Achievements, Experiences, and Improvement Strategies of International Organizations in Promoting Open Science Development: A Case Study of the International Knowledge Centre for Engineering Sciences and Technology (Postprint)

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Abstract

[Purpose/Significance] Open science, as a revolutionary systems engineering project, faces a series of challenges in its development process, requiring breakthroughs from multiple barriers including national boundaries, professional silos, and narrow interests. [Method/Process] China has been making sustained efforts in innovating research incentive systems, fostering an open science environment, and enhancing organizational and platform support to accelerate the comprehensive implementation of the "freedom, openness, cooperation, and sharing" philosophy of open science. Simultaneously, through establishing and operating Category II centers, China has continuously deepened comprehensive cooperation mechanisms with international organizations including UNESCO, accumulating experience in collaborating with international organizations to promote open science development. [Results/Conclusions] Its successful practices demonstrate the effectiveness of open science as a non-market scientific and technological development and innovation incentive mechanism, reflect UNESCO' s unique advantages in leading open science development, and create a positively-oriented global cooperation model for open science development with international organization participation. Summarizing these experiences will help guide China to better leverage its overall institutional advantages within the future "1+1>2" mechanism framework, achieve leapfrog advancement in the process of solving problems and unleashing potential, and open up a new path for open science development with Chinese characteristics.

Full Text

Abstract

Open science, as a revolutionary systems engineering endeavor, faces a series of challenges in its development that require breaking through multiple barriers, including those between nations, professional domains, and narrow interests. [Method/Process] China has made continuous efforts to innovate its scientific research incentive system, create an open science environment, and strengthen organizational and platform support. In the process of accelerating the comprehensive implementation of open science' s core values— "freedom, openness, cooperation, and sharing" —China has also deepened its all-round cooperation mechanisms with international organizations including UNESCO by establishing and operating Category II centers, thereby accumulating valuable experience in collaborating with international organizations to promote open science development. [Result/Conclusion] Its successful practice demonstrates the effectiveness of open science as a non-market incentive mechanism for scientific and technological development and innovation, reflects UNESCO' s unique advantages in leading open science development, and facilitates the creation of a positively-oriented global cooperation model for open science development through the participation of international organizations. Summarizing these experiences will help guide China to better leverage its overall institutional advantages within the "1+1>2" mechanism framework in the future, achieve "overtaking on the bend" in solving problems and unlocking potential, and open up a new path for open science development with Chinese characteristics.

Keywords: open science; international organizations; IKCEST; achievements and experience; problems and countermeasures

Introduction: Open Science Development and the Role of International Organizations

1.2 Overview of UNESCO Category II Centers

Among various non-governmental international scientific and technological organizations, UNESCO has undoubtedly contributed the most to helping developing countries advance their scientific and technological capabilities. UNESCO Category II centers are institutions established when a member state government submits a written application to UNESCO, which is then reviewed and approved by the UNESCO General Conference, followed by the signing of a cooperation agreement with the applying government. Generally, the agreement between UNESCO and the host country is valid for six years; after 2019, according to new regulations, this can be extended to eight years. UNESCO conducts evaluations of Category II centers six years after the agreement takes effect and decides whether to renew or terminate the agreement based on the evaluation results.

In terms of management structure, Category II centers operate under UNESCO'

s support and supervision (typically indicated by adding "under the auspices of UNESCO" to the center' s name), may use UNESCO' s name and logo under conditions and procedures determined by UNESCO, and establish a governing board and advisory committee composed of UNESCO representatives, government officials, and expert members. Serving as advocates for scientific and technological norms and policies, defenders of scientific values, and coordinators of multiple interests and ideas [4], these centers also have the important function of advancing open science development through collaboration with host countries. Currently, approximately 17 Category II centers are located in China, covering multiple fields [5] and focusing on three aspects: science and technology, education, and culture. Geographically, their distribution is relatively concentrated, primarily in international metropolises such as Beijing and Shanghai [6]. Among these centers, institutions like the International Knowledge Centre for Engineering Sciences and Technology (IKCEST) and the International Centre for Engineering Education (ICEE) align with UNESCO' s responsibilities and tasks for developing open science.

Overall, China' s Category II centers have lived up to national expectations in practice, demonstrating active performance. They earnestly fulfill their respective duties as required by UNESCO, advance various tasks in an orderly manner, and exhibit unique advantages such as accepting multi-party management, fully considering the strategies and requirements of both the host country and UNESCO, and continuously adjusting their own plans and tasks to balance the demands of all parties. This has laid a solid foundation for Category II centers to play an important role in China' s open science development.

2. Significant Achievements of UNESCO Category II Centers, Including IKCEST, in Boosting China' s Open Science Development

2.1 Achievements of IKCEST in Boosting China' s Open Science Development

From the perspective of its original mission, much of IKCEST' s work has been carried out around strengthening the pillars of open science and has achieved notable results.

2.1.1 Building an Integrated "One Master Platform with Multiple Sub-platforms" to Provide Free Knowledge Services As previously mentioned, an important aspect of open science practice lies in the construction of platforms that facilitate the dissemination of open knowledge and open data. Currently, IKCEST has collaborated with renowned domestic universities and research institutes to build an integrated "1+N"master-sub-platform operational system, continuously aggregating data resources in the field of engineering science and technology and providing online knowledge services. The framework of the platform construction is shown in Figure 1 [Figure 1: see original paper].

In operation, the platform has also developed six language frameworks, researched and developed a unified search engine, and jointly created international and professional knowledge service products. It has continuously expanded relevant sub-platforms in advantageous fields such as disaster prevention and mitigation, engineering education, and smart cities. Notably, the sub-platform construction based on the IKCEST platform has fully utilized advanced technologies at the forefront of open science development, including open international technical standards and open-source Web technologies (disaster prevention and mitigation sub-platform), online-offline hybrid cloud computing education platform technology (Silk Road Science and Technology sub-platform, Engineering Education sub-platform), and the "comprehensive perception-accurate judgment-appropriate response-self-learning" cycle CityIQ technology (Smart City sub-platform). This has successfully built a platform system that runs through the open science concept in its design and operation, demonstrating the late-mover advantages of international organization Category II centers in assisting China' s open science development platform construction.

By the end of 2021, the total number of datasets across IKCEST' s master and sub-platforms had reached 372, with a data volume exceeding 230 million entries, 38 knowledge service applications, total webpage views exceeding 9 million, and total user visits reaching 2 million. The service covers 220 countries and regions, with overseas users accounting for 66%, and coverage of countries along the "Belt and Road" reaching an impressive 100%.

2.1.2 Promoting Open Science Exchange through Continuous International Symposiums Exchange and sharing constitute the soul of open science development. Since its establishment, IKCEST has been committed to building an international high-end academic exchange platform, providing knowledge sharing and research exchange support for international organizations to address global challenges. Specific cases include: the disaster prevention and mitigation sub-platform provided support for global disaster prevention and mitigation capacity mapping and knowledge sharing support such as the Institution Mapping for Disaster Risk Reduction report in 2020; the Silk Road Science and Technology sub-platform, responding to Thailand' s urgent needs for new energy vehicle industry development, actively organized and hosted the online summit "Post-Pandemic • New Normal—Investment Opportunities in Thailand' s New Energy Vehicle Industry," providing an international exchange platform for its industrial development.

By the end of 2021, IKCEST had cumulatively held 24 international high-end seminars covering themes such as big data, artificial intelligence, and online engineering education, building a high-quality academic exchange platform for renowned experts and scholars at home and abroad. During these events, more than 100 renowned experts, including domestic and foreign academicians and UNESCO project experts, participated, serving an audience of over 17,000 participants. In recent years, IKCEST has also been invited to international confer-

ences as a model "open science platform" to introduce its construction concepts and progress, earning widespread recognition from domestic and international academic communities.

2.1.3 Building Organizational and Activity Platforms for All Social Sectors to Participate in Open Science Development and Providing Free Science and Technology Training One of the essential tenets of open science lies in universal participation in scientific research. Consequently, organizations leading open science development need to provide tangible support for enhancing social participation in research activities. IKCEST established the Silk Road Training Base in 2017, holding multiple forms of online and offline, domestic and overseas training sessions on diverse themes and fields every year. Between 2015 and 2021 alone, IKCEST held 107 training sessions covering 30 themes and 115 countries and regions, training more than 18,000 participants, with women accounting for 35% and training satisfaction exceeding 90% (as of the end of 2021). This has strongly supported the capacity building of universal participation in open science in developing countries through continuously expanding human resources.

2.1.4 Supporting Major Engineering Science and Technology Projects Closely Related to the Development Needs of Developing Countries The deep rooting and widespread acceptance of the open science concept in developing countries largely depend on the demonstration of its practical engineering effectiveness. In view of this, IKCEST has also leveraged its technical and organizational advantages in leading open science development by deeply engaging in engineering construction affairs related to China' s national strategy and relevant countries and regions. For instance, in recent years, IKCEST has participated in the "Belt and Road" China-Pakistan Economic Corridor disaster investigation and data project, as well as Shanghai' s "14th Five-Year Plan" pre-research project. These efforts have also contributed to the achievement of sustainable development goals.

2.2 Achievements of Other UNESCO Category II Centers in Boosting China' s Open Science Development

While IKCEST has effectively boosted China' s open science development, other UNESCO Category II centers have also played active roles. In terms of scientific knowledge dissemination and open science exchange, other Category II centers hold annual academic conferences in various disciplines and professional fields to promote relevant exchanges. For example, the International Centre for Engineering Education (ICEE) holds annual international seminars in the field of engineering education, aiming to improve engineering education quality, explore the deep integration of online education, smart teaching, and engineering education, and promote the global sharing of high-quality engineering education resources. The UNESCO International Centre on Space Technology for Natural and Cultural Heritage (HIST) hosts the Huangshan Dialogue on UNESCO-listed

heritage and sustainable development, building an academic exchange platform for the sustainable development of listed heritage among multiple countries.

In promoting citizen science development, most Category II centers also conduct science and technology training to varying degrees, disseminate scientific and technological knowledge, and assist in capacity building for science in developing countries. For instance, the UNESCO International Training Centre for Intangible Cultural Heritage in the Asia-Pacific Region conducts long-term classroom and field training on frontier topics related to intangible cultural heritage, holding 7-8 training sessions annually on intangible cultural heritage and sustainable development to share preservation experiences. The UNESCO International Centre for Higher Education Innovation (Shenzhen, China) launched the International Institute of Online Education (IIEO) project in 2020 against the backdrop of the pandemic, providing training and career development support for higher education workers and helping higher education institutions in developing countries cultivate educators with online and blended teaching capabilities and information literacy. The International Research and Training Center for Science and Technology Strategy (CISTRAT) holds annual training courses on "Science and Technology Development Planning Strategy Research and Compilation Methods for Developing Countries," conducts international cooperative research and training on science, technology, and innovation policies and strategies, establishes collaborative networks for science and technology policy research, and promotes cooperation among governments, academia, and industry to facilitate knowledge diffusion.

Additionally, institutions such as the UNESCO International Research and Training Center on Erosion and Sedimentation (IRTCES) and the UNESCO International Centre for Theoretical Physics (Asia-Pacific) have also, through implementing various scientific training programs and participating in China' s major scientific research and engineering projects in their respective professional fields, worked to promote the integration of science and education and the integration of industry and research, making important contributions to the cause of Category II centers boosting China' s open science development.

3. Experience Summary and Problems Faced by UNESCO IKCEST in Boosting China' s Open Science Development

In summary, in less than ten years since its establishment, IKCEST has achieved tangible results in serving China' s development through open science through extensive interaction and cooperation with the Chinese government, academia, and society.

3.1 Experience Summary of UNESCO IKCEST in Boosting China' s Open Science Development

3.1.1 Demonstrating the Effectiveness of Open Science as a Non-Market Incentive Mechanism for Scientific and Technological Devel-

opment and Innovation As an organization jointly established and supervised by UNESCO and China, IKCEST and other Category II centers have distinct public attributes. Moreover, although they are also transnational organizations, they differ significantly from international organizations such as the International Monetary Fund (IMF) and the World Bank, which are largely tied to the national interests and geopolitical strategies of major powers and carry obvious ideological tendencies. UNESCO and its Category II centers do not attach additional political or economic conditions when promoting the participation of host countries and developing countries in open science development, nor do they involve profit-making objectives for the organizations themselves. Under UNESCO' s genuine "one country, one vote" system, which tends to fairly reflect the demands of all countries, they have made substantive contributions to promoting open science development in developing countries. Therefore, their purer motivations and actions are more easily recognized by developing countries and make it easier to establish a collaborative mechanism for multiple stakeholders in open science development with Category II centers as the hub. In fact, market failure is also a common problem in the field of scientific and technological innovation in developing countries, and the practices of various countries have fully proven that market mechanisms have been ineffective in inducing the transformation of self-interested secrecy into open, self-interested altruism. Although, according to the purely logical deduction under the rational economic person premise, the construction of open science and technology policies has sufficient logical basis [10], a comparison with the actual problems faced by open science development reveals that the factors constituting its main development barriers are inseparably linked to the market-based scientific research system. Therefore, from this perspective, it is not difficult to understand why Category II centers, which emphasize non-profit objectives rather than transnational technology companies or profit-making international organizations, can play a key role in breaking through the narrow interest barriers hindering open science development.

3.1.2 Reflecting UNESCO' s Unique Advantages in Leading Open Science Development The development of open science requires extensive participation and collaboration from multiple stakeholders. As the largest specialized agency of the United Nations, UNESCO' s "ownership advantages" — comprising intangible assets such as brand and reputation, information, technology, and concepts—and its "internalization advantages"of incorporating Category II center activities under its internal supervision enable it to play a leading role effectively in the process of boosting open science development. Its "location advantages"also enhance the internationalization level and influence of the host city [5]. Of course, one of the keys to the smooth implementation of relevant platform construction and project promotion is that Category II center activities are often based on strategic frameworks and cooperation agreements between UNESCO and the host country system, supported by complete contracts and regulations. This reduces potential resistance and risks in subsequent actions and helps save

the cost of policy implementation for open science development. Furthermore, compared with academic initiatives and development plans of single countries or local regions in the early stages of open science development, open science development boosted by authoritative international organizations such as UNESCO and its Category II centers necessarily demonstrates obvious advantages in the sense of systems engineering. It is also more conducive to integrating diverse stakeholders—research-oriented, technology-oriented, society-oriented, and user-oriented—into the collaborative process of open science development with these organizations as organizational-policy pivots, providing strong external momentum for their cooperation [11].

3.1.3 Contributing to a Positive-Oriented Global Cooperation Model by Actively Aligning with Host Country National Strategies and Developing Country Development Needs According to UNESCO' s relevant rules for establishing Category II centers, the main operating funds for these centers come from the financial appropriations of the host country government, which prompts Category II centers to conduct more research and adapt to the national conditions and policies of the host country. As mentioned earlier in the overview of IKCEST' s practices and achievements, the knowledge service products developed and launched on its platform have actively aligned with China' s national strategies such as the Western Development Strategy, the "Belt and Road" Initiative, poverty alleviation and disaster reduction and rural revitalization projects, and smart city construction and industrial development strategies. This integration has allowed the practice of Category II centers in boosting open science development to merge with the host country' s own development plans and objectives, forming a mutually reinforcing relationship. In this process, a dynamic evolution phenomenon distinct from the rigid relationship model between the World Bank and recipient countries can be clearly observed—namely, through cooperation with UNESCO, China is gradually moving beyond the 单纯的 "recipient and learner stage" to enter a "funder and leader stage" where it gives back to UNESCO with Chinese experience and Chinese strength [6]. Taking IKCEST as an example, in 2021, it co-hosted with the World Federation of Engineering Organizations (WFEO) an online seminar on "Engineering Technology for Poverty Reduction," specifically inviting Chinese experts in the agricultural field to attend and share China' s contributions and experiences in engineering technology for poverty reduction, thereby contributing to the global cause of science and technology-based poverty alleviation. Among the experts participating in the aforementioned 24 major international forums, Chinese scientists accounted for approximately 80%, demonstrating the significant contributions made by the Chinese scientific community to the global development of open science. Practice has proven that this cooperation model between Category II centers and host countries has effectively improved the conditions for developing countries to develop open science, generating widespread policy recognition of the open science concept among their governments, industries, and the public. In an era beset by unequal development and anti-globalization

waves led by developed countries, such cooperation also helps rebuild the confidence of developing country governments and peoples in globalization, positively impacting the fundamental creation of an international environment conducive to open science development.

3.2 Main Problems Faced by Category II Centers in Development

While recognizing achievements and summarizing experiences, it should also be acknowledged that, as a relatively new organizational form of international cooperation in open science, Category II centers, including IKCEST, face some problems and challenges in their own development and role performance.

3.2.1 Qualification Limitations Faced by Category II Centers in Development Since each Category II center is established relying on host country entities such as the Chinese Academy of Sciences or the Chinese Academy of Engineering, they lack independent legal entity status, which often creates restrictions when carrying out specific work. At the same time, because the host entities themselves often regard Category II centers merely as organizations for conducting international cooperation, Category II centers cannot achieve full coverage in relevant agendas involving open science development projects, conferences, etc., further limiting the space for them to play their roles.

3.2.2 Organizational Limitations Faced by Category II Centers in Development Overall, the expert resources currently used by China' s Category II centers in operation mainly come from part-time researchers of their host entities, which results in some centers facing organizational resource constraints in their work due to the lack of support from professional research teams. On the other hand, Category II centers generally suffer from insufficient numbers of full-time personnel engaged in management and service work. Under circumstances where funding sources are generally single and some centers have insufficient operating funds, factors such as heavy workloads, high pressure, and poor compensation seriously affect employee motivation, making the problem of retaining talent more prominent. Due to the influence of China' s overall scientific research management system on the management system of Category II centers, issues often arise such as overly strict administrative management, difficulties in approving overseas travel for institutional personnel, insufficient budgets, and inability to fully implement international exchange and cooperation tasks. Additionally, some Category II centers suffer from varying degrees of low domestic and international visibility and influence, and under the current management system, Category II centers in a "semi-dormant" state face supervision pressure from UNESCO, exacerbating the challenges in their survival and development.

3.2.3 Environmental and Policy Support Problems Faced by Category II Centers in Development For a long time, Western developed countries

led by the United States have expressed dissatisfaction with UNESCO' s "one country, one vote" system and publicly voiced displeasure at the policy tendency for most Category II centers to be located in developing countries. Especially after the United States and Israel announced their withdrawal from UNESCO in 2017, UNESCO itself has faced greater external pressure. Correspondingly, the resource support received by Category II centers has inevitably been significantly affected under the overall tightening environment. At the same time, since China has not yet formulated a national strategic-level development plan in the field of open science development, the existing scientific research management system imposes restrictions on the full performance of Category II centers. Additionally, although Category II centers are rooted domestically, as international organizations they must emphasize the requirements of internationalization construction, often facing difficulties in operations such as policy environment and cultural and market differences, technological capability gaps, and geographical barriers, as well as facing dual pressure from UNESCO and the host country under "results-oriented management" requirements [12].

In short, the problems faced by UNESCO Category II centers in development are caused both by their own shortcomings and by external factors such as domestic and international environments and management systems. Correspondingly, this requires Category II centers to continuously improve their own capabilities while obtaining more robust policy support from the host country.

4. Key Points and Countermeasures for International Organizations and Their Category II Centers to Enhance Their Capacity to Boost Open Science Development

Although UNESCO Category II centers have achieved remarkable results and accumulated valuable experience in boosting open science development, as some scholars have noted, "to obtain continued support from UNESCO and the host government, Category II centers must provide them with the high-quality professional services or platforms they need" [5]. The establishment and maintenance of this virtuous cycle system, where open science development benefits global progress and global progress in turn supports open science development, also highly depends on the sustainability of Category II centers' capacity improvement and role performance. Therefore, to enable international organizations and their Category II centers to better serve China' s open science development, it is necessary to formulate countermeasures targeting the problems mentioned above regarding Category II center development. Efforts should be made continuously from two perspectives: the self-development of Category II centers and policy support from the host country, so that China can benefit from the boost of Category II centers to open science development while also giving back to the Category II center construction cause, thereby consolidating the foundation for broader and longer-term cooperation between China and international organizations.

4.1 Enhancing the Capacity of Category II Centers Themselves

To overcome the aforementioned difficulties, Category II centers represented by IKCEST should mainly commit to continuously improving their capabilities and roles in leading China' s open science development. The specific requirements are:

4.1.1 Attach Great Importance to Open Science as a Primary Work Area Category II centers should organize management and expert teams to carefully study the Recommendation on Open Science, rely on governing boards and advisory committees to plan and layout in advance, especially to study the issue of two-way docking between China' s major national engineering projects and specialized implementation of international cooperation projects. At the same time, tasks supporting open science should be written into the six-year medium-long term plans and biennial plans routinely formulated by Category II centers, with adequate budgets matched and a supervision and evaluation system for quantifying annual and medium-long term achievements in open science development established. They should also understand demands from all parties in their fields through multiple channels, provide precise services, hold training courses with open science as the theme, design relevant curriculum systems, and form best practices for open science.

4.1.2 Actively Build Technologies and Platforms Corresponding to Open Science and Fully Participate in Open Science Practice For platform-centered Category II centers like IKCEST, data resources are the key elements for platform construction and iterative updating. Therefore, besides actively connecting to China' s existing open data platforms, Category II centers should, based on solid research, participate in the open science strategic planning process of their host entities and even at the national level, providing more powerful technical condition support for their leading role by proposing Chinese-style Recommendation on Open Science, especially guidelines for the open interconnection of data platforms. Overall, the organizational dimension development of Category II centers is often embedded in their action dimension. While effectively ensuring the smooth implementation of existing cooperation agreement tasks, Category II centers also need to comprehensively 切入 into the seven action areas recommended by UNESCO [1] based on their experience accumulated in boosting open science development in the host country, carrying out specific work to support open science and continuously strengthening organizational support for mission achievement.

4.1.3 Seek Overall Improvement in Both Extroverted and Connotative Development Dimensions Extroverted development improvement means actively participating in relevant domestic and international conferences to learn from the experiences and practices of other Category II centers or research institutions in open science, actively discussing cooperation possibilities with other institutions, gradually establishing a cooperative network of Category

II centers with oneself as the hub, and then exploring the formation of a larger-scale organizational structure system for large-scale sharing and cooperation among multiple and various international organizations. Connotative development requirements mean that Category II centers such as IKCEST should pay more attention to linking business related to promoting open science development with China' s medium-long term development goals and strategic plans. Past successful experiences show that the rooting of the open science concept in the host country often stems from the actual benefits it brings to the host country. With relatively limited funds and personnel, Category II centers should avoid directly applying the guiding principles of Category I centers to design their own specific business plans, and even need to adjust the weighting relationship between business adapted to local needs and general business. They should focus open science development projects on areas that cooperate with the host country' s development concepts, strategies, and actual needs, intensively leverage their organizational advantages, and simultaneously consolidate their cooperative relationship with the host country.

4.2 The Host Country Providing More Perfect Management Mechanisms and Policy Support for Category II Centers

Open science calls for greater commitment and responsibility. Both UNESCO and its Category II centers have an unshirkable responsibility in developing open science. Moreover, judging from specific business content, Category II centers actually have greater responsibilities, more pressures, and heavier burdens in the open science era. Correspondingly, this requires the host country itself to create a more favorable institutional foundation and research environment for Category II centers to assume responsibilities and cope with pressures. Therefore, while Category II centers do their self-improvement work well, China as the host country also needs to continue making sustained efforts in the following areas to provide support:

4.2.1 Strengthen Financial Support and Strict Supervision, and Explore Financial Management Systems Adapted to Category II Center Development Currently, the financial management system for public institutions used by China' s Category II centers does not adapt well to the needs of Category II centers in conducting international exchange activities [5]. The financial management systems of host entities impose many restrictions. Therefore, to improve the efficiency of financial resource utilization, more flexible supporting financial management systems and comprehensive guarantee systems for human resources and other aspects could be considered in the future based on the actual needs of Category II centers in boosting open science development.

4.2.2 Break Through Interest Barriers and Promote a Large-Scale Sharing Mechanism for Scientific Research Resources Overall, the general construction pattern of China' s relevant platforms, including the scientific research sharing platform established by IKCEST, is still characterized by being

"small, scattered, and chaotic," with a lack of connectivity between platforms. The key factor restricting connectivity lies in the docking of management systems and regulations. Therefore, breaking through the limitations of the original fragmented management system and leveraging China's institutional advantages of overall coordination have become necessary conditions for supporting Category II center work.

4.2.3 Improve Supporting Scientific Research Policies and Management Systems Among the obstacles restricting open science development, none—whether scientific research incentive mechanisms, scientific research resource and process management systems, legal guarantees such as intellectual property rights, or the popularization and training of relevant knowledge and skills—can be overcome or changed by Category II centers themselves. This requires China' s government and scientific research management departments to pay more attention to the development of open science, reflect on and reform various systems that are not adapted to it, and consciously introduce the open science concept when formulating relevant regulations to provide strong support for Category II centers. In fact, a representative positive case in this regard is the "Measures for the Management of Scientific Data" issued by the State Council in 2018, which put forward specific requirements for promoting the open sharing of scientific data and became China' s first systematic national-level administrative regulation in the open science field [13]. However, overall, there is still considerable room for expansion in the progress of relevant legislation compared with the needs of open science development, and the process needs to be accelerated.

4.2.4 Improve the Overall Policy Framework Supporting Open Science Development In addition to continuing to strengthen national resource support for Category II centers to boost open science development, China also urgently needs to learn from developed countries' experiences, formulate a national overall strategic plan for open science as soon as possible, and form a supporting policy system. It should strive to achieve "overtaking on the bend" in institutional arrangements and implementation for leading the open science development trend. In this process, the Chinese government should also actively seek support and participation from UNESCO Category II centers, carefully study the institutional and policy interface issues of implementing its Recommendation on Open Science in China, and make relevant national strategic plans and policies practically feasible. This is crucial because previous national strategic plans of developed countries often failed to truly reflect a global vision and humanistic concern. If China can actively cooperate fully with UNESCO and its Category II centers in the process of formulating relevant national strategies, it will be entirely possible to create a new open science development pattern that balances national needs with a global vision, seizing the commanding heights for leading the next stage of open science development.

In conclusion, in an era where open science development is in the ascendant,

international organizations and institutions represented by UNESCO and its Category II centers such as IKCEST are playing an increasingly important role in promoting the formation of global open science consensus, formulating guiding recommendation frameworks, providing platform construction and technical and intellectual resources support, and connecting open science development policies of various countries. As an important platform for international organizations and developing countries to cooperate in international affairs and conduct foreign exchanges, they can contribute to adapting to the development trend of open science, solving contemporary challenges facing open science development, and breaking through multiple barriers restricting open science development. Looking to the future, there is reason to believe that as long as countries around the world, represented by China, better summarize relevant experiences and provide more powerful support for the construction and role performance of Category II centers, the development of open science will certainly be accelerated by the active participation of Category II centers of international organizations, and the global scientific research enterprise will thus enter a new era of true global sharing.

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Note: Figure translations are in progress. See original paper for figures.