2 Theories and Models of Science Communication

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Introducing communication

Communication is broadly understood as the process whereby an individual or a group sends a message through a channel or a medium to a receiver. There are two main goals in communication. The first is to ensure that the receiver gets the message sent by the sender without any interference. This view is problematic, however, because it takes for granted how the receiver uses the message. The second main goal of communication concerns the recipient of the message being cognitively involved in deriving meaning from the message they receive, and providing feedback as evidence that the message was understood as intended. Accordingly, communication is circular. Communication scholars believe that the success and effectiveness of the communication process is very much dependent on intervening factors that affect how the message is received, interpreted and acted upon by the recipient.

The importance of models in science communication

Communication is a complex process involving several considerations and models have therefore been developed to help illustrate, delineate and depict the structural features of communicative acts.

Scholars group communication models into four categories: transmission or linear models, ritual or expressive models, publicity or display or attention models, and reception models.

The first category, transmission or linear models, is exemplified in what is referred to as the Harold Lasswell formula, which is based on five questions: “who says what, in which channel, to whom, with what effect?” (McQuail and Windahl, 1993, p. 13). In these models, the focus is mainly put on the message sender’s need to persuade. Little regard is given to the receiver of the message, since they are believed to be passive.

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The second category is the ritual or expressive model, which holds that communication is not just utilitarian but can be an end in itself. Proponents of the ritual model, notably James Carey (in 1975), have noted that "communication is linked to such terms as sharing, participation, association, fellowship and the possession of a common faith …" (in McQuail, 2005, p. 70). In this case, communication is conceived as being aimed at uniting people in a common cause. Such a model also perceives communication as performative – for pleasure or entertainment (McQuail and Windahl, 1993, pp. 54–55).

The third category is the publicity model, sometimes known as the display or attention model. Viewed through this model, the objective of the communication process is to capture attention in order to sell a physical product or a social product (McQuail and Windahl, 1993, p. 56). In this model, the aspect of catching and holding the visual or aural attention of the audience is critical. For instance, McQuail (2005) argues that "a good deal of effort in media production is devoted to devices for gaining and keeping attention by catching the eye, arousing emotion and stimulating interest" (pp. 71–72). He further argues that this model also explains the role of the media, which is providing "diversion and passing time" (p. 72).

The fourth category is the reception model of communication propounded mainly by Stuart Hall (1980), who noted that in any communication, multiple meanings can be derived by the receiver. Hall argued that senders of messages "encode" what he called a "preferred reading", but that the receivers of the message can "decode" it in their own way and give the message a "variant or oppositional meaning" based on their experiences and outlook (McQuail, 2005, p. 73). Closely related to the above four categories are the models of science communication described below.

Models that are specific to science communication

The sets of ideas used to explain science communication are also referred to as models rather than theories. These are: the knowledge deficit model; the contextual model; the lay expertise model; and the public engagement or participation model.

The knowledge deficit model

This model, sometimes referred to as the "dissemination model", or what Secko *et al.* (2013) refer to as the "science literacy model", assumes that public scepticism about science is caused by a lack of relevant knowledge. It is based on the assumption that the experts who possess scientific knowledge are unable or unwilling to share it with the public. Several scholars, such as Brossard and Lewenstein (2010), have reviewed literature and studies that have showed a general lack of knowledge among the public regarding basic scientific concepts and facts. Science literacy programmes, including those involving media and communication, have been developed to address this knowledge gap. A key communication objective of such programmes is for scientists to develop simplified scientific information for public consumption (Brossard and Lewenstein, 2010). Secko *et al.* (2013) argue that the knowledge deficit model is pedagogically-oriented, focusing on raising science literacy levels (p. 67).

Similar to the knowledge deficit model is what Tichenor *et al.* (1970) postulated as the "knowledge gap hypothesis". After conducting several studies in the USA they noted that when information was placed in the mass media or other channels of communication, persons with more formal education acquired that information faster, and that over time the difference in the level of knowledge between the least and most educated social classes tended to increase.

The knowledge deficit model is also linked to the KAPs (knowledge, attitudes and practices) model. The KAPs model is applied in every field of inquiry to "investigate what is known, believed and done", and to "investigate experience, opinion and behaviour" (Siltrakool, 2017, p. 24). Gadzekpo *et al.* (2018) studied the understanding (knowledge), predisposition (attitudes) and response (practices) of Ghanaian journalists in relation to reporting on climate change. The researchers established that there was "high awareness, but low knowledge, high conviction but low engagement of media practitioners and institutions towards addressing the incidence and consequences of climate change" (p. 1). They further noted that while awareness and empathy were prerequisite factors for reporting on climate change, they "did not inevitably lead to knowledge and engagement in competently mediating the climate message" (p. 1).

David Dickson (2005), founder and former editor of SciDev.Net, concluded in a commentary about the knowledge deficit model as follows:

> Increased knowledge about modern science does not necessarily lead to greater enthusiasm for science-based technologies. Indeed, there is considerable evidence to the contrary. For example, the more knowledge an individual has about a potentially dangerous technology (such as nuclear power or genetic engineering), the more concern he or she may well feel about that technology.

While the knowledge deficit model has several discernible strengths, as highlighted above, its main shortcoming is its inclination to view communication as one way. Further, perceptions of, and the utilization of, scientific information are more complex than is portrayed in the deficit model. The model also ignores the sociocultural and material contexts that play a major role in the understanding of scientific information.

The contextual model

This model is also called the public engagement model. It proposes that effective science communication requires an understanding of the needs, attitudes and existing knowledge of different audiences (Lewenstein, 2003). Brossard and Lewenstein (2010) point out that the contextual model "acknowledges that individuals do not simply respond as empty containers to information, but rather process information according to social and psychological schemas that have been shaped by their previous experiences, cultural context, and personal circumstances" (pp. 13–14). The context in which individuals receive information on science, and the social forces in society, is also important (Lewenstein 2003, p. 3). Media systems and other societal or institutional circumstances are intervening factors in regard to how messages about science are transmitted. However, like the deficit model, the contextual model also tends to accord too much power to scientists, thus viewing the communication process one way, with hardly any interaction between the source of the scientific information and the recipients (Brossard and Lewenstein, 2010, p. 14).

The lay expertise model

This model calls for an appreciation of local expertise and knowledge regarding scientific subjects under consideration. It foregrounds the significance of the tacit knowledge possessed by communities through, for example, elders and other opinion leaders. Brossard and Lewenstein (2010) argue that there is vast knowledge based in the "lives and histories of real communities" (p. 15). They argue that "communication needs to be structured in ways that acknowledge information, knowledge and expertise already held by communities facing scientific and technical issues" (p. 14). Lewenstein (2003) argues that the "lay-expertise model" puts an emphasis on "knowledge and expertise that is held and validated by social systems other than modern science" (p. 5). However, Brossard and Lewenstein (2010) argue that the lay expertise model aims at placing value on local knowledge as genuine expertise in its own right (p. 15). This they argue is unlike conventional approaches to indigenous knowledge systems, which often use modern science methods to verify traditional beliefs. One of the key criticisms of the lay expertise model is that it devalues the scientific approach whereby knowledge is produced through empirical inquiry, in favour of "lay knowledge" that is often based on hunches and unproven claims.

The public engagement or participation model

In this model of science communication, the scientists, the public and policymakers participate equally in discussions and debates about issues in science and technology. The model is applicable to situations where collaboration is the desired communication objective. As conceptualized in this model, science communication may take the form of participatory engagements to ensure audiences are central in shaping the future of research efforts. Such public participation activities could include community conferences, town hall meetings, community workshops and symposia. Brossard and Lewenstein (2010) point out that "public participation activities are often driven by a commitment to 'democratizing' science – taking control of science from elite scientists and politicians and giving it to public groups through some form of empowerment and political engagement" (p. 16). As in the case of the lay expertise model, the public engagement model has been criticized for diminishing and sometimes downplaying the expertise of scientists (Lewenstein, 2003, p. 6).

Table 2.1 summarizes the basic elements and weaknesses of each of the four models of science communication outlined above.

Applying science communication models

Some scholars – for example, Cormick (2019) – argue that the deficit model should not be used because it is erroneous. Cormick's argument is that people are not empty vessels waiting to be filled with information. Rather, they have their own ideas, beliefs and knowledge that influence how they receive and perceive new scientific information. Effective science communication is not a matter of translating scientific knowledge into simpler information that the public can easily understand. Cormick argues that the deficit model should be "buried" (p. 12).

However, other scholars, such as Hetland (2014), have argued that models of science communication are not mutually exclusive but rather are interrelated. Indeed, in real life, the dissemination of information is usually the starting point for consultation and engagement.

The importance of theory in science communication

In lay person's language the word theory can be used to refer to a guess or an assumption. In academia, on the other hand, theory refers to a tested set of concepts, explanations and principles that make up the body of knowledge in a field of study, such as mass communication (Baran and Davis, 2012, p. 24). While there are many academic definitions of the term theory, the common element among the various definitions is that theories explain phenomena or predict outcomes by describing the relations between variables. Shoemaker *et al*. (2004, p. 112) argue that when we move from description or modelling to understanding how the object or process or system works, we move to theory.

As Baran and Davis (2012) explain, theories of communication vary depending on how one wants to understand the various functions or elements of the communication process. For instance, each element of the communication process – from the sender, to the message, to the channel or media, to the recipient – necessitates specific inquiry and understanding. For example, Stuart Hall's reception theory predicts that different people will perceive a single message in different ways, and their perception may not necessarily match what was meant by the sender.

Table 2.1. Basic elements and weaknesses of models of science communication (adapted from Brossard and Lewenstein 2010, p. 17; Secko *et al*. 2013, p. 67).

Model	Basic elements	Weaknesses
1. Knowledge deficit model	• Scientists are experts and are knowledgeable. • The public have a deficiency of knowledge. Delivery of simplified scientific information leads to public understanding and acceptance of science. • Transfer of knowledge is one way, from scientists to the public. • Good transmission of scientific information leads to a reduced deficit in knowledge. • A reduced knowledge deficit leads to better decisions, and often better support for science.	• Perception and utilization of scientific information is more complex than portrayed in the deficit model. • Overlooks importance of background knowledge and sociocultural circumstances in science communication. • The public is not homogeneous. Reception of information will vary from person to person.
2. Contextual model	• Communication of science is considered to be based on the needs, attitudes and existing knowledge and situations of the different audiences. • Individuals respond to messages based on their unique circumstances. • There is one-way transmission of information from scientists to the public. • Audiences have ability to quickly gain knowledge about topics that are relevant to them.	• According to this model, communication is one way: no interaction between the source and recipient of knowledge. • Absence of adequate opportunity for feedback.
3. Lay expertise model	• Acknowledges the limitations of scientific information. • Acknowledges that audiences might have some pre-existing knowledge. • Highlights interactive nature of scientific process.	• Undermines the expertise of scientists.
4. Public engagement or participation model	• Two-way flow of information between scientists, the public and policymakers. • Communication strengthens relations between science and the public. • Focuses on policy issues involving scientific and technical knowledge. • Tied to democratic ideal of wide public participation in policy process. • Builds mechanisms for engaging citizens in active policymaking. • Real public authority over policy and resources.	• Diminishes the scientist's power. • Citizens can participate in a more emotional than rational way, which can undermine the objective of communication. • More complex, and therefore difficult to explain to donors and policymakers.

Perry (2002) argues that a good theory is developed through scientific inquiry or research, and provides several functions, including aiding understanding of the causes of events, enabling predictions of the future, and providing the foundation for further scientific knowledge, among others (p. 43). Theories of communication can help in predicting how people are likely to receive, perceive and respond to information about science. Such theories also help support the appreciation of recommendations regarding the basic principles of effective science communication.

Selected theories that apply to science communication

In this section we present four theories we consider demonstrative of the relationship between scientists and communication/journalism institutions.

Reception theory

The key proponent of reception theory was Stuart Hall, who in his reception studies noted how audiences made varied interpretations of specific forms of content (Baran and Davis, 2012, p. 304). He noted that while reading "encoded" texts, audiences often interpret or "decode" them in different ways. While the producers of the messages usually have a "preferred or dominant reading", sometimes audiences have alternative interpretations of the messages, in what Hall referred to as a "negotiated meaning", which often differs from the intended meaning. This process has been referred to as the encoding-decoding of discourse (McQuail, 2005, p. 117).

Baran and Davis (2012) highlight several strengths of reception theory, including the fact that it focuses on individuals in the mass communication process and that it respects the intellect and ability of media consumers (p. 305). Further, the theory "acknowledges a range of meanings in media texts" and "seeks an in-depth understanding of how people interpret media content" (p. 305). They also argue that the theory "can provide an insightful analysis of the way media are used in everyday social contexts" (p. 305). However, according to Baran and Davis the theory has some weaknesses, including the fact that "it is usually based on subjective interpretation of audience reports" and "cannot address presence or absence of effects" (p. 305).

For science journalists and communication professionals, reception theory draws attention to the fact that messages can be interpreted in ways that were not initially intended. It highlights the agency of the receivers of the messages and the importance of paying attention to their characteristics to ensure a better encoding of messages. It also brings to light the importance of pre-testing messages.

Agenda-setting theory

Earlier communication scholars, such as Lippman, in 1922 (Baran and Davis, 2012), pointed out the power the media hold in regard to influencing public opinion. Later propaganda scholars, such as Herman and Chomsky (1988), confirmed how powerful elites are able to use the media to propagate their limited concept of reality to the majority. The agenda-setting theory advances the idea that "media do not tell people what to think, but what to think about" (Baran and Davis, 2012, p. 346). Cohen (1963), one of the first proponents of the agenda-setting theory, presented the theory in a foundation statement as follows:

> The press is significantly more than a purveyor of information and opinion. It may not be successful much of the time in telling people what to think, but is stunningly successful in telling its readers what to think about. And it follows from this that the world looks different to different people, depending not only on their personal interests, but also on the map that is drawn for them by the writers, editors, and publishers of the papers they read.
>
> (Cohen, 1963, p. 13, in Baran and Davis, 2012, p. 347)

Other scholars, notably Maxwell McCombs and Donald Shaw, conducted research to test the theory and came to the following conclusion, in yet another foundation statement:

> In choosing and displaying news, editors, newsroom staff, and broadcasters play an important part in shaping political reality. Readers learn not only about a given issue, but how much importance to attach to that issue from the amount of information in a news story and its position … The mass media may well determine the important issues – that is, the media may set the 'agenda'
> (Baran and Davis, 2012, p. 347)

In the context of science journalism and communication, it follows that the scientific issues and topics that the media decide to focus on inevitably become part of the public's agenda. The agenda-setting theory emphasizes the power of the media in guiding people on what to think about, but also recognizes the agency of the public in deciding for themselves what to think. For science journalists and communication professionals, this power, highlighted in the theory, can be harnessed to direct public discourse towards critical issues, such as climate change, public health during global pandemics such as the Coronavirus pandemic, and other topics.

Framing theory

Framing as a theoretical framework was expounded by Entman (1993), who explained it as follows: "to select some aspects of a perceived reality and make them more salient in a communication text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation" (p. 52). The key features in this conceptualization are not only the selection process, but also – and even more so – the intention of the frame sponsors, which is to influence at different levels how an issue is considered for action. Valkenburg *et al*. (1999) define a frame as "a schema of interpretations that enables individuals to: perceive, organize, and make sense of incoming information" (p. 551).

Science journalists and communication professionals can take from framing theory the idea that how topics and issues are portrayed to the public matters a great deal. For example, if the most prevalent voice is that of vaccine pessimists who present a vaccine as a danger to human health rather than a much-needed solution to a health crisis, then the chances are that resistance to receiving such vaccines will be greater.

Diffusion of innovations theory

Baran and Davis (2012) argue that the diffusion of innovations theory (Rogers, 1995) can be seen as an extension of Paul Lazarsfeld's two-step flow theory. Rogers used several studies to show that scientific innovations go through several stages before being widely adopted. They summarize the stages as follows (p. 332):

> First, people become aware of them, often from mass media information. Second, the innovations get adopted by a small group of innovators or early adopters. Third, opinion leaders learn from the early adopters and try the innovation themselves. Fourth, if opinion leaders find them useful, they encourage their friends – the opinion followers. Finally, after most have adopted the innovation, a group of laggards, or late adopters, makes the change.

In a later reformulation of the theory to explain the information flow of the diffusion, McQuail (2005, p. 490) pointed out that Rogers and Shoemaker (1973) postulated four stages: knowledge (whereby the individual is exposed to an awareness of the existence of the innovation so as to gain understanding of how it functions); persuasion (the individual forms a favourable or unfavourable attitude towards the innovation); decision (the individual engages in activities which lead to a choice to adopt or reject the innovation); and confirmation (the individual seeks reinforcement for the innovation decision he or she has made, but may reverse the previous decision if exposed to conflicting messages about the innovation) (McQuail and Windahl, 1993, p. 74).

Arguably, the diffusion of innovation theory is one of the most applicable theories for science communication and journalism, and is closely related to the knowledge deficit model of science communication. While the theory has been widely criticized for its top-down and linear nature, the communication of science and technology remains deeply entrenched in the diffusion tradition.

Conclusion

There has been significant debate within the scholarly community on the application of the different theories and models of science communication. Some scholars, such as Lewenstein (2003), have suggested that these models provide a framework for understanding how the public can engage better with science, and how scientists can make their work more accessible (p. 7). We have attempted to show that models in which science communication is conceived as a linear process are problematic because they do not consider intervening factors that influence how the public interpret the information they receive about science. By paying attention to the recipients of science information, as well as their sociocultural and material contexts, it is possible to communicate in ways that make information about science more understandable and acceptable. In this connection, Faehnrich (2021) appraises the changing media landscape and the impact the digital transformation is having on science communication. He notes the advantages the new channels of communication – such as online social networking sites – offer for science communication, including increased space for public engagement and the diversification of actors who engage in science communication (p. 2). Secko *et al*. (2013) apply the four models of science journalism and communication to journalistic coverage of science and propose several criteria for such application (p. 73). Recently, Khairy (2020) has used the four models of science journalism to understand how the public interacted with news about the Coronavirus pandemic. Thus, from our discussion it is evident that models and theories of science communication and journalism remain relevant not only for scholars but also for practitioners as well.

Summary

- Theory helps predict how people are likely to receive, perceive and respond to information about science.
- Whenever we communicate, we are trying to achieve one or more of the following: to inform, persuade, consult or engage. Theories and models of science communication are aligned to these purposes of communication.
- Several normative theories of communication are applicable to science communication as well: for example, diffusion of innovation theory, reception theory, the knowledge gap hypothesis, framing theory and agenda-setting theory.
- There are four key models that are specific to science communication: the knowledge deficit model, the contextual model, the lay expertise model and the participation model. These differ in regard to the level of audience involvement and consideration of sociocultural factors that influence the way people perceive information. However, some scholars argue that these models of science communication are interrelated and not mutually exclusive.

Discussion questions

1. Discuss the strengths and weaknesses of each of the four models of science communication.
2. Explain the importance of theory in science communication.

Suggested answers to discussion questions

Question 1

Discuss the strengths and weaknesses of each of the four models of science communication.

Suggested answers – summary of key points

Knowledge deficit model

Strengths: A good model for quickly delivering information to large numbers of people and causing mass awareness. Takes into account scientists' expert knowledge.

Weaknesses: Awareness alone may not lead to action. Sees communication as one way. Does not take into account how people's perceptions depend on their sociocultural backgrounds and prior knowledge.

Contextual model

Strengths: Takes into account how people's needs, attitudes, existing knowledge and situations affect their responses.

Weaknesses: The emphasis is still on one-way communication; audience feedback is ignored.

Lay expertise model

Strengths: Takes into account the background knowledge and expertise of the recipients.

Weaknesses: It might undermine the expertise of scientists.

Participation model

Strengths: Takes into account knowledge, experiences and feedback of the target group.

Weaknesses: Participation can be more emotional than evidence-based discussions.

Question 2

Explain the importance of theory in science communication.

Suggested answers – summary of key points

- Theory helps predict how people are likely to receive, perceive and respond to information about science.
- Theory helps in understanding and explaining the outcomes of specific communication interventions.
- Theory helps in designing and planning effective science communication.
- Theory provides the foundation for further research into science communication.

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