainties of the technology. The IYQ promotes assisting others in locating trustworthy quantum information, based on the principles of scientific integrity and transparency [36].

This initiative is supported and promoted by the national representatives of professional societies in the fields of physical research, chemical institutes, organizations that operate in astronomy, optics, nanotechnologies, and many other domains. Moreover, this action is sustained by representatives of industries and academic circles.

4.2. EU Quantum Initiatives

As was previously stated, the EU is one of the current leaders in public funding for quantum technologies [4], placing the European community at the vanguard of quantum advancements. European states are implementing joint measures to establish a quantum ecosystem within the Union, uniting years of experience in quantum research in Europe with the industrial circles and investors. The Quantum Technologies Flagship [38] is the EU funding program, established in 2018 to support innovations in this domain. The measures undertaken are not limited to QC but also target quantum communication, simulation, sensing, and metrology.

Indeed, quantum technology initiatives in the EU go beyond the theoretical exploration of technological advancements; the EU aims to build QC in six European countries by the year 2025. This objective is embedded in the European High-Performance Computing Joint Undertaking (EuroHPC JU) [39] initiative and implies the future free access to the European quantum infrastructure to industrial and scientific circles. The EU supports the development of quantum sensing infrastructure. Under the European Chips Act [40], launched in 2023, the EU will, among other objectives, focus on researching the potential of quantum technologies, especially for the creation of European quantum chips. A pursuit to develop and launch a Quantum Communication Infrastructure (QCI) [41] was declared in 2019. This initiative will help Europe defend against cyberattacks, mitigate decryption risks, and safeguard the EU's critical infrastructure.

4.3. Instagram Communications on Quantum Technologies

The IYQ posts (@quantumyear2025_) cover a wide range of topics. They invite followers to explore the everyday tasks of quantum scientists, provide insights into events conducted within the IYQ framework, share educational materials, and encourage enthusiasts to contribute to the initiative. The IYQ account also provides updates on official events related to the initiative, such as the opening ceremony and engaging speeches. The account also introduced the official mascot of the IYQ—Quinnie.

The posts we retrieved reflect how quantum technologies are connected to the mysteries of the universe and how they shape the society. The communications explain in simple terms the nature of quantum mechanics and quantum physics, which drive quantum innovations, introducing key concepts such as the principle of superposition and quantum entanglement. The properties of quantum technologies are illustrated with real-world applications, including GPS navigation, MRI analysis, LED lighting, advanced AI, and predictive monitoring across various domains.

The official European Commission account for Digital EU updates users on both the current and future pursuits of the organization to lead the quantum technology sector and cover both research activities and practical implementation. The official Instagram account informs followers about bilateral agreements in the field and ongoing initiatives such as the Quantum Technologies Flagship programme, EuroHPC JU, and EuroQCI. This communication sheds light on the progress in the development of European QCs, particularly the first compact QCs. It also highlights key collaborative projects that drive European quantum science forward.

The benefits of quantum technologies emphasized in the EU Instagram communication include enhanced infrastructure security, accelerated technological advancements, improved environmental monitoring, breakthroughs in human body simulation, and the ability to solve societal challenges with more efficiency. The applications of quantum technology featured on @digitalEU include healthcare (MRI and drug discovery), AI, cybersecurity, GPS navigation, and telecommunications. The account incorporates technical terms, educating followers on quantum mechanics and quantum objects; it also promotes the IYQ initiative.

Figure 1 represents a PCA of the retrieved Instagram posts conducted in R 4.4.3. PCA can help uncover the trends and the overlaps in social media communication. In our case, PC1 and PC2 amount to 17.8% of the total variation in the dataset. Most of the posts (in both EU and UN groups) are closely clustered, expectedly indicating that they share similar thematic elements. However, a few outliers, especially among the UN group posts, are more widely spread along PC1 and PC2; this configuration may reflect more diverse topics covered.

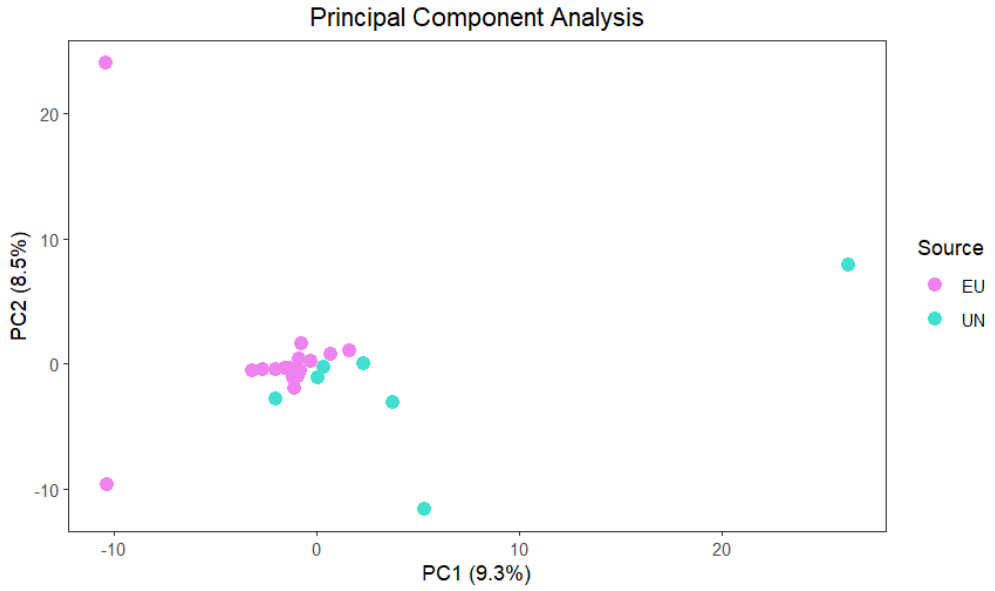

Figure 1. Principal component analysis of Instagram communication.

Figures 2 and 3 illustrate the co-occurrence maps created in VOSviewer for the terms used in the UN group (IYQ and UNESCO) and the EU Instagram communications. We observe five word clusters for the IYQ and UNESCO messages and four clusters for the EU Instagram communications. This observation is supported by the PCA. Despite the fact that the number of analyzed IYQ and UNESCO posts is less than half that of the EU, they show greater diversity. This state of affairs can be attributed to the global IYQ initiative's primary focus on raising public awareness about quantum technologies, as it aims to present the technology from multiple perspectives and gradually introduce individuals to recent and future developments and properties. In contrast, while the EU also employs Instagram

to emphasize the significance of quantum technologies in everyday life, it also uses the platform to inform citizens about the ongoing EU initiatives in this domain.

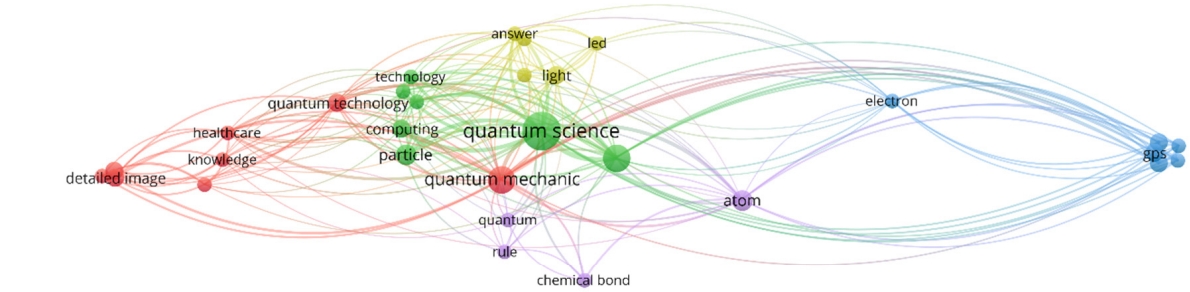

Figure 2. Term co-occurrence map for the UN (IYQ and UNESCO) posts.

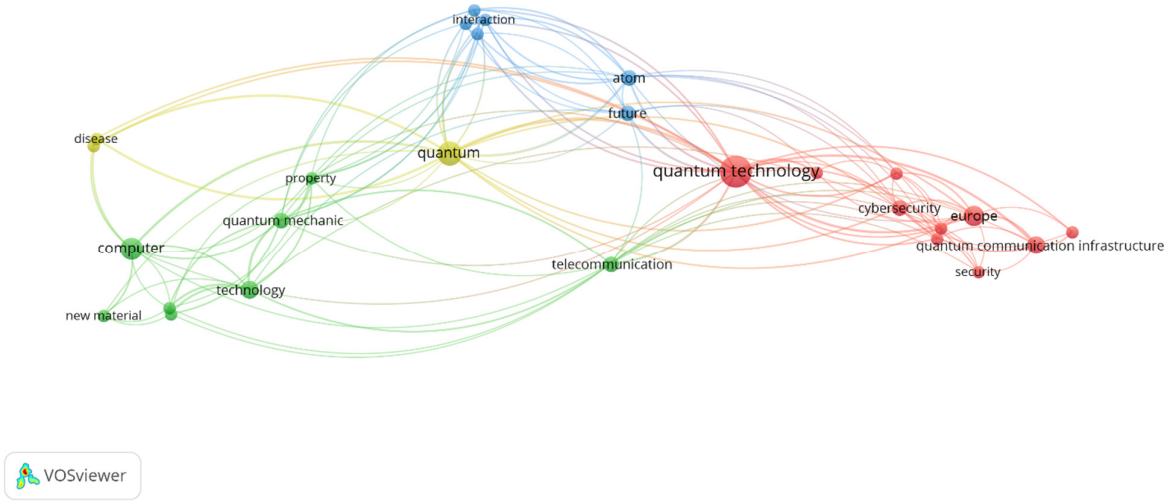

Figure 3. Term co-occurrence map for EU posts.

5. Conclusions

Quantum technology is a highly challenging set of innovations that is expected to provoke disruptive effects on humanity. Some of these effects may have undesired consequences. Society needs to be informed about both the foreseen positive aspects and be prepared to face the negative outcomes. An important aspect of this is raising people's awareness about quantum technology.

There is still not enough literature expanding on the research question of how to enable people's awareness of quantum technology. The literature states that universities, quantum labs, and thematic events may serve as instruments to raise awareness of quantum topics. However, raising society's awareness is not a primary activity of universities and laboratories, while events, particularly exhibitions discussed in the literature, may have a limited outreach. For this reason, social media platforms may be involved.

In this article, we have discussed the activities of supranational organizations and initiatives in promoting public awareness of quantum computing. We have identified topical messages from the Instagram accounts of the IYQ, UNESCO, and the European

Commission account for Digital EU. Despite these accounts having different objectives and audiences, we can identify several trends in their communication:

1. The communications highlight the advancements of quantum technologies and explain the "mysteries" of these innovations, but they do not emphasize the possible negative aspects, such as cybersecurity risks, threats to encryption, and technical limitations.
2. The accounts educate followers on the technical aspects of quantum computing by introducing definitions of basic quantum-related terms, using engaging narration, and providing real-world examples.
3. The narration style is captivating; the posts avoid complicated language, making the message accessible to everyone. The posts invite readers to dive deeper into the exploration of quantum topics, providing links to more detailed materials and actions related to the development of quantum technologies.

The present study is not without limitations, which could, however, be addressed in future research, as this topic offers a wide range of research avenues for further exploration. The study analyzes a limited number of Instagram accounts; future research may examine more social media sources (Instagram, X, Facebook, and LinkedIn) to evaluate communication trends on the topic. It could also be interesting to study the social media communication on quantum technologies from the national accounts of countries with the highest public funding in this field and industry leaders. Moreover, there is a need to evaluate the level of follower engagement in this communication, assess the number of likes and reposts, and conduct a sentiment analysis of the comments.

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