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DESIGNING SCIENCE COMMUNICATION PROCESSES: BRIDGING THE GAP BETWEEN THEORY AND PRACTICE WITH A SCIENCE COMMUNICATION SPECTRUM

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Abstract

Looking at science communication at this moment, one sees new theories being developed and many descriptions of best practices. However, the connection between communication theory and practice is poorly understood. Professionals in the field of science communication are therefore often not connected to the theoretical developments in science communication and vice versa. This hinders the development of science communication theory and also leads to a less effective science communication practice.

Our paper and presentation therefore will focus on the development of the connection between science communication theory and science communication practice. We aim to build a bridge between the science communication researcher and the science communication professional by *designing* and *optimizing* a *science communication process.* Designing and optimizing science communication is a process in which social, cultural, economic, and technical aspects are connected in such a way that the best possible communication effects can be achieved.

The *communication spectrum* is a design instrument that links theoretical concepts and practical insights to build science communication processes in an effective and meaningful way. This instrument gives an integrated overview of possible choices that are made to shape the science communication process. Parts of the process are given more emphasis by connecting them to science communication problem analysis. Problem analysis therefore provides choices that could be made when faced with a specific communication problem. Using the science communication spectrum and existing design theories like problem analysis for science communication processes is - as far as we know - new to the field of science communication in theory and practice.

Keywords: design, problem analysis, effectiveness, optimizing

1. Introduction

Within the field of science communication, there is a watershed between theoretical and practical developments [1]. On the one hand, there is a wide field of best practices, and on the other there is theoretical development. The connection between the two cannot be made by - for example - just bringing professionals and researchers together. A more profound and sustainable connection between theory and practice has to be developed in order to develop an effective daily practice of science communication.

Designing and optimizing a science communication process involves making the best choice at the best moment. Therefore this process of design and optimization could function as a profound and sustainable connection between theory and practice. Most of the time, a science communication professional makes many implicit choices. Design and optimization can make those choices explicit and manageable.

The aim of this paper is to show that theory and practice can be integrated by using a science communication spectrum and problem analysis as instruments of design and optimization. The science communication spectrum described here has been developed in the Section of Science Education and Communication at the Delft University of Technology in the Netherlands.

2. Science communication spectrum

Communication processes are normally closely associated with the organization's policy development. Every step in an organization's policy implementation could be - or should be - supported by a next phase in communication strategy. In order to give insight into the many choices in this process of communication strategy, Gehrels developed a so called *communication spectrum* [2]. Taking this as a starting point, we developed a *science communication spectrum* [3].

The science communication spectrum is an instrument which sorts and analyzes complex science communication processes. The spectrum connects actors and their science communication roles to the different phases of science

policy. Based on these specific roles, choices can be made on communication aspects like communication target, means and effect (see table 1).

The science communication spectrum makes possible choices explicit: with whom to communicate, at what moment, with what effect, and at what time. All the possible choices in the science communication spectrum are based on the literature on science communication. We have chosen for the following seven possible sequential steps in a science communication process:

1) a specific science communication target;
2) the desired effect according to the target group;
3) communication strategy;
4) content of message;
5) communication channel or instrument;
6) tone of voice of message; and
7) persuasiveness of the communication instrument.

One can make a spectrum for any science policy process, and any target group for whom science communication plays a role. The standard frame of a science communication process is depicted in Table1. At the top, one sees the science policy phases. On the left, one sees that the science communication role of the sender and the science communication role of the target group form the starting point. The communication aspects are similar to the possible sequential steps as described above.

Table 1: Framework for a science communication spectrum based on 6 phases of policy making.

Research Policy Phase / **Starting points/ communication aspects**	**Policy phase 1**	**Policy phase 2**	**Policy phase 3**	**Policy phase 4**	**Policy phase 5**	**Policy phase 6**
Starting point						
Role of sender						
Role of target group						
Communication Aspect						
Communication target						
Desired effect						
Communication strategy						
Content of message						
Communication instrument						
Tone of voice						
Persuasiveness						

A basic assumption for the science communication spectrum is that these choices have to be made in sequence, because the choice for one specific option influences the next choice. The spectrum provides an overview of all the possible choices in a specific science communication process depending on policy phases. This overview of a complex science communication process could not be easily seen without a science communication spectrum. Moreover, this directly connects science communication practice to science communication theory by using information from the scientific literature on science communication.

In our recent study we asked science information officers of Dutch universities to fill in the spectrum. Although many of them found it hard to do so (the instrument obviously has to be made more manageable), the instrument gives - as the professionals described - more insight into the many possible choices and their theoretical backgrounds. In particular, the respondents thought that the spectrum could be an instrument to fill the gap between theory and practice [3].

3. The spectrum adjusted

As an example of an adjusted science communication spectrum, we take the case of the European Research Funding Programme (KP 7). Due to time and budget constraints, the science communication to support a research group's funding must be targeted as well as possible. It is therefore necessary to sort out the science communication moments and possibilities in a science communication spectrum.

Within the spectrum (see Table 2), we differentiate the research funding process in six steps:

1) formulating the research question;

2) finding a social basis for research;
3) finding personnel and finance;
4) carrying out the proposed research;
5) disseminating and utilizing the research results;
6) evaluation and feedback.

In the case of this article, we filled in two phases in the policy making of research funding: finding a social basis, and carrying out the proposed research. Furthermore, the spectrum - according to Table 1 - is again about the science communication role of the researcher and the role of the target group. To keep the spectrum simple for this paper, we have only chosen one target group - the lay audience. Of course, other target groups could be used in the spectrum. The communication aspects are also similar to those in Table 1.

Table. 2: Possible execution of a science communication spectrum. As the spectrum consists of a sequence of choices, it has to be read per phase from top to bottom. Every choice in the spectrum influences the next choice. This chart only presents a small part of the science communication spectrum we developed, focusing on the social basis of the research proposal and the carrying out of the research. For example, one can see at a glance the connection between tone of voice and the role of the target audience.

Communi-cation aspect	**formulating the research question (phase 1)**	**finding a social basis for research (phase 2)**	**finding personnel and finance (phase 3)**	**carrying out the proposed research (phase 4)**	**disseminating and utilizing the research results (phase 5)**	**evaluation and feedback (phase 6)**
Role of researcher	- Inspiring - Norma-tive	- Inspiring - Convincing	- Organi-zing	- Organizing	- Instruc-tion	- Asking for feedback - Listening
Role of target group		- Considering		- Learning - Critical consideration		
Communi-cation target		- Engagement		- Awareness - Understanding		
Desired effect		- Awareness - Enjoyment		- Awareness - Understanding - Enjoyment		
Communi-cation strategy		- Creating		- Informing - Dialogue		
Content of message		- Why? - What is the social value?		- Who? What? Where? When? How? - With what result?		
Communica-tion instrument		- Debate		- Press release - Interviews - Open house - Websites - Popular science articles		
Tone of voice		- Popular science		- Popular science		
Persuasive-ness		- Potency - Urgency - Reach		- Societal effect		

As previously stated, the communication spectrum is an instrument which sorts and analyzes complex science communication processes. It depicts all the coherent communication opportunities, but it does *not* help to find the most optimal design for a specific communication process. The science communication spectrum is "only" a road map. In other words, it does not automatically answer the question: Which cells in the spectrum are the best ones to focus on when designing and optimizing the science communication processes the science communication professional wants? A *problem analysis* is needed to determine which cells need emphasis in the science communication process.

4. Problem analysis

There are many design theories, used for different processes and products in different circumstances. In every case, the main issue is to optimize the possible choices. The science communication spectrum makes the possible choices for science communication processes explicit (as depicted in Table 2).

In order to determine which to emphasize, a structural analysis, a problem analysis, is needed [4]. This analysis gives insight into the main focus points of the science communication problem, and shows the 'hot spots' in the science communication spectrum.

Problem analysis is a normal design instrument. Here it consists of a few questions (see left side of Table 3). For example, we analyzed, the problem of finding the social basis for a lay audience, following the case used in Table 2 (see right side of Table 3). The research group needs to find the social basis for the lay audience because backup from a lay audience is important for governmental research funding organizations like the EU

Table 3: Problem analysis of the research group's problem of finding a social basis for funding research for the lay audience.

Question	**Answer**
What is the communication problem?	Finding a social basis for the lay audience.
What is the difference between the existing and the desired situation?	The lay audience does not currently have any insight into the research. Therefore we need the lay audience to be engaged as a basis for funding.
What is the context of the problem?	There are too many other cognitive and affective aspects the lay audience must compete with.
What is the origin of the problem?	The origin of the problem is lack of knowledge about the research program.
Is the problem caused by invalid communication?	Yes. During the years there has been no communication with the lay audience at all.
Is the problem caused by an attitude or behavior problem on the part of the target audience?	Yes. Being unaware of the research content and its impact, the lay audience does not feel an urge to respond in any way.
What are the process constraints?	Time, budget, and lack of specific knowledge on the part of the target group, the lay audience.
Can this problem be solved by communication or not?	Yes. By taking away the deficit and motivating the lay audience to deepen their knowledge.

5. Science communication design

From this analysis of a specific problem, the science communication spectrum could be given more structure. The problem in one sentence is:

Due to a lack of communication over the years, the lay audience does not have any perspective on the research and its results. Filling this gap of knowledge is difficult because the lay audience has many other cognitive and affective distractions.

According to the problem definition, which are the most important cells in the science communication spectrum? In the problem analysis, phase 2 is central, and we must emphasize engaging the lay audience in order to establish a social

basis for research funding. Starting with engagement is probably a good first step to fill in the lack of communication. Engagement is – according to the literature which forms the basis of the science communication spectrum - not about understanding the problem, but about being involved with it in a positive sense.

The communication professional can now see at a glance (see Table 4) where he or she needs to start the science communication process according to the problem analysis (i.e., phase 2, science communication role of the lay audience, engagement). The professional can see the science communication targets, strategy and tone of voice - as identified by the vertical arrow pointing down. Following the vertical arrow pointing up (phase 2 column), one can see the overall role of the lay audience in this phase of research funding policy: consideration. Follows the policy phases in time (black arrow to the right), one sees which communication target step the professional has to make: from engagement to awareness and understanding, moving in time from phase 2 to phase 4 (carrying out the research).

Due to the sequential character of the spectrum, the science communication professional can now make choices which at the end help him or her to develop an effective science communication process. Of course the professional can leave some communication aspects out or add or expand others. The science communication spectrum and the problem analysis are all about optimizing, making the right *explicit* choice at the right moment.

Table 4: Several cells in the science communication spectrum are marked here. See text above for explanation.

Communication aspect	**formulating the research question (phase 1)**	**finding a social basis for research (phase 2)**	**finding personnel and finance (phase 3)**	**carrying out the proposed research (phase 4)**	**disseminating and utilizing the research results (phase 5)**	**evaluation and feedback (phase 6)**
Role of researcher	- Inspiring - Normative	- Inspiring - Convincing	- Organizing	- Organizing	- Instruction	- Asking for feedback - Listening
Role of target group		*- Considering*		*- Learning* *- Critical consideration*		
Communication target		*- Engagement*		*- Awareness* *- Understanding*		
Desired effect		*- Awareness* *- Enjoyment*		*- Awareness* *- Understanding* *- Enjoyment*		
Communication strategy		*- Creating*		*- Informing* *- Dialogue*		
Content of message		*- Why?* *- What is the social value?*		*- Who? What? Where? When? How?* *- With what result?*		
Communication instrument		*- Debate*		*- Press release* *- Interviews* *- Open house* *- Websites* *- Popular science articles*		
Tone of voice		*- Popular science*		*- Popular science*		

Communica-tion aspect	**formulating the research question (phase 1)**	**finding a social basis for research (phase 2)**	**finding personnel and finance (phase 3)**	**carrying out the proposed research (phase 4)**	**disseminating and utilizing the research results (phase 5)**	**evaluation and feedback (phase 6)**
Persuasive-ness		*- Potency* *- Urgency* *- Reach*		*- Societal effect*		

6. Future research

This science communication spectrum and problem analysis helps bridge the gap between science communication theory and practice and helps the communication professional to design an effective science communication process.

Our future research will focus on the design of this science communication process and the design of several other instruments like the science communication spectrum, which can connect science communication theory and practice. As mentioned throughout this article, this is important to help develop effective science communication. Moreover, one of the main questions in our research is how to optimize the process of making spectra and other design analyses. In other words, what are the heuristics of science communication design? With this kind of research the Science Education and Communication group of the Delft University of Technology hopes to deliver significant knowledge for science communication practice, theory, and the connection between the two.

7. References

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