An analysis of public-oriented science communication by Chinese research groups in the context of responsible innovation

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Abstract
Scientific research groups in universities and research institutions are primary units for providing public-oriented science communication. This study is one of the few studies concerning scientific research groups in China. In 2018, our research team surveyed the public-oriented science communication activities of 601 scientific research groups in China using questionnaires. The survey shows that Chinese scientific research groups are active in promoting science to the public, and that related work structure and guarantee mechanisms have been established and have already produced some social benefits. However, there remain challenges, including limited channels for science communication, insufficient collaboration among the participants in the communication process and unbalanced investment. Based on an analysis of the survey results, we put forward several suggestions on how to encourage scientific research groups of universities and research institutions to engage in public-oriented science communication activities.

Keywords
Scientific research groups, science communication, communication channels, communication effects

1. Introduction
The rapid advance of science and technology is shaping economic and social changes in profound ways. Universities and research institutions, as major actors in China’s national innovation system, not only carry out scientific and technological innovation activities but also shoulder increasing social responsibilities. The spread of scientific and technological knowledge across society is slower than its spread inside the scientific community. That has led to information asymmetries and unequal status between scientists and the general public, resulting in alienation and a crisis of trust or even confrontation between them. It was against this background that the concept of ‘responsible innovation’ emerged. Thus, public-oriented science communication is not only an effort made by scientists to fill the gap or deficit between science and the public (Bucchi, 2008; Huang, 2019), but also an important social responsibility of scientific research groups.

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Successful science communication occurs at the nexus of scientists, the public and the government. Science communication is now attracting the attention of governments, science and technology administrators and science funds worldwide. Research on promoting public-oriented science communication has been elevated to an important position on the agenda of universities and research institutes, and their ability to do such research has become a necessary condition for them to undertake projects financed by science funds. In many European countries and the US, science communication with the public is regarded as a ‘third mission’ of universities and research institutions, in addition to teaching and research (Yang and Wang, 2015).

To examine science communication activities currently carried out by universities and research institutions in China and the problems in that process, we conducted an extensive questionnaire survey of 601 research groups on the Chinese mainland. Based on the results, we offer some suggestions for encouraging the participation of universities and research institutions in science communication, which can contribute to the advance of science communication capabilities and science and technology innovation of Chinese research institutions.

2. Research design

2.1 Questionnaire design

Our survey was conducted by combining subjective provision (a questionnaire) and passive acquisition (web crawling). We used the questionnaire to compile types of science communication activities carried out by universities and research institutions in China during the period from July 2017 to June 2018. It had 32 questions covering six aspects: basic information about the surveyed institutions, science communication personnel, science communication funding, science communication activities, the audience for science communication and science communicators’ understanding of their work.

2.2 Sampling design

We collected information on the research centres listed on the official websites of 116 ‘Project 211’ universities and major research institutes (such as the Chinese Academy of Sciences and the Chinese Academy of Social Sciences) on China’s mainland. After that screening, we established a sample set with the complete information of 1915 research centres. Using the classification criteria of the OECD, we divided the sample set into subsets of six research fields: natural sciences; engineering and technology; medical and health sciences; agricultural and veterinary sciences; social sciences; and humanities and arts.

Sampling was conducted according to the following principles. First, we used a proportional stratified sampling method to draw 50% of research centres from each of the six sample subsets and calculate the sample number $S_i$. Then, we used a quota sampling method in the six sample subsets to ensure that each university with research centres in the field had at least one research centre selected, which gave us the sample number $N_i$. Finally, we used a simple random sampling method to draw $S_i - N_i$ samples from the rest of the six sample subsets. Thus, the three parts constituted the final sample.

2.3 Sample description

We distributed an online questionnaire to 1915 research centres in 96 universities and 183 research institutes in 30 provinces of China between May and July 2018. Of those, 418 university-based research centres and 183 research institutes participated in the survey. Indirect validation was also conducted using internet searches. The disciplinary and geographical categories of the participating institutions are shown in Table 1.

3. The current situation of public-oriented science communication conducted by research groups in China

The survey results show that the idea of science communication being the ‘third mission’ of universities and research institutes has been widely accepted, but the development of appropriate systems for that communication is still at an early stage. As conditions for conducting science communication improve, activities
intended to communicate science are becoming normalized.

3.1 Surveyed institutions are actively involved in science communication

The institutions involved in our survey have shown strong interest in engaging in science communication. This can be considered from two aspects. First, they have clear science communication plans and encourage their personnel to take part in science communication. The survey data shows that universities and research institutes have established science communication systems or plans; they also support the government’s science communication and scientific culture policies and actively encourage their researchers to take part in science communication. Among them, 82.87% have science communication policies, participation or promotion; 90.28% have action plans for related activities; 91.93% expect researchers to participate in such activities; and 91.10% can actively respond to the government’s science communication and scientific culture policies. Even institutions that do not have specific science communication and promotion plans or policies have contact with the public (Figure 1).

Second, the surveyed institutions have a positive attitude towards the public’s participation in

### Table 1. Disciplinary and geographical distribution of the surveyed institutions.

| Discipline                             | Number | Proportion | Region               | Number | Proportion |
|----------------------------------------|--------|------------|----------------------|--------|------------|
| Natural sciences                       | 84     | 13.8%      | Northeast China      | 22     | 3.66%      |
| Engineering and technology             | 287    | 47.3%      | North China          | 186    | 30.95%     |
| Medical and health sciences            | 37     | 6.1%       | East China           | 222    | 36.94%     |
| Agricultural and veterinary sciences   | 54     | 8.9%       | South China          | 37     | 6.16%      |
| Social sciences                        | 91     | 15%        | Central China        | 29     | 4.83%      |
| Humanities and arts                   | 48     | 7.9%       | Southwest China      | 48     | 7.99%      |
|                                        |        |            | Northwest China      | 57     | 9.48%      |
| **Total**                              | **601**| **100%**   | **Total**            | **601**| **100%**   |

**Figure 1.** Overview of science communication plans in surveyed institutions.
scientific research (Table 2). They hope to provide better science communication services to the public, but more needs to be done to achieve that.

### 3.2 Support for science communication has been strengthened

Conditions for conducting science communication have been improved, including by the introduction of professional science communicators, the setting up of science communication funds and investments in science communication resources.

First, the surveyed institutions are well staffed with science communication professionals. Twenty-five percent of the institutions have science communication personnel; 12% have personnel with master’s degrees in communication-related fields. In 43% of the institutions, science communication personnel have acquired science communication skills through multiple channels; 32% of the institutions are aware of their researchers’ participation in science popularization activities, and the average participation rate is 12.5%.

Second, there is still room for improvement in the proportion of specialized funds for science communication. Six per cent of the surveyed institutions include annual science communication funding in their budgets. The survey data shows that 1% of the institutions spend over 300,000 yuan, 3% spend between 50,000 and 100,000 yuan, and 2% spend between 10,000 and 20,000 yuan; 85.69% are not sure about the percentage of science communication spending in their annual budget. Among the institutions that list science communication spending in their budget, those that have a budget of less than 5% for science communication account for the majority; only a few have a budget greater than 10%.

Third, the resources (funding and personnel) invested in science communication are reasonable. Only 0.5% of the surveyed institutions think that the resources they put into science communication are sufficient, 93.1% think that the resources are reasonable, and 6.4% think that they are insufficient. Investment of science communication resources also varies among regions: 97.8% in north China, 97.3% in south China, 96.6% in central China, 93.0% in northwest China, 91.9% in east China, 91.7% in southwest China, and only 81.8% in northeast China. This is attributed, to some extent, to the GDP and research input of those regions.

### 3.3 Routine science communication activities have become more diverse

Science communication conducted by the surveyed institutions now involves more activities and contacts with mass media and the use of new media platforms.

First, the number of science communication activities is increasing. Most of the surveyed institutions are not sure about the development of science communication activities in their organizations. However, 36% believe that their science communication activities have increased in the past five years, and only 6% believe that the number of activities remains unchanged or has decreased.

### Table 2. Attitudes of surveyed institutions to public engagement in science.

| Option                                                                 | Strongly oppose | Oppose | Neutral | Agree | Strongly agree | Not sure |
|-----------------------------------------------------------------------|-----------------|--------|---------|-------|----------------|---------|
| The ways and means of science communication should be determined      | 0%              | 0.49% | 4.78%   | 89.79%| 1.15%          | 3.79%   |
| based on public demand                                                 |                 |        |         |       |                |         |
| The public should be actively involved in decision-making about       | 0%              | 1.15% | 26.53%  | 67.71%| 0.49%          | 4.12%   |
| research                                                              |                 |        |         |       |                |         |
| The public should be actively involved in discussions on purposes, but | 0%              | 1.15% | 35.09%  | 54.37%| 1.15%          | 8.24%   |
| not necessarily in decision-making on research directions             |                 |        |         |       |                |         |
| People trust science and scientists                                    | 0%              | 0%    | 22.74%  | 71.66%| 0.66%          | 4.94%   |
| People without scientific education can also participate in           | 0.17%           | 1.15% | 20.76%  | 72.32%| 0.49%          | 5.11%   |
| discussions on research purposes                                       |                 |        |         |       |                |         |

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Second, contacts with mass media are becoming more frequent. In the 12 months before the survey, 1.2% of the surveyed institutions had not communicated with journalists, 3.3% had done so one or two times, 6.1% had done so more than three times, and 89.5% were not sure about their communication with mass media.

Third, science communication is expanding into new media channels. While 87% of the surveyed institutions did not answer our question about science communication channels, the remaining 13% stated that they conduct science communication mainly through traditional media, such as by publishing articles in newspapers and by distributing brochures, flyers and other papers for non-professional readers. Channels that directly engage and interact with the public, such as television interviews and press conferences, are seldom used.

3.4 Surveyed institutions indicate that they have achieved good results in science communication

Of the surveyed institutions, 0.2% considered their work in science communication as very successful, 6.1% considered their work successful, 80.4% considered their work good, 0.3% considered their work unsuccessful, and 13% were not sure about the effectiveness of their science communication.

4. Difficulties and limitations for scientific research groups in conducting science communication

The current situation of science communication in China is on the whole in good shape. Support for science communication and the organization of science communication activities are improving. However, there is still room for improvement in areas such as resource guarantees and activity planning.

4.1 Resource guarantees need to be strengthened

Science communication must be supported by various resources, including human resources and funding. Our survey shows that most institutions do not have science communication departments or specialized science communication managers. Moreover, the funding for science communication is not sufficient.

First, science communication personnel lack communication knowledge and skills. We found that many research institutions attach high importance to the cultivation of science and technology innovation professionals, but they are not paying adequate attention to the introduction of science communication management personnel. Thus, science communication is usually conducted without direction by well-trained professionals. In addition, most research institutions do not have a dedicated department for the management of science communication. As we have noted, the proportion of science communication personnel with a master’s degree in communication-related fields is 12%. This has to do with the recruitment mechanism of universities and scientific research institutions in China: A master’s degree is often the minimum standard. Twenty-nine per cent of the institutions’ science communication personnel do not have a related master’s or bachelor’s degree but have attended seminars or short courses on communication. Overall, 43% of science communication personnel have acquired science communication skills through multiple sources, but the other 57% have not attended any formal training on communication capabilities (Figure 2). The lack of communication skills among science communicators could reduce the effectiveness of science communication.

Second, science communication funding remains undervalued. Most research institutions do not have a dedicated department for science communication management. Our survey data shows that 85% of the surveyed institutions are not clear about the proportion of funding for science communication in their total budget; 67% are not clear about the proportion of the funds for science communication purposes in their total available funds. Among the institutions that have special funding for science communication, 25% have raised that funding to 6%–10% of the total available, and 13% have a science communication budget less than the amount raised. This shows that, in practice, science communication funds
may be used for other purposes, even in organizations that attach high importance to science communication activities.

4.2 Expansion into new media channels for science communication is slow

We found that the surveyed institutions’ science communication channels are limited to traditional media, such as newspapers, brochures and lectures. New media are not used efficiently in science communication activities.

First, newspapers, brochures and other traditional channels remain the major tools for science communication. As we have noted, 87% of the surveyed institutions did not answer our question about science communication channels, and the remaining 13% conduct science communication mainly through traditional media. Channels that directly engage and interact with the public are seldom used (Figure 3).

Second, websites are the main channel of new media communication used by universities and research institutes. Fifty-two percent of the surveyed institutions answered our question about their use of new media channels. Among them, 98% update their websites and about 1% use WeChat. The surveyed institutions lack diversity and innovation in the use of new media and have failed to put new communication channels to good use.

Third, science communication activities are mostly conducted in the form of public lectures. Twenty-nine per cent of the surveyed institutions answered our question about the number of their science communication activities. On average, institutions participated in 29 activities: 38.7% were in the form of public lectures, and 25.1% were in the forms of open days, seminars, guided tours and similar activities, such as opening universities and scientific institutions to the public (Figure 4).

4.3 Unsatisfactory participation of science communication stakeholders

Science communication calls for the involvement of various parties, including scientific researchers, research institutions and the media. Our survey revealed some deficiencies in the way different parties play their roles.

First, some researchers are not able to participate in science communication because they lack time or institutional support. The reasons for non-participation offered in the survey included a lack of time, remuneration or institutional support; divisions of responsibilities; insufficient public interest; and inadequate personal capabilities. Ninety-three per cent of the surveyed institutions did not give a clear answer to this question, and it seems that those institutions have not included science communication in the job duties of their researchers. In the answers provided by the remaining 7%, we found that researchers choose not to
participate in science communication activities not because they think science communication is unimportant, but because they do not have the time to participate.

Second, the effectiveness and quality of science communication activities are overly dependent on activity organizers. The surveyed institutions rarely outsource their science communication activities; typesetting, printing, data visualization, graphic design, activity promotion and website building and maintenance are mostly done by staff within the institutions. Thus, the organization of science communication activities is largely dependent on the organizers, whose level of involvement correlates positively with the effectiveness and quality of those activities; the higher the level of involvement, the more impact the activities have.

Third, there is a lack of regular contact between the media and researchers. When media representatives contact researchers in the surveyed institutions, 60% make direct contact with the researchers; they rarely communicate with the administrative departments of the institutions. That type of media engagement is convenient but does not help to establish regular connections between the institutions and the media, so it has a negative effect on the overall quality of the institutions’ science communication.

Fourth, publicity for science communication activities needs to be strengthened. The majority of the surveyed institutions are not clear about the frequency of communications between their organization and the media, and contact is mostly informal. This is not consistent with the statement by 66% of the institutions that they assess the effects of their communication activities every six months. Either their assessment is not rigorously conducted or their contact with the media has not been taken seriously.
5. Suggestions for improving science communication

As an activity for exchange and sharing, science communication is one of the many types of cultural communication in human society. The only thing that makes it different is that it is about science-related fields (Niu, 2017). Science communication activities by universities and research institutes are becoming more common, but they are still far from sufficient, given the growing public demand for science communication. To strengthen researchers’ awareness of science communication, based on the results of our survey of science communication, we suggest working towards improvements in the following areas.

5.1 Construct a national science communication network at the government level

The science communication of universities and research institutes is shifting towards the participation of various sectors of society. Governments at all levels should incorporate science communication into their management, provide a basic institutional framework and policy environment, and allocate science communication resources to ensure the healthy, stable and sustainable development of science communication. Therefore, it is imperative to establish a national science and technology dissemination network combining the resources of universities and scientific research institutions, supporting knowledge innovation and knowledge application systems, and enhancing the operational quality of the national innovation system.

5.2 Strengthen science communication as regular work of universities and research institutes

First, strengthen the sense of mission and make specific plans. Universities and research institutes should have a strong sense of mission for conducting science communication. Scientific progress and science communication are the two engines driving the development of an innovative society, and both should be responsibilities undertaken by universities and research institutes. An effective system should be established to support science communication. This requires universities and research institutes to seek innovation in their work related to science communication, such as the cultivation of professionals and the construction of a work system and an incentive mechanism. In addition, they should be clear about the functions of science communication, know their priorities in their communication work, formulate overall plans and guidelines for implementation, and then implement those plans.

Second, integrate resources and set up dedicated departments for science communication. The Chinese Academy of Sciences (CAS) has provided a good example in promoting science communication through resource integration. It has set up a dedicated science communication bureau, the affiliated units of which include a general coordination office, a news and liaison office, an administrative office and a science popularization and publication office. The bureau is responsible for guiding and coordinating the science communication efforts of the organizations affiliated with the academy. It is also involved in the communication of important domestic and foreign innovations, the planning of large-scale science popularization activities, research on public opinion, and the management of science popularization and publication.

We suggest two models for science communication inspired by the practice of CAS:

- **University-based model.** Universities can set up science communication offices to coordinate resources within the university (such as disciplines and laboratories) and manage their work on knowledge systems and communication measures, platforms and personnel. This means that science communication platforms, resources and professionals will be integrated into a specified organizational structure, communication system and management system. Such an office will be responsible for science communication as the representative of the university.

- **Society-based model.** Research centres in universities and research institutes can also establish science communication offices based on their disciplines and the societies they belong to, thus coordinating science
communication activities as representative organizations in their disciplines.

Third, focus on key issues and create value by joint efforts. Science communication includes many areas, including scientific knowledge, spirit, methods and thinking, as well as social and cultural content. Issues related to people’s daily lives can be used as engines for promoting science communication. What researchers in universities and institutes should focus on is providing correct interpretations of scientific knowledge and guidance for public opinion. Scientific knowledge should not be pushed on the public; instead, the public should be involved to achieve two-way communication. This will build more effective science communication systems and a process to involve various stakeholders in value creation.

Fourth, adopt a new approach to media integration. In the new media era, due to innovations in technologies and changes in the means of communication, the integration of the various media has increased. The relationship between old and new media is not one of compartmentalization and substitution. According to integrated marketing communications theory, joint media campaigns involving TV, newspapers, cellphones and other platforms are most effective in promoting science communication. We can capture and organize content with web crawler software, analyse the content using big-data approaches, and improve data-storage capacity with cloud computing. We can combine different communication means and channels featuring social networking functions, targeted audiences and specified objectives. We can also make full use of drones and other technologies to enrich the expression of scientific content. The construction of a new ‘integrated communication’ model will have a profound impact in elevating scientific culture in society.

5.3 Create a new model of science communication by using we-media

First, cultivate knowledge-based opinion leaders. Knowledge-based opinion leaders drive much of modern online communication. They must have notable visibility and public recognition, and are mainly involved in information sharing. In an environment that includes myriad sources of information, the public’s demand for high-quality content is growing stronger, and people are more willing to pay for the content they receive. Driven by public demand, bloggers with professional backgrounds have entered the public eye. Some social media apps used in China, such as Zhihu, Douban, Zaihang and Fenda, have introduced incentive mechanisms for original content, and their business models and dissemination have already produced visible results.

Through the commentary sections on we-media platforms, new positions for science communication can be established. Universities and research institutes can choose their science spokespersons and use existing we-media platforms to provide interpretations of new advances in science. Scientists can thus be recognized and respected in society. This will produce positive social effects, create loyal audiences and reduce science communication costs.

Second, inspire the growth of science communication agencies or teams. Institutions may consider commissioning professional third-party companies to work on science communication. Such companies have notable advantages in the formation of science communication plans, the organization of science communication activities, the promotion of communication platforms, data analysis and public surveys and could greatly improve the effectiveness of science communication. This new model of we-media-based third-party science communication should be funded in a manner balancing public benefit and profitability. Under the public-benefit model of science communication, the operational costs are covered by universities and research institutes. Within the scope permitted by government policies, a hybrid funding model would save money for universities and research institutes and also generate income that can be used to bring more people into the science communication process.

5.4 Enhance science communication by using new technologies

First, establish big-data centres to provide data support for science communication. This can be achieved by:
• establishing a nationwide mechanism for sharing information on popular issues, science communication personnel, science communication institutions, science communication activities and science communication service agencies
• building one-stop science communication networks and creating a high-quality and efficient platform and network for science communication with access points and promotion channels for various clients
• connecting networks and infrastructure and encouraging resource sharing
• establishing a sound science communication credit system that integrates the science communication credit information of various sectors and provides support for science communication activities and assessments of research institutions and regional development.

Second, protect the originality and authority of science communication by using blockchain. Blockchain, which is resistant to tampering and features high traceability, has become a revolutionary technology. We should redouble our efforts to develop blockchain platforms in the field of science communication, thus enabling a low-cost, highly efficient and objective technical record of new achievements of science communication workers, preventing arbitrary tampering with the content, and bringing down the cost of protecting science communication. Blockchain developed for science communication purposes can provide universities and research institutes with one-stop services for the protection of scientific knowledge and the overall process of science communication, thus protecting the original contributions and authority of science communicators.

6. Conclusion
Science communication by China’s universities and research institutes is expanding after initial efforts in institutional development via staffing, funding allocation, activity organization and audience engagement. There are still many challenges associated with science communication, but we could start with the local application of technical means and the construction of new science communication models. With a focus on improving the country’s science and technology communication capabilities, a system at the national level can be established to provide motivation and support for universities and research institutes to carry out science communication activities. The adoption of new technologies and methods could improve institutions’ capabilities and boost the development of science and technology communication in China.

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