Science popularization and its ethical standpoint

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Abstract
Science popularization has both academic and policy implications. With the rapid development and large-scale application of science and technology, the demand for science popularization has generally increased, and its status in social development has been significantly improved. New features and challenges have emerged, such as changes in popularization content, the modernization of communication methods and the diversification of participants. In addition, science popularization is also faced with many new ethical issues. These new conditions require deeper consideration about which ethical viewpoints should be adopted in science popularization. Beginning with an analysis of the academic and policy implications of science popularization, this study combines the new characteristics of contemporary science popularization to analyse the ethical issues it faces. Finally, it proposes an ethical viewpoint that should be maintained in science popularization from the perspectives of utilitarianism, deontology, contract theory, and virtue theory, and provides suggestions for converting responsible science popularization initiatives into concrete actions.

Keywords
Ethical viewpoint, public scientific literacy, responsible science popularization, science communication, science popularization

1. The implications of science popularization over time

1.1. Science popularization: Academic concept and policy concept

The English concept of science popularization was first developed in the 1840s. The early concept focused on the popularization of science to the public (Liu, 2010). The main purpose was to inform the public of major academic and scientific events and discoveries by using ‘comprehensible and intelligible language’ that was ‘understandable to the general public’ (Ziman, 1985: 112). The Chinese concept of science popularization (kepu in Chinese) was created in 1949. The term kepu was used as an abbreviation of kexue puji. Over the years, it has gradually expanded from the popularization of scientific
knowledge to the popularization of scientific ideas, methods, spirit and ethics. It has been further developed with increasing promotion of science and technology popularization. There are currently different definitions about the concept of science popularization in China, some from the legal perspective and others from the angles of communication and systems theory. Several researchers have conducted a detailed review on this subject (see e.g. Ren and Zhai, 2012). The 2002 Law of the People’s Republic of China on the Popularization of Science and Technology defines science popularization as ‘the activities organized by the state and the society, in ways that are easy to understand, accept and participate in by the public, for the purpose of popularizing scientific and technological knowledge, promoting scientific method, spreading scientific ideas and advocating the scientific spirit’.

From the above analysis, we can see that science popularization is in a process of dynamic evolution and can be understood from two perspectives – academic and policy. The academic concept of science popularization stresses that the government and the scientific community are at the centre of authority. The communication model is one-way transmission of knowledge, and there is an unbalanced relationship between the actors and audience, implying that knowledge is reliable and scientists can be trusted. Conversely, the policy concept emphasizes that science popularization is an activity that allows the public to receive and apply scientific knowledge and understand science.

1.2. Science popularization and science communication

The development of the public understanding of science and science communication has inspired Chinese researchers to revisit and explore the idea of science popularization. At the beginning of the 21st century, scholars in China had an in-depth discussion on whether the term ‘science popularization’ should be replaced by ‘science communication’, but no definitive conclusion was reached. To this day, the terms are still used interchangeably in certain contexts (Wang and Fu, 2015).

The issue of science communication was first raised by Bernal (1982). He stressed that, in addition to discussion among scientists, science communication should also include communication to the public (Bernal, 1982). The British report Science in Public further expanded the targets of science communication to include mutual communication within the scientific community and between the scientific community and other actors, such as the media (including museums and science centres), the public, the government or other authorities in power and other agencies and industries that influence policy-making (Ren and Zhai, 2012). In terms of the conceptual implications, science communication is non-centralized, with an equal relationship between the actor and audience, in which the public both understands and participates in science. Compared to the one-way communication of science popularization, it puts more emphasis on interaction and consultation.

Science popularization and science communication are not mutually exclusive. Rather, they are two spectra of behaviours that coexist in reality and progress conceptually (i.e. from the deficit model to the democratic or dialogue model). The deficit model assumes that the public lacks scientific literacy, which leads to people’s doubts about the development of science and technology; and thus scientists with scientific literacy need to disseminate knowledge to the public to fill the ‘empty bottle’. It adopts a top-down and one-way method of communication. The public understanding of science, however, stresses two-way communication and the subjectivity and initiative of the public. On this basis, a new paradigm of ‘public participation in science’ has been formed, which posits that scientists and the public are equal and can have discussions and dialogues. Beyond simply understanding science, the public should also participate in science, and scientists also need to understand the public (i.e. the democratic model or dialogue model).

Whether the deficit model, democratic model or dialogue model has been used, improving the public’s scientific literacy has always been a major objective of science popularization, and the definition and measurement of scientific literacy have
become important aspects in measuring the effectiveness of science popularization. Therefore, three questions must be considered in conducting science popularization: What kind of scientific literacy should the public have? What kind of scientific literacy does the public need? How can we improve the scientific literacy of the public?

2. New features and challenges of contemporary science popularization and associated ethical problems

2.1. The content of popularization: From established science to science in action

In the 1980s, the sociology of scientific knowledge gained popularity and put forward the theory of ‘science in action’, which suggested that the construction of scientific knowledge is a social process and that scientific knowledge has been transformed from established science into science in action. This means that knowledge is no longer an objective truth, which changes the relationships between scientific research and scientific communication, as well as between scientists and the public and government. This raises two more questions: What are the concerns of the public? What kind of public literacy should be improved? The following is an analysis based on the Pusztai case.

Árpád Pusztai, a senior scientist at the Rowett Institute in the UK, led research on the safety of genetically modified (GM) foods in 1995. On 10 August 1998, during an interview for the TV programme *World in Action*, Pusztai announced an unpublished finding from his research: rats that had consumed GM potatoes showed mild developmental delays and affected immune systems. The interview caused a heated public debate. A few days later, the institute publicly apologized for releasing incorrect information. They announced Pusztai’s early retirement and referred his data to a review committee. The committee concluded that Pusztai’s results could not support his conclusions, but 24 scientists from different countries believed Pusztai’s research was of good quality with reasonable conclusions (Duan, 2009). The Royal Society set up a special committee to investigate Pusztai’s study, and the review concluded that the experiment was poorly designed and that the study could not prove that there were problems with the safety of GM potatoes. In October 1999, the *Lancet* officially published the paper by Pusztai and his co-authors (Dai and Cai, 2016).

The scientific validity in this case is still inconclusive. However, what we want to address is whether Pusztai violated basic academic ethics by rushing to publicize his results through the media before the experiment was completed and the data was published. In the proper chain of events, Pusztai should have first verified the scientific validity of his conclusions through peer review within the scientific community before disseminating them to the public. ‘Science is science only because it has passed peer review and validation’ (Tan, 2011). Pusztai also had a fierce struggle in his mind, ‘but in the end, his ethical principles prompted his decision to publish his research findings to the public without delay.’ He thought that ‘the British taxpayers, who invested £1.6 million in this scientific project of the Rowett Institute, had a right to be informed’ (Smith, 2011: 12).

The ethical questions in this case are: What are responsible research and innovation? What is responsible science communication? In the case of established science, there is a relatively unified consensus within the scientific community regarding the reliability of knowledge and the certainty of consequences, and we only need to pay attention to the reliability and accuracy of re-creation and re-expression in science popularization. However, in the case of science in action, knowledge is no longer objective truth; rather, it is something uncertain with unpredictable consequences. When communicating science that is still controversial, there will be ethical problems and spillovers of controversies during the popularization stage. It is therefore necessary to think about the correct view about uncertainties and possible risks and learn how to take a rational approach to scientific research controversies.

2.2. Modernization of communication: The ‘self-media era’

The rapid development of the internet and new media technologies has profoundly changed science
popularization methods and channels, providing diverse options for improving the public’s scientific literacy. Self-media adopt modernized and electronic means to transmit information to an unspecified group or a specific individual. They are defined by features such as privatization, popularization, generalization, and autonomy, and their common forms include blogs, Weibo, WeChat, posts, forums, bulletin board systems, and other online communities.

Through the effects of new technologies such as the internet, various self-media forms have diluted the advantages of traditional communication channels in information dissemination and opinion guidance and redefined the concept of media. In terms of communication channels, the communication capability of self-media is notably higher due to their low threshold, convenience in operation and expression of individual opinions, enhanced interactivity, and faster communication speed. In terms of content, most of the self-media have adopted easy-to-understand and ‘down-to-earth’ means of presentation defined by features such as open and transparent information and public participation, individuality challenging the public and a mixture of opinions and knowledge.

While self-media have broadened the path to transmit scientific information, they are difficult to regulate without an effective quality-control mechanism. This causes several ethical problems. On the one hand, voices against mainstream scientific views and scientific evidence—and even pseudo-science and unfounded rumours—also get widely spread in the process of science communication. Studies have shown that, due to the absence of scientists and science communicators in the microblogging space, voices against mainstream views have dominated the debate over controversial scientific issues, including genetic modification, earthquake forecasting, and food safety. On the other hand, scientists are often attacked by ‘cyber democracy’ during their science communication activities. According to the results of a survey on whether scientists are worried about being verbally abused, there were also clear differences in gender: female and male scientists scored 2.9 and 2.6 points, respectively, suggesting that female scientists are more worried about being verbally abused.

2.3. Diversification of participants: The dialogue model

The dialogue model (Figure 1) is based on reflection about paradigms such as the deficit model and public understanding of science, emphasizing ‘knowing’ and ‘questioning’ (Liu, 2009). In the dialogue model, the role of communicators is not limited to the government and the scientific community; rather, it includes diversified actors such as science fans, science media, the general public, and industries. The increased differentiation and stratification of the target audience generates diverse demands. In the new media environment represented by the internet, it is now possible for citizens to increase their participation in science communication; the scientific community—which originally held the initiative in scientific information dissemination—has been challenged as never before; and there is a clear trend of decentralization. The dissemination of scientific information has evolved from one-way communication to two-way interaction. Various groups have been further divided, and some science popularization and science communication workers have been separated from the scientific community. As an important channel for the public to access scientific and technological information, the media have been

![Figure 1. The dialogue model.](image-url)
able to shape public opinion through the processing of such information, which makes them both intermediaries and important influencing factors in the dialogue.

This raises two ethical questions: Is the knowledge being transmitted reliable? Are scientists and communicators still credible? The scientific knowledge obtained by the public is reconstructed by science communicators and is shaped by the values and interests of the communicators themselves. Some scientists are motivated to carry out science popularization to win public support for certain scientific research projects and seek greater research funding, and some choose to carry out science popularization on a certain topic for political reasons or in return for funding. Therefore, types of science popularization that are loaded with values and interests may have deviated from scientific facts. This shift in discourse has challenged the authority of the scientific community and communicators.

3. The correct ethical standpoint of science popularization

3.1. Ethics

Ethics is the moral principle of human ethics, which refers to the moral codes governing interpersonal relations. Ethics addresses the question of what is good and desirable. In its early stage, ethics takes the form of customs and habits that are chosen and promoted by people and society through good behaviour. Those customs and habits gradually evolve into social conventions and norms defining justified behaviour.

Etymologically, the English word ‘ethics’ originated from the Greek word ethos, and the word ‘moral’ originated from the Latin word moralis. Both words contain the meaning of traditional customs and behavioural habits and place emphasis on behaviours to be advocated and observed. Both also pursue the goal of kindness. Morality is an individual, subjective spirit, while ethics is a social, objective spirit and a social consciousness. Morality emphasizes that individuals are virtuous because they consciously follow good behaviours, while ethics emphasizes that the relationships between human beings, between human beings and society and between human beings and nature must be handled in accordance with norms.

3.2. The ethical standpoints of science popularization

Ethical standpoints define the right and proper thing to do. Here we discuss the ethical standpoints of science popularization by referring to mainstream ethical theories such as utilitarianism, deontology, contract theory and virtue theory.

Utilitarianism views the pursuit of happiness and pleasure as justified behaviour. It focuses on the consequences of behaviours and judges whether a behaviour is good or not based on the consequences. Utilitarianism proposes that the best outcome is to achieve the greatest good, so an action is morally right only when it brings the maximum good. This means that the safety, health and welfare of the public should be put above everything else.

Deontology focuses on the behaviour itself. This philosophy argues that the moral principles one should follow are self-evident, that one can usually rely on intuition to discover the right moral principles and that free will means to practise a moral code (i.e. moral self-discipline). Deontologists emphasize that whether an act is justified should not be judged solely by its consequences. The act itself also has moral significance; that is, it should be honest, harmless, just and responsible.

Contract theory holds that contracts or original agreements are made for the purpose of establishing a fundamental moral principle that guides the design of the basic societal structure (i.e. justice). Through a rules-based framework, contract theory sees the motivation and normative ethics of individual behaviour as a social agreement. In other words, the rights and responsibilities of the parties to the dialogue and the parties to the contract should be clarified.

Virtue theory takes the actor as its focus and asks the question ‘What kind of person should I be?’ The theory holds that human virtue is a quality that helps people become kind-hearted and excellent. There is no such thing as an abstract virtue that transcends history, and virtue can be achieved only through practice.
The ethical norms to be followed in science popularization should conform to the common features of human ethics and reflect the particularity of science popularization. In the three aspects of content, form and purpose, science popularization ethics is closely related to ethical norms in other fields. With regard to content, it should be guided by the values of science and technology ethics and the principle of ‘science towards goodness’. The form of science popularization should conform to the code of communication ethics and establish a sound code of conduct that ensures truthful and accurate information and upholding basic legal principles and moral ethics. Finally, in terms of the purpose and influence of science popularization, it should aim to deliver the desired goals and influence of science and education ethics.

As there are intersections between science popularization ethics and ethics in other fields, the ethical standpoint of science popularization is multifaceted and three-dimensional but still consistent with the basic values of ethics. In short, the following ethical standpoints should be established for science popularization. First, keep to the value orientation of goodness and improve life through science and technology; second, observe the basic moral principles and pay attention to the health, safety and welfare of the public; third, deal with risks and negotiate a better contract together and fourth, move towards civilization and foster a just, responsible, virtuous community.

4. Responsible science popularization: From appeal to action

The basic principles of responsible science popularization are to uphold the value of ‘science towards goodness’ and maintain the moral high ground. Only by observing the moral code can we ensure good words and actions, only by standing on the moral high ground can we gain wider trust and only by holding that high ground can we build stronger influence and have more say in the development of ethical rules.

First, we need to establish ethical awareness. Fostering the awareness of ethics is a precondition of self-discipline. The announcement of the Science Popularization Ethics Initiative on 24 September 2020 was an important symbol of increasing ethical awareness. The initiative should be widely disseminated in science museums, science popularization literature, science and technology news and other sectors, thus inspiring the exploration and discussion of science popularization ethics in the professional field and wider society, turning science popularization ethics from an unknown concept into a specific concept for studies and discussion and promoting the establishment of science popularization ethics awareness in the science popularization industry.

Second, we need to establish the ethical norms and clarify the code of conduct in the case of ethical problems. This will provide a basis for resolving ethical problems in the process of science popularization. Based on the Science Popularization Ethics Initiative, we should encourage the science popularization communities in different fields, such as science and technology museums, science popularization creators’ groups and science and technology media, to establish their internal ethical guiding norms and promote ethical construction by addressing problems in science popularization, thus laying the groundwork for science popularization ethics.

Third, we need to improve our ethical decision-making abilities and creatively explore new ways to solve new ethical problems. On the basis of establishing ethical norms in science popularization-related industries, reforms should be conducted to find new problems and methods to address the ethical problems in science popularization practices, and thus to improve the level of ethical governance and the ability to make good decisions on practical ethical problems, laying the foundation for a full-fledged ethical governance system for science popularization.

Fourth, we need to strengthen international cooperation and consultation while actively participating in the development of ethical rules for the communication of cutting-edge science and technology, thus continuously amplifying our voice. We should promote international exchanges on science popularization, study good foreign theories on science and technology ethics and seek inspiration from advanced ideas of ethical governance of science
popularization from different cultural backgrounds to enrich science popularization ethics in China.

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