The new stage of public engagement with science in the digital media environment: citizen science communicators in the discussion of GMOs on Zhihu

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(Received 31 March 2021; final version received 4 April 2022)

In the digital media environment, public engagement with science around controversial scientific topics such as genetically modified organisms (GMOs) has greatly expanded. But the public’s role as science communicators in such engagement has been virtually ignored. Through an online ethnography of the discussion of GMOs on Zhihu, the biggest Chinese knowledge-sharing network, this study identifies a new group: citizen science communicators involved in online science communication. The emergence and popularity of this new group brings public engagement with science to a new stage – public engagement with science communication – and changes the role of the public in science communication from audiences to communicators. The development of digital platforms and the revolution of the understanding of science communication all contribute to the emergence and popularity of this group in the Chinese digital environment.

Keywords: public engagement with science; genetically modified organisms; online science communication; digital media environment; online ethnography

Introduction

Public engagement with science (PES) has become one of the most discussed fields in STS (Felt and Davies 2020) and is believed to be necessary for opening up science and its governance, especially in the face of controversial scientific issues such as genetically modified organisms (GMOs) (Stilgoe, Lock, and Wilsdon 2014). Healthy and institutionalized PES – which is seen as an important measure in the democratization process of science – not only helps to narrow the relationship between science, scientists and the public, but also helps to integrate scientific expertise and lay knowledge to solve real-world problems (Irwin 2001, 2014; Laurent 2011). PES has also undergone a gradual deepening process in the past 20 years. The development of the digital media environment,
especially social media platforms, has provided an unprecedented opportunity for citizens to engage with science (Boulianne and Theocharis 2020; Jünger and Fähnrich 2020). This article uses the method of online ethnography to investigate the scientific discussion of one of the most controversial science-related topics – GMOs in China – on the biggest Chinese knowledge-sharing network platform, Zhihu, to explore the new mechanism of PES on Chinese digital media.

**The development of public engagement with science**

From the end of the twentieth century, public engagement with science (PES) has been proposed as the advanced substitute for public understanding of science (PUS), with the participation model contained therein criticizing and replacing the deficit model (Jünger and Fähnrich 2020) – PES has since experienced a series of developments and evolutions (Strasser et al. 2019). PES was first introduced into the field of science governance and science-related policymaking based on the idea of citizen democracy and the rediscovery of citizens’ local knowledge (Wynne 1996; Durant 2008). Chilvers and Kearnes (2016, 4) even directly referred to the initial PES as “science governance rhetoric.” At this stage, the forms of PES proposed by academic and professional circles clearly had a deliberative political tendency, such as science consensus conferences (Joss and Durant 1995a, 1995b), science juries (Rogers-Hayden, Mohr, and Pidgeon 2007), and science scenario workshops (Hatzilacou et al. 2007). Although recently some scholars have claimed that with the objective knowledge gap on scientific issues, we should not rely solely on civil politics – citizens and experts should also play different roles in scientific issues (Collins 2014; Jones 2014). In the political dimension, PES has already made great progress in the Anglo-American context (Strasser et al. 2019).

With the development of PES in the political dimension came another PES pattern: public engagement with scientific research (citizen science), where amateurs can not only contribute political and democratic value, but they can also contribute to the production of scientific knowledge (Bonney 1996; Shirk et al. 2012; Strasser et al. 2019). “Citizen science” also presents its own evolutionary developmental path, from “public understanding of research” to “public engagement with natural observation” concentrated in the fields of plant and animal taxonomy, geology, anthropology and simple astronomy (Field and Powell 2001; Strasser et al. 2019). Recently, some experimental science research, such as medicine, physics and machine learning, has also gradually been opened to public engagement (Haklay 2013; PGP-UK 2018).

In summary, from public understanding of science, PES has generally experienced a process of development. PES was proposed as an advanced alternative to the deficit model, but initially in practice and academia it was divided into two forms: political and consultative public engagement with scientific discussion, and governance with political and deliberative significance; and public
engagement with scientific knowledge production (citizen science). In recent years, these two trends have gradually merged (Hecker et al. 2018). Within the field of research in which the public can get involved, citizen science has also undergone a gradual expansion process. It is clear that around scientific issues, the scope of possible public participation is expanding.

However, the development of PES in China has happened differently from that in the West. Firstly, China lacks long-term public awareness and active experience of public engagement compared to the Anglo-American context, and the Chinese public is generally not as enthusiastic about public affairs (Jia and Liu 2014). For instance, the Chinese public has been found to pay scant attention to science that has little application to their lives, such as theoretical physics or the history of science, and rarely if ever actively participates in the production of such scientific knowledge (Chen, Shi, and Xu 2009; Jia and Liu 2014). The overall level of Chinese citizens’ scientific literacy is far lower than that found in Western countries. Secondly, because of the power structure within the Chinese government, in which the government firmly holds the core power, with very limited space left for the public, the opinions and knowledge provided by Chinese citizens through PES are difficult to see effectively and transparently reflected in relevant policymaking (Jia and Liu 2014). Therefore, both the political and scientific research dimensions of PES in China, especially in the pre-digital media era, have progressed along a difficult path to that of the West (Jia and Liu 2014; Wang, Zhong, and Jia 2015).

Among many controversial scientific topics attracting public attention and engagement, GMOs have become a special case among the scientific fields in both Western and Chinese contexts (Valve 2008). Since their creation, GMOs have been heavily debated among many stakeholders, involving much public engagement, but it has still been difficult for all those involved to make decisions about their efficacy and ethical dimensions (National Research Council 2015). Some Western countries have even held nationwide public discussion and engagement projects about GMOs, such as GM Nations? in the UK (Horlick-Jones et al. 2006). In China, the public tends to demonstrate a more active attitude and willingness to participate in issues related to people’s livelihoods (Yang 2021a). Due to the close relevance between GMOs and daily food intake and its uncertainty compared to matters of “hard science,” which are far removed from the public’s daily lives, this subject has attracted extensive public attention (Wang, Zhong, and Jia 2015; Yang 2021a). The involvement of many opinion leaders and well-known scientists, such as Cui Yongyuan and Fang Zhouzi, also makes GMOs much more exposed in the Chinese media than other scientific issues (Wang, Zhong, and Jia 2015). In this context, some PES activities related only to GMOs have taken place in China, such as “public golden rice tasting” in 2013 (Wang, Zhong, and Jia 2015). The Chinese public has also begun to actively participate in the discussion and debate over GMOs on various social media platforms, forming an active special case of Chinese PES (Wang, Zhong, and Jia
Furthermore, because it touches on many publicly relevant themes, including food safety, biodiversity and resource distribution, with a certain amount of expert disagreement around public perceptions, GMOs have been propelled by corporate actors into a highly sensitive context, alert and mobilized to questions of environment and globalization (Bucchi 2008, 71). Therefore, GMOs have become the most active scientific field of PES in China, and thus are a valuable object for exploration of PES in China.

Public engagement with science in the digital media environment

The rapidly developed digital media environment is believed to offer an attractive space for PES, especially for the interaction between scientists and the public, (Stilgoe, Lock, and Wilsdon 2014; Didegah, Mejlggaard, and Sørensen 2018). Due to its participatory and democratizing characteristics (Dickel and Franzen 2016), the digital media environment is considered to play a significant role in mobilizing and satisfying the will of the public – especially “science enthusiasts or so-called ‘geeks’” (Stilgoe, Lock, and Wilsdon 2014, 9) – in their engagement with science, in public engagement with scientific discussion, scientific policy making, scientific research and direct interaction with scientists (Segerberg and Bennett 2011; Darling et al. 2013; Pearce et al. 2014; Bombaci et al. 2016; Dickel and Franzen 2016). However, much research on online PES has been from the perspective of scientists, such as how digital media platforms can help scientists enhance the possibility of dialogue with the public (Schäfer et al. 2018; Jünger and Fähnrich 2020), how digital media platforms can increase their public exposure (Fitzgerald and Radmanesh 2015; Sugimoto et al. 2017), training for public communication and dialogue (Peters et al. 2014; Jahng and Lee 2018), and even how digital media can be used by scientists to achieve better academic communication within the scientific community (Weller and Puschmann 2011; Collins, Shiffman, and Rock 2016) and enhance the academic influence of scientists (Sugimoto et al. 2017). Some scholars claim that their online PES studies aim to help scientists to engage better with the public (Jünger and Fähnrich 2020). The little research that has been done on online PES from the perspective of the public also mostly places them in the role of the audience or “invited participants” to study their feedback behaviors in the online science communication or discussion process (Kahle, Sharon, and Baram-Tsabari 2016). Further potential positions of the public in online PES are under-researched, especially in the face of controversial scientific topics, such as GMOs.

Although the overall development of PES in China lags behind the Anglo-American context, a similar situation in the digital environment has taken place in China. In the past two decades, the digital media environment has developed rapidly in China, and users have shown exponential growth (Wang 2021). Some studies show that the digital media environment has provided great convenience
and a possible space for the Chinese public to participate in the discussion and governance of scientific affairs, especially around some controversial scientific and technological topics of public concern, such as GMOs (Wang, Zhong, and Jia 2015; Yang 2021b).

While many scholars believe that the digital media environment is an ideal space for dialogue and public engagement, not just for science, some researchers claim that interaction on digital media can bring people with similar views, identities and backgrounds closer together, and further establish communication barriers between people with different views and identities, often referred to as “echo chambers” (Usher, Holcomb, and Littman 2018). Such a phenomenon has also been found to exist in online scientific discussions and PES (Pearce et al. 2014; Michailidou 2017; Schäfer and Metag 2021). Some studies have found that the digital media environment helps make the public’s attitude towards controversial scientific issues such as GMOs more polarized, even leading to irrational attacks (Hart and Nisbet 2012; Chu, Yang, and Liu 2021). More importantly, for PES, some studies show that the empowerment provided by digital media is not equally distributed. The digital gap caused by media literacy causes the discourse space and its growth among different people on the digital media platform to become unbalanced (DiMaggio et al. 2004; Yang 2022). Some studies have found that scientists are more likely to obtain fuller and faster growth of discourse space on digital media platforms than the public. Therefore, the digital environment does not bring fairer public participation or dialogue but widens the gap between scientists and the public (Park and Thelwall 2006; Yang 2022). To determine whether the digital media environment has indeed proved more effective and equal for PES, especially in the Chinese context around GMOs – generally ignored by international academics – more empirical research is needed.

Research objects and methods

Research objects

This study uses Zhihu as an example of a Chinese digital media environment. Zhihu, founded in 2010, is now the biggest knowledge-sharing network (or Q&A platform) in China based on a user-generated content model. It accommodates more than 3000 scientific sections (topics), 1.5 million science-related questions, and more than 3 million answers (Yang 2021b), which makes Zhihu one of the most comprehensive and popular science communication digital platforms in China (Yang 2021b). Because of its specific knowledge-sharing feature and social functions, it is easier for Zhihu to create interactions between different groups of people in the science discussion and communication process, such as scientists/public, public/public and scientists/scientists. Some Chinese scholars believe that Zhihu has realized effective interaction and dialogue between scientists and the public in the scientific discussion process (Yang 2016; Ju 2019). Furthermore, compared with other social media platforms like Weibo and WeChat that face
more stringent online censorship, due to its target users having a higher education level and its special characteristics of knowledge sharing, the severity of online censorship on Zhihu is relatively weaker. Faced with some controversial science and technology topics, such as GMOs and nanotechnology, Zhihu has provided a protective cover for knowledge-based discussion, so that more public members can participate in this discussion (Yang 2021a). Zhihu is therefore an appropriate site for exploring the situation and current dynamics of PES around GMOs in the Chinese digital media environment.

Methods

This study is mainly based on the method of online ethnography, which is a research approach for investigating how users interact with one another in online communities (Markham 2005). In online ethnography, observational investigation focuses on the virtual communities such as online chatrooms or forums as its “field” (Bogdan and Biklen 2007). As a research approach, online ethnography can help to investigate and explore the interactions and communications between different groups or individuals in a community more deeply under the network environment (Hine 2000). There are many ways to conduct online ethnography, such as following the users, their online behaviors, their online discourse, or their interactions on other levels (Marcus 1995). Since the online science communication and interactions between Chinese scientists and the public on Zhihu are mainly reflected at the textual level, the online ethnography in this study mainly focuses on textual and discourse interactions between those users. The scientist users, in this study, have been identified as those who had at least a master’s degree in a scientific discipline and were engaged in science-related work, which may be not related to GMOs. This approach was taken because, in China, most science students need to spend three years to complete their master’s degree and most of their study time involves laboratory work, which makes it easier for those science students with a master’s degree to be accepted and recognized as scientists by both others and themselves.

With the GMOs section on Zhihu chosen as the main research field, to conduct the participatory observation and data collection, the author registered a Zhihu account in December 2017 and participated in the GMOs section on Zhihu from January 2018 until the end of 2019, thus the online ethnographic observation lasted almost two years. During the online ethnography, the researchers logged onto Zhihu, entered the GMOs section, made observations, and wrote observation logs almost every other day. Each observation lasted from 30 minutes to an hour. By the end of the ethnographic observation, the researchers had observed the community for 219 hours.

The GMOs section on Zhihu was established in February 2011 and has become one of the most active science sections, attracting more than 400,000 followers by the end of 2020. During the first six months of the online ethnography, the author
mainly examined and recorded the users and their behaviors, such as their questions, answers, comments and likes. After six months, the focus of the observation shifted to the daily changes of this section, such as the introduction of new questions, the provision of new answers, and changes in the numbers of likes and comments. During each observation, the author recorded the following information: the identity of users, the roles of those users on Zhihu, the content of questions, responses to each question, followers of each question, assenters of each answer, active users and their online behaviors, and online discursive behaviors between those users (Yang 2021b). The information about users’ educational background and career on their homepage was used as the main criteria for defining their identity. Most of the information above was recorded as text, such as the content of answers, questions and comments, along with the description of the identity of the users who provided them. Some data changes were also recorded (Yang 2021b).

This ethnographic study was ethically reviewed by the author’s department and proposed in line with ethical requirements such as participant anonymization. All the data was recorded in Chinese and later translated into English at the analysis stage. This content was read and further understood by the author manually to explore the discourse features of the data. The angles involved in reading are relatively broad and did not follow a strict coding table to provide more possibilities for understanding.

Findings: citizen science communicators and the new stage of PES around GMOs on Zhihu

Through the long-term online ethnography of the GMOs section on Zhihu, the most notable finding is that a special group emerged in the process of online science communication, identified as citizen science communicators. The emergence and activeness of this group has brought China’s online PES to a new stage. The following analysis focuses on this group by exploring their online behavior and discourse characteristics on Zhihu using evidence from observations.

Who are the citizen science communicators?

Citizen science communicators (CSCs) are those non-scientist citizens who actively engage in the science communication process as communicators, disseminating scientific knowledge or science-related information to other citizens (Yang 2021b). For instance, the (anonymized) user shown in Figure 1 is currently a law student in the U.S. rather than a traditional scientist (user 1). But she has widely participated in online discussion and communication about GMOs on Zhihu. For instance, she answered the question, “How to explain genetically modified technology to old women in a simple way” and gained 399 likes by the end of 2019 (Figure 1). During the long-term ethnographic observation, this user
answered more than 50 questions around many scientific topics, including GMOs and climatic change, and most have received many likes on Zhihu.

Another example of a typical CSC is an insurance broker with an educational background in finance and insurance (user 2). This user, without professional scientific education and work experience, answered 73 questions about GMOs on Zhihu during the ethnographic observation. When answering questions, user 2 also tried to use some “data” to make his opinion seem more scientific:

According to the data from the Development Research Center of the State Council, by 2020, the food demand will reach 548.87 million tons based on 1.43 billion people. By then, China’s domestic food supply gap will be 40 million to 50 million tons. Genetically modified crops can just fill such a food supply gap. (Question: Why should we promote genetically modified crops? Answer-provider: Chitianwanjiue, 12/10/2018)

When such unqualified users provide scientific information and answers to other members of the public and actively undertake a scientist’s traditional responsibility to disseminate scientific-related information to others, they act as CSCs (Yang 2021b). CSCs are not a rare phenomenon on Zhihu. Taking the 998 excellent answers1 on the topic of GMOs on Zhihu in October 2019 as examples, only 270 answers were provided by scientists, while CSCs provided more than 60% (some answers were written by media organizations rather than individuals and some answer providers’ identities were difficult to clarify, marked as NULL on the following tables) (Yang 2021b, 997) (Table 1). Because the Zhihu platform

Table 1. Identities of excellent answers providers and active answer providers on the topic of GMOs on Zhihu (Yang 2021b).

|                      | CSCs  | Scientists | Null  | Total |
|----------------------|-------|------------|-------|-------|
| Excellent answer providers | 618   | 270        | 110   | 998   |
|                       | (61.9%) | (27.1%)    | (11.0%) | (100%) |
| Most active answer providers | 11    | 14         | 5     | 30    |
|                       | (36.7%) | (46.7%)    | (16.6%) | (100%) |
is public, without a specific answer threshold, when an answer becomes a high-quality answer, it means that it has effectively answered relevant questions and has been recognized by other public users. This shows that CSCs are highly involved in scientific knowledge-sharing on Zhihu. Further investigation on this topic found that the number one active answer provider, who answered the most questions, was also a CSC. Calculating the ratio of CSCs and scientists among the 30 users who answered the most questions, CSCs still occupied a large proportion (36.7%) (Table 1). Among the top 50 answers that received the most likes in the GMOs section on Zhihu during the online ethnography period, 23 were provided by scientists and 19 were written by CSCs (Table 2).

Evidence from the online ethnography suggests that among the GMOs topic on Zhihu, CSCs already play an active role as communicators and are accepted in this role by other public users. In terms of identification of CSCs, they are not just self-appointed spokespersons on Zhihu but are recognized as science

Table 2. Identities of the answer-providers of the top 50 answers that received the most likes on the topic of GMOs on Zhihu.

| Answer code | Number of likes | Identity of answer-provider | Answer code | Number of likes | Identity of answer-provider |
|-------------|----------------|----------------------------|-------------|----------------|----------------------------|
| 1           | 87,000         | S                          | 26          | 21,000         | CSC                        |
| 2           | 85,000         | S                          | 27          | 21,000         | S                          |
| 3           | 82,000         | S                          | 28          | 21,000         | CSC                        |
| 4           | 68,000         | CSC                        | 29          | 19,000         | NULL                       |
| 5           | 66,000         | CSC                        | 30          | 18,000         | S                          |
| 6           | 52,000         | CSC                        | 31          | 18,000         | NULL                       |
| 7           | 52,000         | CSC                        | 32          | 16,000         | S                          |
| 8           | 49,000         | S                          | 33          | 16,000         | CSC                        |
| 9           | 46,000         | S                          | 34          | 15,000         | CSC                        |
| 10          | 44,000         | CSC                        | 35          | 15,000         | CSC                        |
| 11          | 43,000         | S                          | 36          | 14,000         | NULL                       |
| 12          | 39,000         | CSC                        | 37          | 14,000         | S                          |
| 13          | 38,000         | NULL                       | 38          | 14,000         | CSC                        |
| 14          | 35,000         | S                          | 39          | 14,000         | NULL                       |
| 15          | 34,000         | CSC                        | 40          | 14,000         | S                          |
| 16          | 33,000         | NULL                       | 41          | 14,000         | S                          |
| 17          | 27,000         | S                          | 42          | 13,000         | CSC                        |
| 18          | 26,000         | S                          | 43          | 13,000         | CSC                        |
| 19          | 25,000         | S                          | 44          | 13,000         | S                          |
| 20          | 24,000         | S                          | 45          | 12,000         | S                          |
| 21          | 24,000         | CSC                        | 46          | 12,000         | S                          |
| 22          | 23,000         | CSC                        | 47          | 12,000         | NULL                       |
| 23          | 22,000         | CSC                        | 48          | 11,000         | S                          |
| 24          | 22,000         | NULL                       | 49          | 11,000         | S                          |
| 25          | 21,000         | CSC                        | 50          | 11,000         | NULL                       |
communicators by Chinese netizens on the platform, based on their popularity and the large number of likes they receive. Further diachronic analysis of the proportion of CSCs among the most active answer providers and excellent answer-providers also reveals that the phenomenon of CSCs has become more obvious, and CSCs have become increasingly active and more common in the GMOs section during the two-year online ethnography period (Yang 2021b) (Figure 2). In addition to Zhihu, CSCs also exist widely on other social media network platforms in China, such as TikTok, Weibo, and WeChat (Yang 2021a).

**Public engagement with science communication: from PES to PESC around GMOs discussion on Zhihu**

As discussed above, during the development of PES, the fields of science that the public can get involved in have experienced a gradual expansion process. The “science process” not only includes the governance of scientific affairs and the production of scientific knowledge, but also the dissemination and popularization of scientific knowledge. If we regard citizen science as an extension of traditional PES into the field of scientific knowledge production, the phenomenon of CSCs found in the online ethnography on Zhihu can be seen as a new stage of PES. This is especially true in relation to the discussion about GMOs in the field of public science communication: non-scientist users have begun to participate in

![Figure 2. Diachronic changes of the proportion of CSCs during the online ethnography period.](image)
the online science communication process about GMOs in the Chinese digital environment as active participants.

Strasser et al. (2019) summarized the development of PES as the process of expanding “citizen empowerment” in the field of “science-issues.” Initially, science was considered to be a special type of knowledge controlled by elite groups. Only elites who had received professional scientific training had the right to participate in related matters. Especially under the deficit model, the public can only accept education from scientists in a passive position. Almost everything in science needs to be decided by scientists (Bucchi 2008). With the development of the democratization of science and the rediscovery of the value of lay knowledge, the public’s legitimate rights of participation in scientific affairs have gradually expanded. As participants, they are believed to be meaningful in promoting the democracy of science and society and improving the results of scientific governance (Irwin 2001, 2014). Meanwhile, the value of the public as assistants to scientists in knowledge-production has also gradually been recognized in the scientific research process. “Citizen empowerment” in the field of scientific knowledge production has also gradually been realized (Strasser et al. 2019). In the digital media environment, such as Zhihu, this citizen empowerment has further developed into the field of science communication. In traditional science communication, especially in China’s science popularization, members of the public who have not received a science education are not qualified to be communicators of scientific knowledge and can only be audiences in the science communication process. However, on Zhihu, those CSCs without a professional scientific background not only participate in the process of science communication as science communicators, but also receive considerable recognition from other members of the public around the topic of GMOs, being involved in an increasingly active situation. For instance, at the end of the online observation, the two typical CSCs, user 1 and user 2 mentioned above, had accrued more than 13,000 and 36,000 followers respectively. Another representative CSC (user 3), who is a real estate agency and has an educational background in sociology, provided 13 answers about GMOs on Zhihu during the ethnographic period, receiving more than 80,000 followers (Table 3). The emergence and popularity of CSCs on Zhihu indicates that, in the Chinese digital media environment, PES around GMOs has developed to a new stage: public engagement with science communication (PESC) (Figure 3).

Table 3. Number of GMOs answers provided by representative CSCs and their followers.

| Number of GMOs answers provided by user | Number of followers | Average likes |
|----------------------------------------|---------------------|---------------|
| CSC – user 1                           | 12                  | 13,242        | 208           |
| CSC – user 2                           | 73                  | 36,519        | 164           |
| CSC – user 3                           | 13                  | 81,335        | 188           |
CSCs have also changed the previous characteristics of GMOs discussion and communication in China: scientists were previously considered to be the only legitimate communicators, as Chinese scientist Rao Yi observed: “GMOs should first and foremost be a scientific issue” (Yang 2021a). Thus, discussion of GMOs was expected to involve “positivity and support,” otherwise it would be denounced as anti-science or pseudoscience. But on Zhihu, in the communication led by CSCs, more public, non-scientific dimensions, and differing attitudes, such as suspicion about GMOs, have been effectively introduced into the discussion. User 1 has a legal background but no formally training in science, thus she would not be considered to be qualified to intervene in GMO topics as a communicator in the traditional Chinese context. But during the ethnographic observation, she actively answered 12 GMOs-related questions, and effectively combined scientific knowledge and relevant legal knowledge about GMOs, expanding the discussion dimensions. Her answers were also recognized by other users, as shown in Figure 1, and the average number of likes for her 12 GMOs answers totaled 208. The average numbers of likes for user 2 and user 3 were also significant (164 and 188, respectively) (Table 3). A similar situation can be seen with other CSCs on Zhihu, for instance, under one CSC’s answer about GMOs on

![Figure 3. The development from PES to PESC.](image)

![Figure 4. A comment on a CSC’s answer.](image)
Zhihu, a public user commented that “Your answer is really good” (Figure 4). The evidence above indicates that other users on Zhihu recognized the CSCs’ identity as science communicators in the GMOs section.

From the perspective of PESC, some researchers claim that the public could participate in the science communication process, but such research always regards the public as an “active audience” (Nisbet and Schaufele 2009; Davies and Horst 2016). This process is regarded as the public providing feedback to scientists and science communication led by scientists or having a dialogue with scientists in the role of the audience (Davies and Horst 2016, 196). These researchers do not clearly recognize the possibility and value of the public as communicators in the process of science communication. Some scholars have also discovered that the public participates in science communication as creators in the digital media environment, as public science journalists (Fahy and Nisbet 2011). However, such scholars do not position public participation from the perspective of the interactive relationship between scientists and the public. Based on such understandings of science communication or PES, the role of the scientist as communicator and the role of the public as audience in public science communication is assumed to be fixed.

However, the online ethnography findings discussed above show that the Chinese public is involved in scientific affairs in the digital media environment as more active participants and has gradually gained a status similar to that enjoyed by scientists. This phenomenon also appears with the continuous development of PES, which expands the main body of scientific affairs, allowing the public to legally enter the domain that originally belonged only to scientists. On Zhihu, with the emergence and popularity of CSCs, the public has become engaged in the online science communication process about GMOs not in an “active audience” mode, but in an “active communicator” mode. The group of communicators in the online science communication process has expanded. In traditional Chinese science communication, or science popularization, the public is considered to lack the necessary scientific literacy to effectively intervene in scientific affairs, let alone act as communicators in the science communication process. Members of the public discussing GMOs on Zhihu collect relevant information about GMOs by themselves and pass it to other public users through their own understanding. While in terms of scientific accuracy and credibility they may not be comparable to traditional scientists, their emergence and popularity demonstrates the public’s awareness of their participation in scientific affairs, especially in terms of more active communication.

During the online ethnography, user 2, an insurance specialist with no formal training in science, provided 73 answers about GMOs on Zhihu and received more than 12,000 likes. User 2 not only collected and integrated information by himself to provide other public users with scientific knowledge about GMOs, but he also clearly realized the importance and significance of participating in scientific discussion and communication as a member of the public:
PRSV (papaya ringspot virus) or PLDMV Papaya mosaic potexvirus are mostly transmitted by aphids. The papaya without genetic modifications is prone to dying easily. Therefore, there is basically no unmodified papaya in the world now. (11/05/2018)

Because very few people really understand this scientific principle, many of them will question the authenticity of this information. I learned this information from a Research Fellow in Guangzhou Research Institute of Agricultural Sciences, and I have also verified it by myself. So, it is worthy to be believed. (06/09/2018)

Other CSC users also expressed similar sentiments in the discussion of GMOs, for instance a user with an educational background in Chinese history said:

I think the discussions about GMOs, even from the scientific perspective, should involve the public actively. We cannot rely too much on scientists. We’ve already learned a lot about the science of GMOs on various occasions, and we can share what we’ve learned with the other public and then have a discussion. Wouldn’t that be nice too? (12/11/2018)

The emergence and popularity of CSCs – with the public’s growing awareness of participating in scientific communication as communicators and the enhancement of their scientific information collection and integration capabilities – have not only pushed PES to a new stage (PESC) but have also changed the role of the public from “passive or active audience” to “active communicators” around the topic of GMOs in the Chinese digital environment.

**Discussion: how CSCs emerged and achieved popularity on Zhihu**

The online ethnography data analysed above shows that CSCs have become an increasingly active and influential group in the scientific discussion of GMOs on Zhihu. But why are CSC numbers expanding and actively engaging in such science-related topics? Bennett and Segerberg’s (2012) connective action theory provides an analytical framework to explore this question, and a lens to understand specific mechanisms that attract the public – especially CSCs – to collaborate and produce creative, self-expressive, and self-initiated media products on Zhihu.

According to Bennett and Segerberg (2013), digital media platforms provide the public with a convenient platform for their personalized participation and further results in collective actions, which means that “digital media can replace traditional organizations, allowing the emergence of activism based on personal actions” (Vicari and Cappai 2016, 1657). Therefore, under the digital environment logic, each individual – even those who were originally thought to have limited discourse power and space – is encouraged and has the possibility to participate in the content creation and sharing process, like the CSCs on Zhihu, which can be described as “science communication activism.”

Due to its mobilizational, decentralized feature, the digital media environment can greatly promote the emergence and development of personalized activism and act as an ideal space for wider engagement (Bennett and Segerberg 2013; Vicari
and Cappai 2016). Zhihu is principally designed as a content-sharing and social networking site. Beyond a simple and intuitive interface, Zhihu also features instructions to guide new users at all levels of participation. Its informal and unregulated mentorship also provides opportunities for users to take on different responsibilities and have different levels of involvement. At any level of participation and activism of users on Zhihu, from viewing an answer to answering a question, users contribute greatly to its online knowledge-sharing community. Zhihu’s database takes into account every comment, like and disagreement. The most popular answers with the most likes are promoted on the Zhihu homepage and the main page of each topic. Registered users can access a customizable profile as well as followed and follower lists to keep track of favorite topics, questions and users and to receive updates when a new answer is provided under a subscribed question or topic. These features are all conducive to generating a personalized “science communication activism” culture on the platform, which further promotes users with no formal scientific training to participate in scientific discussion and to take on the role of communicators of scientific information.

In addition to its platform features and the personalized “science communication activism” culture constructed on it, the development of science communication has also promoted CSCs’ engagement in scientific discussion on Zhihu. Science communication has experienced a deficit model, and the dialogue model has gradually moved towards the engagement model (including citizen science) (Trench 2008; Davies and Horst 2016). The emphasis on the public and their lay knowledge has also increased within science communication and governance of scientific affairs (Burns, O’Connor, and Stocklmayer 2003; Nisbet and Scheufele 2009). Although this academic approach has not been particularly smooth in its transition into practice, an atmosphere that respects the public’s right to speak has gradually developed among scientists (Irwin, Bucchi, and Trench 2014). In the Chinese context, in the report of the 19th National Congress of the Communist Party of China, the Party pointed out that it is necessary to build a social governance pattern of co-construction of scientific affairs and to strengthen public participation in science and technology governance; it was noted that the public’s right to a voice should be respected, and that the public should also be given sufficient space for a voice in science communication activities.

Meanwhile, the interdisciplinarity of some popular science-related topics also makes the public’s engagement and the activeness of CSCs easier. The topic of GMOs in the current Chinese discourse environment, as an example, is not only about science itself, such as gene-editing technology or synthetic biology, but also concerns other aspects, including economics, politics, culture and entertainment (Wang, Zhong, and Jia 2015). This context allows the Chinese public to participate in and discuss science-related topics such as GMOs from a broader perspective, thereby lowering the barriers for them to engage with scientific discussion, alongside the growth in Chinese citizens’ scientific literacy and ability to participate in scientific discussions.
The platform, the culture, the scientists, and the public themselves have together promoted the public’s engagement with the discussion of scientific topics in the digital media environment, which has further contributed to creating the CSCs group and promoted its growth on Zhihu.

Conclusion
The emergence and popularity of CSCs in the GMOs discussion on Zhihu provides a new way of understanding PES and the relationship between scientists and the public in the digital media environment. Public engagement with science communication (PESC) greatly expands our understanding of PES and citizen science and reconstructs the scientist-public interactional relationships in the communication and discussion of controversial scientific issues, such as GMOs, in the digital media environment. In the traditional PES model or public engagement with scientific discussion, at best the public is introduced into science communication as a positive audience or the object of dialogue/education, or as scientist’s assistants. The rapid development of digital media and changes within the science communication environment provide the conditions for such a traditional PES model to develop. In the new PESC model related to CSCs proposed in this study, members of the public with no formal scientific training can also play the role of science communicators in the online science communication and discussion process, and further be accepted and recognized by other publics in the digital media environment, which can be seen as a kind of online “science communication activism.” The roles that the public can play in PES have been further diversified. The dialogue between scientists and the public is also no longer a dialogue between “communicators” and “active audiences providing feedback,” but between two groups of “possible communicators/audiences.” The boundaries and barriers between scientists and the public in the science communication process may be further broken, and the monopoly of scientists in their long-term role as the only “legitimate science communicators,” especially in the traditional media environment, may also be eliminated under the PESC model (Yang 2021a). This may lead to the possibility of more equal dialogue and relationships between scientists and the public in science communication. Under the PESC model, the public and scientists may be able to exchange their views and knowledge more fairly about controversial scientific issues such as GMOs, to better realize the socialized governance of such controversial scientific issues, not only in the Chinese digital context, but also globally.

Note
1. “Excellent answers” (精品回答) are selected by the Zhihu platform in each topic section based on the number of likes, comments, and content quality of the answers, combined with comprehensive algorithmic measurements. The selected “excellent answers” all feature higher quality content, contain more information, and the number of likes and comments.
received are the greatest in the entire topic section. Therefore, they are also the most popular and influential answers in each topic section.

Disclosure statement
No potential conflict of interest was reported by the author(s).

Funding
This project is partly funded by the Chinese State-Sponsored Postgraduate Program for Building High-level Universities (Funding Number: 201706340047).

Ethical community
Ethics Administrator office of Sociological Studies.
The University of Sheffield.

Data of approval: 23/11/2018
Approval Number: 023021

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