Deliverable 3.2 – Report on experts' views on current science communication quality and demands

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Executive Summary

This report presents deliverable D3.2 “Report on experts’ views on current science communication quality and demands”.[1]

To deal with the issue in focus, we conducted a Delphi study to examine experts’ opinions on questions of science communication quality online. Delphi studies are applicable in settings where the objective is to forecast, to explore consent or dissent, to develop standards or to evaluate certain developments. The Delphi encompassed two waves of surveys with 26 (wave 1) and 19 (wave 2) science communciation scholars from across the world. Results of the first wave of the Delphi showed that experts hold very different perspectives on both actual quality criteria as well as the ways in which quality standards can be promoted and secured in digital science communication. The second wave, however, revealed more commonalities and shared perspectives with regard to generalizable quality standards and approaches to differentiate quality demands in different situational settings. Together with a robust discussion of quality standards in the Rethinkerspaces (third wave) which will feed in our perspectives on science communication quality, the results of the study will serve as a basis to develop and promote a framework for quality criteria for science communication online (D3.3) and will be used for the development of training resources including a train the trainer approach (D3.4).

[1] Please note that the title of D3.2 was changed slightly due to a reorientation of the research in WP3. The original title was “Report on experts’ views on current science communication *training* and demands”. To deal with demands for science communication training we focussed especially on issues of science communication *quality* as we regard dealing with and keeping quality standards as a core concern of science communicators in the context of the digital transformation. We thus aligned the title with this focus.

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1. Introduction

With the COVID-19 pandemic, the socio-political importance of science communication has been further demonstrated. The crisis has helped science journalism regain its importance and attention in many countries. Alongside these traditional communicators, a huge variety of other societal actors, such as scientists and scientific organizations but also activist groups, corporations, political actors, bloggers, vloggers, science enthusiasts, science sceptics and many more, have, by using digital media, communicated about COVID-19 and related scientific information. Although the challenges posed by SARS-CoV-2 are unique in their scale and scope, the tremendous changes in media and public communication influence science communication in general. Accordingly, the mapping of the science communication ecosystem in RETHINK countries conducted in WP1 (cf. D1.1) demonstrates the diversification of voices engaged in science communication. These changes have been leading to new possibilities of science communication and public engagement, but at the same time to new threats such as fake news and science denial as well as an increasing fragmentation of the public sphere. These developments are not without consequences for the *quality* of public science communication. Many of the actors involved in science communication today are not part of the traditional media where editorial standards and regulation is typically applied. In a much more diverse science communication ecosystem, the maintenance of quality has become of central concern and reflecting upon the *quality* of science communication is of vital importance for science communicators.

But how does "good" science communication look like in the digital science communication ecosystem? Which standards can be applied to assess the quality of science communication, and how do these differ from traditional evaluation criteria? And finally, how can quality standards of science communication be promoted in an increasingly complex digital media environment?

As science communication research has not yet given much attention to these issues, we have conducted a Delphi study. The research was dedicated to respond to the questions in focus and to the development of a set of criteria and indicators to measure science communication quality which addresses the specific needs and features of the digital media landscape. The Delphi study consisted of two waves of online surveys with 26 (wave 1) and 19 (wave 2) science communication scholars. The following report presents the results of the Delphi study. Section 2 gives an overview of previous research, section 3 and 4 will explain our method and empirical approach in detail. Section 5 will then present and discuss the results of the study. Finally, in section 6 we will discuss our findings, identify

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research perspectives and give an outlook for the steps which will follow this research in the context of RETHINK.

2. Science Communication Quality

It is widely agreed that the spread of digital media not only changes public communication but has had a fundamental impact on the developments of society (Hepp & Hasebrink 2018). Overall, the internet has changed mediated communication across multiple dimensions (Neuberger, 2014, 567). In a social dimension, the pre-digital roles of communicators and recipients have blurred (Bruns 2005). As a consequence, there is a tremendous increase and diversification of individual and corporate actors who become publicly visible via online channels and thus can affect public discourse and opinion (Kaiser et al. 2017). Online media have changed the ways information is produced and consumed. New forms of collaboration and interaction have been established whereby the Internet "simplifies reciprocal, multi-level and sequential communication" (Neuberger 2014a, 567). In a time-related dimension, online communication is characterized by its pace and actuality on the one hand and its function as an extensive archive on the other side. On a societal level, media change has led to fundamental changes: Traditional institutional orders of society are eroding as can be seen with regard to the changing role of journalism which no longer is the main source of societal information but has become one voice among many others in the networked public sphere (Newman et al. 2019, Benkler 2006; Castells 2007). In addition, there is an increasing conversion of mass media and other communication networks (Castells 2007, 238). "Accordingly, news articles rival with user-generated content like blog posts, personal status updates, song recommendations, or cat pictures for the user's attention" (Kaiser et al. 2017, 10). Instead, they become part of a patchwork of content whose sources are (at least partly) unrecognizable and whose credibility is often difficult to assess. Research shows that a quarter of surveyed German users do not recognize journalistic content on the web (Neuberger 2014b) or do not even care about the sources of the news that they consume (Hölig & Hasebrink 2013, 533; cf. Newman et al. 2019).

These developments thus go along with a fundamental de- or recontextualization of media content, a certain loss of orientation and a "collapse of context" in public communication (Neuberger 2014a). This also holds true for the field of science communication understood here in the most

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comprehensive perspective as any communication related to science (Schäfer et al. 2015). Whereas science journalism is on the decline (Bauer 2013) in the digital science communication landscape, a huge variety of societal actors such as universities and research centers, activist groups, corporations, political actors, bloggers, vloggers, science enthusiasts, science sceptics and many more are, by using digital media, communicating about science related content in the online public sphere (Allgaier 2019; Metag & Schäfer 2019; Fähnrich 2018). While these developments might be regarded as a step towards a politically fostered democratization of science (Kahan et al. 2017), they also bring about certain risks for science communication, especially with regard to its quality standards (Peters et al. 2012).

With the described changes in media and public communication, science communication quality has come under academic and political scrutiny (e.g. Nisbet & Scheufele 2009). Based on the normative assumption that scientifically informed knowledge is an important prerequisite for responsible decision making in the knowledge society, science communication is related to a variety of objectives: "Awareness, including familiarity with new aspects of science, Enjoyment or other affective responses, e.g. appreciating science as entertainment or art, Interest, as evidenced by voluntary involvement with science or its communication, Opinions, the forming, reforming, or confirming of science-related attitudes, Understanding of science, its content, processes, and social factors." (Burns et al. 2003, 191; cf. Davies & Horst 2016). To meet these objectives, it is regarded as desirable that citizens use high quality journalistic or media content to be adequately and accurately informed about relevant topics (Dohle 2017) and the related scientific evidence. However, the pluralization of content and the simultaneous fragmentation of the public sphere in the context of the digital media environment imply new possibilities, but at the same time lead to new threats to the quality of science communication. Against this backdrop, there seems to be a societal need to secure science communication quality and to maintain and improve the quality of interactions between science, media and society. But what is science communication quality and which approaches could be applied to assess this quality in a digital media environment?

Overall, dealing with questions of quality in the context of digital communication is a challenging endeavor. Quality has been largely analyzed in journalism studies (e.g. Gertler 2013; Lacy & Rosenstiel 2015; Neuberger 2014b) and more recently in digital communication research (Chai et al. 2009). Different models and frameworks have been developed to tackle the vagueness of the concept

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but less so in the context of (digital) science communication (Rögener & Wormer 2014). Previous literature has pointed to a huge variety of definitions, the relativity and dynamics of the concept and related difficulties to assess and evaluate communication quality (Lacy & Rosenstiel 2015, Neuberger 2014, Rögener & Wormer 2014). There is consent that quality cannot be defined "objectively" but is dependent on the expectations of certain actors (journalists, scientists, bloggers, users) towards certain media content. Previous research has examined public communication quality from different sides: In a demand perspective, the focus is on the interaction between the needs and requirements of media users and the respective media content (Dohle 2017, Urban & Schweiger 2014, Prochazka et al. 2014). From a production perspective those who produce media content specify and apply characteristics that are associated with high or low quality (Gertler 2013). In both perspectives, however, quality is a “matter of degree. It is not as simple as having or not having quality.” (Lacy & Rosenstiel 2015). In a digital context, however, with “content that has been created by users from different backgrounds, for different domains and consumed by users with different requirements” (Chai et al. 2009, 791), defining and assessing communication quality is even more complex and challenging – but maybe also more urgent to serve the overall societal aims of science communication.

3. Objective, Delphi design & panel

Against this backdrop, this study is dedicated to the quality of science communication in a digital environment. Its purpose is less to come up with definite definitions and criteria but rather to serve as a starting point for a sound reflection of science communication quality in a digital environment. Questions in focus are: how can we approach science communication quality in a digital environment? Is it necessary and possible to develop certain standards for science communication quality and its assessment? And if so, where should these standards derive from and how could they be established, institutionalized and secured given the complexity of the digital science communication environment.

Besides producer and consumer-oriented approaches, expert panels have been playing an important role in quality research (Gertler 2013). Given the highly normative and complex framework of science communication quality, it thus seems appropriate to approach the issue by systematically gathering science communication scholars‘ judgements in the context of a Delphi study.

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3.1 The Delphi method

The Delphi method has been developed as an approach that allows a group of experts to deal effectively with a complex problem in the context of an iterative and anonymous process (Linstone & Turoff 1975, 3; Niederberger & Renn 2019). The approach “serves to generate reasonably reliable statements for questions about which only incomplete knowledge, unsubstantiated hypotheses or mere assumptions exist. This happens through collective intelligence, the structured use of the knowledge of an expert community – including tacit knowledge and to a certain extent through the exchange of arguments, ideally in a space of domination-free communication" (Steinmüller 2019, 34). Delphi studies are applicable in settings where the objective is to forecast, to explore consent or dissent, to develop standards or to evaluate certain developments. Delphi studies thus can entail explorative, prognostic or normative elements (Cuhls 2019, 5). With regard to the fundamental transformation of public science communication and related changes for quality assessment and demands, such an approach appeared most appropriate.

3.2 Delphi panel

It was decided to conduct the Delphi study with science communication scholars. Scholars are considered to be experts for the questions in focus as they overlook the developments of the digital transformation of science communication. Based on their research experience and expertise they are able to objectively evaluate these developments as well as related quality issues and demands. Therefore, scholars were selected and approached for their outstanding experience in the field of science communication, digital communication and/or quality research. Moreover, we aimed to contact experts from all parts of the world and different national backgrounds, from different disciplines (esp. communication sciences, sociology/STS, psychology), and including different genders and status groups (from postdoctoral level to full professorship). In total, 70 potential panelists were contacted via e-mail and invited to take part in the Delphi study. With the e-mail, experts received an information sheet which detailed the objective of the research, gave specifics about the research process and their required involvement and provided information about ethical standards and funding. The information sheet can be found in the appendix.

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A panel of 31 people accepted our invitation to take part in the study. The number of actual participants in wave 1 who took part in the questionnaire and completed the majority of it was 26 (response rate 83,8%), in the second wave 19 scholars took part in the survey and completed the questionnaire (response rate of 61,2%). In the following, we present selected sociodemographic information about participating scholars. Participating experts represented 17 different national perspectives.[2] Scholars were full or associate professors (63 % for wave 2), meaning that junior scholars were fewer represented. Experts had a background in communication science, STS, media studies, political science, psychology, and other fields. The final panel consisted of approximately two thirds men and one third women. We have refrained from collecting more detailed sociodemographic data to facilitate anonymity of the experts as the field is rather small and as it is not necessary for our inquiry.

3.3 Research design and data collection

To deal with the questions in focus, the Delphi study was conducted in two waves. Participating scholars of wave 1 were asked to respond to an initial questionnaire with a set of open questions to share their expertise regarding the issues in focus. Data collection for wave 1 took place between November 2019 and January 2020. Responses to the first survey wave were analyzed and preliminary results were used to develop the second questionnaire which sought to generate an in-depth-discussion of different perspectives and a final judgement. Wave 2 was conducted between May 2020 and June 2020. Data collection was conducted anonymously with the tool SoSciSurvey that is free of charge for academic contexts. Questionnaires for each wave were developed by WP3 lead and assistant and were reviewed by Frank Kuper (Vrije Universiteit Amsterdam) as well as Andy Ridgway, Emma Weitkamp, and Clare Wilkinson (University of the West of England) from the RETHINK team.

Based on the Delphi results with science communication scholars a third step (wave 3) will include participants from Rethinkerspaces which will discuss the results and will offer initial ideas to promote quality standards in their specific national contexts. Therefore, a briefing has been developed and

[2] Participating experts indicate the following countries as their countries of residence: Austria, Australia, Brazil, Denmark, Estonia, Germany, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, UK, USA, South Africa, Switzerland

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hosts of Rethinkerspaces have be trained to conduct this exercise. Figure 1 displays the research process.

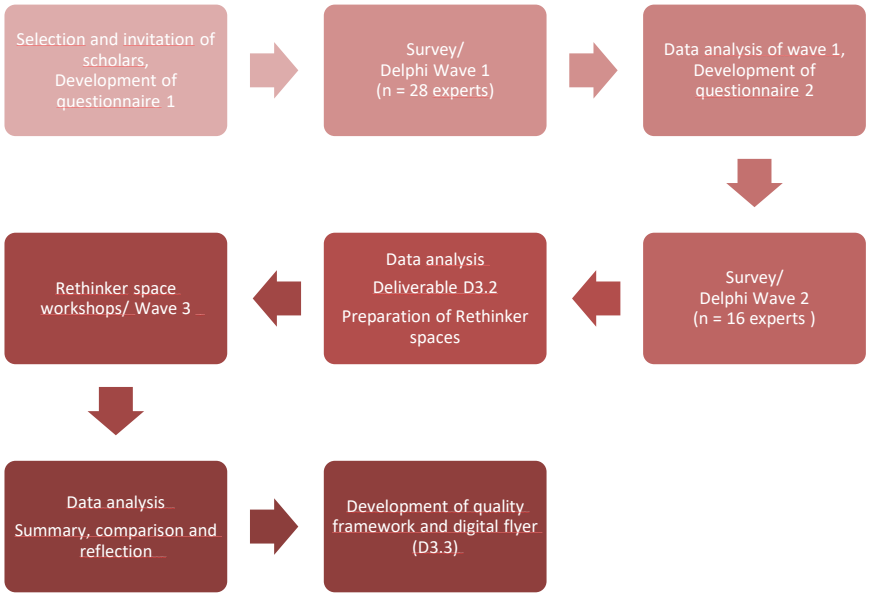

Figure 1: Research design of T3.2 and connections to T3.3

4. Questionnaire development and data analysis

4.1 Questionnaire development for wave 1

The questionnaire of wave 1 encompassed a range of open questions (Steinmüller 2019; Surowiecki 2004). Experts were asked for their judgement by using predictive questions (e.g. to outline prospective developments in digital science communication), normative assessments (e.g. should there be awareness of science communication quality standards, where should standards derive from?) and instrumental questions (e.g. how can quality standards be implemented and evaluated?).

The questionnaire entailed three sections:

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A. *Conceptualizing science communication in the context of digitalization*
B. *Conceptualizing quality in the context of digital science communication*
C. *Quality assurance and promotion of standards*

The questionnaire started with an opening question on how participating scholars would define science communication online. This question aimed to orient participants towards the issue in focus. In a second step, the conceptualization of quality was addressed by using two questions: To approach the question what science communication quality online actually meant to the scholars, we asked for their assessment of the most important quality criteria. The question was completely open to ensure a comprehensive perspective on factors that scholars associate with science communication quality. To narrow the perspective, the second question asked for potential fields of reference to define science communication quality, such as (science) journalism, PR or audience research. The third section of questions dealt with quality assurance and promotion and thus asked if quality in science communication could be assessed and what such an assessment would look like. In a final question, potential approaches to convey and promote science communication quality were surveyed.

4.2 Data analysis of wave 1 and questionnaire development for wave 2

To analyze the data and to prepare the second questionnaire, the situational analysis approach developed by Adele Clarke (Clarke, 2003; Clarke et al., 2018; cf. Fähnrich 2018) was used. Situational analysis is an approach derived from grounded theory that allows analysis of complex social phenomena ("situations") which Clarke et al. (2018) regard as central units of examination:

> "A situation is not merely a moment in time, a narrow spatial or temporal unit or a brief encounter or event … Rather it usually involves a somewhat enduring arrangement of relations among many different kinds and categories of elements … It usually includes a number of events over at least a short period of time, and can endure considerably longer" (Clarke et al. 2018, p. 17).

Using situational analysis for data analysis is especially valuable as the approach contributes to a "big picture analysis" and allows multiple forms of data to be integrated (Clarke et al., 2018, p. 150). However, situational analysis does not claim full objectivity and validity. Instead, analyses need to be

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"understood to be partial, historical, situated." (Clarke et al. 2018, p. 19) Situational analysis is based on the development of "maps," which allow access to the data material and support its interpretation. In general, three types of maps are distinguished (Clarke et al. 2018, p. xxiv):

1) *Situational maps*: They display major elements in the situation of inquiry and provoke analysis of relations among them; these elements can be of human, nonhuman, discursive, affective or geopolitical nature.
2) *Social worlds/arenas maps*: These maps are used to display the most important actors (social worlds, organizations, institutions, etc.) and the discourse arena(s) in which they are involved.
3) *Positional maps*: These maps help to visualize major positions taken, and not taken, in discussions, debates, and extant discourse materials in the situation, in this context also particular axes of difference, concern, and controversy about important issues become visible.

The maps are applied as heuristic tools and are useful in the context of the Delphi study because they can also serve to develop or to adapt survey instruments throughout the research process. Correspondingly, situational and positional maps have been used to the analyze data generated in wave 1 and to prepare the second Delphi wave which, again, was developed by the team from Zeppelin University and was revised and supported by the RETHINK team.

The second questionnaire followed the same structure as the first questionnaire (cf. points A, B, C in section 4.1). However, and in contrast to the first wave that followed an exploratory approach, the second wave aimed at summarizing, complementing, consolidating and reflecting the initial findings. To this end, the results of wave 1 were presented and explained by applying situational analysis maps for systematization and visualization within the questionnaire and built the basis for follow-up questions.

Based on the open responses to define science communication, a synthesis of the various approaches was offered in the first section of the questionnaire (*A – Conceptualizing science communication in the context of digitalization*). The proposed definition consisted of a) a broad definition for science communication in digital contexts and b) a matrix to describe different situational settings of science communication online. Participants were asked to add to the categories presented. In the second section (*B –*

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Conceptualizing quality in the context of digital science communication), a comprehensive list of quality criteria was displayed in the form of an ordered situational map (cf. section 5) which allowed for reflection and the indication of further categories that should be added. In a next step, participants were asked to select criteria that they considered as generalizable for science communication online. Moreover, they were asked to select two of five presented situational settings and to discuss how these would differ in terms of quality standards. In the third section (*C – Quality assurance and promotion of standards*) a positional map was presented to the participants that dealt with their initial responses on how to promote science communication quality online. Participants were asked to explain, which of the approaches were already used, which were considered most effective and what role science communication professionals and scholars should play to promote science communication quality.

5 Results

5.1 Quality criteria for science communication in a digital environment

5.1.1 Explorative identification of quality criteria

Due to the difficulties described above to define and conceptualize quality, research has often dealt with the exploration of quality critieria. Accordingly, our first approach was to ask experts for criteria that they would associate with science communication quality in a digital media environment.

To analyze their results, we used situational maps (cf. section 4.2) which are not only useful in the context of data analysis, but also to visualize the findings. To approach the data and to position elements and their links (Clarke et al. 2018), a so called messy situational map was developed first and then restructured into an ordered situational map.

The messy situational map displays the full range of associations that came to participants' minds in wave 1 when asked for quality criteria in general and possible points of reference to evaluate science communication quality online.

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Figure 2. Messy situational map, Delphi wave 1, quality criteria and potential points of reference to evaluate science communication quality online.

The different colours and positions of categories visualize a first attempt to structure the responses. On this basis, it can be shown that experts apply very different categories when referring to quality of science communication online. On the basis of wave 1, mentioned criteria were grouped into 5 categories: *Content criteria* refer to characteristics of the information per se. These encompass aspects such as accuracy, objectivity, relevance, multiple perspectives, completeness, truthfulness and credibility which are known from (science) journalism and science itself; in addition, aspects such as legitimacy and reputation of sources fall into this category and might be associated with strategic communication. *Presentation criteria* refer to the way information is exchanged and which modes of interaction are applied. In this regard, quality criteria mentioned are transparency (of authors, sources, backgrounds), language characteristics such as readability and comprehensibility. In addition, criteria included reading appeal and the question as to whether science communication online is engaging. These criteria show several overlaps with a group of criteria that we denominate as *procedural criteria,* and which refer to aspects relating to goals and audience orientation and thus align with effectiveness. These criteria seem much more relevant to online contexts and so increasingly important given the trend of digitalization In addition, *technical quality criteria* are considered to have a high impact on quality. In this category, the adoption of specific platform criteria

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(e.g. regarding different standards such as the lengths and tone of posts on social media platforms such as Facebook, Twitter or Instagram, to name but a few examples) and offers for interactivity are associated with quality. Moreover, overall characteristics of online communication which become apparent in the level of hybridity and media convergence, e.g. through links, are indicated Finally, *context criteria* form a meta category that deals with the institutional and moral framework of science communication online.

Content criteria	**Presentation criteria**	**Procedural criteria**	**Technical criteria**	**Context criteria**
- accurate - neutral/non-partisan - objective - factual - complete - evidence based - empirical - relatable - based on the most current and best evidence - not distorted/ unbiased - truthful - relevant - depth of themes - representation of multiple perspectives - holistic (w2) - audience relevant questions (w2)	- appealing - engaging - comprehensible - clear - interesting - stimulating - share-worthy - informative - civil - brief - aesthetic - simplified - accessible (language/style) - entertaining - transparent regarding context of communication (e.g. author, intention, sources, funding etc.) - accommodation of diversity - audience relevant framing (w2)	- clear motivation, aim or purpose - clear definition of goals, objectives, outcomes - measurable indicators for evaluative work - effectiveness/ impact in short and longer-terms - application of evidence-based practices to design science communication (e.g. from psychology, audience research)	- technically accessible for relevant audiences (target groups) - attractive in the given medium - opportunities for dialogue/feedback and/or participation - creative in technical terms - integration of contextual cues (likes, shares, comments) - providing links to related content - connectivity - - dynamic/ interactive	- reliability of evidence - competence of author - morally acceptable intent of communication - morally acceptable funding and agenda - expertise of sources - deriving from independent research - orientation towards public good - without a particularistic agenda - credibility (w2) - values-oriented (w2) - impartial (w2)

Figure 3: Ordered situational map, Delphi wave 1 and 2, grouped quality criteria. Criteria added in wave 2 are donoted as (w2).

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These criteria were presented to the experts in wave 2. Participants were asked whether there were categories that they would like to add. Most experts stated that the list was already very comprehensive and indicated some overlap. Only a few added further. Figure 3 displays quality criteria collected in both waves.

Experts in wave 1 were also asked to explain where from standards to assess science communication quality should derive. In terms of fields of research and practice, participants suggested audience research, psychological research, strategic communication, journalism and public relations, and media literacy as fields that have extensively dealt with effects of public communication. Referring to specific targets of science communication, anticipating audience preferences or considering platform features were regarded as central influencing factors. In both waves, some scholars argue that context is so important that overall science communication quality criteria cannot be defined. Others however are less skeptical and argue that it is important and valuable to develop a framework of such criteria.

5.1.2 Generalizable criteria

Therefore, experts were asked, in wave 2, to indicate which criteria they considered as most important to evaluate quality in science communication online *in general* (cf. figure 4).

reliability of evidence (13)	clear motivation, aim or purpose (13)	accessible language & style (12)	transparent context (12)
engaging (12)	technically accessible (12)	comprehensible (11)	relevant (11)
opportunities for dialogue & feedback (10)	expertise of sources (10)	accurate (10)	relatable (10)

Figure 4.: Criteria of general relevance for science communication online, number of mentions (n = 16)

To respond to this question, experts could tick all of the listed categories that they found most relevant (multiple choice). We listed the 12 categories that were chosen by 10 or more experts (n=16) in wave 2. These include criteria across all categories (cf. figure 3): “reliability of evidence” and a “clear motivation, aim or purpose”, and thus overall context and procedural criteria, were considered

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as the most important quality criteria for science communication online in general. Moreover, audience related categories such as accessibility, both in terms of language and style but also in technical terms, and context transparency were considered very important. Engaging communication and communication that offers opportunities for dialogue were highlighted by respondents. Criteria such as accuracy, comprehensiveness and reliability have been previously identified as important quality criteria for journalism (for an overview see Lacy and Rosenstiel 2015, cf. Rögener & Wormer 2016) and remain important to our respondents. Also, criteria such as "engaging" and "opportunities for dialogue/feedback" have for long been discussed as core quality criteria of science communication (cf. Bucchi & Trench 2016). In contrast, demands for transparency and clarity about the expertise of sources can be related more closely to the "new" science communication landscape and the ongoing diversification of science communicators beyond scientists and science journalists, channels and formats (cf. Neuberger 2014b).

5.1.3. Quality criteria for different situational settings

Against the backdrop of the diversity of science communication online, we used wave 2 to explore quality requirements for different situational settings in which science communication occurs. We suggested six settings that differed in terms of communicator, channel and purpose. We then asked experts to compare two of them with regard to quality criteria and to explain which would be relevant and which would not apply. We proposed the following situational settings:

A. *A news section on a university website presenting the latest research from their organization*
B. *The Twitter thread of a scholar commenting on policy issues by referring to the latest evidence*
C. *A governmental campaign on different social media referring to public health issues*
D. *The blog of environmental activists citing scientific studies to strengthen their argument*
E. *An influencer's post on Instagram presenting spectacular scientific experiments*
F. *A podcast provided by the science section of a leading daily newspaper*

To analyze the responses, we used so called social world maps of the situational analysis approach which are used to make the differences of situational settings (or social worlds) and their contexts visible (Clarke et al. 2018). Overall, again, some experts remarked that making distinctions would be difficult although for different reasons. Whereas one participant stated that the assessment of quality was first and foremost a question of the purpose of the communication in focus (w2, P5), other

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respondents emphazised the “intense competition for attention” as a core context factor (w2, P7) arguing that any “quality assessment is in the eye of the audience” (w2, P6). One respondent stated that the multiple possible modes of interaction of communicators and platforms would make quality assessments difficult. Moreover, the level of “controversy or urgency” was introduced as an intervening factor, especially against the backdrop of COVID 19 (w2, P16). Although many participants compared the settings and hinted at differences in the quality assessments of different situations it was obviously difficult for experts to eliminate criteria. Asked for the (ir)relevance of the given criteria in different situational settings it was argued that it was rather a “matter of relative importance of different criteria in different settings, rather than a case of some not applying. They all apply, to a greater or lesser extent.” (w2, P2)

Figure 5 displays a summary of the responses and lists those criteria that were considered *especially* relevant for the given situation. This does not mean that other criteria might not apply but tries to mark differences between different settings of science communication that might be relevant for different stakeholder groups including science communication trainers, policy makers or lay communicators.

It is striking that experts chose those situational settings that they are probably most familiar with: the university website, the scholars’ thread on twitter, and the podcast of the newspaper. The government campaign was chosen less but still considered. The situational settings D and E, the blog of environmental activists and the Instagram post were not discussed at all (except from one arguing that the Instagram post needed to be “engaging”) which is particularly unfortunate as these examples differ more that all the others from the “old” and analogue science communication landscape and thus would have been especially interesting to compare. We will use the Rethinkerspaces to discuss these open points further.

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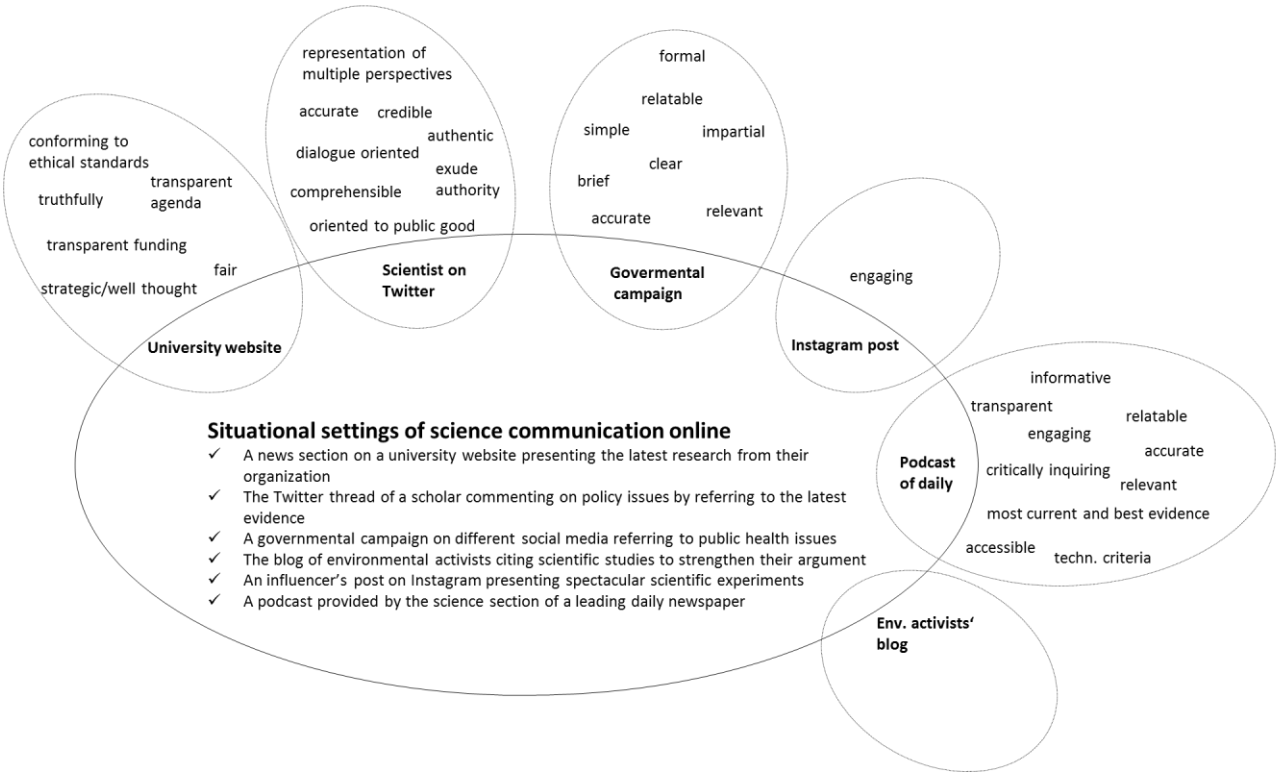

Figure 5: Social world map: Criteria of special relevance in different situational settings of science communication online.

5.2 Conveying, promoting and/or securing quality criteria for science communication online

5.2.1 Status quo of quality promotion

Discussing quality criteria of science communication online is closely connected to questions of how these criteria could be transformed into quality *standards*. Against this backdrop, the first wave of the Delphi asked how experts would convey, promote or even secure the quality criteria that they considered most important. Figure 6 derives from the responses of experts collected in wave 1. It shows that experts hold very diverse and even contradictory positions on how to promote, convey or secure quality standards. Their responses have been analyzed by using a positional map: "The goal [of positional maps] is to represent all the major positions articulated in the materials on their own terms." (Clarke et al. 2018). In the context of situational analysis, these maps thus lay out the various positions of a discourse.

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Different arguments can be located on a continuum with "direct intervention" to secure the quality of science communciation (e.g. "fact checking", collaboration with/regulation of platforms) on the one hand and "self-regulation" (e.g. "quality standards should be conveyed and promoted as reflective tools and not as deterministic tools") on the other, with "incentivisation" ("the best we can hope for is to foster a culture in which we can discuss openly and constructively criticize outputs with one another") in between the poles. Another distinction can be made between formal and informal approaches.

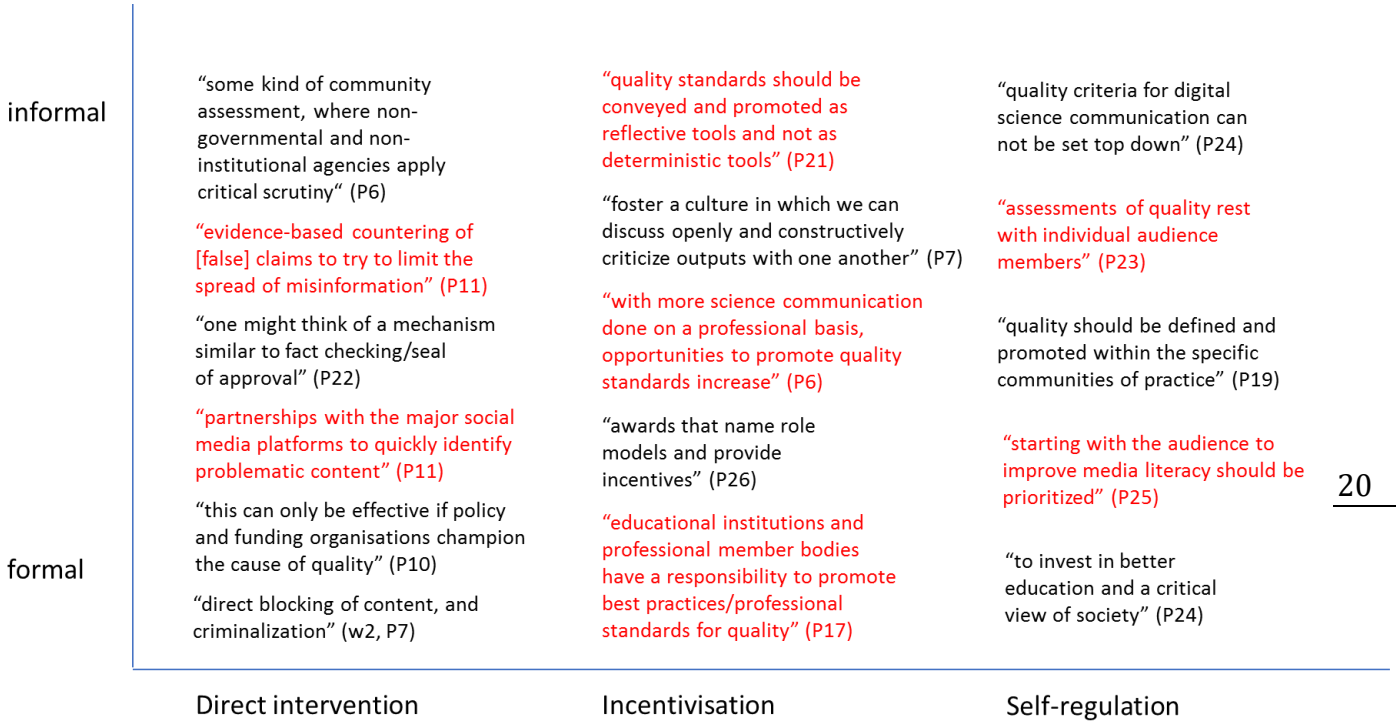

Fig. 6: Positional map: Conveying, promoting and/or securing quality criteria for science communication online. Results of wave 1, additional dimensions from wave 2 are denoted as (w2).

In wave 2, experts were also asked to discuss which of these approaches was already taking place. Many participants responded that all formats were taking place, "albeit to different degrees" (w2, p4), and also listed examples for the different approaches. Many experts emphazised differences in national and political contexts, thus stressing the societal and political embedness of science communication: "In authorative countries, we have strict regulation and surpression of digital (science) communication. In western countries with liberal democracies, incentivisation and self-regulation dominate" (w2, p14), with few opportunities for "regulation appearing between governments and social media companies" (w2, p2). In these political contexts, experts state that approaches of incentivisation and self-regulation are particularly visible. Experts also argue that the

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increasing science communication training of scientists and the growing demand for outreach and public engagement activities "as part of research funding and assessment contributes to best standards" (w2, p12). In this regard, an overall "normative acceptance" of quality promotion by science communication professionals including public relations and journalism is noted.

5.2.2 Opportunities to improve science communication quality

Finally, we asked experts which approaches had the potential to facilitate the implementation of quality standards and might be strengthened. Moreover, the participants were asked for the role that science communication professionals and science communication scholars should play in ensuring that quality standards are met.

Overall, the responses of experts refer to different approaches, which, as one participant states, are not mutually exclusive. Instead "a combination of various interventions working at the same time" (w2, P12) would be needed. Based on the results of wave 2, there are three perspectives which are considered especially relevant and which can be mapped toa macro, meso and micro-perspective.

On the *macro level*, experts locate the responsibility to promote science communication quality at a societal level "including government, society and social media companies" (w2, p2). They stress the need to start and engage in social discourses, for example with regard to ethical requirements and regulation of social media communication as an essential environment of science communication. Moreover, digital literacy education should be more effective and convey "better standards". Approaching these tasks of "building competency and literacy" (w2, P16), however, should be undertaken with the communities themselves, including schools and public education in general (w2, P15). In a related perspective, "to promote and encourage scholarly discussion and reflection", by means of research like ours, is considered as an important "starting point" (w2, p12).

On a meso level, experts refer to professional bodies, science communication societies and associations, and also scientific institutions and their role in quality assurance. Their contribution is seen in providing "background knowledge" of quality assurance (w2, p10). By integrating questions of quality in their "internal debates" (w2, p15) and by the "establishment of standards and education" they could contribute even more to the promotion of science communication quality. Whereas the professionalization of science communication has been discussed quite controversially in recent time (cf. e.g. Bauer 2013), one expert argues that linking professionalization with quality

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would be valuable. Such a stronger focus on quality in science communication, “may help to overcome a recent trend in seeing some ‘stigma’ attached to science communciation as being a mere “PR” excercise for scientific institutions [...]” (w2, P6). In this context, the exchange with other communities (science journalism, science public relations) is regarded especially valuable.

On a micro level, experts address the responsbilities of science communication professionals, science communication scholars, scientists, “other” actors who communicate science via digital means, and consumers of digital science communication content. Science journalists and PR experts, for example, are supposed to align with the standards and demands defined by their professional communities to “justify their choices [...]” (w2, P13) within this framework. In this regard, science communication professionals are also considered as a kind of facilitator in collaboration with scientists. The latter are even relieved of responsibility to a certain extent as they shouldn’t “be expected to do everything on their own just as we don’t expect politicians or executives to manage all their own communication”. Instead, they would need professional assistance to maintain quality standards, “especially in cases were there’s a need for robust planning, implementation, and evaluation.” (w2, p14) Few respondents to the Delphi refer to “other” communicators such as influencers or activists who contribute to the public perception of science and therefore should conform to quality standards in one way or another. However, respondents do not clarify what this would mean in detail. Comparably, it is argued that “consumers of science communication cannot disregard their own responsibility” (w2, p7).. Finally, science communication scholars are expected to contribut to science communication quality, too. “They are expected “to advance conceptual understanding and theory” (w2, P10) of science communiation and thus contribute to the development of approaches for explanation and forecast. Furthermore, scholars should“produce transparency” (w2, P8) and “provide empirical evidence” (w2, P10) to oberserve and reflect upon the development of science communication practice. Whereas these can be considered as ongoing activities, respodents emphazised that collaboration with practitioners should be strenghtened, e.g. to “provide material for reflection” (w2, P8), to “collaborate in research projects” (w2, P11), and to utilise knowledge to “solve specific practical problems” (w2, P13). One expert concludes that “this is an excellent example of a challenge where ongoing collaboration and interaction are needed between researchers and practitioners.” (w2, p6)

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6 Conclusion and next steps

Currently, the ongoing Covid-19 crisis confirms the importance of communicating scientific information, but it also points to the challenges of science communication in the digital media world.

The starting point of the research underlying this report was the fundamental changes in science communication in the digital media context. Science communication can no longer be reduced to science journalism and public relations, but encompasses all communication about science (Schäfer et al. 2020). In the digital ecosystem of science communication (cf. also D1.1), the changes in public communication lead to a differentiation of communicators and goals, channels and formats as well as the reception and impact of science communication (cf. Schäfer et al. 2020, Kahan et al. 2017). Science communication is often associated with socio-political goals. If one follows this normative perspective, the question arises as to what criteria can be used to identify "good" science communication in the digital media environment. This question of the quality of science communication has been asked in various ways in research and practice of science communication, but has not yet been answered satisfactorily with regard to science communication online: "Quality criteria for science communication were weakly developed before online platforms emerged. (...) But there was not much effort given to developing alternative criteria. (w1, p6)

The present study aimed to examine the changes in the quality of science communication in the context of the digital media environment. The report comprehensively presented the results of the Delphi study with science communication researchers. In the following, some key observations are discussed and further steps in the context of RETHINK are explained:

- The study was conducted (only) with science communication researchers in order to ensure a certain degree of comparability within the panel. However, the great heterogeneity of the perspectives on quality criteria and highly controversial perspectives on how to secure certain standards was striking.
- There were also significant differences in the participants' attitudes to the fundamental question of the extent to which quality criteria can be determined at all. Some

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participants insisted in both waves on the context-dependence of these factors, while other participants were quite willing to name generalizable criteria.

- Surprising was the low consideration of science communication settings beyond "traditional" science communication. When asked about quality criteria for different science communication settings, almost all participants chose settings in the fields of science journalism, university public relations, and scientist communication. The question as to which quality criteria should apply, for example, to the communication of influencers or NGOs on social media, was not answered. One participant criticized "Our community is coming full-circle back to knowledge deficit thinking. (w2, p15). Although this conclusion seems very drastic, the focus on traditional forms of science communication is striking. This is unfortunate, since it is precisely the "new" situational settings of science communication that probably pose the greatest challenges for ensuring quality and thus deserve closer attention, analysis and reflection.
- It is also interesting to compare the perspectives of the scholars with science communication practice. In the Delphi study, for example, the experts often state that the dialog orientation of science communication is a central quality criterion. At the same time, science communication practitioners point out in a study in WP1 (cf. D1.1) that dialog and interaction are hard to find.
- Within the framework of RETHINK, we assume that the precise definition of quality standards can provide both professional science communicators and laypersons with assistance and orientation in the evaluation of science communication in an increasingly complex media environment. Against the background of the great number and variety of the criteria mentioned, we have attempted to identify generalizable criteria on the one hand and to find superordinate categories on the other. Our five main categories are content criteria, presentation criteria, procedural criteria, technical criteria and context criteria. In our opinion, changes in quality assessments in the context of digitization can be found especially in the last three main categories. Here, an intensive examination of the question of how the quality of digital science communication can be evaluated and promoted is necessary.
- To this end, a number of starting points were identified and systematized in the Delphi study. For the experts questioned, combining different interventions seems most appropriate. Overall, experts agree on the need for education but also for reflection and raising awareness within the science communication community. In this regard, also

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strengthening the collaboration between scientists and practitioners to evaluate the quality discourse is considered an important approach.

- Against this backdrop, the next steps of the RETHINK project will aim at strengthening these approaches: In the next step, a sound discussion on science communciation quality online with Rethinkerspace participants and a presentation of Delphi results will serve as kind of a third wave of the Delphi and will bring further insights and deepen our understanding of the quality assessments of international science communication practitioners.
- The development of a manual (digital flyer) and teaching material including a train the trainer approach will further contribute to the promotion and reflection of science communication quality within RETHINK.

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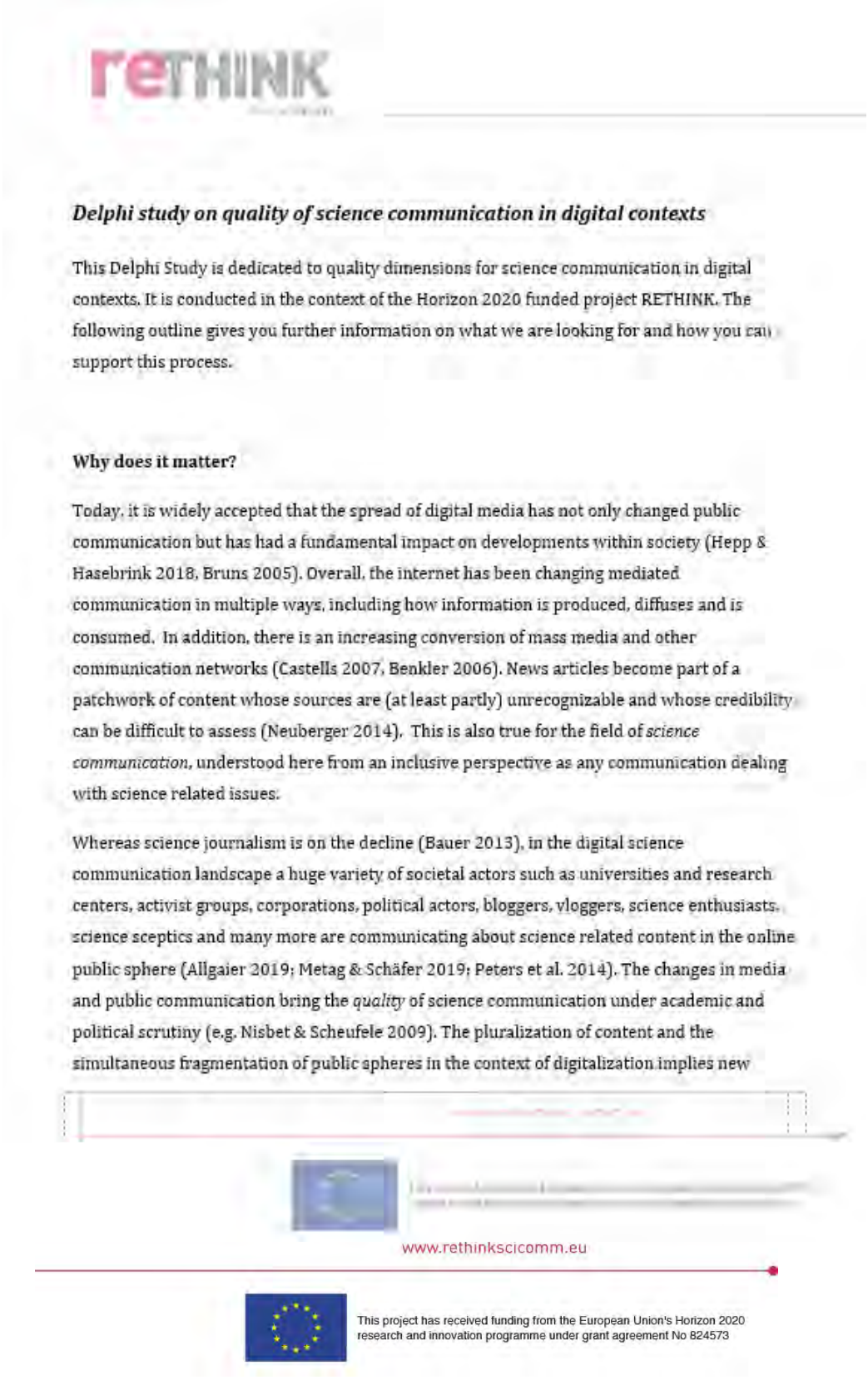
8 Appendix

1. Information sent to potential participants in the context of the invitation to take part in the Delphi



reTHINK

Delphi study on quality of science communication in digital contexts

This Delphi Study is dedicated to quality dimensions for science communication in digital contexts. It is conducted in the context of the Horizon 2020 funded project RETHINK. The following outline gives you further information on what we are looking for and how you can support this process.

Why does it matter?

Today, it is widely accepted that the spread of digital media has not only changed public communication but has had a fundamental impact on developments within society (Hepp & Hasebrink 2018, Bruns 2005). Overall, the internet has been changing mediated communication in multiple ways, including how information is produced, diffuses and is consumed. In addition, there is an increasing conversion of mass media and other communication networks (Castells 2007, Benkler 2006). News articles become part of a patchwork of content whose sources are (at least partly) unrecognizable and whose credibility can be difficult to assess (Neuberger 2014). This is also true for the field of *science communication*, understood here from an inclusive perspective as any communication dealing with science related issues.

Whereas science journalism is on the decline (Bauer 2013), in the digital science communication landscape a huge variety of societal actors such as universities and research centers, activist groups, corporations, political actors, bloggers, vloggers, science enthusiasts, science sceptics and many more are communicating about science related content in the online public sphere (Allgaier 2019; Metag & Schäfer 2019; Peters et al. 2014). The changes in media and public communication bring the *quality* of science communication under academic and political scrutiny (e.g. Nisbet & Scheufele 2009). The pluralization of content and the simultaneous fragmentation of public spheres in the context of digitalization implies new

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possibilities, but at the same time leads to new threats to the quality of science communication. But what is science communication quality and how could it be assessed in a digital media environment? Previous research has hardly dealt with communication quality in the context of (digital) science communication. Research in other fields, however, has pointed to a huge variety of definitions, the relativity and dynamics of the quality concept and difficulties related to assessing and evaluating communication quality (Lacy & Rosenstiel 2015, Neuberger 2014, Rögener & Wormer 2014). Against this backdrop, defining and assessing communication quality is even more complex and challenging in a digital context – but maybe also more urgently needed to serve the overall societal aims of science communication.

What are we aiming at?

Against this backdrop, this study is seeking to explore what quality means in relation to science communication content in a digital environment. Its purpose is less to come up with concrete definitions and criteria but rather to serve as a starting point for a sound reflection on science communication quality in a digital environment. Questions in focus are: how can we approach science communication quality in a digital environment? Is it necessary and possible to develop certain standards for science communication quality and its assessment? And if so, where should these standards derive from and how could they be established, institutionalized and secured given the complexity of the digital science communication environment?

Your participation

Given the highly normative and complex framework of science communication quality, we have decided to conduct a Delphi study. Delphi studies are used in settings where the objective is to forecast, to explore consent or dissent, to develop standards or to evaluate certain developments (Steinmüller 2019). We think that your expertise and perspective would be an

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important contribution to explore science communication quality in the context of a Delphi study.

Considering your outstanding knowledge and expertise we are convinced that you would offer an important and valuable contribution to the planned Delphi on science communication quality. Therefore, we would like to invite you to take part in two linked surveys which are part of the study. The two waves will be conducted in November 2019 and in February 2020 with a four week time slot to respond.

Questionnaires will consist of 5 to 7 open questions which we would like you to answer. The questionnaire will ask for your expert judgement by using predictive questions (e.g. to outline prospective developments in digital science communication), normative assessments (e.g. should there be awareness for science communication quality, where should standards derive from) and instrumental questions (e.g. how can quality standards be implemented and evaluated).

We anticipate that it will take approx. 30 to 45 minutes to answer the questions. However, time needed might differ. Moreover, you are of course free to decide not to answer questions if you feel that you are not able to make an assessment.

Who else will participate?

With this Delphi we seek to use the "wisdom of the crowds" (Surowiecki 2004). We invite scholars who are experienced in the field of science communication, digital communication and/or quality research. As we try to integrate as many different opinions as possible the expert panel will include scholars from different disciplines, national backgrounds and status groups. For practical reasons we have to limit participation but aim to secure a panel of approx. 30 scholars.

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Again, for practical reasons, we have decided not to integrate science communication practitioners at this point in the research. However, we will have workshops with a range of European science communication practitioners in the context of RETHINK that will be used to discuss the results of this study against the backdrop of their expertise and experience.

Data collection and analysis will be strictly anonymous. However, there will be the opportunity to indicate participants in the final publication.

Context, funding and ethics

The study is conducted in the context of the project RETHINK which is funded by the European Commission in the Horizon 2020 framework (SwafS-19-2018-2019). Purpose of the project RETHINK is to provide an unprecedented view of the new science communication landscape to reveal the barriers and inequalities that stand in the way of open and reflexive connections between science and society. It encourages evidence-based transformations in science communication practice as well as guiding relevant policy to further open Research & Innovation (R&I) to society. Outputs will be new ways of training those who engage in science communication, including those underserved by current training - such as bloggers and social media commentators. There will be online briefs aimed at changing current science communication practices to break down barriers preventing open R&I and reach underserved audiences across the EU. Strategies will be developed to improve individual and collective sensemaking by enhancing its openness and reflexivity. Guidance on policy will also be provided to create an environment that encourages open R&I. All of these outputs will be open access, as will the data generated during the research process to encourage a broad discussion and maximise uptake. More information on the project: https://cordis.europa.eu/project/rcn/219057/factsheet/en

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This research was authorized by the Ethics Commission of the Zeppelin University (Germany) and complies with all applicable regulations. The data we collect are processed, stored and shared in accordance with the European Data Protection Regulation. This means that your data will not be identified in any reports or publications and any data extracts will be carefully reviewed to ensure you are not identifiable. Any sensitive or identifiable data will be kept confidential, whereas aggregated and pseudonymised data will be shared with our project partners and third parties. The information gathered will be used for the purposes of the study report, academic dissemination, and potentially as a basis for future guidelines on best practices in science communication. The final report will be published online and will be publicly available.

Team & Contact

The Delphi Study is conducted by a team of researchers involved in the RETHINK project. Please feel free to contact the researcher team in case of questions.

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2. Questionnaire Wave 1

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Delphi study: Quality of Science Communication in a Digital Media Environment (Wave 1)

Thanks for your participation in our research. This Delphi study is part of the Eu-funded project RETHINK and seeks to investigate the meaning of quality in the context of science communication within the digital media environment. The Delphi study is split into two waves. This questionnaire is part of the first wave, which explores the overall conceptualisation of science communication in the context of digitalisation. The questionnaire, therefore, entails three short sections with open questions, which we anticipate will take approximately 30 to 45 minutes to complete.

Should you have queries, please do not hesitate to contact us.

Thank you in advance and best regards, also on behalf of the RETHINK team,

Birte Fähnrich and Laura Heintz

Next

Dr. Birte Fähnrich, Laura Heintz, M.A. I RETHINK (Horizon 2020, Grant Agreement number 824573) I http://www.rethinkscicomm.eu I Center for Political Communication I Zeppelin University I Am Seemooser Horn 20 I 88045 Friedrichshafen I Germany I birte.faehnrich@bbaw.de I laura.heintz@zu.de

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A. Conceptualising science communication in the context of digitalisation

There is a global consensus that the spread of digital media has profoundly changed public communication. This is also true in relation to science communication, which is evident in the immense pluralisation of science-related content, the fragmentation of audiences and the increasing differentiation of professional and lay communicators, to name but a few developments. In the digital media environment, science communication has developed from a basic journalistic domain into a patchwork of highly heterogenous and complex phenomena of public communication. This patchwork encompasses journalistic formats as well as an array of science-related content on websites, blogs, wikis or platforms such as YouTube, Instagram, etc.

Against this backdrop, we would like to start this Delphi study with a conceptualisation of science communication in the digital media environment. We would thus like to ask you to share your perspective on what science communication means to you. There are no right or wrong answers, as our purpose is to look for a definition as a starting point:

Q1: How would you define science communication in the digital media environment?

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B. Conceptualising quality in the context of digital science communication

Digitalization has enabled considerable diversification in the area of science communication, e.g. in terms of communicators, formats, issues, etc. We observe that science communication originating from different types of communicators (e.g. professional communicators, enthusiastic lay people) and employing very different platforms (blogs, YouTube channels, Instagram) also vary in terms of quality. Considering this context, please provide your views on the following questions:

Q2: Consindering the diversity of science communication online, what are the most important quality criteria for evaluating different science communication phenomena?

Q3: Where should quality criteria for science communication be drawn from (e.g. journalism, science, public relations, other)?

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C. Quality assurance and promotion of standards

Thinking about the quality of science communication in an increasingly diverse digital media environment raises questions about how to also ensure quality in science communication. Please share your views on quality assurance in the digital science communication environment.

Q4: Should there be a quality assessment of science communication outputs in the digital media environment? If so, what might such an assessment look like, and who should be in charge?

Q5: How could quality standards for science communication in the digital media environment be conveyed and promoted?

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Thank you for completing this questionnaire!

The study is conducted in the context of the project RETHINK which is funded by the European Commission in the Horizon 2020 framework (SwafS-19-2018-2019).

Please feel free to contact the researcher team in case of questions.

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3. Questionnaire Wave 2

Dear Participant,

Once again, thank you for participating in our DELPHI study on the 'Quality of Science Communication in Digital Contexts', which is part of the Horizon 2020-funded project RETHINK!

The first wave of our study, which included the participation of 26 international and interdisciplinary scholars, aimed at collecting a broad range of different perspectives and assessments on the topic. To this end, we asked you how you would conceptualise/define science communication online and how this could be promoted, conveyed or even regulated. We used this open and exploratory approach because it is assumed that we cannot simply adopt existing criteria and apply them to new science communication phenomena. Therefore, we need a fundamental reassessment of science communication quality in the digital context.

In the analysis of your responses, we summarised, ordered and interpreted the results via the situational analysis approach. Situational analysis, which was developed by Adele Clarke (2003, cf. Clarke et al. 2018), enables the analysis of elements and the complex social constellations in which they are embedded by using different forms of visual maps. These visualisations are not only applied as analytical tools but are also used in the results alongside quotes. Quotes are demarcated in the usual way.

With this second wave, we ask that you comment on and add to the preliminary results. We will then present our interpretations of your thoughts and the breadth of your perspectives to order, focus and support the findings.

Again, the questionnaire will comprise three sections, with each building upon the prior one. Based on your previous responses, the questionnaire will start with further clarification of the notion of 'science communication in digital contexts'. It will then move on to refine the quality criteria that emerged from your responses, as applied in different situational settings, and ask you to reflect upon approaches to promoting these criteria in the online science communication landscape, as identified through the initial questionnaire responses.

Thank you for taking the time to respond once again! Please do not hesitate to contact us with any questions.

Next

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I. Conceptualising science communication in Digital Contexts

In the first wave, we asked you to define science communication against the backdrop of the digital transformation. We did so because existing definitions vary considerably, and they were not developed with digital contexts in mind. We received quite a broad range of responses. Whereas some of you indicated that the digital context would not necessarily change the overall concept of science communication, others argued that the tremendous changes that are afforded through digital tools would require 'a new—and presumably ongoing—conceptual understanding' (P3). We would like to interrogate this perspective further.

Different participants emphasised the diversification of science communicators, channels, forms and contexts in the digital environment and concluded that we should not 'define "science communication" too narrowly' and that, against the backdrop of the digital media environment, 'the definition of science communication comes down to the content being communicated (or not)' (P24). Drawing on your responses, we propose the following definition:

Science communication in digital contexts encompasses all forms of communication about science-related topics via digital media.

This definition is descriptive and broad; thus, it helps cover the entire digital science communication landscape, reaching from professional science journalism or university communication on websites, blogs and public engagement by scholars via Twitter to diverse forms of science-related communication, whether by science enthusiasts or deniers on YouTube, Reddit or other platforms. However, we acknowledge that such a broad definition is hardly useful as an actual working definition. Instead, we need to draw at least 'fuzzy boundaries' (P19) to distinguish different situational settings of science communication in digital contexts.

Such a situational setting could encompass, for instance, political actors that aim to change people's behaviour with regard to health issues and thus use a public information campaign that is run and shared on diverse online channels. A completely different setting could entail a company that applies the latest findings from nutritional science in their PR communication on different social media to improve its overall reputation. Another situational setting again could refer to a scientist involved in citizen science who uses online tools to foster a mutual learning experience with a group of lay participants.

Given that there are numerous situational settings, we think that it is useful to systemise the field on a more general level. Therefore, we aimed at developing a matrix to distinguish different settings of digital science communication. To this end, we analysed your responses from wave 1 and inductively built categories. On this basis, the situational settings of digital science communication are shaped by different combinations of the following (and potentially further) categories:

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Category	Examples
Actors involved	scientists, journalists, politicians, engineers, industry, citizens, PR offices, non-governmental organisations
Roles taken by these actors	knowledgeable people, lay, professional, non-professional, authority, communicators, multipliers, recipients
Intentions of the actors	information, increase science literacy, learning, attitude and behavioural change, entertainment, fun
Level of formality of communication	organised actions, spontaneous communication
Content	aspect of science, such as knowledge, findings, practices and processes, methods, scientists, scientific expertise, science policy
Platforms used	websites, blogs, social media
Level of convergence	limited to a few platforms, shared on many platforms
Modes of communication	informational, popular, dialogic, interactive, controversial, discursive, referring to opinions, ideas and/or facts
Types of presentation	text, audio, video
Levels of publicity	closed groups, clearly defined publics, diverse publics
Types of effects	with regard to changes of knowledge, attitude behaviour, measurable/not measurable, short term/long term

Tab. 1: Categories that shape different situational settings of science communication in digital contexts

QUESTION:

1) Do you have further categories in mind that would be useful to add to the matrix to distinguish different situational settings of science communication online?

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II. Quality Criteria of Science Communication Online

In the second section, we would like to return to science communication quality. In the first wave, we asked you for the most important quality criteria for evaluating science communication online. We summarised your responses and ordered them into five groups:

- Content criteria: The characteristics of the content of the communication
- Presentation criteria: General user-oriented criteria
- Technical criteria: The specific characteristics of digital communication
- Context criteria: The respective background of the communication
- Procedural criteria: The conditions of production

Many of you have argued that quality criteria always depend on the actual situational setting of communication. For instance, one respondent stated, 'What makes for a quality post on "I fucking love science" won't cleanly, clearly or necessarily apply to what makes for quality content in the New York Times'. (P12). We agree with this assessment and also see the need for different quality criteria that are 'appropriate to what people are trying to do' (P7) and the respective situational settings. However, we are interested in exploring whether there are some criteria that could be regarded as general quality criteria for science communication online.

The following table gives an overview of the criteria mentioned.

QUESTION:

2) From the list below, which criteria are the most important to evaluate quality in science communication online in general? Please tick all that apply.

Content criteria

- ☐ accurate
- ☐ neutral/non-partisan
- ☐ objective
- ☐ factual
- ☐ complete
- ☐ evidence based
- ☐ empirical
- ☐ relatable
- ☐ based on the most current and best evidence
- ☐ not distorted/ unbiased
- ☐ truthful
- ☐ relevant
- ☐ depth of themes
- ☐ representation of multiple perspectives

Presentation criteria

- ☐ appealing
- ☐ engaging
- ☐ comprehensible
- ☐ clear
- ☐ interesting
- ☐ stimulating
- ☐ share-worthy
- ☐ informative
- ☐ civil
- ☐ brief
- ☐ aesthetic
- ☐ simplified
- ☐ accessible (language/style)
- ☐ entertaining
- ☐ transparent regarding context of communication (e.g. author, intention, sources, funding etc.)
- ☐ accommodation of diversity

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Technical criteria

- ☐ technically accessible for relevant audiences (target groups)
- ☐ attractive in the given medium
- ☐ opportunities for dialogue/feedback and/or participation
- ☐ creative in technical terms
- ☐ integration of contextual cues (likes, shares, comments)
- ☐ providing links to related content
- ☐ connectivity
- ☐ dynamic/interactive

Context criteria

- ☐ reliability of evidence
- ☐ competence of author
- ☐ morally acceptable intent of communication
- ☐ morally acceptable funding and agenda
- ☐ expertise of sources
- ☐ deriving from independent research
- ☐ orientation towards public good/without a particular agenda

Procedural criteria

- ☐ clear motivation, aim or purpose
- ☐ clear definition of goals, objectives, outcomes
- ☐ measurable indicators for evaluative work
- ☐ effectiveness/impact in the short and long terms
- ☐ application of evidence-based practices to design science communication (e.g. from psychology, audience research)

QUESTION:

3) Are there criteria that you would like to add?

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Now, please think of the following situational settings of digital science communication:
A. A news section on a university website presenting the latest research from their organisation
B. The Twitter thread of a scholar commenting on policy issues by referring to the latest evidence
C. A governmental campaign on different social media referring to public health issues
D. The blog of environmental activists citing scientific studies to strengthen their argument
E. An influencer's post on Instagram presenting spectacular scientific experiments
F. A podcast provided by the science section of a leading daily

QUESTION:

4) Please select two of these situational settings. How would these differ in terms of quality? Please explain which criteria would be relevant, and which would not apply.

III. Promotion of Quality Standards

Finally, we would like to revisit possible approaches to assess, promote, convey and/or secure quality standards in digital science communication online. We received a broad range of responses representing very different and potentially conflicting arguments from which we have built a positional map to visualise the main positions in this discourse.

Based on the analysis, there are two extreme positions: one argues for the total independence of the online sphere, while the other argues for direct interventions by regulatory bodies, platform companies or other entities. Between these positions, setting incentives presents a third way to promote science communication quality in the online world. Moreover, responses that resemble these three positions might be distinguished regarding the degree of formalisation or institutionalisation. Figure 1 displays these major positions.

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QUESTIONS:

5) In your observations of the online science communication landscape, which activities on the map do you think are already taking place?

6) Which of these approaches has the potential to ensure sustainable quality standards and might be strengthened?

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7) What should the role of science communication professionals be? How could science communication professionals be encouraged to reflect on these quality issues?

8) What role(s) could science communication researchers play in increasing science communication quality in the digital world?

IV. Sociodemographic Information

Finally, we would like to ask you for some sociodemographic information.

9) Please name the country in which you are currently employed.

10) Please indicate your disciplinary background.

- ☐ Communication science
- ☐ STS
- ☐ Media Studies
- ☐ Psychology
- ☐ Political Science
- ☐ Other, please indicate

11) What is the level of your current position?

- ○ Pre-doc/junior researcher
- ○ Assistant professor/post-doc/senior researcher
- ○ Associate/full professor

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If there is anything else that you would like to tell us, please use this space.

Thank you for your support and investing your time in our research! We hope that our work can also contribute to the overall discourse on science communication quality. The next step in the context of the RETHINK project will be to discuss the outcome of this DELPHI study with science communication practitioners, scientists, journalists and decision makers in six European countries. We are looking forward to their input and will be happy to share our results in the near future.

The study is conducted in the context of the project RETHINK which is funded by the European Commission in the Horizon 2020 framework (SwafS-19-2018-2019).

If there is anything else that you would like to tell us, please send your questions and remarks to birte.faehnrich@bbaw.de

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4. Raw Data

Wave 1

Conceptualising science communication in the context of digitalisation

ID	Q1 Definition of science communication in the digital media environment
P1	I wouldn't necessarily define it any differently in the digital media compared to any other venue or platform. There are myriad goals of, assumptions made and techniques used by science communication academics and practitioners. Some are shared quite broadly, others are more specialist or niche. Digital media also vary widely. The way, and the reasons, I would use Twitter would be different to YouTube, and this would in part be driven by my goal(s) for the particular communication enterprise I was undertaking. If I wanted to engage people with some content related to, for example, climate uncertainty, I might craft short video artefacts. But then I might use twitter to draw attention to them, or to circulate brief points from them in the media sphere. Science communication for me is far more about intent than platform.
P2	online mediated interactions between the scientific community and its members and non-scientists themselves, and between non-scientists concerning science-related issues.
P3	With the continuing change in the media ecosystem and the rise of digital media, boundaries have been eroded. Today, science journalists often work cross-media, tweeting, giving interviews as experts, writing books and sometimes political recommendations (cf. the examples in Allan et al. 2011; Dunwoody 2014). Even a (still quite small) proportion of scientists use social media to address audiences beyond their peers directly (Pscheida et al. 2013; van Noorden 2014). This is partly about imparting knowledge, but partly also about self-portrayal. In addition, facets of scientific work that were barely accessible 30 years ago - and can also be commented on, likened to or shared by non-scientists - become fundamentally visible to the public online and on social media. As a result, established role patterns become blurred, and the boundary between the academic specialist public and the general public "becomes blurred on the Internet" (Neuberger 2014: 339). The result is a mixture of science-related communication, which requires a new - and presumably ongoing - conceptual understanding. The concept of science communication is helpful because it can characterise this subject area and include more than "just" science journalism or public relations. Such a broad understanding of science communication should include "all forms of communication focused on scientific knowledge or scientific work, both within and outside institutionalised science, including its production, content, use and effects" (Schäfer et al. 2015: 13). This understanding is "broad" in several respects. On the one hand, it encompasses communication about all sciences, including the "MINT" subjects, the social sciences, behavioural sciences and the humanities, thus overcoming the reduction to the "sciences" that can still be found in the English-speaking world. There is also a "wide" understanding of the forms of communication: I even think it makes sense to use the umbrella term not only for communication outside science, but also for "scholarly communication", i.e. to extend communication within science. Because their audiences have expanded and their external borders have become more permeable: In repositories such as ArXiv, original scientific texts are openly accessible,

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	Twitter feeds, livestreams and blogs make research work accessible to a larger and non-scientific public, and specialist texts can be reviewed and evaluated on PubPeer or PubMedCommons, on VroniPlag or retractionwatch an extended audience can participate in the control of scientific misconduct, in Citizen Science projects (also in Germany or Switzerland) interested parties can participate in research, on crowdfunding platforms they can view sketchy funding applications and even co-finance research.
P4	Science communication includes any encounters with or representations of scientific knowledge - in this case in online spaces.
P5	For me, science communication is any direct or mediated communication in, for, or about science. As such, science communication was never only a basic journalistic domain, as described in the text above. I prefer a broad definition as the one I provided because in digital media environments, communication can still be more or less direct or mediated, the difference between digital and non-digital environments is that the former is always mediated through digital technology.
P6	I would define science communication as "the social conversation about science". This definition seeks to emphasise exchanges of information and ideas among citizens and communities over the more usual priority given to strategiic and persuasive communication from scientific agencies outwards towards non-scientist publics. The development of online media has influenced this definition: the means of participatory communication have become more easily available with the development of Worldwide Web from the early 1990s, and the many and diverse platforms that have grown up within the global network. However, it can also be argued that shifts in science-society relations towards greater openness and transparency of scientific institutions were already under way before "the digital media environment" emerged as we now know it. The development of digital media accelerated tendencies that were at least latent in society before their emergence.
P7	I define scicom as organised actions aiming to communicate scientific knowledge, methodology, processes or practices in settings where non-scientists are a recognised part of the audience. I am not sure the digital environment has changed that - but of course it has made it more complex. audiences are harder to get a grip on - both wider but also less segmented. communicators are much more diverse and it is much harder to assess credentials and distinguish between various forms of (non)authority.
P8	Anything connecting science / scientists with their stakeholders using online technologies
P9	For me, science communication is both a sub-field of communication practice and research focused on communicating about scientific research and other issues involving scientific questions (e.g. policies that involve scientific questions), as well as the scientific community (i.e. topics related to the trustworthiness of people who do science). Digital media, to me, is just a question of broad category of channel and has no specific meaning except inasmuch as digital media provide a distinct set of affordances that other channels may not.
P10	Public communication of science can be defined as efforts, initiatives and platforms that make science-related information (about new advances in science and the process of science) visible, accessible and relevant to diverse public audiences in a way that they find meaningful and relevant, and that enables them to respond. This definition can apply to physical environments, but equally to digital environments.
P11	Broadly. I think anything that has the potential to impact perceptions of science, whether these are the perceptions of lay audiences, scientists themselves, government officials, activists, etc. To me, science communication is journalist articles, blog content, social media posts, link sharing, memes about science, and audience comments that might follow all of the above, etc. If it can impact how people think about science and it is being shared or consumed, it will fall under my umbrella definition of science communication.
P12	I guess I'd define science communication (practice) as any communicative interaction about 'expert knowledge of the empirical world'-that's a

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	crass but workable definition of science-where that knowledge matters and is central to the interaction, most commonly between those in a privileged position regarding this knowledge (scientists, journalists, etc) and some lay or non-expert audience. This encompasses anything from popularisation, eg from scientists to lay public, through to engagement activities, eg RRI where discussion can flow both ways, through to participatory science. I'd define science communication (academic) as the study of such practices, including the theories underpinning them, their implications, the processes at play, and so on. In the digital media environment, I think this is the same, though it might manifest in its own particular ways, so galaxy zoo is less "hands on" and social engaged than the Christmas bird count (you can't all go out for drinks at the end of the day), yet YouTube is more interactive than classic media.
P13	Social media posts about science, science blogs, science videos on YouTube, Vimeo, or other platforms, science memes on various platforms. Communicators might include science communication professionals (e.g., public information officers, journalists) or those who generate knowledge and wish to share science (e.g., scientists).
P14	I define science communication broadly as any communication referring to science (as body of knowledge, as epistemic approach, and as social system) and scientific expertise (i.e. science applied to practical problems and decisions). Two distinctions are important regarding (1) the community or culture in which the communication takes place (simplified as dichotomy within science/between scientific peers or crossing the borders of science/between scientists and non-scientists or between non-scientists), and (2) and the character of communication as private vs. public (roughly distinguished between strictly private communication between two or few people, semi-public communication such as in conferences, school classes or organizations that require some kind of membership, or public communication that principally everybody can become involved in without invitation or membership). While the general definition (first paragraph) applies to digital media environments too, digital media strongly affect the two mentioned distinctions. Digital media environments increase the overlap of scholarly and popular communication (e.g., scientific sources become available to non-scientists - Open Access; scientists use social media like Twitter and blogs to address a mixed audience; scientists respond to communication of non-scientists). Furthermore, digital environments tend to blur the distinction between private and public communication. The same media (e.g., WhatsApp, WeChat, Facebook, Twitter) can be used for individual communication, for communication in networks of different sizes, or for public communication).
P15	Science communication in the digital media environment is a collective learning process by adaptive and interactive communication tools. Inclusive public engagement activities, where people could accept possibilities for two different perspectives to be right at the same time, based on an environment of mutual trust, is one of the key issues.
P16	From my understanding, science communication is a field of research and practice. Science communication research has moved from a focus on scientific literacy and understanding to a focus public participation and engagement. Much of this work has focussed on the activities of institutionally-supported forms of science communication carried out by or supported through funding by research organisations, government bodies, media organisations or cultural institutions, such as science centres. The focus is on how science communication can, or is moving away from one-way methods of communication to emphasise the "democratisation" of science. Most recently, researchers have taken a "Science in Society" lens, which looks at how publics talk about and use science outside of institutionally-sanctioned settings. This includes digital settings such as websites, blogs and social media platforms. From a professional practice perspective, science communicators rely on institutional or

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	philanthropic funding to carry out their work. . Much of this funded work aims to increase science literacy or understanding but under the language of "public engagement". Some online science communicators are attempting to work independently on their science communication activities and are achieving some success because they are filling holes left by the decline in institutional support for regular science reporting and broadcasting.
P17	From my understanding, science communication research has moved from a focus on scientific literacy and understanding to a focus public participation and engagement. Much of this work has focussed on the activities of institutionally-supported forms of science communication carried out by or supported through funding by research organisations, government bodies, media organisations or cultural institutions, such as science centres. The focus is on how science communication can, or is moving away from professionals engaging in one-way methods of communication to emphasise activities that focus on the "democratisation" of science. Most recently, researchers have taken a "Science in Society" lens, which looks at how publics talk about and use science outside of institutionally-sanctioned settings i.e. how non-professional science communicators communicate about science. This research includes public communication happening on digital settings such as websites, blogs and social media platforms. From a professional practice perspective, professional science writers/communicators rely on institutional or philanthropic funding to carry out their work. Much of this funded work aims to increase science literacy or understanding but under the language of "public engagement". There is increasing pressure on professional science communicators working institutional settings to use online and social media to attract audiences. Some online science communicators are attempting to work independently on their science communication activities and are achieving some success because they are filling holes left by the decline in institutional support for regular science reporting and broadcasting. There is also an emerging group of science communicators who do not identify as professional science communicators using previous understandings. These individuals are difficult to capture through institutional channels.
P18	Science communication encompasses the communication of scientific information from scientific authorities to the public, as well as public engagement with scientific topics and issues that arise surrounding the support of, or potential regulation of, scientific research and applications of new scientific developments. In addition to providing numerous low-cost channels of communication, the digital environment uniquely enables a variety of public engagement activities, including commenting, discussion forums, and of course social media.
P19	First: I do not come to science communication from a journalism angle, but from the angle of informal science learning or choice learning, which is a different tradition and different academic school of thought. In this tradition, science communication is a bi-directional process of mutual learning between an audience and a science communicator in a facilitated process in which both sides learn. In this tradition, science communication and science engagement are not much different, and only differ from informal science learning in who the actors are and what they are aiming at. All that said, science communication in the digital media environment pertains to any form of engagement on- or offline in which media are used for interaction between parties around scientific ideas, concepts or processes. Alas, I think definitions will not be helpful. More helpful will be to draw fuzzy boundaries around the concept of science communication and the concept of digital media environments.
P20	Science communication in the digital media environment as in pre-deigital era is defined by the focus on matters of science (technical knowledge, public debates and controversies about them, and types key players active in field). Is is however increasingly if not enotrely non-distinct from
P21	Science communication is highly dynamic and distributed interaction in a socio-technical network amongst and between scientists, engineers, policy makers, industry and the lay audience, concerning all the topics raised by and through the development of science and technology in which opinions, ideas and facts are not perse clearly seperated.
P22	Science communication in the digital environment continues its traditional purpose of public education and management of attidues toward broadly understood science. At the same time it benefits from adopting certain features and affordances of the new communication technologies while it also confronts the arising disadvantages, mostly to do with facticity, trust, transparency and ways in which they are reflected in public

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	agendas and discourses about science matters. In this sense science communication is more similar now to other forms of public and promotional communication: in the hybridity of its forms, great vigour injected through more interactive media (social media, apps) and opportunities afforded by easier and more attractive visual language avialable to communicatiors. At the same time, however, science is perhaps more acutely politicized now in the murky, emotionally charged environment of the social media and its dynamics of both fragmentation and virality. Science communication thus can become a battle ground rather than a meeting place.
P23	I would define it in the same way that I would define science communication in a cultural environment that does not just include digital media. I would define it as the communication of scientific facts, concepts, frameworks of understanding, through public culture -- a broad culture that comprises experts from other areas of knowledge, journalists, writers, critics, and citizens -- with the aim of increasing public understanding of scientific facts, processes, and scientific culture.
P24	In my view, science communication is any intentional attempt or initiative to bring together or bring into dialogue representatives and representations of the universe of science and representatives and representations of the larger society. The same conception applies to the digital world, where there is a huge range of new possibilities for this approach and dialogue to take place.
P25	Everyone communicates whether they want it or not, so the definition of science communication comes down to the content being communicated (or not). Many important topics in the public domain are informed by scientific efforts, from the economy to space exploration. A news article about inflation rates (from and economic perspective) can be a science story depending on the frame and the sources used. Journalists are typically seen as one of the main actors in the communication of science, but now scientists, PR offices at universities, laypeople, NGOs, etc. communicate frequently about science in multiple platforms. Science communication is the dissemination of information about scientific ideas to specific audiences across specific platforms with a particular goal.
P26	Science communication is any kind of communication that makes science an issue.Communicators can be representatives of the science system, but also external actors such as journalists, citizens and interest groups. This is a broad understanding of science communication. In the digital context, the diversity of communicators increases. For an overall view, it is good not to define "science communication" too narrowly.

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ID	Q2 Most important criteria	Q3 Where should quality criteria for science communication be drawn from
P1	For me, quality criteria depend on the intent of the communication enterprise. If the goal of a communication was to convey the vastness of space to people with minimal astronomical knowledge, then pertinent, high-production-value videos might be critical to the 'quality' of the communication enterprise. If the goal was to make people laugh and relax with a little science-inspired entertainment, then a rough-and-ready, no-script and no-edit podcast could do the job brilliantly. Quality in either case would be a matter of the phenomenon being fit-for-purpose and fit-for-audience, less a matter of some intrinsic quality of the communication artefact itself (whether online or otherwise). Even something as superficially simple as "accuracy"as a quality criterion might not be important if your goal is to inspire people to act. Being wrong could motivate certain audiences to engage with the material more stridently than being correct.	See above.
P2	evidenced-based transparent regarding its author and sources used transparent regarding its funding and agenda accessible to wide audiences facilitates informed decision making or further learning/engagement with the issue	media literacy, education, journalism
P3	First an foremost: this VERY much depends on the audience. I think accuracy is the basic underlying criterion - but scicomm can't be 100% as accurate as a scientific paper - it always needs to simplify. so the question is: how much, and in what dimensions? Neutrality is important as well: scicomm should be a neutral, "honest broker" communicating without an own particularistic agenda. Reaching an audience is also a quality criterion. If only accuracy was important, everybody could read scientific papers. But obviously, few people do. So reaching people is important, and that means: adapting your communication, going where you can find an audience, and ultimately making a compromise between 100% accuracy and being appealing to people	Again: First an foremost: this VERY much depends on the audience. Accuracy should be drawn from science. Neutrality from journalism. Reaching an audience: from PR.

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P4	I am not sure that 'quality' is a helpful term or criterion. It will always be locally defined rather than universal - as in, quality is always in the eye of the beholder. Perhaps it is more useful to ask whose needs are being served, what work is being done, or what voices and knowledges are being reinforced in particular examples of science communication.	Again, I think that 'quality' in all these domains is contested - so it is not clear how they could act as inspiration. Journalism is perhaps the most useful point of comparison as this has a long tradition and explicit reflection on its role in democracy and as a means of enabling critical public sphere debate.
P5	Quality criteria for different science communication phenomena is a clever term, as it can relate to many different aspects of quality assessment. First of all, there is the 'source' of information - this source can be evaluated based on quality criteria (experience, competence, integrity, credibility, etc.). Secondly, there is the actual 'content' - which, as well, can be assessed based on quality criteria (e.g., in line with what I know so far, believable, etc.). In digital contexts, the source of information and the content can be placed on different digital platforms (such as YouTube, Facebook, a news site etc.) and the the quality of this platform has to be taken into account as well. On many platforms, there are also contextual cues, such as likes, shares, comments etc. that impact quality assessments as well.	I believe that quality assessments are based on subjective, individual perceptions. As such they should be drawn from psychological research on this matter.
P6	Quality criteria for science communication were weakly developed before online platforms emrged. In the dominant science-centric view of two or three decades ago, accuracy in information was the primary, if not exclusive, criterion. Partly through shifts in thinking about models of science communication, this very restrictive basis of assessing quality lost validity. But there was not much effort given to developing alternative criteria. Considering online communication generally, some issues quickly came to attention that remain with us, also in relation to science communication online. These include: widespread anonymity (or pseudonymity) among Internet users; the ease of recycling impact-ful, and possibly false, infomration and the difficulty of correcting or refuting it; the repetition of information without attribution to its source. On the basis of concerns such as these, we can identify as quality criteria the following, among others: clear identification of authors and publishers; authentication of claims to be informed or authoritative; transparency as to how stories or arguments have been constructed; full attribution of information to original sources. However, the definition of science communication as "the social conversation about science" suggests one quality criterion above others -	Quality criteria for science commmunication could be drawn from the three sectors named - from journalism (e.g. independence of the communicator to present their information and point of view but also avoidance of conflicts of interest); from science (e.g. visible rigour in assembling evidence and argument); from public relations (e.g. care in identifying publics and their interests). The basic elements of ethics in journalism, science and public relatiions are closely related to each other and the core principles of good practice and professional standards that apply in these sectors also have application, with relevant modifications, in science communication.

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	what does a given piece of science communication contribute to the social conversation?	
P7	that depends very much on the purpose of the communication. If it is to convey information, of course quality relates to how effectively it does that. If the purpose is to inspire interest or curiosity the quality criterion has to be about that - and so on. Identity creation can be important and should be measured in terms of story-telling My main point is that we cannot have one single quality criterion - we need many - appropriate to what people are trying to do.	Following from the thing above, it is clear that they should be drawn from different places - depending on purpose.
P8	It's probably to diverse to attempt to affix one quality criteria, but in my own efforts to communicate science online I would always seek to maximise both engagement and accuracy of concept being discussed.	From a robust ethical conversation involving science and its key stakeholders
P9	In the end, effectiveness seems to be a question of whether you have the impact you intend to have both in the short and longer-terms. In this regard, my sense is that communication can affect various beliefs (trust-related beliefs, efficacy beliefs, normative beliefs, identity beliefs), feelings (i.e., various discrete emotions), and frames, as well as overall salience. If you change a belief, feeling, or frame on purpose or purposefully make something salient than you've been initially effective. More broadly, if the beliefs, feelings, frames, or salience leads to intended behavioral outcomes than you've been more substantively effective.	Individual, organizational, or institutional goals (noting that things like journalism can be understood as a societal institution).
P10	The credibility and accuracy remain important criteria, coupled with accessibility (both in terms of the platform and the language/style). It should also be clear who the communication is for (target publics) and the content should be relevant to them. As far as possible, there should be opportunities for dialogue/feedback and/or participation by the audiences.	In my view, the best place to look for quality criteria for science communication, is the emerging field called 'the science of science communication', spearheaded by the National Academies of Science in the US. The rationale for this effort is exactly to look for evidence of what works in science communication, instead of communicating science according to a 'gut feeling'. Over the last few years a considerable body of knowledge has emerged - from scholars in fields like communication science and behavioural psychology - about what works (and what does not) when science is communicated to lay audiences. In particular, this body of knowledge considers how communication is affected by so-called 'disrupted' communication ecosystems, including digital platforms.
P11	While I am inclined to say "accurate," I'll actually start by saying that content needs to be engaging to the target audience. If audiences don't pay attention to something, it kind of doesn't exist (i.e., if a tree falls in the woods and no one is around to hear it, does it make a sound?). Quality science communication will be content that audiences want to consume. In	All of the above. If we are communicating through media, we need to understand the demands and logistics of journalists, editors, etc. If we want to get better at message framing and targeting communications we need to embrace (rather than run away from) the

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	the digital environment this also likely means they are willing to share it to others so we are not preaching to the choir. Accuracy is probably the next most important quality criteria, in my opinion. With mis/disinformation emerging as problems in science, it seems critically important to place an emphasis on determining the quality of content so as to make sure it is not fabricated or false. This means that issues related to being objective, fact-based, and complete are important characteristics. This means it should be non-partisan, especially for issues that might be politically contentious. As a researcher, I'll note that quality content should be empirical and based on the most current and best evidence. It should also be clear and targeted. It should be written with purpose and for an audience in the same way we target political campaign materials, ads, etc. If the goal is to build public support for science, we should not be afraid to embrace the toolkit that best positions us to do so (e.g., those of marketers, advertisers, etc.). If I am listing the quality criteria, here is my current list: 1. Engaging (interesting, stimulating, share-worthy, etc.) 2. Accurate (objective, factual, complete, not distorted, non-partisan) 3. Empirical (informed by high-quality research) 4. Targeted (phrased clearly and written with an audience in mind)	practices of advertisers and marketers. We should (and do) study communication using science-based methods, searching for evidence to answer the tough questions. We should study popular culture to understand what different audiences care about and follow in the digital space. In other words, we should cast a wide net when trying to better the practice of science communication.
P12	I can't answer that as is. I think "quality" is only meaningful when related to aim/goal/aspiration. So what makes for a quality post on I fucking love science won't cleanly, clearly or necessarily apply to what makes for quality content on the New York Times. If I were to throw some potential criteria, I guess I'd say a) some commitment to accuracy, something like "truthiness" and not truth per se, because sometimes, (science) fiction can be incredibly instructive in terms of imagining implications of science. b) an understanding of for the audience (and a respect of the audience) c) and maybe this is the most important, but hard to assess, a clear motivation, aim or purpose and an alignment from goal to practice (especially in terms of getting to the right audience in the right kinds of	All of these and more. Science communication is related to all these, but it isn't any of these (unless the field wants to box itself in), so while these are all helpful, science communication should dream a little about what it wants to be; what it aspires to.

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	way).	
P13	Goals and objectives of the communication should be met.	Unsure of the "quality" to which this question is referring. Much of the quality criteria will depend on the goals and objectives of the communication.
P14		
P15	Three criteria; "communicating for", "listening for" and "learning with."	The areas where an interactive communication, or a dialogue on science, technology and innovation happens.
P16	From my understanding, science communication is a field of research and practice. Science communication research has moved from a focus on scientific literacy and understanding to a focus public participation and engagement. Much of this work has focussed on the activities of institutionally-supported forms of science communication carried out by or supported through funding by research organisations, government bodies, media organisations or cultural institutions, such as science centres. The focus is on how science communication can, or is moving away from one-way methods of communication to emphasise the "democratisation" of science. Most recently, researchers have taken a "Science in Society" lens, which looks at how publics talk about and use science outside of institutionally-sanctioned settings. This includes digital settings such as websites, blogs and social media platforms. From a professional practice perspective, science communicators rely on institutional or philanthropic funding to carry out their work. . Much of this funded work aims to increase science literacy or understanding but under the language of "public engagement". Some online science communicators are attempting to work independently on their science communication activities and are achieving some success because they are filling holes left by the decline in institutional support for regular science reporting and broadcasting.	
P17	I have been thinking about this quite a bit. I was recently involved in a study looking at the impact of digital transformation on science communication practices in Canada. We asked members of the Science Writers and Communicators of Canada (SWCC) to tell us what made good science writing and/or communication. They said that science communication needed to be accurate/factual, engaging, relatable, clear, relevant, and accessible—and used storytelling/narration, made particularly important language choices (e.g. simple language, no jargon), included independent research, and relied on credible/trusted sources of information. We also asked respondents to name up to three people or organisations who/that produce or engage in good science writing and/or science communication practices in Canada.	This is one of the challenges with science communication being a field, not one industry or sector. The field encompasses journalism, science public relations, and education. All of these are relevant and quality criteria must account for best practices/professional standards in these industries and sectors. This may include tensions and areas of difference in what is considered quality.

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	Respondents particularly noted the blogging salon, Science Borealis, the philanthropically-funded marine science magazine, Hakai Magazine, and the national broadcaster, the Canadian Broadcasting Corporation (CBC) as entities engaging in good science writing and/or communication practices online. We also survey French Canadian science communicators who were members of the Association des Communicateurs Scientifiques du Québec (ACS). ASC survey respondents indicated that good science writing and/or communication was targeted, rigorous, vulgarized, accurate, entertaining, accessible, with a message tailored to the public, and created a good connection with the public. They particularly noted Radio-Canada and Les débrouillards magazine as entities engaging in good science writing and/or communication practices. I think these responses are worth consideration.	
P18	Factual and scientific accuracy stand out as some of the most important and most widely applicable criteria. However, an important caveat is that a variety of ethical, social, legal concerns are extremely relevant to healthy science communication, yet operate somewhat independently of objective scientific facts. For example, ethical debates about gene editing may include important perspectives that should be a part of regulatory and broader social discussions, but do not necessarily engage the nuts and bolts of how gene editing works. Here, representation of multiple perspectives (or at least equality of opportunity for expression of multiple perspectives) may also be an important criterion. At the same time, in the context of content designed to educate the public about objective scientific facts (as well as processes, procedures, findings, etc.) may be complicated by a wide representation of possibly critical perspectives. Context is important.	If we consider public engagement as a fundamentally democratic concern, democratic theory may provide useful insights for determining and evaluating quality. Do citizens receive the information they need to make decisions and provide healthy input into democratic processes relevant to science? Do spaces afford citizens the tools and resources required to engage in healthy public discourse?
P19	Wait, not what does it mean to conduct quality science communication, but more narrowly what the most important criteria for evaluating it? Those are different. But OK, just for evaluating. Well, that asks the question: who asks for the evaluation and what are their criteria for quality or success? In that sense, the most important criterion is that someone who funds or designs it thought deeply about what they wanted to accomplish, and does so with realistic expectations (so no such vision statement-y stuff as increasing public science literacy).	Wherever the source s from. If it is a journalism effort, then clearly journalism standards have to be used. If it is an informal science education effort, then we want to look towards this (huge) community for standards of quality. If it is edutainment, then look there. This is important: science journalist aim at other things than educators, who aim at other things as entertainers, and again those are different from public information officers or marketing people. It all depends: are you seeking to convey neutral information? Are you seeking to increase the

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	I am sure this is not what you were asking for, so here something about quality: (1) have evidence-based practices in design been applied? (2) Are goals, objectives and outcomes clearly defined and linked to what is being done? Have measurable indicators been identified and operationalized that allow for evaluative work? When it comes to quality of the thing itself: Does it take into account the need and desire of the audience AND the designer?	capacity of the public to engage in scientific phenomena? Are you trying to change behavior or persuade people in some way? Hence, my answer is: it all depends.
P20	Science communication in the digital media environment as in pre-deigital era is defined by the focus on matters of science (technical knowledge, public debates and controversies about them, and types key players active in field). Is is however increasingly if not enotrely non-distinct from	
P21	From a systems perspective I would suggest the following criteria to describe the density and intensity of the interaction within the network. Whether this leads to a high or low quality of interaction is hard to say: - dynamics - density - connectivity	To me science communication is a distributed continous dynamic process of interaction in which the various contexts or disciplinary angles to the network are less relevant when it comes down to develop/define quality critiria for science communication as such. So to me the quality criteria should be based on socio-technical network itself. These criteria gain specific meaing when they are seen from e.g. journalism, science, etc.
P22	I am not entirely certain what you mean by science communication phenomena. Given the preamble to this question, I shall interpret this term as meaning formats and/or channels through which communication about science flows. To my mind quality criteria should be multi-dimensional and dervied from: 1.the purpose (strategic aim) for which such communication is conducted. (This may relate to 'traditional' criteria such as knowledge or interest activation) 2.technical quality (such as larity, appropriatness for specific audiences, attractivenss in the given medium) 3.creativity, both in technical terms (for example developing new methods of visualization or using /introducing interactive features) and, let's call them, rhetorical terms (related to argumentation, relevant science communication topoi, and stylistics) 4. public interest stance (orientatination towards public good, civility, and accomodation of diversity not to be understood as a carte blance for either	In my previous answer I have already indicated that I would privilege strategic communication (public relations, advertising) as a starting point. I argue that such purpose-focused framework should be augmented with other criteria by reaching to rhetoric, and to a combination of media literacy (as a critical approach to media texts such as those produced and encountered in the digital media) and audience research. Critically, however, I see science communication as a form of public communication and would therefore advocate also that attentionshould be given to public interest as an important criterion (if not necessaily the easiest one to operationalize in all contexts).

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	relativism or conflating facts with beliefs)	
P23	I think the same criteria applies online and offline -- a consideration of the source, their expertise, their motivation for communication, and the effect they hope to achieve with their communication. When evaluating a source's expertise, there are two concepts from science studies that are valuable and useful. Both come from the work of sociologists of science Collins and Evans and their work on expertise. The first concept is whether the source has a legitimate claim to be able to contribute to the public understanding of science. The second applies to specialist expertise, and asks what are the bounds of a source's expertise. How far does their expertise extend.	The criteria should be drawn from philosophy, specifically from the epistemology of knowledge.
P24	This is a difficult question as there isn't an objective way of assessing the quality of digital science communication initiatives. But there are some criteria that can help identify quality materials in a sea of misinformation. One of them, in my view, is the reputation of the sources, be they scientific institutions, academic journals, mass media or the researchers themselves. In the case of researchers, those linked to well-known scientific and academic institutions, with publications in relevant journals and with a strong presence in digital media gain more credibility. Well-aesthetically finished and well-written materials also tend to gain more confidence. Another quality criterion is the level of depth of the themes exposed and under discussion. Today many vehicles and initiatives just repeat what is being said on other platforms, without further critical and analytical reflection and without adequately explaining what is behind the big debates. Citing primary sources and providing links to related content where we can check data and more details on the topic discussed also helps users to trust the content they are having access to.	I do not believe that an instance will be responsible for dictating the quality criteria for science communication. These criteria are dynamically constructed by producers and consumers of science communication. In my opinion, what helps to create good quality criteria is a better training and greater commitment of the science communicators and a better education and critical view of society, users of science communication. But this is a long-term effort and it will only work if both education and science communication invest less in content transmission and more in stimulating reflection and critical thinking.
P25	The question of journalistic quality has been explored by researchers for quite a long time (see Lacy, S., & Rosenstiel, T. (2015). Defining and measuring quality journalism. New Brunswick, Rutgers). More specifically, some have attempted to provide a set of criteria for the evaluation of science or environmental stories (e.g. Rögener, W., & Wormer, H. (2017). Defining criteria for good environmental journalism and testing their applicability: An environmental news review as a first step to more evidence based environmental science reporting. Public understanding of science, 26(4), 418-433.). In journalism it seems a bit more straightforward to define such criteria than in non-journalism contexts. Some of these ideas can be used o think about quality parameters for science communication. Accuracy is	See above. Probably journalism in terms of content. If the goal of the communication efforts is to persuade the audience, I would say PR.

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	probably a key criterion, as is objectivity.	
P26	Quality must be defined differently for internal and external scientific communication: - Communication within science must be based on the methodological and ethical standards of a discipline, with the audience itself being counted among the experts. - External science communication aimed at a mass audience of laypeople must have different qualities. Here, in addition to scientific standards (transparency regarding authors and conduct of the study, degree of certainty of the results, limitations of a study, contradictory results in other studies, independence and transparency regarding financing, etc.), journalistic communication qualities must also be taken into account (relevance, comprehensibility, reading appeal, brevity, etc.). But standards can also be contradictory. Journalism tends to exaggerate results. In such cases, scientific seriousness should take precedence.	Science and journalism must be in the foreground. Public relations criteria should be of secondary relevance. The goal of university PR to gain reputation and trust should depend on the fulfilment of the standards of science. That this happens depends on the critical discourse in the public.

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ID	Q4 Quality assessment of science communication outputs online	Q5 How could quality standards for science communication in the digital media environment be conveyed and promoted
P1		Again, I'm sorry, but without context I don't know how to make sense of this question.
P2	I find this question very hard to respond to in the abstract. I get the impression the word "quality" here is being used as a substitute for "accuracy" or something similar, perhaps? Because I believe quality depends on goals and context, the idea that there might generic quality criteria (digital or otherwise) doesn't really make sense to me. Similarly, the idea that some kind of people should be in charge doesn't really work. If your goal is to be funny in a way somehow inspired by science, should there be a panel of comedians judging it? If you want to accurately convey astronomy or chemistry facts, then there would be different criteria and different judges. Climate change would be a wonderfully complex one here. If you want people to push for policy action that responds to challenges that have been flagged by climate science research, quality could be measured by the influence your communication had in getting into specific politicians' speeches. If you wanted to ensure a local counsel recycled more effectively, then the science content is irrelevant as long as they started to do so.	by collaborating with search provides (Google, YouTube) to add quality assurance tags on search results
P3	wisdom of the crowd + expert ranking	
P4		I am not convinced that they need to be. Who gets to decide what is 'good' quality? This is an inevitably political question.
P5	I think this is an impossible task. Any official assessment would inevitably be treated with suspicion; a more productive exemplar might be grassroots efforts such as Retraction Watch (in science) or fact checking sites (in journalism).	I guess the best way would be to work as closely with people as possible, but also in this regard, I am not sure how to do this.
P6	There probably should be such an assessment. The question then still is, what do people see as quality of science communication, what do they expect, what do they want. This is probably not a question of what is true and what is not. I do not support such categories, as science - for me - does not produce truth to that degree. Because of evidence criteria and limitations of research, science actually produces the best knowledge available in a given	As more science communication is done on a professional basis, that is, by suitably trained people employed specifically and perhaps exclusively for such work, the opportunities increase to promote quality standards, both through the founding education and continuing professional development such science communicators receive.The proliferating short training courses in public communication for scientists also offer a forum in which to promote quality standards.

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	period of time. Of course science communication can the be tested in that sense if it is representing the best knowledge available. But this is probably a narrow scientific view and does not account for the fact that people might interpret this knowledge based on their own predispositions. So yes, there should be quality assessment but how that would look like or who should be charge are questions I cannot answer at this stage.	However, even as this professionalisation gathers pace and these training initiatives multiply, there are many more individuals and groups engaged in forms of science communication who do this activity out of personal interest, as a pastime, or as a type of political campaigning. These actors maay be less amenable to learning about or adopting formal quality standards, though, in many cases, they may have developed standards for themselves that are equivalent. Forums, networks and associations of science communicators are increasingly evident at the level of cities, regions, states and the global community These may be a valuable means of spreading ideas about quslity standards and stimulating discussion on them.
P7	If these linked questions imply that there might be a single regulatory agency for such assessment, the answer must be No - mainly because such a form of quality assessment is not practicable in the digital media environment. This is too diffuse, even chaotic, to be effectively monitored or assessed in this way. The best that might be hoped for is some kind of community assessment, where non-governmental and non-institutional agencies apply critical scrutiny. A possible model for this is the blog, Retraction Watch, which monitors scientific publishing with a focus on retraction of papers; this interest group is funded by charitable foundations and public subscription.	By whom, for what purpose. Do you assume that we (the global community of the eco-system of science communication) can all agree on standards and constitute an authority that will enforce them?
P8	The question of 'should there be' seems to presuppose that it is possible to create and implement such a thing. I don't think it is, so I don't find it so interesting to discuss whether there should be one. I think we need to think of the eco-system of science communication as a pluralistic one in which many different actors contribute. The best we can hope for is that we foster a culture in which we can discuss openly and constructively criticize outputs with one another - right now such a communal culture of professional norms and critique does not seem to be much of a priority. But it would be better if it was.	Under educational authorities in each country.
	Yes, for school / educational resources. For everyone else no.	There's value in trying to articulate and codify social norms, though I'd be

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		hesitant to suggest that any one organization should have a monopoly on deciding what those norms are; it's for individuals or groups to show evidence that a norm exists and that any such norm has injunctive/proscriptive value.
P9	Should isn't the right word for me. If people want to assess quality then they can set up systems to do that and make an argument for why their approach is worthwhile.	In my view, this can only be effective is policy and funding organisations (such as science academies, scientific societies and science foundations) champion the cause of quality in science communication.
P10	Any form of evaluation and monitoring must be an integral part of the planning of a project from the start - not an afterthought once the project is already running. Every aspect of a communication strategy (or initiative) should be designed with evaluation in mind. A key starting point is to make the communication objectives (or goals) absolutely clear. If you don't know what you want to achieve, it is not possible to measure whether you have achieved it. The old adage of SMART objectives still holds true ... make your objectives Simple, Measureable, Achievable, Realistic and Time-bound. In addition to the efficacy of the communication, I think that it is equally important to think about ethics as a part of the quality of communication. What constitutes ethical (responsible) science communication? For example, the importance of being clear, honest and transparent about the project; not hyping up findings, talking frankly about limitations and uncertainties in science. The principles of effective public engagement are also relevant here: Openness to listen and learn from audiences; engaging in 'true' dialogue; being tolerant of different points of view; avoiding confrontational interactions, etc.	Tough to say. I'm curious to see what the other participants think of when they are asked to define "quality" standards. Perhaps work like this can help us coalesce around a definition of quality, but until that is established, how do you communicate something that is likely to involve much disagreement. The other problem is that it isn't just science communicators who communicate science. While the field of science communication is relatively small, so many groups are involved in communication that it makes it difficult to get everyone on the same page. Being more interdisciplinary is one approach. Publishing outside of one's typical journals is part of this, as well. Ultimately, the degree to which "quality standards" will be implemented and promoted by large groups of people is very much dependent on what "quality standards" are defined to mean and how widespread agreement with that definition happens to be.
P11	I'm not exactly sure what that means. If we are talking about policing what people post, that seems impossible and full of ethical questions. At the same time, we certainly need to be aware of the quality of content that people are encountering and identifying the best ways to correct misleading or inaccurate content. In other words, I am not for censoring "flat earthers," but I am for evidence-based countering of their claims to try to limit the spread of misinformation.	Ah! This is tough one and it seems very deeply platform dependant. I could imagine a set of symbols next to content which could be equally applied to facebook, twitter, google searches.

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	Our assessment tool should be focused on identifying potentially problematic content (false, misleading stories or claims that are actually spreading and being seen by people in digital spaces. There would be no central person in charge. But, partnerships would likely need to be made with the major social media platforms to quickly identify problematic content. If the content can be removed due to reasons that violate current terms of use, the content should be removed. But, if that isn't the case, emplying research-based approaches to correct or stifle the spread of misinformation should be employed. This would also apply to factually accurate, but misleading content.	
P12	I don't know that quality assessment is helpful unless something is done with that assessment (monitoring for monitoring's sake seems a waste). So the more fundamental question become "what would a QA model look like for SCOM in the digital media look like when applied." This turns to a political question of freedom of expression, trust, honesty etc. I actually think there should be some editorial oversight. The freedom of expression/speech argument is fallacious when applied to the digital media because freedom of speech doesn't equate to freedom of platform access and exposure. This seems important. So socailly harmful, dangerous material or intentionally deceitful content (epistemically harmful) seem to require moderation in some form or another, and conversely for especially meritorious content. As to who would be in charge, I don't have a good answer. I go back and forth on this, so if my thoughts clarify, I'll get back to you. Another questions is at what level it should be applied: on a google search page or on the actual article/page itself, for example. These might suggest different roles for different actors in the digital media world.	It seems like much of this will depend on who upholds these quality standards. For example, if an organization communicates science, then they should be responsible for the quality of their communications, which would align with their organization's goals.
P13	Again, the assessment of quality (or evaluation) should be based on goals of communication. Presumably, designer of the communication plan should be in charge of setting goals. With regards to who should be "in charge" in a more general sense, there are questions about the democratic potential of the Internet	

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	and freedom of speech that make this question a challenging one.	
P14		First, sharing and using the quality standards among science communication practitioners and researchers. Then, having dialogue with them to get the standards better. (Loop back to the first). We should keep in mind that there would be no perfect standards so we keep learning among the stakeholders.
P15	Of course, it is depending on the situation. When communication in the digital media environment is getting more and more impact on the process of science, technology and innovation policy, we need to assess science communication from the viewpoint of quality criteria. Some third-party organizations needed.	First, sharing and using the quality standards among science communication practitioners and researchers. Then, having dialogue with them to get the standards better. (Loop back to the first). We should keep in mind that there would be no perfect standards so we keep learning among the stakeholders.
P16	From my understanding, science communication is a field of research and practice. Science communication research has moved from a focus on scientific literacy and understanding to a focus public participation and engagement. Much of this work has focussed on the activities of institutionally-supported forms of science communication carried out by or supported through funding by research organisations, government bodies, media organisations or cultural institutions, such as science centres. The focus is on how science communication can, or is moving away from one-way methods of communication to emphasise the "democratisation" of science. Most recently, researchers have taken a "Science in Society" lens, which looks at how publics talk about and use science outside of institutionally-sanctioned settings. This includes digital settings such as websites, blogs and social media platforms. From a professional practice perspective, science communicators rely on institutional or philanthropic funding to carry out their work. . Much of this funded work aims to increase science literacy or understanding but under the language of “public engagement”. Some online science communicators are attempting to work independently on their science communication activities and are achieving some success because they are filling holes left by the decline in institutional support for regular science reporting and broadcasting.	
P17	I think a generalised quality assessment might be unrealistic given the diversity of the field. However, I do believe educational	The dissemination of information on best practices for the construction, operation, and feature sets of different kinds of digital spaces could be one

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	institutions teaching science communication and professional member bodies, such as national and international science communication organisations have a responsibility to promote best practices/professional standards for quality digital science writing/communication outputs. This includes organising awards and prizes for quality science communication e.g. the Science Writers and Communicators of Canada have a People's Choice award for Canadian Science Online - https://sciencewriters.ca/peopleschoice. They promote the finalists with the aim of encouraging quality science communication in Canada.	path. Again - context is important. For example, in some spaces, it may make sense not to offer commentary and discussion features, whereas these may be essential in others. In a word - flexible. Quality standards should be conveyed and promoted with an eye toward which standards make sense for which parts of the digital environment. Digital media offers unprecedented variability, which I think requires a more context-sensitive approach.
P18	Yes. However, carrying it out raises a number of difficult issues. The smaller question of who should be in charge, however, is somewhat more tractable. I think assessment would be best carried out by independent actors (i.e. neither government nor entities with financial interests at stake).	They should be defined and promoted within the specific communities of practice that represent those professionals who engage in them. I think that might also radiate out to laypeople, volunteers, and hobbyists who identify with one of these communities. In that sense this is a typical problem that is no different from any other place. It is easier, though, to reach these communities now. I am a little more worried about new communities that may not have professional organizations or organized forms of coming together which help facilitate the dialogue and community building necessary to create and socialize community norms. No community, no norms for quality.
P19	Sounds like censorship to me... Quality control has many layers, and we need to distinguish them or else it sounds like Big Brother. Layer 1: Those who design and conduct If they are professionals, then they likely are beholden to the standards of their trade. Some now regularly conduct evaluation, others don't. Depends on funding sources and demands from those. Then there are the market driven ones whose control criteria is commercial success. Inasmuch as only those things that find customers survive, the commercial success is the quality control. Layer 2: Those who fund or support: Media organizations, online providers, agencies etc: if they are in a professional environment, then they are highly motivated to play by the rules and ensure quality. No need.	They should be defined and promoted within the specific communities of practice that represent those professionals who engage in them. I think that might also radiate out to laypeople, volunteers, and hobbyists who identify with one of these communities. In that sense this is a typical problem that is no different from any other place. It is easier, though, to reach these communities now. I am a little more worried about new communities that may not have professional organizations or organized forms of coming together which help facilitate the dialogue and community building necessary to create and socialize community norms. No community, no norms for quality.

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	Layer 3: The Wild West of the internet, with fake news and misinformation, pseudoscience and conspiracy theories I think you are wondering about that. Let me start my answer by acknowledging the tension between avoiding harm to audiences, consumers, participants or the social fabric, and creating censorship by governmental agencies or private firms. If Facebook or Twitter are asked to take down clearly misleading or false stuff, where do they start and end, where is the line. Frankly, I am torn: I want to allow for mechanisms that out and shame the bad and the harmful, using the community as a control mechanism, but I also want experts with power and good will to eliminate the truly bad and harmful. I am just worried that when the tide turns (think Hungary), then what we see as good and high quality becomes bad and harmful in the eye of the powers that be. So: I don't know.	
P20	Science communication in the digital media environment as in pre-deigital era is defined by the focus on matters of science (technical knowledge, public debates and controversies about them, and types key players active in field). Is is however increasingly if not enotrely non-distinct from	One should keep in mind that the digital environment has its own values and might not allign with the values in the realm of science and technology development. Having said that, again it should be made clear that there is no right or wrong process, these criteria should therefore be used to foster reflection on the network by the professionals and lay audiences involved. So, these quality standards should be conveyed and promoted as reflective tools and not as deterministic tools.
P21	To further and nurture interaction this interation should only be assessed on a interaction/process level concerning activity, connectivity, etc. Any criterium that infleunces the free space of the digital environment should be avoided. e.g. criteria concerning the content.	This could be presented as for example as a rating, or some sort of seal of approval.
P22	I think it would be helpful for such criteria to be publicly kown and applied to examples of science communication. One might think here of a mechanism similar to fact checking as increasingly visible in political communication contexts (see for example FactCheck.org{EM_REGISTERED}, A Project of The Annenberg Public Policy Center). So, not for profit bodies who can demonstarte their impartiality and competence.	Formal training and guides to good practice can also help well-intentioned amateur science communicators not to fall into traps, dispense with authoritative science discourse, and pursue quality in science communication and public dialogue.

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P23	Assessments of quality rest with individual audience members. This is a skill of literacy that is similar to general media literacy in that audience members should adopt a critical stance towards any information they encounter in media, asking basic questions, such as: Who is the source of this claim? What is the evidence to support this claim? Why is this source communicating this information in this way? What effect does the communicator want to have? It is these basic critical reasoning skills that lie at the core of any evaluation of quality. Appointing someone as in charge of quality in online environments is doomed to fail, as online environments can be chaotic and impossible to police or control.	In online environments, communicators must demonstrate in almost all their communications their credibility, the evidence for their claims, and their motivation for communication. Only in that way can audiences evaluate in a transparent way, the communicators' motivations and therefore judge their quality.
P24	As I said, I do not believe that the quality criteria for digital science communication can be set top down by any specific instance and actors. This is a misunderstanding of what the digital world is. If, in the digital age, the very quality control of science, which is peer review, is in question, I find it naive to think that we could do something similar in science communication. I think any attempt to do so will spark a debate about legitimacy and authority that seems obsolete to me regarding digital content.	More science comm programs and more training.
P25	This questions probably applies to all forms of public communication, not only science. This could be a slippery road. Facebook has banned deep fakes as a start point. What else should be banned and is Facebook or whatever platform responsible for banning content? Twitter has its own criteria to remove content. Every platform would have a slightly different criteria. There has always been misinformation and sensationalized content, but now it is more widespread and easy to encounter, which is why we hear more calls to control it. Giving the responsibility to the content producers or disseminators seems dangerous. Some places like Singapore and China put that burden on the government, which can also be extremely dangerous. This is why I think that starting with the audience to improve media literacy should be prioritize. This way audiences would reward what they deem to be quality content and penalize inaccurate misinformation. This of course is also very challenging to accomplish, but the burden and responsibility is not giving to a small number of people that probably have their own self-	In addition to a discourse on the quality of science communication, there should be instructions (textbooks with case studies, training, codes of ethics). In addition to criticism, there should also be awards that name role models and provide incentives.

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interests in mind..

P26

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5. Raw data

Wave2

Conceptualising science communication in Digital Contexts

ID	Q1 Further categories situational settings
P1	
P2	I think actors should also include non-citizens (eg people from other countries focused on US politics), and definitely government organisations. I think that your 'intention' category should include more explicit elements of political / social change, and potentially even bad faith actors (disinformation campaigns, trolls).
P3	
P4	I think this is a good definition, and a good taxonomy. The examples in the second column of the taxonomy are not exhaustive, of course - other actors (think tanks, churches ...), roles (conflict parties, mediators ...), content etc. exist and would in fact fall under the mentioned definition.
P5	
P6	I would add "objectives" where you talk about the 'intentions' of the actors. One could (perhaps) think of adding a category of 'initiators' (i.e. who is behind these initiatives at a higher level that the public usually don't see, who encourages and supports it) - could be, for example, governments, research funders, lobby groups, etc
P7	
P8	No, the categories make a lot of sense. I also like the definition provided although you rightly state that it is broad.
P9	I would not just give examples for the categories, but develop a rubric for it like we did in the paper we wrote for AAAS: Storksdieck, M; Stylinski, C.; Bailey, D. (2016). Typology for Public Engagement with Science: A Conceptual Framework for Public Engagement Involving Scientists. Corvallis, OR: Center for Research on Lifelong STEM Learning. https://www.aaas.org/sites/default/files/content_files/AAAS_Typology.pdf One category that is missing (in part because your examples for modes of communication are confusing) is the degree to which communication falls on a spectrum of one-way to bidirectional (degree of engagement). Is the purpose to be a sender (but not receiver) of information on the one end of the spectrum, to full dialogue and two-way learning on the other end. This clarification is essential to the way one ought to think about the basic task or challenge at hand.
P10	
P11	
P12	Two points here: 1.I think I can understand why you did what you did with "Intentions", but I still wonder if motivations should not be interrogated more carefully. Looking at your intentions category, it seems that you recognise three: public education (with the sense of public interest being the key motivation here); change intervention (implicitly, in the public interest as we see in public health campaigns), and communication's/audience's gratification (with the uses&gratification theory in the background). How can you then account for other self-interested interventions (self-interest here not to be understood to mean necessarily completely untruthful communication). For example, when a company, or researchers communicate to influence research agendas (we have seen media discussion about which illnesses are profitable to develop medicines for and which are not); or where

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research/knowledge is used as a reputation/legitimacy tool for organizations; or finally, what about intentionally misleading communication, of which there is plenty manufactured for the digital circulation?. Are these purposes sufficiently explained by the ones your list? Or, do you think that declared intentions are sufficient?

2. "Popular" seems to be an odd one out in your Modes of Communication. It might be helpful to think about how you construct dimensions of your categories? Modes seem to be about content (facts, information), and for lack of a better term "genre" (argument, dialogue), and then there is "popular"???

P13 In our writing, we have also differentiated …

tone/style (aggressive, humorous, etc.)
framing (it's different because it's both a potential effect and context/wrapping to content)
level of cognition (fast/slow; heuristic/systematic; central/peripheral)

Dudo and I have also argued that it's yes to differentiate by...

Tactics -things communicators can directly control (message content, tone, source, channel, associated behaviors/context)
Objectives - things that tactics can affect in terms of processing level, beliefs/evaluations, feelings, frames
Goals - behaviors (which communication cannot affect directly)

With regards to things at the level of objectives and goals, we have also argued that ethical communication requires communicators to be open to changing their own beliefs/feelings/frames, as well as their own behavior. I'm not sure I see much above that suggests that a primary purpose of communication should be to potentially change the communicator.

P14 two further categories:

- internal forms (science, scholarly communication) and external forms (relationship between science and other societal systems as politics and economics, boundary-crossing)

- knowledge related types of action (exploration/research, testing of hypotheses, distribution, appropriation, public debating)

P15 Platforms seem very 2000s. Nobody blogs any more. Instead, one of the key distinguishing factors is how algorithmically-driven the delivery is. Is it pull in the sense that audiences visit sites, use news aggregators, or get news alerts on their phones? Or is it algorithmic in the sense that their Twitter, FB, Tik Tok feeds etc. are curated based on personal preference,s social networks etc.?

Also, should there be categories for:

- level of controversy (i.e., communicating about new cancer treatments vs. GMOs)
- level of competitiveness (i.e., are we dealing with a crowded communication space (e.g., renewable energy) where science is just one of many voices, and many frames etc. are already established, or something like COVID-19 where relatively unknown virologists can rise to superstardom because their messages are largely uncontested?

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P16	Perhaps type of science. I'm sensitive here that "science" does not have a universally shared definition (in some contexts and languages, it encompasses all intellectual fields, in other contexts, it's reserved for the bio-physical sciences). Another possible aspect is attitudinal disposition. Those of us involved/working in SCOM primarily (thought not only) focus on science communication done by those largely supportive or positive towards science, but not all those engaged in practicing SCOM share such positive views. Anti-GMO activists (for example) might be expressing a critical stance, yet do so by communicating science.
P17	Perhaps worth explicitly adding "activism", "political action" or similar to some of the examples (like under the "Intention of the actors" category). You could even add "polemic" to Modes of communication. While these kinds of examples could fall under the broader ones already listed, I'm thinking politically motivated action is becoming increasingly yes in some areas that could be considered 'sci comm'.
P18	The Table 1 has already showed a diversity of categories, thanks for developing a wonderful matrix. If we could add a category, I think "the level of inclusiveness" could be one of the categories. Actors involved category has broad actors, but I think, in an actor like citizens, there are diverse citizens. We need to include broad groups in the actors.
P19	First, three quick comments on the existing categories and examples: I am surprised to see no reference among Actors or elsewhere to science museums and centres. Levels of *publicity* appears to be a literal translation of the German Offentlichkeit; if there is an equivalent English word for this term, it would be *publicness* and that is very clumsy. So, the category might be renamed, Types of public. In examples for Types of effects, it would be useful to include 'pleasure' - in line with the entertainment and fun in Intention of the actors I would suggest adding the category, Contexts, for which examples might be informal learning, science centres,research centres, universities, science cafés, etc

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ID	**Q2 Most important criteria to evaluate quality in science communication online- Content criteria**													
	accurate	neutral/ non-partisan	objective	factual	complete	evidence based	empirical	Re-latable	based on the most current and best evidence	not dist-orted/ un-biased	Truth -ful	relevant	Depth of themes	representation of multiple perspectives
P1	no	no	no	no	no	no	no	no	no	no	no	no	no	no
P2	no	no	no	no	no	no	no	no	no	no	yes	yes	no	yes
P3	no	no	no	no	no	no	no	no	no	no	no	no	no	no
P4	no	no	no	no	no	no	no	no	no	no	no	no	no	no
P5	no	no	no	no	no	no	no	no	no	no	no	no	no	no
P6	yes	no	yes	no	no	yes	no	yes	no	yes	yes	yes	no	no
P7	yes	no	no	no	no	no	no	yes	no	no	no	yes	no	no
P8	yes	yes	no	yes	no	yes	no	yes	yes	no	no	yes	no	yes
P9	yes	no	no	yes	no	no	no	yes	no	no	yes	yes	no	no
P10	yes	no	yes	yes	no	yes	no	yes	yes	no	no	no	no	no
P11	no	no	no	no	no	yes	yes	yes	yes	no	no	yes	no	yes
P12	yes	no	no	no	no	yes	no	yes	yes	no	no	yes	no	yes
P13	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
P14	no	yes	no	yes	no	no	no	no	yes	no	no	no	no	no
P15	no	yes	no	no	no	no	no	no	no	no	no	no	no	yes
P16	yes	no	no	no	no	no	no	no	yes	no	no	no	no	no
P17	yes	no	no	yes	no	yes	no	yes	yes	no	no	yes	no	no
P18	yes	no	no	yes	no	yes	no	no	no	yes	yes	yes	yes	yes
P19	no	no	no	no	yes	no	no	yes	no	no	no	yes	no	yes

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ID	**Q2 Most important criteria to evaluate quality in science communication online- Presentation criteria**

	Appea-ling	En-gagin g	Com-prehen -sible	clear	Interes-ting	Stimula-ting	share-worth y	Informa-tive	civil	brief	Aes-thetic	Simple-fied	accessible (language /style)	Enter-taining	Trans-parent regarding context of communi cation (e.g. author, intention, sources, funding etc.)	Accom-modation of diversity
P1	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
P2	no	yes	no	no	no	no	no	no	no	no	no	no	yes	yes	yes	no
P3	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
P4	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
P5	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
P6	yes	yes	yes	yes	no	no	no	no	no	no	yes	yes	yes	no	yes	yes
P7	no	yes	no	no	no	yes	no	no	no	no	no	no	yes	no	yes	no
P8	no	yes	yes	no	yes	no	no	yes	no	no	no	no	yes	no	yes	no
P9	no	yes	yes	no	no	no	no	no	no	no	no	no	no	no	yes	yes
P10	no	yes	yes	no	no	no	no	no	yes	no	no	no	yes	no	no	yes
P11	no	no	yes	no	no	no	no	no	yes	no	no	no	yes	no	yes	yes
P12	no	yes	yes	no	no	no	no	no	no	no	no	no	yes	no	yes	yes
P13	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes
P14	no	no	no	no	yes	no	no	no	no	no	no	no	no	no	yes	no
P15	no	no	no	no	no	no	no	no	no	yes	no	no	no	no	no	no
P16	no	yes	yes	no	no	no	no	no	no	no	no	no	yes	no	no	no
P17	no	yes	yes	no	no	no	no	no	no	no	no	no	yes	no	yes	no
P18	no	yes	yes	yes	yes	no	no	no	no	no	no	no	yes	no	yes	yes
P19	no	yes	yes	no	no	no	no	yes	no	no	no	no	yes	no	yes	no

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ID	**Q2 Most important criteria to evaluate quality in science communication online- Technical criteria**							
	technically accessible for relevant audiences (target groups)	attractive in the given medium	opportunities for dialogue/feedback and/or participation	creative in technical terms	integration of contextual cues (likes, shares, comments)	providing links to related content	connectivity	dynamic/interactive
P1	no	no	no	no	no	no	no	no
P2	no	yes	no	yes	no	no	no	no
P3	no	no	no	no	no	no	no	no
P4	no	no	no	no	no	no	no	no
P5	no	no	no	no	no	no	no	no
P6	yes	yes	yes	no	no	no	no	yes
P7	yes	yes	no	no	no	yes	no	yes
P8	yes	no	yes	no	no	yes	yes	no
P9	yes	no	yes	no	no	no	no	yes
P10	yes	no	no	no	no	no	no	yes
P11	yes	no	yes	no	no	yes	no	no
P12	yes	no	yes	yes	no	yes	no	no
P13	yes	yes	yes	yes	yes	yes	yes	yes
P14	yes	no	yes	no	yes	no	no	no
P15	no	no	yes	no	no	no	no	no
P16	yes	no	no	no	no	yes	yes	no
P17	yes	no	no	no	no	yes	no	no
P18	yes	no	yes	no	no	no	yes	yes
P19	no	no	yes	no	no	yes	no	yes

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ID	**Q2 Most important criteria to evaluate quality in science communication online- Context criteria**						
	reliability of evidence	competence of author	morally acceptable intent of communication	morally acceptable funding and agenda	expertise of sources	deriving from independent research	orientation towards public good/without a particular agenda
P1	no	no	no	no	no	no	no
P2	no	no	no	no	no	yes	yes
P3	no	no	no	no	no	no	no
P4	no	no	no	no	no	no	no
P5	no	no	no	no	no	no	no
P6	yes	yes	yes	yes	yes	no	no
P7	yes	yes	no	no	yes	no	yes
P8	yes	yes	no	no	yes	yes	yes
P9	yes	no	no	no	yes	no	no
P10	no	yes	yes	no	yes	no	yes
P11	yes	no	yes	yes	no	no	no
P12	yes	yes	yes	no	yes	no	F
P13	yes	yes	yes	yes	yes	yes	yes
P14	yes	yes	yes	yes	yes	yes	no
P15	yes	no	no	no	yes	yes	yes
P16	yes	no	yes	no	no	no	no
P17	yes	yes	no	no	yes	no	no
P18	yes	yes	no	no	no	no	yes
P19	yes	no	yes	no	no	no	no

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ID	**Q2 Most important criteria to evaluate quality in science communication online- Procedural criteria**				
	clear motivation, aim or purpose	clear definition of goals, objectives, outcomes	measurable indicators for evaluative work	effectiveness/impact in the short and long terms	application of evidence-based practices to design science communication (e.g. from psychology, audience research)
P1	no	no	no	no	no
P2	yes	yes	no	no	no
P3	no	no	no	no	no
P4	no	no	no	no	no
P5	no	no	no	no	no
P6	yes	no	no	yes	yes
P7	yes	yes	no	no	no
P8	yes	yes	no	yes	yes
P9	yes	yes	no	no	yes
P10	yes	yes	no	no	no
P11	yes	no	no	no	no
P12	yes	yes	yes	yes	yes
P13	yes	yes	yes	yes	yes
P14	yes	yes	yes	no	no
P15	no	no	yes	yes	yes
P16	no	no	no	no	yes
P17	yes	yes	yes	no	no
P18	yes	no	no	yes	yes
P19	yes	no	no	no	no

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ID	Q3 Quality criteria to add	Q4 Quality criteria relavant in different situational settings
P1		
P2	I think that your content / presentation criteria misses the importance of story - if I was assessing a science communication product I would look first and foremost to assess that it is truthful (accurate, impartial, holistic) and story driven (engaging, values oriented, audience focused).	C and E obviously speak to very different criteria - one is seeking first and foremost to be engaging, the other is seeking very much to be accurate, impartial and formal. Both however should be judged on how successfully they connect with their audiences / provide relevant information, so it's more a difference of emphasis than kind.
P3		
P4	I struggle with the above question, for the reasons stated in the question: it depends on the context. What do I want to achieve, in which audience. Therefore, I don't think this is a very useful exercise.	
P5		
P6	No, I think this list is already quite long (some overlap). However, with a focus on 'who' communicates, I think 'credibility' (encompassing perceived expertise and trust) is also key.	In A (university research web site) content and context criteria would be most yes, in particular, transparency about the funding of the research; as well as presenting it truthfully and without distortion (no hype or overselling). Although, one could argue that most of the other quality criteria would also apply, so it is not easy to exclude some of them. In C (government campaign on social media), presentation criteria would be paramount (making it engaging, clear, brief, and simple and catering for diverse audiences), but you cannot exclude the other criteria. So, I would argue that it is a matter of relative importance of different criteria in different settings, rather than a case of some not applying. They all apply, to a greater or lesser extent. Note: in terms of context, I think all communication has an agenda, even those orientated towards the public good.
P7		A has to consider the political and competitive interest of their organisation at the same time as they have to do fair and correct scicom - a balance B has to establish a trustworthy persona with credibility, authority and authenticity - also a balance F has to criticially inquire into the science - not just results but also the way it is organised, fundet etc.
P8	No.	I select settings A and B. The two can potentially differ on all criteria

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		developed. For instance, when it comes to content criteria, A could be biased in that sense that it is organizational communication (where it is also about reputation building) but at the same time B could be biased as well towards the specific perceptions of that scholar. Both can be, but not necessarily are accurate, neutral/non-partisan, objective, factual, complete, evidence based, empirical, relatable, based on the most current and best evidence, not distorted/ unbiased, truthful, relevant, showing depth of themes and representing multiple perspectives. I think this is pretty much dependent on the specific goals these communicators have. At the same time, presentation criteria differ, but this seems to be dependent on the specific digital platform that is used. The question whether these platforms are appealing, engaging, comprehensible, clear, interesting, stimulating, share-worthy, informative, civil, brief, aesthetic, simplified, accessible (language/style), entertaining, transparent regarding context of communication (e.g. author, intention, sources, funding etc.) and accommodating diversity seems to be dependent on the platform, and any evaluation lies with the audience. However, communicators have a say in that sense that they chose which platforms to use. The same applies to technical criteria, for which communicators have an impact when choosing platform. Referring to the examples, a university website might reach more specific audiences than does Twitter. However, Twitter has often been described as being an elite medium. Clearly opportunities for dialogue/feedback and/or participation, as well as contextual cues are increased on Twitter but you need to have an account (you don't need that for the website). For the context and procedural criteria, again, I have to say it depends. There is no easy solution, as communicators and platform interact in these criteria and at the end, any quality assessment is in the eye of the audience.
P9	This exercise is murky. I would prefer a clean definition of what you mean by, for instance, procedural criteria (these groupings). Your half sentence summary from above is not sufficient. That would allow me to get a better sense of whether the 5 sub-criteria are	A vs C: purpose and target group are different; in A the message is to support the sender; in C the sender requires audience trust to change behavior. Etc.

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	sufficient, or whether something is missing. Something is off here. The sub-criteria are also not entirely clear. What do you mean, for instance, by "morally acceptable intent of communication"?	one can noodle this through the various permutations, but the message is clear: we are comparing apples and oranges and, so your rubric chose about success and best practices needs to adjust to purpose, all within the context of the silly debate within science communication on which of these 6 scenarios are legit.
P10		B and F The scholar might have some experience on Twitter doing science communication, but they might not be aware of basic principles. The immediacy of Twitter might be more prone to writing mistakes, as opposed to a more controlled context were things can be edited and more time spent on the final product, such as a podcast. Both would probably rely on the latest evidence, but the podcast would probably be more engaging and accesible. Motivations might be clearer to asses for the podcast (e.g. informational), specially if the scholar is not someone one follows already.
P11		
P12	I can't think of anything else :)	B. I would treat this as a expert scrutiny conducted in public so and in this case, it seems to me that the following are most salient: accuracy, representation of multiple perspectives, comprehensibility and accessibility and diversity; providing links, orientation to public good. The aim here is to avoid discursive closure and to counter power dynamics relevant to production and assessment of "expert" knowledge and its use in supporting particular policy preferences. F. I would treat this as public education in he context of intense competition for attention. So in this case I would highlight the importance of: relatability and relevance; most current and best evidence; accuracy; engaging, accessible, comprehensible, transparent; all of your technical criteria I have ticked in the order in which they appear; same for the context criteria. Looking back on my response, I am struck by the fact that I have not referred to procedural criteria at all. I am not sure what to make of this: perhaps that they apply to some kinds of communication more than others?

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		It also seems clear that the selection and relative weighting of the criteria will depend on the type of communication assessed. In a marketing research, they would devise a number of "ideal' types, give them catchy names and attach specific evaluation criteria to these types. Do you feel this might be possible/useful as a practical guide in this case?
P13	I clicked pretty much everything because 'it depends' … the idea of generic 'quality' to me is tricky because it could be any of these things, depending on the objectives/goals. It might be different if you asked me how much I would prioritize each element but I'd probably still say 'it depends.' Put differently, I think we have to think in terms of 'effectiveness' rather than quality as researchers and allow non-academics to define quality for their context.	If we just take a and b, the biggest thing that I'd focus on is the degree to which they seem to be achieving their objectives/goals in ethical ways. My expectation is that the university folks should have more resources and thus be better able to think strategically, although a good twitter strategy would be nice it seems unlikely to come from a single scholar working in isolation.
P14	No, but many of the above mentioned criteria are (more or less) synonyms.	The institutional context is made explicit only in case A (university) and C (government). An interest in public relations can be assumed here. In all other cases, it depends on the role and motives of the particular user. Microblog (Twitter), blog and podcast are formats which can be used for all sorts of communication, for better or worse.
P15	Need to respond to schemas that audiences care about (framing). Need to respond questions that audiences ask, rather than questions that experts think audiences should have asked. Just to echo the last checkbox: Should be based on social scientific evidence that messages will likely be effective or have been proven to be effective in other contexts. We need to stop the trial-and-error nonsense by social and bench scientists who think they "know what works" or that they "are good at this."	A blog violates all the principles above. it speaks to the choir, i.e., not to audiences it should reach. That's assuming that anyone reads blogs any more anyway. Twitter as a microblog can do the opposite, i.e., reach beyond the choir if well constructed, hitting the right hashtags, etc. But even evidence from Twitter suggests that we're largely talking to ourselves. Again, as I said earlier, one of the key variables is the level of controversy or urgency. COVID-19 showed this nicely.
P16		a) & e) I would hope/expect A to be significantly more concerned with completeness/accuracy than E. I think the respective audiences would expect E to be more over the top so take into account in the "epistemic accounting" so to speak.
P17	None to add. Under context criteria, I would disentangle "orientation toward public good" and "without a particular agenda". These are not necessarily the same at all to me. For example, I personally would tick the first, but not the second if they were separated.	

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For Procedural Criteria, I think it's worth being overtly more nuanced with the notion of "measurable". Need to be wary of inadvertently conflating 'measurable' with 'quantitative'. This seems to happen a lot unless explicitly considered.	
P18	[Chosen settings] A. A news section on a university website presenting the latest research from their organisation B. The Twitter thread of a scholar commenting on policy issues by referring to the latest evidence [How would these differ in terms of quality? Please explain which criteria would be relevant, and which would not apply] "A" is authorized by organisations, but "B" is not. Therefore the content in "A" could be regarded as having better quality. However, citizens could regard "B" as authorized because the scholars belong to their organizations even if they commented on something as personal. In that context criteria, I think it is yes to distinguishing "A" and "B." From the viewpoint of technical criteria, I think "B" would be more interactive and dynamic.
Nothing, thank you for making these great criteria. I think these cover enough.	
P19	Taking these two, C. A governmental campaign on different social media referring to public health issues D. The blog of environmental activists citing scientific studies to strengthen their argument I would expect, or hope, to find the same or similar quality criteria met in these apparently very different contexts: the information should be complete, the presentation should be engaging, it should be clear were the information comes from, etc. In any two cases, the differentces in terms of quality are likely to be less significant than the similarities.
Under technical criteria, Transparent regarding source of information Diversity of formats (text, audio, video, image etc.)	

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Promotion of Quality Standards

ID	Q5 Activities onlne science communication landsape already taken place	Q6 Approach to ensure sustainable quality standards
P1		
P2	A variety of incentives / threats of regulation appear to be emerging between governments and social media companies. Education is clearly moving towards an effort to improve critical thinking when engaging online. I think the landscape after Covid will look quite different.	Really not sure. I think the key thing is for social media companies to understand their role in society and the ethics surrounding their responsibility. But that's only going to happen via big society conversation (including government, society and social media companies), bits of regulation, and shocks (eg Covid) that might get us to move.
P3		
P4	They are all taking place, albeit to different degrees.	
P5		
P6	I've observed the following direct interventions (only): Community assessment: Fact-checking organisations such as Africa Check (https://africacheck.org/) make a significant contribution to this. Evidence-based countering of false claims: Many scientists have spoken up against misinformation about the novel coronavirus and COVID-19 (for example https://www.nature.com/articles/d41586-020-01266-z?fbclid=IwAR3zTatlJo_SMufHzBn99Xfrj6I0ci254C7qHqFEv2F5zGBF3Vx4IdpOdL4) Partnerships with major social media platforms: I have seen, in the context of COVID-19, that some social media platforms have accepted some responsibility for combating misinformation and they are therefore regulating content. For example, YouTube has removed certain videos that 'violated' their community standards. Similarly, in the context of Facebook and anti-vaccine content; see https://www.cnbc.com/2019/09/05/who-partners-with-facebook-stop-the-spread-of-inaccurate-vaccine-information.html	Evidently, they can all play a role and make a contribution. Clearly, in my experience, we do not yet see much evidence of 'incentivisation' or 'self-regulation'.
P7	I think most of them already take place to certain degrees	All of them, and the mix is yes. Consumers of science communication cannot disregard their own responsibility, but the system also has to try and re-inforce some criteria - even though neither system will be perfect
P8	A lot of them are already taking place. For instance, investments in better education and any type of literacy, globally, have been ongoing. Also, the field of science communication has been professionalized for quite some time now. What I have not seen are awards that	Fact checking in partnership with digital platforms, incentivized by the communities, seems a promising way forward.

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	name role models, but I do know that in some countries there are incentives for public engagement with science.	
P9	All of the ones listed above are being used to some degree. What's missing above is direct blocking of content, and criminalization. I am not saying we should use it, just that those could be used (and are being used - think China).	It will always be a mix of all these.
P10	Most of the observations under incentivisation and self-regulation.	Media literacy
P11		
P12	Fact checking Fostering culture of deliberation (sort of) Role models The heavy focus of public engagement as part of research funding and assessment contributes to promoting best standards The same can be said about public science literacy, looking at the culture of engagement across science related public institutions such as museums and the popularity of various science based media content, to mention, (BBC Four) 'Digging for Britain', Attenborough's The Blue Planet, prof Brian Cox and his near celebrity status as a scientist very visible in the media.	I don't agree that they are necessarily mutually exclusive. I think we need a combination of various interventions working at the same time. It might be helpful to think by analogy to public affairs media/communication content regulation: while some may be regulated more strenuously, others are self-regulated or (cf broadcast/newspapers in UK). There is also obviously need for both professional education and public literacy and modelling of excellent behaviours.
P13	I guess there's probably incentivization in terms of awards but also in terms of normative acceptance. There's lots of self-regulation (and non-self-regulation). I don't see how direct intervention makes much sense though I suppose communicators could voluntarily commit to ethical standards (many public relations societies and journalism groups have such standards).	Anyone communicating in their professional role should have to justify their choices just like researchers and instructors. If you think you're doing something good and want to get rewarded for it then you're responsible for showing your impact (either at the individual or organizational level). This especially applies to people who are taking money for communication; they need to justify their activities in terms of some type of evidence-based strategy and, ultimately, impact.
P14	It depends. In authoritative countries, we have strict regulation and surpressing of digital (science) communication. In western countries with liberal democracies, incentivisation and self-regulation dominate, especially in science journalism and in the external social media communication of scientists.	incentivisation, self-regulation (formal and informal)
P15	It's very telling that direct interventions are largely targeted toward (mis)information. Our community is coming full-circle back to knowledge deficit thinking. "If people only knew the RIGHT information, the world would be better off." It's both amusing and sad to see our field completely reinvent the same nonsense under new labels. Clearly there is some traction for this with factchecking on FB and Twitter. Beyond that, I see few pathways forward for policing academic discourse with the public top-down. Why	I think there is a lot of wisdom in P24 and P25 . Both are about building competency and literacy among communities. How they use it, should be up to them in democratic system.

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	would I care what AAAS, the Leopoldina, or acatech thinks about how I should communicate? They all do a horrible job at communicating themselves. The last thing they should do is tell others how to do it better.	
P16	There is some fact checking already on some platform, and the google's page ranking algorithm (to some extent) tries to account for accuracy (hence knowledge graphs are more likely to return info from wikipedia than Quora). There are awards for 'role models' but this seems a circular issue....those who care about such awards are already listening /following the ones likely to win.	I think digital literacy education is most likely to yield better standards, but it would need to be implemented from school or such like. I fear that any too top-down approach (while it may lead to 'better' content) would significantly narrow what counts as content. For those who are or want to be professional science communicators, professional bodies offer a very reach avenue. I know in some countries, the professional bodies overlap (eg, SCOM with sci journalism or with PR), and in these overlap, there are opportunities to foster much better learning for members of such organisations.
P17	Column 1 - 1, 2, 3, 4 Column 2 - 4 Column 3 - not sure This is very hard to respond to	
P18	I think formal and self-regulation activities have already taken place. Formal education including educational TV programs contributed to increasing a media and scientific literacy.	Semi-formal and incentivisational approach could be yes for developing sustainable quality standards, because fostering open and reflective culture might be one of the basic and yes infrastructures.
P19	Very few, and those that are happening probably do so through long-established structures, e.g. of professional training and education in media / scicomm / digital media In the context of the Covid-19 crisis, there is perhaps some evidence of 'volunteer' community assessmentl countering of false claims and fact-checking. But - subject to verification from surveys of media usage in this crisis - it may be that digital media users are reverting to institutional and legacy-media sources as a means of quality assurnace	Continuing deepening and extension of professional education and continuing professional development (CPD) in science communication abd digital media

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Promotion of Quality Standards

ID	Q7 Role of science communication professionals	Q8 Role of science communication researchers
P1		
P2	To help improve the science communication landscape, and to understand more the challenges our audiences face.	Make better content!
P3		
P4		
P5		
P6	As you noted in the outline of your study, the concept of quality in science communication (what it means, and how we measure it) is still debated (often vague or complex). So, a starting point would be to promote and encourage scholarly discussion and reflection (as you are doing with this study) and then to bridge the gap by bringing the discussion to the community of science communication practitioners. A bigger focus on quality science communication (research and practice) may help to overcome a recent trend in seeing some 'stigma' attached to science communication as being a mere "PR" exercise for scientific institutions and individual scientists.	If we want to promote science communication quality in practice, this should be informed by solid research. So, it goes without saying, that this is an excellent example of a challenge where ongoing collaboration and interaction are needed between researchers and practitioners.
P8	Aren't they already?	I think the role of research is primarily to produce transparency about what is happening and what various forms of scicom produces. In my eyes practitioners are better at practice than researchers, but researchers can provide material for reflection by practitioners.
P9	It depends on your definition of what science communication professionals are and to what degree their motivation is to establish or maintain quality. What I think is, though, that science communication professionals probably have the necessary skills to do that.	As a researcher, it is their task analyze the quality of science communication.
P10	They help share and define criteria, and as a community, provide the background knowledge on why quality ensurance might be needed in the first place.	same as in in non-digital world: they provide empirical evidence and they advance conceptual understanding and theory.
P11	Profesionalization of science communication trough societies and associations.	We have to partner more with practitioners to share the research and collaborate in research projects.
P12		
P13	professional science communicators (and communication) should be the site of both the establishment of the standards and education is explicit, as well as where debates about such issues should be actively encouraged.This is not to say that the profession should always be considered as the arbiter of what is/is not right in terms of public good, because	My view is that the answer lies in knowledge generation in order to follow up developments in practice, to systematise knowledge and promote existing best practice, to develop where possible predictive knowledge that can be utilised to solve specific practical problems, and to contribute to

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	we know that profession do not necessarily always reflect in a straightforward way, what we might call public interest ("altruistic" orientation). However, is should be their duty to keep such debates alive.	debates in communication and sociology of science.
P14	It seems hard to imagine that individual scientists could be expected to consistently communicate effectively on their own, especially in cases where there's a need for robust planning, implementation, and evaluation. We need to create systems where scientists aren't expected to do everything on their own just was we don't expect politicians or executives to manage all their own communication.	We need to expect ourselves and our colleagues to put the same rigorous thinking into communicating that we put into research and teaching. We have to get away from ad hoc, amateur-hour stuff (or at least build on a professional layers such that we're not relying almost-exclusively on amateurs).
P15	Questions of quality should be part of science communication programmes at universities and a subject in internal debates of professional associations.	Researchers can support practitioners in several ways: They can help to define quality standards, measure empirically the compliance of science communication with these standards, and develop strategies for quality management.
P16	Science communication professionals are one group bench scientists should turn to when they think about communicating. It's like a car mechanic. Some stuff I can easily fix myself as a lay person. By analogy, bench scientist can do some forms of communication well, especially ones that capitalize on their professional training. For almost everything else, they should turn to the practice and science of science communication ... i.e., practitioners and social scientists.	It's the foundation for everything. Science communication is the one area in which bench scientists routinely engage in and recommend activities that are diametrically opposed to the best available social science. I am a social scientist. If I perform an appendicitis after havign watched a couple of youtube videos, the patient might barely survive, and i might even mage to stitch him back up. But it's still a fundamentally bad idea, painful for everyone, and does more harm than good. Bench scientists doing scicomm by themselves is the same thing.
P17	I think this is one of the tough questions for SCOM on social media when SCOM is taken as broadly as it is here. Much of SCOM in this broad setting is not done by SCOM professional, but are one-offs by others. For me, if an individual considers themselves a professional science communicator, they stake an epistemic claim about what they value as knowledge, so they have more over responsibilities. I think (as mentioned above) professional associations have a role to play here.	There is much research in this space, so (ironically) communicating it would be a good start. One challenge is the need to publish (almost anything) at the expense of producing some practically worthwhile material. Perhaps there is a space for a 'trade' journal for science communication. The kinds of things that aren's so academically minded, but show practical applications.
P18	Very hard to answer as what constitutes a 'science communication professional' can vary enormously. Sorry to be difficult, but I can't think of context-free responses here, it would depend on the type of sci comm person, the intent and audience of the communication being 'quality checked' and numerous other elements.	See response to question 7.
P19	Professional science communicators should communicate for", "listen for" and "learn with" a diversity of actors. These interactive communication could foster an open and reflective culture.	Providing an evidence on effective and sustainable science communication. I think science communication research itself should be objective and reliable.

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Sociodemographics

ID	Country background	Disciplinary background						Current position
		Communication science	STS	Media studies	Psychology	Political science	Other disciplines	
P1		no	no	no	no	no		Assistant professor/post-doc/senior researcher
P2	Australia	no	no	no	no	yes		
P3		no	no	no	no	no		Associate/full professor
P4	Switzerland	yes	no	no	no	no		
P5		no	no	no	no	no		Assistant professor/post-doc/senior researcher
P6	South Africa	no	no	no	no	no	Natural science	Associate/full professor
P7	Denmark	no	yes	no	no	no		Assistant professor/post-doc/senior researcher
P8	Germany	yes	no	no	no	no		Associate/full professor
P9	USA	yes	no	no	no	no	learning science	Associate/full professor
P10	United State	no	no	yes	no	no	Interdisciplinary environmental science	Associate/full professor
P11	Austria	no	yes	no	no	no		Associate/full professor
P12	UK	yes	no	no	no	no		Associate/full professor
P13	United States	yes	no	no	no	no		Associate/full professor
P14	Germany	yes	no	no	no	no		Associate/full professor
P15	US	yes	no	no	no	yes		Associate/full professor
P16	NZ	yes	yes	no	no	no	Philosophy	Assistant professor/post-doc/senior researcher
P17	Australia	no	no	no	no	no	science communication	Associate/full professor
P18	Japan	yes	no	no	no	no		Associate/full professor
P19	Ireland	no	no	yes	no	no		

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