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# Supporting Quality in Science Communication: Insights from the QUEST Project

*ABSTRACT: How to promote quality is a critical aspect to consider when re-examining science communication, analysed in the research carried out in QUEST project presented in this paper. Engaging key stakeholders in a codesign process - through interviews, focus groups, workshops and surveys - the research identified barriers to quality science communication and on the basis of these, proposes a series of tools and supporting documents that can serve as incentives toward quality science communication for different stakeholders across the fields of journalism, social media, and museum communication. Among these particularly important is training to also promote professionalism of communicators.*

**Keywords:** Professionalism, professional development and training in science communication, Science and media, Science centres and museums

## Introduction

For decades, there have been efforts to increase and improve science communication. This has become especially pertinent in the time of a global pandemic when it is not only epidemiologists and virologists called upon to publicly communicate science, but also sociologists, economists, and policy-makers, alongside journalists and science communicators. The extent to which this communication is effective, clear and trustworthy, affects more people than ever around the world. QUEST (QUality and Effectiveness in Science and Technology communication) is a research project funded by the European Commission to tackle the issue of assessing and improving the quality of science communication (<https://questproject.eu/>).

There is no doubt that the volume of science communication has increased over time, in particular when it comes to hot topics. Despite its increasing output, the question of how to ensure quality in science communication remains a critical consideration. Existing barriers and disincentives for science communication need to be identified as starting points to develop incentives for promoting science communication to wider publics. As highlighted by Davies et al. [2019], the diverse actors and media involved in the science communication ecosystem need to be given careful examination. The factors affecting quality in science communication start with scientists themselves, before passing through different communication channels to the public. The issues affecting how scientists communicate and the challenges facing different fields of communication such as journalism, social media, and museums are appraised below.

39 In recent decades, the different barriers that hinder quality in science communication  
40 have started to be identified. Firstly, focusing on scientists, it has been demonstrated  
41 that they are interested in, and recognise the value of, communicating outside  
42 academia to public audiences, but feel that such time consuming activity is not  
43 sufficiently recognised in career progression or funding awards [The Royal Society,  
44 2006; Olson, 2017]. A survey of more than 6,000 US-based scientists showed a  
45 significant appetite for science communication to help improve public trust in the  
46 scientific community, but with both personal confidence and institutional support being  
47 noted as potential barriers [Rose et al., 2020].

48 Secondly, the media is also vulnerable to challenges affecting the quality of science  
49 communication. The literature reveals some of the sweeping changes in journalistic  
50 practice and consumption in recent years, with the advent of digital production, social  
51 media, web 2.0 and 3.0 [Angler, 2017]. These and other significant changes in the  
52 media landscape affect the ability of journalists to reliably report sound, evidence-  
53 based science news [Allan, 2011]. Davies et al. [2019] highlight issues that include the  
54 decreasing influence of traditional 'legacy media' alongside a well-developed public  
55 appetite for social media posts on science which are sometimes unintentionally  
56 misleading or deliberately manipulated to spread fake news and pseudoscience. A  
57 public inundated by mixed messaging and a range of interpretations is far less likely to  
58 develop trust in science messages in the media generally – leading potentially to  
59 disillusionment and disengagement among citizens. Meanwhile, science journalists  
60 report a daily bombardment of press releases and corporate communications whose  
61 branded content seeks to present a one-sided and favourable message [Bauer &  
62 Howard, 2009]. Still, the role of science journalists in society today, and their  
63 importance to democracy, is probably as critical as ever [Pfisterer, Paschke, & Pasotti,  
64 2019].

65 Thirdly, the Internet is rapidly becoming a primary source of information about scientific  
66 issues. Social media in particular have rapidly become the main information sources  
67 for many of their users, and the amount of information that competes for their attention  
68 is huge [Shearier & Grieco, 2019; Matsa et al., 2018]. On social media, users tend to  
69 segregate in echo chambers where people share similar backgrounds and ideas [Zollo  
70 et al., 2017]. Confrontation with opposing views is almost nonexistent, and scientists  
71 and communicators are too often guilty of hiding in their metaphorical ivory towers  
72 [Schmidt et al., 2017; Schmidt et al., 2018]. In such a polarized context, the need to  
73 make science communication effective, avoiding the risk of preaching to the choir, is a  
74 key challenge.

75  
76 Finally, museums are cultural environments that can facilitate dialogue and the sharing  
77 of ideas around both science and art. One of the critical challenges facing museums is  
78 the need to be truly inclusive and engage disparate and diverse audiences. The  
79 science museum visionary Gorman stated that "interesting science is often created  
80 where boundaries are crossed, in border territories where connections are suddenly  
81 perceived between problems in seemingly unrelated areas" [Gorman, 2008, p. 522].  
82 Just over a decade later and his message has become ever more pressing, as there  
83 is now a critical "need for civic spaces to function as dynamic, bidirectional bridges

84 between science and society – as colliders of ideas and people [...] this must be a  
85 central role of science museums of the present and future” [Gorman, 2020, p. 150].  
86 Involving public audiences in participatory approaches, co-creation activities, and  
87 citizen science initiatives, will lead to citizens having a louder voice in the decision-  
88 making and governance of museums, and will strengthen the relationship between  
89 science and society [Rodari & Merzagora, 2007; Bandelli & Konijn, 2013; Sforzi et al.,  
90 2018]. The demand for ever improving science communication from the museum field  
91 grows more critical all the time: “In times of ecological collapse and global pandemics,  
92 it has never been more urgent to focus on reimagining our existing science museums  
93 and creating new edge spaces, to bring science-in-the-making into contact with policy,  
94 to bring research into contact with the public - the future of our planet depends on it”  
95 [Gorman, 2020, p. 153].

96  
97 Starting from these challenges, QUEST has been working to identify the barriers to  
98 achieving quality in science communication, as perceived by stakeholders. The project  
99 subsequently developed tools to overcome these barriers, in order to support and  
100 promote high quality science communication. This paper shares the main outputs of  
101 the research undertaken during the QUEST project. The methodological approach is  
102 presented, followed by the obstacles and disincentives to achieving quality in science  
103 communication. The subsequent part presents a selection of tools, tailored to directly  
104 engaging key stakeholders in how to overcome these obstacles.  
105 In the final part of the paper, future directions and recommendations for all the decision-  
106 makers involved in promoting quality in science communication are discussed.

## 107 **Methodology**

108 The QUEST project is multidisciplinary by design; it is a collaborative project with eight  
109 partners from different fields of science communication across six European countries.  
110 The belief that practitioners of all disciplines, as well as policy-makers, and civil society,  
111 are equally important to achieving quality in science communication, is central to the  
112 project.

113 The methodology included a review of the existing literature on the promotion of quality  
114 in science communication (see Davies et al., 2019), an assessment of the provision  
115 for science communication education across Europe (see Costa et al., 2019), and  
116 initiated a series of activities that directly engaged key science communication  
117 stakeholders in co-design approaches to recognise the challenges they are facing,  
118 identify possible solutions, and develop tools to support quality in science  
119 communication.

120 The co-designed activities involved online and in-person components, and between  
121 Spring 2019 and Autumn 2020 included: 62 structured and semi-structured interviews  
122 with experts, focus groups with 67 stakeholders (scientists, journalists and editors,  
123 museum explainers, social media content managers, university and research institute  
124 governance staff), multi-stakeholder workshops with 74 participants, and surveys (for  
125 a total of 139 answers collected). The stakeholders engaged were mainly from the 6  
126 countries involved in QUEST project, i.e. Italy, France, Estonia, UK, Ireland and

127 Norway, but also from other EU and non-EU countries, e.g. Germany, The  
128 Netherlands, Belgium, Switzerland Spain and African countries, reached among the  
129 contacts of the partners and through a snowball. Support systems to make the online  
130 sessions interactive were put in place, using different platforms, such as padlet, survey  
131 monkey, and slack.

132 Quantitative and qualitative analysis of the data collected from the different activities  
133 identified the key challenges facing science communication, as perceived by  
134 stakeholders, and provided vital input for developing tools and solutions for promoting  
135 quality in science communication. The collection of stakeholder data represented the  
136 first phase of a three-step process. In the second step, the contributions from the  
137 stakeholders were further explored by the research team in a second round of  
138 discussions with both the same and different stakeholder groups. On the basis of the  
139 results from this second step, tools for supporting quality in science communication  
140 were developed, tested and validated with stakeholders. Non-European testing groups  
141 were also involved in the validation phase to make the tools implementable worldwide.

## 142 **Quality in Science Communication: Obstacles and Disincentives**

### 143 *Science Communication Obstacles and Disincentives for Scientists and Research* 144 *Institutions*

145 Communicating science to public audiences is increasingly recognized as a  
146 responsibility of scientists [Greenwood, 2001; Leshner, 2003], similarly, it is often  
147 stressed that researchers can play a role in supporting effective policy making  
148 [Pfisterer, Paschke, & Pasotti, 2019]. In general, the third mission of universities and  
149 research institutions, to use their knowledge to engage with society and address its  
150 needs [García et al., 2012], is increasingly promoted. What encourages scientists to  
151 communicate their work? Which incentives and rewards do their organisations and  
152 media offer? Are scientists trained to deal with journalists and to engage with the  
153 public? Do they trust communication specialists hired by their institutions? These are  
154 the questions that frequently arise in science communication literature and which are  
155 at the basis of the investigation carried out by QUEST through a series of focus groups  
156 with scientists, interviews and surveys with the decision-makers, and other  
157 stakeholders at university and research institution level.

158  
159 Although it is important for scientists to be able to communicate to non-technical  
160 audiences, researchers often either lack the skill or confidence to communicate to non-  
161 scientists. They are thoroughly trained in research methodologies, analytical skills, and  
162 the ability to communicate with other scientists, but they usually receive limited training  
163 in communication of scientific concepts to a general audience [Brownell et al, 2013],  
164 which is still considered in scientific academia to be a soft skill. This was confirmed by  
165 the scientists participating in QUEST activities. In addition, increased specialisation  
166 over time, research time pressure [Besley & Nisbet, 2011; Pearson et al., 1997], the  
167 lack of incentives, in terms of credits for career advancement, as well as being wary of  
168 the media each contribute to the current situation. Science communication to the public

169 audiences is then perceived by scientists as an extra effort that brings great  
170 satisfaction, but which is also very demanding in terms of time for preparation, as  
171 emerged in the QUEST focus groups.

172

173 Public information officers and science communicators 'embedded' in universities and  
174 in industry could be crucial in conveying scientific results to public audiences, through  
175 mediators (such as journalists, the media, and museums) or directly (through websites  
176 and social media), but, as highlighted by both researchers and communication officers  
177 engaged in QUEST co-design activities, more trust and stable interactions between  
178 scientists and these intermediaries is needed to build a more efficient and reliable  
179 exchange. The European Commission and its policies promoting open access  
180 publication, communication, and compulsory dissemination activities for the projects it  
181 funds also play an important role in this context. However, scientists participating in  
182 the QUEST project felt that there is more quantity in science communication than  
183 quality, and that qualitative indicators are needed in order to reverse this trend.

#### 184 *Science Communication Obstacles and Disincentives in Journalism*

185 The media plays a crucial role in interpreting and framing scientific endeavour and  
186 research outputs to the public at large. When science reporting is trusted and deemed  
187 to be reliable, citizens can make well-informed decisions about science and its impact  
188 on their daily lives. In the era of pandemics and the devastating effects of climate  
189 change, trust in quality science journalism through the different media has never been  
190 more important, [as evidenced by polls during 2020](#) [Open Knowledge Foundation,  
191 2020]. Conversely, the effect of fake news and misinformation about scientific  
192 endeavour has never been more widespread than during the Coronavirus crisis.  
193 [Surveys](#) have pointed to an 'infodemic' of [false claims](#) and inaccurate data over this  
194 period [OFCOM, 2020]. As a result, it is clear that the role of science journalists in  
195 communicating reliable information has become more significant than ever.

196 However, the role of the science journalist is arguably more complex and more  
197 pressurised than that of other specialist reporters, since science itself is often done on  
198 the edge of the knowable, its findings open to misinterpretation, deliberate or  
199 inadvertent bias, and, occasionally, fraud [Goldacre, 2008]. That complexity  
200 sometimes generates barriers and obstacles to the clear and effective interpretation of  
201 scientific findings to the public; witness the current conflicting scientific and medical  
202 opinion about tackling the impact of COVID-19. Additionally, dwindling revenues for  
203 legacy media have meant news organisations are less likely to employ science  
204 specialists [De Semir, 2010]. General journalists handling science stories find  
205 themselves often lacking basic science literacy and the inability to properly interpret  
206 scientific data and statistics, especially given professional time constraints and the  
207 pressure of deadlines [Angler, 2017; Schunemann, 2013].

208 QUEST focused on three key scientific topics: vaccination, climate change and artificial  
209 intelligence. In each case evidence was uncovered about the spread of distrust amid  
210 a climate of deliberate misinformation.

211 Through direct contact with stakeholders and journalism practitioners the QUEST  
212 project discovered that training and tools supporting journalists, for example handling  
213 statistics and interpreting scientific papers, are particularly needed.

214 The interviews with practitioners demonstrated that science journalists are sometimes  
215 conflicted about their role; whether to act as a translator of often complex science, or  
216 to develop a more investigative slant as a ‘watchdog’, exposing bias, fraud or  
217 negligence. The process of interrogating claims, interpreting data and minimising  
218 uncertainty can be a lengthy one, again subject to the imperative of deadlines and  
219 editorial scheduling [Murcott & Williams, 2013; Schunemann, 2013]. As QUEST’s  
220 mapping exercise revealed [Costa et al., 2019], science communication courses vastly  
221 outnumber discrete science journalism programmes in universities across Europe.

## 222 *Science Communication Obstacles and Disincentives in Museums*

223 The cloud of financial uncertainty looms large over every science museum or science  
224 centre, with funding for museums in decline even before the onset of the global  
225 economic recession of 2020 [Dorfman, 2017]. This uncertainty exacerbates the tension  
226 caused by museums accepting private or public funding (and subsequently declaring  
227 those sources), while the growing expectation of museums curating and sustaining a  
228 significant digital presence is a further challenge for professionals working in the  
229 museum sector. Underpinning these obstacles to improving science communication is  
230 the issue of inclusivity. This was the most pervasive issue that was raised by museum  
231 professionals taking part in QUEST interviews. Academic research conducted in  
232 nonformal learning spaces such as museums has shown for some time that museums  
233 and their programmes of exhibitions, events, and activities are not designed for  
234 everyone equally [Dawson, 2014]. The need for museums to be more inclusive and to  
235 finally extend “beyond a privileged subset of the population” has been highlighted by  
236 researchers as not just an obstacle to be overcome, but a matter of social justice that  
237 the museum sector urgently needs to address [Kinsley, 2016, p. 474].

238  
239 Overcoming these barriers will not be easy and strong cooperation will be needed to  
240 navigate “the tough parts of change-making, to listen and understand visitors, to help  
241 set a direction informed by racialized and marginalized voices, and to establish ways  
242 of working together that are supportive, rooted in social justice, care, and  
243 consideration” [Ng, Ware, & Greenberg, 2017, p. 151]. The pressing need to overcome  
244 these obstacles has only been amplified by the racial reckoning and the global  
245 pandemic that have affected almost every aspect of life in 2020 [Farhi & Ellison, 2020;  
246 Auðardóttir & Rúdólfsdóttir, 2020]. The position of museums in society as cultural  
247 spaces, academic spaces, safe spaces, and spaces of research, education, and  
248 entertainment, should not be taken for granted, and in the face of the current  
249 challenges, there are opportunities for positive change, as was repeatedly expressed  
250 by stakeholders in QUEST activities [Davies, et al., 2019].

251  
252 At the height of the first spate of national lockdowns in Europe, an examination of 100  
253 of the largest Italian state museums showed that their engagement with public  
254 audiences did not cease during that period, but instead moved from physical

255 interaction to digital activity, with the museums doubling their online engagement in  
256 that time [Agostino, Arnaboldi, & Lampis, 2020]. While digital engagement is not  
257 always synonymous with accessibility, it is at least a path towards addressing some of  
258 the inequalities that museum visitors can experience [Kraybill, 2015]. Given the global  
259 events of 2020, there should be no further motivation needed to tackle these obstacles  
260 of accessibility. As Brown et al. [2020] suggest, the time is now for museums “to act  
261 and to commit [...] to providing the vital and relevant support that all peoples, including  
262 migrants and refugees, deserve [...] to act with humility and courage, to reform [...] and  
263 become cultural institutions which welcome, support, and value all communities” (p. 4).

#### 264 *Science Communication Obstacles and Disincentives in Social Media*

265 As we have heard from scholars, communicators and journalists engaged in surveys  
266 and workshops within the QUEST project, communicating science on social media is  
267 sometimes considered a more challenging task than using traditional media, such as  
268 books, conferences, even interviews in the press and on radio/TV. This is in part due  
269 to the fact that many experienced scientists, journalists, and communicators are less  
270 familiar with social networks because such platforms were not relevant or did not exist  
271 earlier in their careers, while younger professionals can face other kinds of constraint:  
272 using social media is in fact very time-consuming, without a clear and immediate  
273 reward, e.g. revenues or in academic acknowledgment.

274  
275 Social media platforms are ever-changing and one needs to keep up to date and build  
276 skills. With some exceptions (LinkedIn, Twitter), social media are mainly seen as  
277 means of leisure, and the QUEST project found that some scientists may fear being  
278 criticized by colleagues and the public for using them. A further obstacle is around the  
279 role of ‘opinion leader’ on social media, which tends towards more of an influencer than  
280 a science advocate and communicator. A big hurdle, connected with the lack of  
281 reimbursement for this input, is the possibility of getting sponsors to support one’s  
282 activity, and the possible conflict of interests deriving from this. Further problems arise  
283 concerning the specificities of most social networks, which require fast, short and  
284 simple messages, and therefore are not always consistent with the complexity of  
285 science or the communication needs of an institution.

286  
287 Other peculiarities of social media make it difficult to communicate science through  
288 them. A strong polarisation, users’ segregation in echo chambers and selective  
289 exposure is widely observed on social media [Del Vicario et al., 2016; Schmidt et al.,  
290 2017; Zollo et al., 2017; Zollo, 2019]. These dynamics may not help in science  
291 communication, which flourishes best when it engages different points of view in a civil  
292 exchange. On social media, reality is often depicted in black and white, false or true,  
293 while the idea of science as a growing process, gradually approaching reliable  
294 knowledge, is difficult to convey. People usually like, comment and share more with  
295 their gut than by rational thinking. Such emotional responses don’t seem to be very  
296 consistent with a scientific method, and the potential for hate speech too is a further  
297 danger. Bullying and trolling are common on social media, and not everyone can feel  
298 equipped to deal with them as emerged in QUEST focus groups with scientists. All of



299 these can be disincentives to the use of social media for science communication,  
300 especially by renowned scientists, science institutions and organizations, while young  
301 professionals can feel more confident, if they are well-trained to do it.

302

303 Last, but not least, there are obstacles related to the audience, which vary by country  
304 and platform [Davies et al., 2019]. Some platforms are used more by young people,  
305 others by middle-aged adults, and a gender gap can also be observed in some cases.  
306 Not all of these audiences have a background or a specific interest in science, as those  
307 who buy and read science magazines, watch or listen to science radio or TV  
308 programmes, or attend science festivals. On social media, anyone can stumble into a  
309 post or a tweet regarding science. This can be seen as an added value of these tools,  
310 since they allow communicators to reach out to people who may not have had a prior  
311 interest in science. On the other hand, this can be a challenge for communicators who  
312 engage audiences with no scientific background or interest, or even anti-science or  
313 hostile positions.

#### 314 **QUEST Tools for Supporting Quality in Science Communication**

315 Starting from the identification of the barriers and obstacles highlighted above, QUEST  
316 has been developing different tools and supporting material to address them, which  
317 can potentially work as incentives toward quality science communication.

##### 318 *Addressing the need for quality Indicators: The QUEST KPIs*

319 The ongoing pandemic has brought forward a renewed awareness of how important  
320 science communication is, and also how failures in communicating scientific studies or  
321 concepts can have harmful consequences for society [Saitz & Schwitzer, 2020].  
322 Concerns about the quality of science communication and calls to improve it are  
323 nothing new, but, as mentioned above, they have increased with the widespread use  
324 of social media and the erosion of legacy media. “Contemporary information overload  
325 requires the user to be more competent, and it demands new definitions of quality, as  
326 noted by Buchi and Trench [2014, p. 10]. Despite this, conceptualisations of quality in  
327 science communication are rare. In scholarly literature, the term is often associated  
328 with one or few key characteristics such as accuracy, objectivity, context, style, story-  
329 telling or engagement, but few have attempted to offer a holistic framework of quality  
330 components. These include Seethaler et al. [2019] who produced a set of ethics and  
331 values for effective science communication, and twelve core skills for effective science  
332 communication by Mercer-Mapstone and Kuchel [2017].

333

334 A framework of quality can be an effective tool in addressing the disincentives and  
335 obstacles previously described in this paper. It makes it easier to identify problematic  
336 science communication content and offer recommendations for improving it. It provides  
337 a basis for developing skills, including designing science communication programmes  
338 or courses. It also helps to create a common understanding of quality among science  
339 communication stakeholders, since a focus on different quality aspects by different  
340 stakeholders (e.g. journalists and researchers) is a frequent source of tension in

341 science communication. Therefore, QUEST set out to develop Key Performance  
342 Indicators for quality in science communication. Consultation and co-design processes  
343 with science communication stakeholders produced a set of twelve quality indicators,  
344 arranged into three main dimensions of quality: trustworthiness and scientific rigour,  
345 presentation and style, and connection with the society [see Olesk et al., 2020].  
346

347 The quality mapping exercise with stakeholders generated two key takeaway  
348 messages: a) different strands of science communication possess common underlying  
349 principles that make it possible to formulate a single framework of quality and use a  
350 common evaluation scheme on all forms of science communication; and b) quality  
351 should be considered as a multi-dimensional property that should be evaluated not by  
352 the presence or absence of a single quality element but by the combination of all  
353 elements. In this way, the quality framework QUEST is offering, contributes to a new  
354 view on science communication with both practical and theoretical implications. Our  
355 results seek to incentivise science communication by providing a set of guidelines  
356 based on the quality framework. These can also be used as a self-evaluation tool for  
357 people engaged in science communication. The quality indicators also offer a set of  
358 questions for further research about whether and how the perceived quality of science  
359 communication content translates into effective communication with the public. While  
360 journalists interviewed for QUEST expressed reservations about hard-and-fast  
361 guidelines in a profession already well-resourced with editorial codes and established  
362 ethical standards, there is every indication that the checklist drawn up within the project  
363 – on aspects of scientific rigour, presentation, and connection with the audience – will  
364 provide support in particular to general journalists covering science topics, trainee  
365 journalists, and science journalism students. The scientists who validated the QUEST  
366 KPIs acknowledge that these can support their communication to the public, also  
367 through social media.

### 368 *Addressing the need for Time and Capacities in Journalism: The INQUEST Tool*

369 To enable journalists writing about science to overcome the reported barriers and  
370 obstacles to the clear and effective interpretation of scientific findings to the public, and  
371 to do this without requiring investment in more science journalists, the QUEST project  
372 designed and prototyped new forms of digital support for journalists, taking as its  
373 framework the three main dimensions of quality as presented in the KPIs, i.e.  
374 trustworthiness and scientific rigour, presentation and style, and connection with the  
375 society. This support was implemented in an interactive tool called INQUEST, which  
376 was co-designed with both experienced science journalists and less-experienced  
377 journalists seeking support to write about science.

378 The experienced science journalists reported using diverse sources of digital  
379 information for developing new stories about science-related topics, each with  
380 advantages and disadvantages. Therefore, to offset the disadvantages associated with  
381 each single type of source, design decisions were made to develop the INQUEST tool  
382 to discover information from multiple source types automatically, and to present this  
383 content to journalists who are writing new stories. These diverse sources included:  
384 science content available in published academic papers, reputable science blogs, and

385 the science pages of established newspapers; non-science news content published in  
386 newspapers, to provide the wider context for science-related content; science news  
387 alerts such as EurekAlert!; and targeted social media sources such as the Twitter  
388 accounts of recognised scientists and research groups. INQUEST presents  
389 information and content from all of these sources in a common format, to stimulate  
390 journalist discovery and understanding.

391 Some of the experienced journalists reported writing for specific science journalism  
392 audiences. Therefore, the INQUEST tool was developed to present audience personas  
393 that represent a broader range of readers, their behaviours and their attitudes towards  
394 science, that journalists believe could be current and future audiences, when writing  
395 about science-related topics. A literature search revealed no existing audience  
396 personas for science journalism in the public domain, therefore existing research was  
397 identified to propose four important science audience segments: 'sciencephiles' with a  
398 strong interest in science, extensive knowledge and belief in its potential; the critically  
399 interested, also with strong support for science but with less trust in it; passive  
400 supporters with moderate levels of interest, trust, and knowledge; and disengaged  
401 people who are not interested in science, do not know much about it and harbour  
402 critical views toward it. Based on these segments, the INQUEST tool was implemented  
403 with a first set of 8 science audience personas based on the sciencephile (1 persona)  
404 critically interested (1) passive supporters (2) and disengaged (4) audience segments,  
405 specialized them to describe excluded audiences from the ethnic minorities and with  
406 lower incomes.

407 In response to the experienced science journalists' reports that explaining science was  
408 important, the design team investigated different theories that might support more  
409 effective explanation with different strategies. In the first version of the INQUEST tool,  
410 interactive explanation sparks were designed for different types of rhetorical  
411 relationship developed in narrative text. Each spark was designed to direct the  
412 journalist, and in particular less experienced ones, to think about new ways of  
413 explaining more entities extracted from existing papers, articles, stories and news  
414 alerts.

415 Likewise, the project's developing digital search and research tool, is designed to  
416 assist science journalists to reach more widely in both storytelling and connecting with  
417 audiences. [Maiden et al., 2020].

#### 418 *Addressing the need for more Capacity and Skill in Journalism: The QUEST* 419 *Curriculum on Science Journalism*

420 To address the imbalance between science communication courses and science  
421 journalism programmes [Costa et al., 2020], QUEST has developed a subject-specific  
422 curriculum combining the skills of rigorous investigation and of producing scientifically  
423 accurate reports on complex topics that are accessible to a lay audience.

424 In the era of enormous public concern about pandemics, a growing anti-vaccination  
425 movement, the devastating effects of climate change, and fear of AI, trust in quality  
426 science journalism through the different media has never been more important.  
427 Conversely, the effect of fake news and misinformation about scientific initiatives –  
428 often generated by unaccountable social media influencers - has never been more

429 widespread and damaging [OFCOM, 2020]. With that in mind, there is a clear  
430 imperative to offer the next generation of journalists the opportunity and training to  
431 properly interrogate scientific findings and transmit evidence-based, accessible and  
432 engaging information to the public at large.

433 Evidence from QUEST's semi-structured workshops with journalists, editors and other  
434 stakeholders reveals that general journalists handling science stories find themselves  
435 often lacking basic science literacy and the inability to properly interpret scientific data  
436 and statistics, especially given professional time constraints and the pressure of  
437 deadlines. Specific modules have been developed, in consultation with working  
438 journalists, to address these shortcomings. Students will also study the module  
439 Science, Media and Society on the critical role played by scientific endeavour in  
440 supporting a well-functioning democracy.

441 The curriculum has been developed in parallel with QUEST's KPIs for quality and  
442 effective science communication, with the same emphasis on rigorously researched  
443 and engaging communication. Universities across Europe will be encouraged to adopt  
444 the curriculum or specific modules to enhance the effectiveness of science journalists  
445 and to boost professional recognition and public confidence.

446 *Addressing the need to improve Inclusivity and Academic credibility in Museums: The*  
447 *QUEST Academic Writing Handbook for Museum Communicators*

448 The need to improve issues of inclusivity facing museums is not just a fundamental  
449 challenge for the museum sector, but as has been argued above, a matter of social  
450 justice. The obstacles and disincentives facing the museum sector are so endemic that  
451 reforms are needed at both national and international level in order to succeed. Policy-  
452 makers should be prioritising issues of diversity, equality, and inclusion, and museums  
453 themselves should have clear and publicly-accessible policies on social inclusion. The  
454 QUEST Academic Writing Handbook for Museum Communicators is a grassroots  
455 approach to empowering museum professionals to take ownership of the research in  
456 their field and to share their work in a more credible, robust, and far-reaching capacity  
457 in order to tackle issues of equality.

458  
459 A crucial area of science communication that museum professionals are often  
460 excluded from is academic writing — the type of communication most often used for  
461 disseminating scholarship and research. While some museums are large enough to  
462 sustain a research department, most museums do not have the capacity to support  
463 their staff engaging in the evidence-based and peer-reviewed processes of academic  
464 writing and publishing. The QUEST Academic Writing Handbook addresses this by  
465 providing a resource that will encourage museum staff — especially educators and  
466 communicators working in museums, galleries, and science centres — to become  
467 more involved in how research from their field is written about and shared. The  
468 professional development of educators and communicators working in museums has  
469 been in need of support for some time [Bevan & Xanthoudaki, 2008] and the  
470 communication and education that takes place, in science museums especially, needs  
471 more clarity on best practice [Tran & King, 2007]. While there are limited opportunities  
472 for professional learning open to science communication professionals working in the

473 museum sector [Roche, et al., 2018], the most meaningful processes for professional  
474 development are likely to be the embedding of peer-learning through a co-creative and  
475 reflective practice approach within the museum itself [Moore et al., 2020].

476

477 If museum educators and communicators become more involved in academic writing  
478 they would have greater ownership over research outputs stemming from the museum  
479 sector. This could have the dual effects of strengthening the relationship between  
480 museum-based professionals and academic research, as well as bringing more  
481 creativity and professional communication standards to academic writing — a form of  
482 communication that is notoriously inaccessible to the public [Culler & Lamb, 2003].  
483 Similarly, it would empower museum professionals to have more input into how their  
484 field is portrayed within the academic literature and how museum research is  
485 communicated to public audiences. Building up a community of practice and the  
486 development of skills in this area would increase the professionalism and credibility of  
487 museum-based communicators and educators. The QUEST Academic Writing  
488 Handbook is designed to address a pertinent question regarding theory and practice  
489 in science communication that was captured by an interviewee during the data  
490 collection stage of the QUEST project: “How is it that those who are doing science  
491 communication aren't reading the articles, and those who are writing the articles aren't  
492 doing any science communication?” [Davies et al., 2019].

493

494 Facing a lack of recognition and sometimes academic credibility for their work, the  
495 QUEST Academic Writing Handbook was itself designed by science communicators  
496 working in a museum environment. Using a co-creation process, the format and design  
497 of the handbook were chosen by those communicators to appeal to fellow museum  
498 professionals in the hope that the handbook might embolden them to write about their  
499 experiences in academic and professional journals and consequently add new  
500 dimensions to their own science communication skills.

501 *Addressing the need for Capacity in Social Media: tailored suggestions based on a*  
502 *data-driven approach*

503 The Internet and social media are a big part of the information landscape. Undoubtedly,  
504 they represent a valuable channel for science communication, provided that they are  
505 used with purpose and that their own peculiarities are taken into account. Scientists,  
506 journalists, science communicators and practitioners may access a variety of material  
507 on the use of social media through workshops, courses, books, and articles [Lewis,  
508 2018]. Most of this content is based on first-hand experience of their peers and  
509 colleagues. QUEST adopted a novel, data-driven approach to develop tailored  
510 recommendations for the use of social media in science communication. Our  
511 suggestions come from a thorough investigation of the activity of more than 1,000  
512 social media accounts aiming to communicate and disseminate science [Davies et al.,  
513 2019], as well as from qualitative insights from literature review, surveys, and  
514 workshops organised throughout the QUEST project.

515 To ensure quality in science communication, our tips include specific  
516 recommendations grouped in three main conceptual areas, i.e. i) trustworthiness and

517 scientific rigour, ii) presentation and style, and iii) impact on society. Along with  
518 recommendations to include references to the relevant scientific or official source(s)  
519 and to fact-check the content, we highlight the need of declaring conflicts of interest  
520 and considering gender and background balance, seeking a diversity of sources (e.g.  
521 in interviewees' selection). When communicating science, it is easy to yield to technical  
522 jargon. However, using narrative and storytelling is usually more appealing to the  
523 public, as well as including specific calls to action, e.g. asking questions, inviting to  
524 post and/or do something, organising flash mobs. In relation to the content of science  
525 communication, one should take care not only in terms of scientific rigour of what is  
526 communicated, but also of clarity and consistency among the different parts (e.g.,  
527 between the title and the text). Particular attention should be devoted to ensure that  
528 the length and complexity of sentences, the wording, and the assumptions are tailored  
529 to one's target audience. As for the effectiveness, our suggestions can be summarised  
530 in what we called "the 3Ts' rule". We recommended our participants to always take into  
531 account 1) the Type of a tweet/post (post with only text, picture, video, link), 2) its Text  
532 (e.g., including hashtags or links), and 3) the Time when posting or tweeting during the  
533 day/week. Moreover, we provided specific suggestions to deal with controversial topics  
534 such as climate change, vaccines, and artificial intelligence. Our tips also include a  
535 checklist summarising all our suggestions in a more schematic way, to have it at hand  
536 when necessary. We do not expect that all the items in the checklist are achieved  
537 simultaneously, however our advice is to follow the 3Ts rule whenever possible, and  
538 to consider at least an element from the three aforementioned conceptual areas.  
539 A first draft of our tips was field-tested with the direct help of 27 science communication  
540 accounts and their social media managers, that applied our tips to (some of) their  
541 tweets and/or Facebook posts for a five-month period. At the end of this experimental  
542 phase, we analysed the impact of our suggestions in terms of their adoption and  
543 effectiveness. Our preliminary results are very promising and show that Facebook  
544 posts and tweets following our tips achieved a significant higher median engagement  
545 than the others produced in the same period. This highlights the benefits that a data-  
546 driven, co-creating approach can provide to improve and foster science communication  
547 on social media.

#### 548 *Addressing the need for Increased Capacities and Skills: The QUEST Toolkits*

549 QUEST research highlighted the need for specific capacities and skills for all  
550 stakeholders to achieve quality in science communication. What emerged from the  
551 QUEST mapping of the existing educational offerings in science communication is a  
552 fragmented European landscape [Costa et al., 2019]. Courses in science  
553 communication are present in almost every European country, but they are diverse in  
554 terms of context, target audience, and curricula. Most prepare science journalists and  
555 communicators for a wide scope of jobs, while few target scientists or PhD students.  
556

557 In light of this, QUEST has been developing a suite of tools that can support different  
558 stakeholders to ensure quality in science communication. These tools will be gathered  
559 in four toolkits, each one targeting different stakeholders: scientists, journalists,  
560 museum professionals, and social media content managers. The toolkits comprise the

561 KPIs and the specific tools for journalism, museums and social media, listed above.  
562 Moreover, specific tips for each stakeholder are currently being developed and  
563 validated and will be provided in a graphic format to make them even more accessible  
564 to practitioners. These tips will also be included in PowerPoint presentations that can  
565 be used both by science communication trainers and directly by the target groups for  
566 self-directed learning.

567

568 A future development for the toolkits is the intention to produce a series of podcasts,  
569 with the purpose of adding specific focus, context and a human dimension to the range  
570 of deliverables. Working journalists attending a QUEST workshop had previously noted  
571 the difficulty of sourcing female scientists to contribute to their articles. The gender gap  
572 in science and technology has been well documented and attributed to an unsupportive  
573 culture within the scientific workforce [Blair-Loy & Cech, 2010]. To address this  
574 imbalance, and in recognition of the important role played by female scientists,  
575 researchers, science communicators and journalists, the majority of contributors and  
576 interviewees to the podcasts will be women. Focusing on specific scientific  
577 breakthroughs, a number of the podcasts will feature discussion between scientists  
578 keen to disseminate their findings and journalists tasked to report them in articles and  
579 broadcasts. In particular, they will explore how effective the communication between  
580 them proved to be, and crucially, how well served the general public ultimately were.  
581 Another will consider the media coverage of COVID-19, again reflecting on its  
582 effectiveness and identifying lessons learnt. A further podcast will shed light on the  
583 ways science galleries and museums are taking steps to diversify their visitor and  
584 audience profiles, and a final production will focus on the powerful role social media  
585 plays in the dissemination of scientific stories and research findings.

## 586 **Incentivising Quality in Science Communication at All Levels: Preliminary** 587 **Insights from the QUEST Policy Recommendations**

588 Policies play a key role in the promotion of more and better science communication, in  
589 order to overcome obstacles and challenges. QUEST policy recommendations will  
590 suggest strategies to be introduced by the decision-makers that have a role in the  
591 governance of science communication in the EU at the different levels, including policy  
592 makers at EU and national level, editors, governance bodies at research institutions  
593 and universities.

594 The most pressing issues and obstacles faced by the science communication  
595 ecosystem, highlighted in QUEST research are being analysed to be translated into a  
596 list of policy recommendations and incentives that will play a pivotal role in the  
597 promotion of better-quality science communication. Although their development is still  
598 ongoing, the QUEST Policy Recommendations will focus on suggesting I) existing  
599 good practices; II) practices that are not yet in place and could be created to overcome  
600 identified issues.

601 A combination of desk analysis and interviews with the main actors of the science  
602 communication ecosystem (i.e. journalists, scientists, policy makers, media industry,  
603 museums professionals, governance of research institutions from the public and the

604 private sector, etc.) has been employed for this purpose, focusing on the needs and  
605 barriers of three different actors: researcher communicators (University/Research  
606 Organizations/Corporate Communication Officers, P.R. officers, etc.), scientific  
607 journalists and scientific museums.

608 Preliminary results of this ongoing analysis, aimed to investigate the framework  
609 conditions for incentivising quality science communication, are as follows:

610 For institutions focused on research, the QUEST policy recommendations highlight the  
611 need to reinforce the relationship and the trust between academia and the general  
612 public (science-society relationship) and to impact on the collaboration between  
613 researchers and communicators. To this aim, policy recommendation should revolve  
614 around the need to:

- 615 · Increase the skill and competence in science communication fields of  
616 researchers and scientists, e.g. addressing the governance of RPOs to  
617 promote specific trainings also within science curricula
- 618 · Revise the role of communication officers and build a more efficient and  
619 reliable exchange between scientists and these intermediaries based on  
620 trust, e.g. by promoting exchanges and collaboration between them
- 621 · Establish networks and activities where science communication educators  
622 can meet, share best practice, and agree on key educational content would  
623 benefit the field and young science communicators
- 624 · Create a new set of competences and skills in field of public engagement in  
625 the RPOs

626 For the **scientific journalists** the QUEST policy recommendations focus on issues of  
627 misinformation, science complexity and the role of science journalists. To address  
628 these aspects, QUEST policy recommendations will provide suggestions on the need  
629 to:

- 630 · Improve science journalists' critical and evaluation capacities (watchdog  
631 role)
- 632 · Reward and acknowledge thorough science journalism
- 633 · Improve quality and effectiveness of services such as for example science  
634 media centres
- 635 · Reduce the conflicts, improve collaboration, mutual understanding and  
636 learning between journalists and scientists/communicators

637 For **museums**, the QUEST policy recommendations take into account the issue of  
638 inclusivity and the need for museums to be more equitable. QUEST final  
639 recommendations for the museum sector will consider the necessary steps to be  
640 undertaken and the actors to be involved in establishing Diversity, Equality, and  
641 Inclusion (DEI) policies within science museums.

642 The QUEST policy recommendations focus on tackling the issues of misinformation  
643 spread by **social media**, but also on nurturing the opportunities of a two dialogue with  
644 a wider audience and in a more timely manner than with other tools.

645 To do so, the QUEST policy recommendations will:

- 646 - Promote synergies among policy makers, researchers and platforms in order to  
647 combine transparency, freedom of speech, and accountability;  
648



- 649 - Share and incentivise adoption of good practices (i.e. FB Data for Good);  
650 - Investigate business models to shape a new role for journalists and popularizers  
651 on social media.

## 652 **Conclusion**

653 In the last decades, increasing attention has been given to the quality of science  
654 communication and the challenges associated with it. The QUEST project tried to take  
655 a step forward, investigating these challenges, engaging directly with different science  
656 communication stakeholders and co-designing tools that can support them in  
657 implementing quality science communication. The issues of limited capacity and lack  
658 of time, as often reported by scientists, are tackled. Moreover, changes needed at the  
659 policy level have also been considered, targeting those that have decision-making  
660 roles, including policy-makers at national and European levels, as well as editors and  
661 university and research decision-making bodies.

662 Among other current barriers identified are the lack of expertise, of time and  
663 recognition, of indicators to evaluate the quality of science communication. Rapidly  
664 changing business models and diminishing newsroom resources are difficulties faced  
665 by journalists in combination with the rising power of public relations. For museums,  
666 the chronic underfunding of the arts and cultural sectors, coupled with a pressing need  
667 to tackle issues of social inclusion, are key aspects of the struggle to improve the  
668 quality of science communication. In the case of social media, the lack of competency  
669 and confidence in using these new channels, as well as the demand of time for their  
670 use without a clear and immediate reward (e.g., revenues, academic acknowledgment)  
671 are some of the key challenges. Moreover, the critical aspect of how to manage and  
672 limit polarisation in public discussions on social media has to be considered.

673 Starting from this array of evidence, QUEST has been developing a series of tools and  
674 supporting documents that can work as incentives towards ensuring quality in science  
675 communication. In particular, a set of key performance indicators were produced that  
676 have already been implemented as guiding principles for science communication; an  
677 AI tool to incentivise journalists in writing about science in a factual and engaging way  
678 has been developed for journalists looking for different angles to tell their stories; a  
679 curriculum for science journalism has been developed to be implemented by  
680 universities in order to fill the current educational gaps; and an academic writing  
681 handbook has been created to support museum communicators in sharing their  
682 expertise. Moreover, a set of tips, recommendations and guidelines for the different  
683 actors and media have been developed and will be part of specific toolkits for them.

684 As a final output of the project, recognizing the key role that policy can play in  
685 promoting quality science communication, policy recommendations for the different  
686 decision-makers are under development to ensure quality in science communication  
687 in journalism, social media, and museums.

688

689

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697

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