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Communicating science addressing contentious environmental issues: utilizing Luhmann's social systems theory

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For complex and socially contentious environmental issues, such as climate change and disease prevention, science communication has proven difficult. As many science communication scholars have determined, education is not the only factor impacting the public's willingness to act upon or even accept scientific information. In this study, we propose using Niklas Luhmann's theory of social systems as a framework for research in science and environmental communication. We argue that by focusing on the functions of relevant social systems, the occurrence of communication conflicts may be explained, and new approaches to overcome communication obstacles can be developed. In this study, we provide examples of the theory's utility by looking at pertinent studies regarding relevant systems integral to addressing climate change and sustainability issues, as well as propose new subjects for exploration.

KEYWORDS

Niklas Luhmann, systems theory, science communication, environmental communication, empirical research

1 Introduction

Communicating science addressing complex environmental issues is a complicated task, and as many studies have shown, educating people on the science (i.e., the knowledge deficit model) does not change their thinking (Simis et al., 2016; Scheufele, 2022). Attempts have been made to examine general communication challenges from psychology, sociology, and communication sciences (e.g., Claude Shannon and Warren Weaver's transmission model or Ajzen's theory of planned behavior). These general communication models have served as reference models for analyzing and understanding special challenges in science and environmental communication, even though they have been under critique almost from the start. Of particular influence is Watzlawick et al. (1969)'s critique from a radical constructivist perspective in their seminal book "Pragmatics of Human Communication"—one of the major sources for Niklas Luhmann's systemic conceptualization of the communication process. We suggest using Luhmann's approach to communication in social systems as a framework for empirical studies in science and environmental communication since it draws from both sources: the classical conduit model and the constructivist critique informed by psychology and behavioral studies. This study aims to outline how core components of Luhmann's theory can be utilized for the analysis of conflicts and challenges experienced in the communication of complex issues such as climate change.

In this study, we focus on the interplay between social systems of relevance for communicating and, thus, addressing socially contentious environmental issues. We use Luhmann's theory of social systems (Luhmann, 1989, 2000, 2018) to ground our thinking. Our interest in the theory is for new perspectives on science and environmental communication. In particular, we want to explore systems theory as a framework to reflect on and analyze systemic complexities in times of digital communication, social media, and artificial intelligence. The first section of this article highlights important aspects of Luhmann's theory, while the latter section uses this theory to discuss how the selected elements can be used to model communication conflicts by referring to case studies highlighting the fault lines between social systems in science and environmental communication.

2 Luhmann's theory of social systems

At the onset of this discussion, we acknowledge that the abstractness of Luhmann's theory and his characteristic writing style provide a challenge even for proficient readers of German, and critics frequently complain about the over-complexity of Luhmann's terminology and writing for applied research purposes. Thus, most academic discussions pivot around systems theory as a "Theory," while his practical impact and, namely, the potential of his theory to provide a basis for empirical research have been widely overlooked or disputed, as in the pertinent debate between Luhmann and the German philosopher Jürgen Habermas (Luhmann and Habermas, 1971).

Only recently have scholars started utilizing Luhmann's approach as a means to analyze, model, and moderate conflicts in deliberative processes. Notably, in the field of environmental communication, Luhmann's (1989) book on Ecological Communication has been well recognized and sparked lively discussion on its empirical applicability to issues such as climate change, sustainability, energy systems, and natural resources use and management (see, for example, Stephens et al., 2008; Feldpausch-Parker et al., 2013; Feldpausch-Parker et al., 2024; McGreavy et al., 2013; Rickard and Feldpausch-Parker, 2016; Hall et al., 2017; Hakobyan, 2023). This impact of "Ecological Communication" is remarkable as the book is seen as one of Luhmann's less-known texts, presenting an exception in Luhmann's overall work insofar as it "is relatively short but also includes every aspect of Luhmann's complex theoretical position, and it provides the theoretical framework within which concrete social themes and problems are addressed and handled" (see the Translator's Introduction by John Bednarz, jr., in Luhmann, 1989, vii). Moreover, with its focus on critical environmental events that have changed how publics perceive and discuss environmental issues (the nuclear disaster in Chornobyl, the observation of ozone depletion, and the dying of forests due to environmental pollution), "Ecological Communication" is still highly topical for the fields of environmental and science communication.

However, using "Ecological Communication" as a starting point for theory building comes with a price. In this book, Luhmann assumes a sound knowledge of his specific terminology as well as of 20th-century sociological concepts and the language of the logic of philosophy. Nevertheless, we argue that the concept allows for empirical studies in social science research. To outline these possibilities, we briefly recap aspects of Luhmann's theory from his collective works, including the functional differentiation of social systems, codes, programs, the process of communication, and the concept of autopoiesis. We then discuss how these elements of his theory allow for a new lever in the analysis of complex and contentious issues. Following the theoretical components, we provide research exemplars in the form of case studies to demonstrate the value and utility of Luhmann's theory for addressing science and environmental communication.

3 Functional differentiation, codes, and programs

The basic organizing principle of modern societies is their differentiation into diverse social subsystems, each fulfilling specific functions (see Table 1). For example, the function of the political system is to produce collectively binding decisions on the grounds of the distinction between government and opposition (Luhmann, 1982). The function of the scientific system is to gain new knowledge by assessing what is true and what is not (Luhmann, 2018), and the function of the mass media is "the directing of self-observation of the social system" (Luhmann, 2000, p. 97). In other words: Luhmann does not consider the distribution of information as the primary function of the mass media system, but rather that media outlets create a mirror of society.

This functional differentiation corresponds to the increasing complexity of societies. It does not originate from a willfully designed creative act but emerges from a process Luhmann describes as evolutionary "in the sense of the Darwinian concept of selection" (Luhmann, 1995, p. 434). In the case of climate change, the political system is responsible for policy creation, the scientific system is responsible for the provision of facts, and the mass media system creates what people can know or observe about climate change. For example, representatives from a multitude of nations ratified the Paris Agreement in 2015. This agreement was informed by scientific research from organizations such as the Intergovernmental Panel on Climate Change. Mass media coverage of climate change informed the public's conceptualizations and perceptions of the issue and, at the same time, formed a reflection of these conceptualizations and perceptions.

TABLE 1 Examples of functionally differentiated social systems, their related codes, and selected programs as suggested in Luhmann (1989).

Functional social system	Code	Programs (examples)
Political system	Majority/minority	Legislative procedures, proceedings for succession of power
Scientific system	True/untrue	Theories, methods
Economic system	Payment/non-payment	Ensure prospects of meeting demands
Mass media system	Information/ not information	Reporting standards, codes of conduct

Luhmann defines codes as means to determine whether a communication is part of a functional system or not. They are strictly binary and draw the line between "in"—being part of the system—and "out"—not being part of the system. Thus, codes are specific to a social system. For example, the political system in democracies is led by the code of majority/minority (Luhmann, 1989, p. 86), the scientific system is led by the code of true/untrue (Luhmann, 2018, p. 192), and the system of mass media is led by the opposition of information/non-information (Luhmann, 2000, p. 17; see Table 1). It should also be noted that these codes do not include a value judgment. For instance, if we focus on the scientific system, the binaries of true and untrue are based on the function of the system, which is to gain knowledge—regardless of whether this knowledge pleases or not, is expected or unexpected, etc.

Programs define under which circumstances information can be coded and thus operated by a social system. They ensure that the binary distinctions (i.e., codes) are conducted correctly or according to the rules. Hence, they complement and mitigate the strictness of the codes. They also ensure the cohesion of processes within a social system; everything can be classified according to the code by using appropriate programs. For example, programs of the political system are procedures that ensure the succession of power or legislative procedures, and programs of the scientific system are theories and methods (Luhmann, 2018, p. 403 ff.). Programs of the economic system are market assessments and programs of the mass media system are established reporting standards or codes of conduct.

In the case of climate change, the scientific system conducts research. Regardless of the respective field of study or the research area, all contributions must conform to the basic binary "true/untrue" to be accepted as "scientific." Moreover, results must be based on accepted programs, such as approved methods and peer reviews, to be adopted as a valid contribution—even though these programs can vary broadly between and even within disciplines. Thus, all kinds of studies, papers, etc. contribute scientifically valid knowledge to the field of climate change. The political system, on the other hand, has the function of creating binding decisions based on the distinction between majority/minority. Legislative procedures intended to encourage desirable behavior, prevent undesirable behavior, or sanction undesirable behavior—for example, defining limits for CO_2 emission—follow a deliberative process that ensures that the final text is accepted by the majority. Parliamentary procedures ensure that this process and the final decision are carried out in accordance with regulations (programs). The function of the economic system is to ensure the prospect of meeting demands (Luhmann, 1984) by asking how and by whom measures to reduce CO_2 emissions will be paid. Finally, the system of mass media has the function of producing a reflection of reality for society and discriminating between information and non-information. The decision to cover something or not thus asks: is it new—or do people already know? Examples of programs specific for the mass media systems are fact-checking routines as well as professional and ethical standards (programs) to ensure the quality and reliability of the outlets. Following this line of thinking, the research exemplar described below showcases how systems and their corresponding codes and programs can be used to unpack the complexities of environmental systems management for the encouragement of climate change resiliency and how these social systems impact decision-making for climate adaptation.

Exemplary case study: when resiliencies collide

The case presented by Feldpausch-Parker et al. (2024) Handbook of Environmental Communication is focused on a series of public participation workshops aimed at determining stakeholder interest and receptivity to small-scale dam removals in the Hudson River Watershed (HRW) for fisheries conservation and watershed resiliency. Such small-scale dam removal projects, similar to any other project that changes the characteristics of a landscape, are often ripe for stakeholder conflict and contentious decision-making on the part of managers and dam owners. This case study utilized empirical frameworks based on Luhmann's theory to analyze community discourses occurring during the workshops. These frameworks included the Socio-Political Evaluation of Energy Deployment (SPEED) framework by Stephens et al. (2008) and the Socio-Political and Watershed (de)Naturalized Systems (SPAWNS) framework, which was created for this project. In this case, environmental, economic, political, judicial, and even cultural interests collided. Participants in the workshop discussions attempted to balance risks and uncertainties against benefits and long-term advantages of dam removal within the context of social systems, which brought to light relevant system codes and programs (e.g., lawful/unlawful, functional/non-functional, and payment/non-payment). Additionally, unexpected obstacles emerged in the process when, within one social system, people argued for and against dam removal with the same goal: fostering environmental, economic, and social resilience. Stakeholders, unfortunately, were just arguing for different resiliency strategies (i.e., dam removal for fisheries conservation vs. retrofitting existing dams with micro hydropower). Thus, this pitted attempts at watershed resiliency to climate change against energy systems' resiliency to climate change. Such an analysis not only has practical utility for decision-making but also demonstrates how the flexibility of Luhmann's theory "becomes an adaptable heuristic matrix with the respective binaries relevant to the case as categories and corresponding programs as routines."

4 Communication

Communication is the fundamental operation of social systems. "You cannot not communicate"—the first of the five pragmatic axioms of communication by Watzlawick et al. (1969)—is probably the most quoted statement on communication and, in its original sense, a fundamental of Luhmann's systemic concept of communication: communication is not a behavioral option to be chosen or not, but the process that makes and maintains a social system (Luhmann, 1995, p. 139). At the same time, Luhmann's concept fundamentally differs from conduit models of communication, such as Shannon and Weaver (1949)'s transmission model. Luhmann's model consists of three independent but necessary selections: information, utterance, and understanding. At first glance, these steps might resemble the stages of the Shannon-Weaver model: encoding, transmission, and decoding. But, in contrast to this standard conduit model

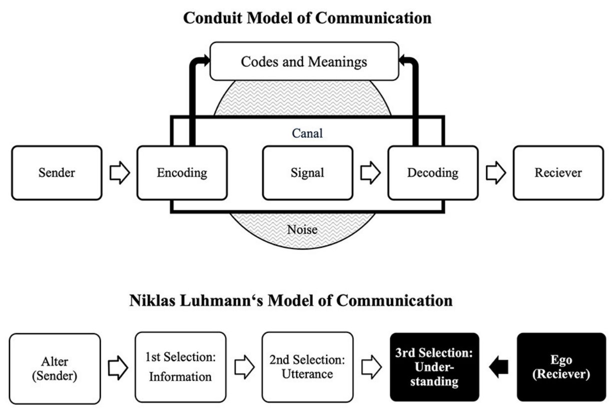

FIGURE 1
Conduit model of communication developed by Claude Shannon and Warren Weaver compared to Niklas Luhmann's model of communication.

of communication, which proceeds linearly and unidirectionally, Luhmann's three selections do not proceed linearly. In fact, responsibility for and control of the process is being transferred from Alter (conduit model: sender) to Ego (conduit model: receiver) during its course (see Figure 1). It is not until after all three selections have occurred that communication has happened. In this sense, communication happens retroactively.

With the third selection, Luhmann transfers the focus from the intention and the informative interest of the sender (deficit models) and the process (conduit model) to the recipient. In this way, Luhmann's model is particularly well suited to modeling interactions on social media, even interactions between humans and artificial intelligence (Esposito, 2022). On social media, there is a plethora of information available on climate change, its reasons, drivers, countermeasures, etc. A social media user selects only a fraction of this information that seems relevant and trustworthy (the information). However, not every interesting piece of information is shared with the network. If a social media user decides to share or like content, this counts in Luhmann's model as the second selection (the utterance). At this point, the control over process changes: not everything shared with a network is selected to be interesting and trustworthy by others, but if it is (the understanding), then a communication event has occurred. It is important to note that by "understanding" (in the sense of the third selection), nothing is being said about a factual "correct" understanding of meaning or acceptance or consent with the piece of information received (Luhmann, 1995, p. 148 f.). The following research case study demonstrates Luhmann's theory and the relevance of the three selections required for a communication event. It also provides important food for thought for science and environmental communication practitioners attempting to reach disparate audiences.

Exemplary case study: feeling left out: underserved audiences in science communication

In their explorative study, Humm et al. (2020) conducted qualitative interviews with science communicators of pilot projects aimed at audiences that rarely or never engage with science. They collected empirical data from three groups in Germany: young Muslims with a migration background, students in vocational training (Berufsschüler), and residents of a marginalized city quarter (Humm et al., 2020, p. 165). From this, they derived exclusion factors that hindered participation and differentiated between material (e.g., financial resources, language skills) and emotional exclusion factors (e.g., frustration, habitual distance). Quotes from the focus groups showed how even specially designed programs were not accepted by the intended groups because of diverse factors ranging from perceived relevance of the content to outright fear when bad experiences with the school system caused them to have generally poor attitudes toward "education" or "science." If we consider these results and, in particular, the narratives from the interview partners themselves in the light of Luhmann's communication model, one can easily identify the three selections. The first selection in this example is the identification of topics by professional science communicators. The second selection is constituted by how the events, materials, etc., were designed to convey this information. It should be noted that these two selections are both within the control of the individual(s) conveying information (e.g., scientists and science communicators). The third selection, however, is not. The third selection is completely owned by the audience, who thus determines whether a communication event has happened (or not) by their willingness to accept or reject the selected and conveyed information.

5 Autopoiesis and resonance

The term "autopoiesis" is one of the most controversial terms in Luhmann's concept, especially as Luhmann's use deviates from other theorists. The neologism "autopoiesis" itself has been introduced by the Chilean biologists and neuroscientists Humberto Maturana and Francisco J. Varela (Varela et al., 1974). However, whereas Maturana and Varela apply the term exclusively to living systems, Luhmann extends it to psychic and social systems, defining them as self-referentially closed and autopoietic (Luhmann, 1985). We focus on social systems only. Their main goal is to uphold their differentiation from the environment and continue processing (Luhmann, 1989, p. 14). To put it another way: social systems strive to stay intact and undisturbed, and they do so by communicating within themselves. In this sense, social systems are self-sufficient but not completely solipsistic (Luhmann, 1995, p. 10). Although they display an operational closure of their processes (communications), interaction with other social systems is still possible, enabled by the interplay of programs and codes that allows for resonance (Luhmann, 1989, p. 45). Resonance occurs "only in exceptional cases." Only then, a system can "reverberate" to something happening in another system (Luhmann, 1989, p. 15). As the requirements for this resonance are set by the codes and regulated by programs, the characteristic of such an "exceptional case" is that it satisfies the codes and programs of all resonating systems. In the final case study we present below, the authors provide a compelling example of autopoiesis and resonance in action, as can be seen in discourses surrounding renewable energy policy. Similar to the first case study presented, the demonstration of these concepts has both practical and scholarly implications.

Exemplary case study: social-ecological system resonance: a theoretical framework for brokering sustainable solutions

Hall et al. (2017) demonstrate how resonance enabled the development and deployment of a renewable energy policy in Texas that generated more wind electricity than any US state in 2016. The authors conducted in-depth interviews with energy policy interveners. As the starting point for the remarkable development, they present the anecdote of a momentous dinner table conversation in which a college student on Thanksgiving vacation provokes his father—an influential businessman—with the statement: "Dad, we gotta do something about air pollution." This topical scene became part of a narrative processed by communication in several distinct social systems: the economic, the political, and the scientific system. In these processes, data have been collected, curated, and redacted to accommodate simultaneously the codes of all social systems involved. For example, activists highlighted that they deliberately avoided the topic of "climate change" and focused instead on "air pollution" and resulting costs, as well as expected market chances for wind energy and legislative necessities. This way, the selected (first selection) and transmitted (second selection) information matched the code true/untrue from the scientific system, as well as the code payment/non-payment from the economic system, the code lawful/not lawful in the legal system, and finally the code majority/minority of the political system, and could thus be processed in each system individually. In effect, the systems reverberate and can cause and intensify their respective processes without direct contact or exchange. In the case of Texas legislation, it led to the development of a unique and, for the traditionally fossil fuels-focused state, unexpected, renewable energy policy. Hall et al. (2017, p. 390) state that Luhmann's resonance "offers a grammar for designing solutions-oriented research as the strategic coordination of capacities, resources, and information to address multiple related problems in a manner consistent with existing site-specific value logics."

6 Future utilizations for Luhmann's theory in science and environmental communication

This study aims to show that Luhmann's theory provides a framework to analyze and describe empirical discursive data. We referred to current case studies in the field that either use selected elements of Luhmann's theory or in which the application of characteristic elements could add another facet to the analysis. Moving forward, there are additional research spaces where Luhmann's theory could be key to unpacking social complexities and addressing environmental issues in an age of digital communication, social media, and artificial intelligence. For example, in examining interactions and interdependencies, significant differences between the scientific and mass media systems become visible.

As a vignette, the significance of the interplay between codes and programs becomes apparent on closer inspection of how "alternative facts" are presented. While producers of alternative facts assert their participation in the scientific system by referring to the code as true/untrue, they deny the applicability of established scientific procedures, such as double-blind testing or evidence-based impact measurement. Instead, these producers and their followers advocate their programs of validation as equivalent (e.g., anecdotes and single cases). Similarly, social media claims that standards of good journalistic practices maintained by traditional mass media do not apply to their practices and standards because they are not media outlets but mere platforms. Alternatively, they rely on "the swarm intelligence" and apparently "self-evident" truths. This is the gateway for fake news as well as for misunderstandings and (deliberate) misinformation camouflaged as "alternative science."

In closing, while Luhmann's social systems theory has been rarely seen as a theory that can be used for applied research, we argue that it has great potential for applied scholarship in science and environmental communication. The examples above focused on decision-making on the smaller scale of local communities (Feldpausch-Parker et al., 2024), on the scale of legislation in U.S. states (Hall et al., 2017), and science communication with underserved audiences (Humm et al., 2020). They serve as examples of ways to apply Luhmann's theory to empirical data, both to model and better understand conflicts in the communication of environmental issues and to develop strategies to overcome these challenges.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Author contributions

AK: Conceptualization, Writing – original draft, Writing – review & editing. AF-P: Conceptualization, Writing – original draft, Writing – review & editing.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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