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Editorial

Editorial: Science Communication in the Digital Age—New Actors, Environments, and Practices

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Abstract
Digitalization challenges science communication in theoretical as well as methodological ways. It raises questions on how scientists, organizations, and institutions, as well as citizens and actors from other fields communicate about science and how science communication affects politics and the public. This thematic issue presents a collection of articles attempting to tackle digitalization's challenge for science communication research. In this editorial, we provide a short overview of the included articles. Additionally, we outline some future avenues that research could follow to examine further the implications that digital channels could have for science communication.

Keywords
climate change; Covid-19; digital media; experts; Facebook; science communication; science literacy; social media; TikTok; Twitter; YouTube

Issue
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1. Introduction

Science communication has undergone tectonic shifts in recent years, many of which have been introduced by or catalyzed through digitalization. On the level of social implications of digital media (Neuberger, 2009), opportunities to participate in science communication are increased by lowering participation barriers, both for communicators and audience; transparency is augmented; and the ability to select content according to individual needs is improved. Digital media has given rise to a pluralization of voices in science communication, along with individualization and, in some cases, fragmentation or even polarization of audiences (Schäfer & Metag, 2021). Other characteristics of digital information environments are also posing challenges for communication about science: misinformation and disinformation distributed on various platforms (Scheufele & Krause, 2019), hardening counter-publics online (Kaiser & Puschmann, 2017), online attacks on scientists, and a lack of institutional support for scientific communicators (Gosse et al., 2021; Nölleke et al., 2023). Many of these trends were accentuated, amplified, and accelerated during the Covid-19 pandemic. The number and types of voices and the amount of information available online have increased during the pandemic to what has been called an "infodemic" (Krause et al., 2022; Lu et al., 2021). This encompasses problematic aspects such as disinformation and conspirational thinking (Schäfer et al., 2022), as well as the crowding out of other topics such as climate change. However, it also demonstrates a strong representation of science in the public discourse.

Digital channels allow communicators to use different formats, codes, and content, combining visual, textual, and auditory elements. Science journalists use platforms like YouTube and Twitter to communicate; the visibility of scientists and science online has hence increased and received more attention (Metag, 2021).

On the level of spatial factors (Neuberger, 2009), digital media can overcome geographical boundaries and change the contexts in which people communicate. They can help with public engagement for scientists and scientific organizations, enabling them to address audiences directly using multimodal and interactive methods of communication (Schäfer, 2017). On a temporal level (Neuberger, 2009), the speed and dynamics of information diffusion are accelerated by digital media, allowing synchronous and asynchronous communication, as well as storage of communication for usage on future occasions.

Against such a background, this thematic issue presents an overview of current studies on science communication in the online sphere. The 12 articles address some of the benefits and challenges of online communication already outlined as well as the blurring boundaries between communicators, content, and audiences. Each article has a specific focus: on different scientific actors communicating online, on how audiences are affected by particular kinds of online science communication, or on how online discourse about scientific issues is structured and can be described.

2. Scientists, Scientific Institutions, and Science Influencers on Online Platforms

Scientists and scientific institutions are presented with many options for communicating through online platforms but also face various challenges when doing so. Focusing on whether a topic's history affects science communication, Kaija Biermann, Nicola Peters, and Monika Taddicken (2023) compare similarities and differences between climate professionals and Covid-19 experts regarding advocacy and assessments of policies and political actors on Twitter. They find that authorities on climate deal with politics more often in their tweets than Covid-19 specialists. A lot of research on science communication in social media relies on Twitter data. Still, Adrian Rauchfleisch, Jo-Ju Kao, Tzu-Hsuan Tseng, Chia-Tzu Ho, and Lu-Yi Li (2023) argue that, in Taiwan, scientists are more active on Facebook even in their professional roles. They analyze predictors of Facebook communication reach and demonstrate that posts that address current issues and include opinions are likely to be shared most widely. In the context of the underrepresentation of female scientists in the media, Brigitte Huber and Luis Quesada Baena (2023) explore the potential for female scholars to overcome gender stereotypes on TikTok. Using content analysis, the authors show that women scientists use TikTok to explain facts and concepts, to discuss what being a (female) scholar is like, and also, in some cases, to address gender stereotypes. Influencers have gained importance on social media, which offers the opportunity for diversification of the spectrum of science communicators. In this regard, Belén Cambronero-Saiz, Carmen Cristófol-Rodríguez, and Jesús Segarra-Saavedra (2023) study whether there are differences in the type of comments posted on Spanish science popularization channels on YouTube depending on the creator's gender. They find that women are more likely to receive negative sexist comments and that these remarks often address their intellectual ability or personality. Converse to these studies looking at single scientists or influencers, Isabel Sörensen, Silke Fürst, Daniel Vogler, and Mike S. Schäfer (2023) take an organizational perspective, conducting a longitudinal analysis of all Swiss Higher Education Institutions' communication on Facebook, Instagram, and Twitter. They present the differences between channels over time, like increased communication on Instagram but not on Facebook or Twitter, and between types of universities, with universities of applied sciences most active on Facebook and Instagram while research universities more often using Twitter.

3. Online Public Discourse About Scientific Issues

As mentioned above, communication about science on social media platforms has frequently been investigated on Twitter. Two studies in this issue provide insights into research gaps that exist in this field. Hendrik Meyer, Amelia Katelin Peach, Lars Guenther, Hadas Emma Kedar, and Michael Brüggemann (2023) explore the interplay of "triggers" and discursive features that attract attention to climate change. Combining manual and automated Twitter content analysis, they find intense politicization of climate change and calls for action in the Twitter discourse and identify causes: political events generating posts that stress the reality of climate change, and amplification of tweets about protests and cultural events if they include a call for action. The study by Hannah Schmid-Petri, Moritz Bürger, Stephan Schlögl, Mara Schwind, Jelena Mitrović, and Ramona Kühn (2023) concerns Covid-19 on Twitter. It closes a research gap by focusing on multilingual Twitter discourses, analyzing how the topic of vaccination was discussed and evaluated in German, Russian, Turkish, and Polish language communities in Germany. While the authors do not find many structural connections between the communities, they reveal that the content of the debate in the different language communities is similar.

In China, specific social media platforms like Twitter and Facebook are not available. Instead, Weibo has emerged as a virtual online platform with similar affordances. Jinghong Xu, Difan Guo, Jing Xu, and Chang Luo (2023) investigate science communication about the Omicron variant of Covid-19 on Weibo using content and social network analysis. The actors they identify show relatively consistent values and positions in their posts. Regarding the challenge of inaccurate scientific information spreading during the Covid-19 pandemic, Markus Schug, Helena Bilandzic, and Susanne Kinnebrock (2023) analyze how scientific evidence is presented and how findings are questioned using evidencing and counter-evidencing strategies in the online

content of two popular German "alternative news" media sites. They find that the coverage contradicts scientific evidence and follows a political agenda agitating against Covid-19 policies.

4. Audiences and the Reception of Science Communication Online

From an audience perspective, the question of whether people possess—or should possess—some kind of scientific literacy has been discussed in the field of science communication research for decades. Many researchers have worked on defining concepts and measurements of scientific and information literacy. In their article, Han Wang, Lina Li, Jing Wu, and Hao Gao (2023) investigate scientific information literacy and the demographic differences among the Chinese public through a cross-sectional survey. The results reveal that the Chinese public has relatively low levels of ability to assess information quality and to express opinions about science. Two other articles in this issue provide further insights into how specific characteristics of online communication about science can influence audiences. First, Anna Schorn and Werner Wirth (2023) study how explainer videos on Youtube that use exemplars (the "meet Bob" trope) affect attitudes towards voluntary carbon offsetting and perceived effectiveness. Their experiments reveal that appeals to injunctive social norms can positively influence sustainable minority behavior. Second, Jana Laura Egelhofer (2023), with an experimental design drawing on the interplay of political populism and science, analyzes how politicians' attacks addressing science and journalism on social media affect citizens' trust in journalists and scientists themselves and the information provided by them. She finds somewhat limited effects, showing that only citizens with strong anti-elitist attitudes are susceptible to disinformation accusations by politicians, indicating less belief in discredited scientific information.

5. Conclusion

In science communication research, the distinct characteristics of digital media can influence not only the methods used and theories developed but also the questions that researchers ask. Contributions to this thematic issue show that the social implications of digital media are very prominent. The studies examine users, influencers, and individual experts and their communication channels, the role of the audience in science communication, and the interplay between audience reaction and content production. In particular, the greater vulnerability of certain groups online is apparent. Aspects on the level of time, space, and characters are less present than the social aspects. However, the articles here nonetheless offer some insights. The temporal dimension is reflected in this thematic issue by research examining attention to topics on social media and a longitudinal analysis of a science communicator's social media. Regarding the spatial dimension, the studies included here illustrate that obstacles to and opportunities for science communication can differ vastly depending on the context. The level of examining characters and their use in digital media is present in a study examining the effects of visual content in this thematic issue.

This presents new avenues for future studies that could examine how the rate of information diffusion and the speed of generating scientific findings clash, the potential of digital media to expand the spatial dimensions of science communication, and how digital media can integrate different visual as well as auditory elements. Manual content analysis is still the dominant method of examining digital communication. However, longitudinal analyses that capture temporal aspects and methods combining visual and textual elements are required to enhance our understanding. In addition, these studies show that it is worth the effort to compare national contexts to identify global trends as well as local specifics. Therefore, there is potential for further development, both in terms of methods and questions.

Overall, this thematic issue provides an illustrative picture of the changing landscape of science communication in the digital age. It highlights the importance of addressing the challenges posed by digital media while leveraging its opportunities to engage with audiences effectively.

Conflict of Interests

The authors declare no conflict of interests.

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