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# Media Literacy, Scientific Literacy, and Science Videos on the Internet

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Although video is not a new format for communicating about science, video-sharing platforms have democratized the process. Individuals who wish to share information or ideas about science can use these platforms to connect with potentially large and diverse audiences. This has benefits and drawbacks. The benefits are related to increased access to scientific information and greater public engagement with science. The drawbacks are related to communication within echo chambers and the spread of misinformation. This mini-review presents these benefits and drawbacks with respect to the science video landscape and media and scientific literacies. It concludes with a brief synthesis of ideas and recommendations for future research avenues.

**Keywords:** science videos, media literacy, scientific literacy, pseudoscience, misinformation, youtube, social media

## INTRODUCTION

For more than a century, science communicators have recognized film's potential to depict and popularize science (Gouyon, 2015). The tools of filmmaking and, more recently, video production have long been available to amateurs; however, the ability to reach large audiences was historically limited to those with access to distribution networks (Salazkina and Fibla-Gutierrez, 2018). Online video-sharing has created new opportunities for both professional and amateur producers to reach large and diverse audiences (Davis and León, 2018; Rosenthal, 2018). It also has great potential for engaging audiences with science-related content (Erviti and Stengler, 2016). This is part of an ongoing trend toward more immediate and on-demand access to large amounts of scientific information (Miller, 2010; Takahashi and Tandoc, 2015). In a sense, online video has democratized science communication, allowing anybody with a computer device and internet connection to become a science video producer and consumer.

With more people creating science videos, there are more opportunities for the public to engage with science. In many ways, this is a positive development, but there are also drawbacks. This article highlights three of those drawbacks. First, online information sources may poorly separate facts from opinions (Brossard, 2013), perhaps due to a lack of gatekeepers (Shapiro and Park, 2015). Second, the abundance of video content can lead to information overload and selective exposure (Takahashi and Tandoc, 2015). Third, online discourse around contentious issues tends to devolve into polarized echo chambers (Bessi et al., 2016). These three drawbacks can work synergistically, and scholars have expressed concerns over the use of online videos to spread "bad" science. Some have called for institutional remedies to control the information available to the public (e.g., Donzelli et al., 2018), whereas others have focused more on audience psychology (e.g., Landrum et al., 2019).

This article provides a mini-review of the research on science videos on the internet, drawing on concepts from communication and educational psychology. It serves as a clearinghouse of ideas in three major sections. The first section presents key elements of the science video landscape, providing a framework for the later sections. The second section discusses the roles of media literacy and scientific literacy in the context of science videos on the internet, emphasizing audience psychology. The third section discusses some of the benefits and drawbacks of a media landscape in which more people than ever can create and consume science videos. Although promoting benefits and reducing drawbacks may involve public institutions, there is an attendant need to understand the roles of audience psychology and sociology. The conclusion highlights this need and argues for continued efforts to bolster media literacy and scientific literacy in public.

## SCIENCE VIDEO LANDSCAPE

For framing purposes, this article provides a concise overview of the science video landscape. Elements of this landscape include the producers of video content, the messages contained in the videos, the online video distribution platforms, and the audiences watching the videos. These elements broadly align with Berlo (1960) SMCR model of communication as a process involving a source, message, channel, and receiver. Although that model may oversimplify the communication process, it is a useful framework for discussing the surface features of science videos on the internet.

### Source

In past decades, science videos reaching large audiences were usually from professional science communicators or organizations. Online video has changed this, blurring the line between professional and amateur producers (Morcillo et al., 2016). Although many online science videos come from media companies, they may also come from scientists, science educators, engineers, and interest groups, to name a few (Welbourne and Grant, 2016; Rosenthal, 2018), and there is evidence that audiences like science videos more when they come from scientists vs. non-scientists (Sugimoto and Thelwall, 2013). Despite the diversity of science video producers, minorities are underrepresented in their ranks (Campbell et al., 2019).

### Message

Video producers use many techniques and genres to communicate about science (Morcillo et al., 2016). Online science videos often have an informational purpose but also frequently aim to raise awareness or entertain (De Lara et al., 2017). Videos targeting awareness present information about an issue to enhance its salience or perceived importance. The information contained in online science videos can be scientific, pseudoscientific, or non-scientific and can move audiences toward or away from mainstream scientific views (Ervti et al., 2018; Landrum and Olshansky, 2020).

## Channel

Video can be an effective tool for communicating about scientific issues (Ferraro et al., 2019) and there is an ongoing need to understand channel effects (Jeffres, 2015). The channel of online video has many distribution platforms. Among those channels, YouTube seems the most popular for individuals seeking science-related information (Metag, 2020), but users can also find and share videos on social media, such as Facebook, and social messaging platforms, such as WhatsApp.

Extensions of the SMCR model often include feedback involving the two-way flow of information (Narula, 2006). In the past, video broadcast allowed limited feedback (e.g., writing letters) from large and diffuse audiences (Beyer et al., 2007). Video sharing platforms have changed that dynamic, creating channel affordances for audiences to share ideas more directly with content producers (Ervti and Stengler, 2016). Live video streaming creates additional feedback mechanisms, where producers can interact in real-time with their audiences (Wang and Li, 2020).

## Receiver

The different online video platforms have potentially large audiences. YouTube alone has more than two billion users (YouTube, 2020). Although there is evidence most of those users do not regularly watch science videos (Tsai et al., 2016; Rosenthal, 2018), it is likely most will encounter such videos—including those spreading misinformation—at some point. Several factors affect motivation to seek science videos on YouTube, including perceived social norms, enjoyment of science, and an information orientation to YouTube (Rosenthal, 2018). The effects of science videos on audiences include more participation in scientific discourse (Shapiro and Park, 2015) and more positive perceptions of scientists (Brewer and Ley, 2017).

## Noise

Another extension of the SMCR model involves noise, which refers to distortions or errors interfering with message transmission (Narula, 2006; Shrivastava, 2012). For example, low internet bandwidth can lead to video pixilation, reducing the image quality. That is one kind of channel noise because it arises due to features of the communication channel. There are two additional kinds of noise relevant to this article. First, the diversity and bulk of science video content can cause information overload, which is a source of noise (Ruff, 2002). Second, individuals with low media literacy may have difficulty navigating content and those with low scientific literacy may have difficulty interpreting the meaning of messages, which can create semantic noise (Shrivastava, 2012). The next section discusses media literacy and scientific literacy and how they may influence audience reception and responses to science videos on the internet.

## LITERACY

To understand specific forms of literacy, it is useful to begin with the general concept. Hillerich (1976) gave a straightforward dictionary definition of literacy as “the state or quality of

being literate; ability to read and write” (p. 50). He then drew on broader definitions regarding functional aspects of literacy enabling individuals to participate in groups or communities. Still other definitions emphasize societal changes requiring updated notions of literacy [see Barton (2017)]. Keefe and Copeland (2011) stated five core principles of literacy going beyond the development of knowledge and skills. The gist of their framework is that literacy is a social practice, mode of empowerment, and human right anybody can develop through connecting with others. Certainly, a basic ability to understand written language is essential to both media literacy (Cappello, 2017) and scientific literacy (Laugksch, 2000), but both kinds of literacy are largely subsumed within the broader characterization of literacy.

## Media Literacy

Much like with the general concept of literacy, scholarly definitions of media literacy have evolved over time (Cappello, 2017). Whereas, an early definition focused on the ability to consume and create media, a more recent definition considers it as a framework of participation, which involves consumption and creation, but also “builds an understanding of the role of media in society as well as essential skills of inquiry and self-expression necessary for citizens of a democracy” (Thoman and Jolls, 2008, p. 42).

This kind of literacy may also serve a protective function in a media landscape containing information-related risks. Individuals with high media literacy can better protect their privacy, avoid cybercrimes, and reject fake news and other misinformation (Lee, 2018). In the context of science communication, misinformation is doubtless a problem. There is evidence that structural changes, such as issuing corrective information, can be an effective way of combatting scientific misinformation (Bode and Vraga, 2015), but there is an accompanying need to enhance public media literacy and encourage more open dialogue about contentious issues (Scheufele and Krause, 2019; Vraga and Tully, 2019). In the context of health information, a kind of scientific information, Madathil et al. (2015) called for media literacy education to help individuals make more informed health decisions. Being able to sift through multiple and sometimes conflicting messages requires cautious and critical media use [see also, Cooper (2011)].

Naturally, the importance of media literacy extends to video sharing sites, where the sheer volume of video content necessitates a critical or at least cautious approach by audiences. Meyers (2012) emphasized this importance when young people engage with informational videos on YouTube. Because online video sharing allows virtually anybody to create video content, audiences need to rely more on themselves to evaluate authority and credibility. He argued, not only do individuals need to be able to critically assess the qualities of sources and messages, but they also need to have appropriate responses when it comes to sharing information and participating in discourse. Part of this process involves the evaluation of scientific claims, which implicates scientific literacy.

## Scientific Literacy

There are many overlapping conceptualizations of scientific literacy (Laugksch, 2000; Jarman and McClune, 2007). According to a popular and parsimonious definition, scientific literacy involves “understanding of scientific terminology and concepts; scientific enquiry and practice; and the interactions of science, technology, and society” (Jarman and McClune, 2007, p. 3). In short, it entails knowing about scientific facts, the process of discovering those facts, and how people collectively use that knowledge. Measures of scientific literacy have commonly gauged factual and process knowledge (National Academies, 2016). Scholars have drawn on such operationalizations to examine public understanding of scientific sub-domains, such as climate change (Kahlor and Rosenthal, 2009; Kahan et al., 2012), indoor air quality (Rosenthal, 2011), and nanotechnology (Drummond and Fischhoff, 2017). There have also been efforts to disambiguate religious beliefs from scientific understanding because, for example, someone who does not believe in human evolution may still have good knowledge of what the theory describes (Roos, 2012; Kahan, 2017).

Scientific literacy can benefit people at the micro- and macro-level (Laugksch, 2000; Yacoubian, 2018). At the micro-level, scientifically literate individuals have the skills and confidence to make science-related decisions, which often involves interpreting scientific information in the media (e.g., Nisbet et al., 2015; Nordheim et al., 2019). At the macro-level, a scientifically literate society can provide the supply of individuals with skills needed for scientific advancement. Further, a scientifically literate public may be more supportive of science and, importantly, engaged with democratic decision-making about science-based issues (Yacoubian, 2018).

Emphasizing the macro-level perspective, Roth and Lee (2002) argued scientific literacy is less about the minds of individuals and more about collective activities; it is not a property of individuals but an achievement of society. In conclusion, they called for more work documenting “conversational spaces that enable scientific literacy to emerge and permit life-long learning” in informal or other non-traditional learning venues (p. 53). Science videos on the internet often provide that space and are beneficial in that regard. The next section focuses on this and other benefits before turning to some of the drawbacks of science videos on the internet.

## CHARACTERIZING SCIENCE VIDEOS ON THE INTERNET

### Benefits

There are many potential benefits of science videos on the internet. This section reviews three benefits, beginning with a discussion of video as a learning tool. Ferraro et al. (2019) argued that the auditory and visual experience of videos is a powerful tool for science education and engagement. The structure and organization of video content may serve as a guide for audience’s attention and knowledge construction (Merkt et al., 2018), especially when there are interactive features, such as clickable elements (Tsai et al., 2016; Palaigeorgiou et al., 2019). Carefully

selected online videos may be an effective complement to classroom science education by supporting independent learning (Pecay, 2017) and allowing learners to take new perspectives (Higgins et al., 2018). This benefit is pronounced among youths (Moll and Nielsen, 2017; Dunlop et al., 2020), whose orientations to some topics affect their reactions, like engaging in serious discourse (Meyers, 2012). Outside formal learning venues, both students and members of the public may use online videos to learn about many topics, including science (Moghavvemi et al., 2018; Rosenthal, 2018).

Part of how online science videos support learning is through the co-construction of knowledge by audience members. Dubovi and Tabak (2020) studied YouTube user comments about science videos, finding disagreements led to “rise-above collaborative elaboration,” in which commenters provided evidence to support their claims. In a similar study of YouTube videos about antimicrobial resistance, Djerf-Pierre et al. (2019) found users were engaged with the issue and their comments expressed emotion, assigned blame, and called for action. These studies show a second potential benefit of science videos to encourage scientific discourse in public. This benefit is largely a function of online video supporting not only feedback from audiences, but engagement among audience members (Ksiazek et al., 2014). Further, Morcillo et al. (2018) discussed how producers engage in community building, which they do to ensure their own success, but which also creates a sense of connection with their audiences. Erviti and Stengler (2016) reported similar instances of community building by video producers. In other words, discourse as co-construction of knowledge may involve not only exchanges between audience members but also with content producers.

Despite some unique affordances of online video to facilitate discourse about science, audiences are unlikely to become engaged with the content if the scientific issues are not important to them. Scholars have talked about this personal importance in terms of issue involvement, which is positively related message processing (Petty and Cacioppo, 1979, 1986). Kahlor et al. (2006) used this idea to predict the seeking and processing of environmental risk information, another kind of scientific information. Given the sheer volume and variety of online science videos, it is likely most people can find personally involving content. This can create new points of public engagement with science. Although research has not shown this in a science communication context, Cha (2014) argued content variety is an advantage of video sharing sites and found it is positively associated with video consumption. However, as the next section suggests, content variety is a double-edged sword.

## Drawbacks

Whereas content variety may create many points of public engagement with science, it can also lead to information overload and selective exposure (Takahashi and Tandoc, 2015; Lee et al., 2017). Karlsen et al. (2017) expressed concern over the sheer quantity of health information online and difficulty for some individuals in finding credible health-related videos on YouTube. They suggested unfamiliarity with new media technology and low health knowledge exacerbate this difficulty, which has clear

implications for media literacy and scientific literacy. There is additional difficulty related to source selection. Erviti et al. (2020) found messages opposing science are more likely to appear in user-generated content than in content from media companies.

Another reason content variety is a double-edged sword is because some producers create content to lead viewers away from scientific consensus (Erviti et al., 2018; Allgaier, 2019), creating a polarizing conduit of pseudoscience and misinformation (Bessi et al., 2016). Highly polarizing videos tend to garner more audience engagement in terms of likes or comments (Briones et al., 2012; Heydari et al., 2019). This can produce epistemic bubbles and echo chambers, where groups of likeminded individuals become entrenched in their viewpoints through patterns of media use (Nguyen, 2020). One explanation of this social and psychological entrenchment is confirmation bias, or the tendency of individuals to focus on information supporting their existing beliefs (Ling, 2020). This tendency is more likely among individuals who believe their current knowledge about an issue is sufficient (Jang, 2014). Of course, people who know the least about an issue tend to overestimate their knowledge the most (Kruger and Dunning, 1999), and echo chambers may amplify this effect in the context of scientific issues (Bentley et al., 2019).

Although selective exposure and echo chambers are not new phenomena, there may be more opportunities for them to manifest in a new media landscape. This is partly because anyone can create media content and have direct access to potentially large audiences. As a result, the role of information gatekeeper has shifted away from media professionals and toward a more diffuse group of actors who guide information to smaller audiences (Lewis, 2020). On the one hand, this more specialized gatekeeping can be beneficial because it personalizes the information audiences receive, possibly leading to more issue involvement and engagement. On the other hand, there is less clear separation between facts and opinions, especially on scientific topics (Brossard, 2013). When opinion appears as scientific fact, more engagement probably leads away from constructive discourse.

## DISCUSSION

The value of science in public is related to factual knowledge but determined largely by what individuals find relevant to their own lives (Brossard and Lewenstein, 2009; PytlikZillig et al., 2018). The introduction of this article used quotation marks to characterize “bad” science because the value of science is often subjective (Parsons and Wright, 2015). This is not to say pseudoscience and scientific misinformation should be regarded in some instances as “good,” but that their characterization should holistically reflect both the quality of the information and the ways the public uses it. This means, on the one hand, content producers (e.g., YouTube channels) and content hosts (e.g., YouTube) ought to understand what kinds of impacts their content may have on public discourse and prioritize content supporting public engagement across ideological divides. On the other hand, audiences ought to understand the different

motivations of content producers (e.g., to persuade) and content hosts (e.g., to generate advertising revenue) and approach the content cautiously and critically.

Of course, what producers and audiences *ought* to do is an ideal that may be difficult to achieve. This article suggests the nexus of media literacy and scientific literacy may be an effective angle for pursuing that ideal. Those literacies help individuals sift through and make sense of science videos on the internet, while they learn new information and avoid information overload. This is an obvious statement, but with subtleties that reveal gaps in the current literature. Scholars have already called for more research about the types and producers of science video content (Allgaier, 2019), online video platforms (Erviti et al., 2020), and audience traits and states (Landrum et al., 2019). These are important areas of future research. For one, studying the variety of science video content could provide a useful replication of Cha (2014), and extend it to account for audience orientations as a potential moderator (Rosenthal, 2018). The discussion below highlights some additional gaps related to media and scientific literacies and the benefits and drawbacks of science videos on the internet.

First, if young people can learn from science videos by taking new perspectives, what happens if they encounter an appealing anti-science perspective? As Meyers (2012) found, science videos can generate discourse among learners. Although science videos on the internet can support independent learning (Pecay, 2017), there is evidence that learners need scaffolding to generate constructive discourse, at least in face-to-face settings (Nussbaum et al., 2009). What kinds of scaffolding would support more constructive discourse among youths in, for example, the comments sections of online videos? And who would provide that scaffolding? A couple obvious providers are teachers and parents. But what levels of media and scientific literacy should they have to provide effective scaffolding? This raises the separate but related issue of parental mediation, which involves monitoring and regulating the media use of children, often focusing on developing media skills (e.g., Livingstone et al., 2017). However, parents may need both media literacy and scientific literacy to properly guide their children away from potentially detrimental perspectives. There is scant research on this topic, which represents a potentially fruitful avenue of future research.

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Second, whereas media literacy and scientific literacy can help audiences be more discerning, can they also equip individuals and organizations with the knowledge and skills to spread pseudoscience and misinformation? For example, the Cocktail Conversation Guide to Global Warming shows savviness in both communication and scientific misrepresentation. If bolstering these literacies in public equips the anti-science camp with new capabilities, then there may be an enhanced need for regulatory solutions, such as censorship. But that would go against recent calls for media literacy training as an alternative to censorship (e.g., AlNajjar, 2019). At the same time, the consumption of science videos on the internet is increasingly a collaborative social activity (Dubovi and Tabak, 2020). The co-construction of knowledge, as an affordance of the communication channel, may also serve as a tool to combat the spread of pseudoscience and misinformation. How much does that mechanism depend on the media and scientific literacy of the participants? Research in this area would bring a more sociological perspective to the issue.

Most of the research about science videos on the internet has appeared since 2015. It is a relatively new research area, but with strong links to more established domains, and is growing rapidly. This article presented a broad sampling of the recent literature and discussed the roles of media literacy and scientific literacy vis-à-vis the benefits and drawbacks of science videos on the internet. Hopefully, readers can use some of these ideas to enhance their own thinking about this topic or initiate new and interesting lines of thought.

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