D1.1 REVIEW PAPER OF PREVIOUS EU PROJECTS' RESULTS AND RECOMMENDATIONS

WP1 – Getting insights on mistrust in science and challenges to science society co-creation

Task 1.2 – Analysis of results and outputs of EU projects

Prepared by Josephina Antoniou and Antonis Antoniou (UCLan Cyprus)

Reviewed by Agata Gurzawska, Evren Yalaz, & Evan Fisher (TRI IE), Charalampos Patrikakis, Panayiotis Monachelis, & Nikolas Voudouris (UniWA)

This work is licensed under a **Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) license.**

Funded by the European Union

Project ID: 101058623
Funding Programme: HORIZON-WIDERA-2021-ERA-01
Topic: HORIZON-WIDERA-2021-ERA-01-44
Deliverable: D1.1 Review Paper of Previous EU Projects' Results and Recommendations

Project summary

Although studies show that most people trust science, media coverage, political debates, and social media give the impression that public mistrust in science is widespread.

The VERITY project uses health and environment as case studies to examine varying levels of public trust in science and to seek solutions to the scepticism undermining public policy. It aims to strengthen the public's confidence in scientific findings, foster informed decision-making based on scientific evidence, and facilitate a more constructive and mutually beneficial relationship between science and society by enhancing trust in scientific research.

VERITY is centred around three questions: What do people trust? Whom do people trust? How is trust built? To find answers, the project moves through four stages, starting with surveys of existing research and citizen groups and finishing with the creation of a 'Protocol of Recommendations.' The aim of this Protocol is to provide guidelines and methods for traditional and non-traditional 'Stewards of Trust' to enhance trust in science and facilitate science-society co-creation.

The core aim of VERITY is to re-shape the **'Ecosystem of Trust in science'**, a conceptual space where societal trust in science is formed, shaped, negotiated, and influenced. It encompasses the complex interactions, dynamics, and factors that contribute to the construction, negotiation, enhancement, or reduction of trust in science. The actors within this Ecosystem aim to enhance the public's confidence in scientific research and promote a more inclusive and accountable scientific enterprise.

Previous EU-funded projects have focused on particular actors within the Ecosystem of Trust (e.g., scientists, research funding organisations, research ethics committees) to explore the impact of particular 'machines of trust' (e.g., science communication, research ethics). VERITY goes beyond the state of the art by conceptualising **'Stewards of Trust'** as the actors within the Ecosystem that are responsible for upholding societal trust in science and facilitating science-society co-creation. These actors are organisations, groups, or individuals who possess extensive expertise and a strong commitment to trust in science, as evidenced by their official mandates, missions, or their influential positions in the field. As such, they play a crucial role in shaping the direction and outcomes of the initiative.

VERITY brings these actors together to strengthen societal trust in science. The project employs interdisciplinary expertise from research institutions and universities to develop tools and methods, including the Protocol of Recommendations, to increase societal trust in science, research, and innovation through original research and small-scale participatory activities. The VERITY tools and protocol will have open science and stakeholder participation at their core and consider society's needs, expectations, and values regarding science, research, and innovation.

VERITY findings will be widely disseminated to different 'Stewards of Trust', such as policymakers, research funding and performing organisations, higher education institutions and non-traditional stewards such as journalists or influencers, to enhance societal trust in science and facilitate science-society co-creation.

Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.

Project Information

Project full title: deVEloping scientific Research with ethIcs and inTegritY

Acronym: VERITY

Project ID: 101058623

Funding Programme: HORIZON-WIDERA-2021-ERA-01

Topic: HORIZON-WIDERA-2021-ERA-01-44

Start and end date: 1 September 2022 – 31 August 2025

Duration: 36 months

Website: https://www.VERITYproject.eu/

Consortium partners:

Logo	Partner	Abbreviation	Country
TRILATERAL RESEARCH	TRILATERAL RESEARCH LIMITED	TRI IE	IE
eurec	EUREC OFFICE GUG	EUREC	DE
SCIENCE BUSINESS	SRL SCIENCE BUSINESS PUBLISHING INTERNATIONAL	SB Int	BE
ZSI	ZENTRUM FUR SOZIALE INNOVATION GMBH	ZSI	AT
University of Central Lancashire UCLan Cyprus	UCLAN CYPRUS LIMITED	UCLAN CY	CY
	PANEPISTIMIO DYTIKIS ATTIKIS	UniWA	EL
TRILATERAL RESEARCH	TRILATERAL RESEARCH LTD	TRI UK	UK

About D1.1 Review Paper of Previous EU Projects' Results and Recommendations

Authors: Josephina Antoniou and Antonis Antoniou (UCLan Cyprus)

Contributors: Agata Gurzawska, Evren Yalaz (TRI IE), Philipp Hövel (EUREC Office), Panagiotis Monachelis (UniWA), Pamela Bartar, Gábor Szüdi (ZSI)

Other (external) contributors: N/A

Submission date: 4 December 2023

Dissemination level: PU - Public

CONTENTS

EXECUTIVE SUMMARY

This deliverable report presents a thorough analysis of the results of various EU-funded projects that directly or indirectly dealt with the issues of trust in science, research and innovation, and science-society co-creation. The analysis is guided by the following objectives:

1. Review and systematise the results of previous projects regarding the issues of public trust in science and science-society co-creation.

2. Examine what kind of tools these projects used and present their main findings.

3. Identify the most important shortcomings and barriers in these approaches.

The findings of this report were mainly produced from the thematic analysis of 59 carefully selected projects under the Horizon 2020 – Science with and for Society (SwafS) Programme, and can be divided into the following five themes:

1. The spectrum of the public's roles in science-society co-creation

2. Collaborative decision-making and public trust in science

3. The importance of science communication strategies

4. Responsible Research and Innovation (RRI) as a means of promoting trust in science

5. Barriers, challenges, and strategies to overcome them

The five themes highlight (1) the relationship between the public and science, (2) the ways in which European citizens participate in scientific activities, (3) the role of society in decision-making and shaping the course of scientific research, (4) the importance of how scientific achievements are communicated, and finally, (5) the various challenges in developing and sustaining public trust in science via various approaches and actions, such as targeted outreach activities. The main findings under each theme are as follows:

(1) When participating in co-creation and science communication actions, **members of the public can take on different roles**, from a passive role as recipients of scientific information and education, to an active one as knowledge co-producers. The roles the public plays in citizen science and co-creation actions raise important questions regarding the allocation or sharing of power as well as issues of communication between scientists and the public. For example, when public engagement activities are promoted, it seems that most of these initiatives are produced from the perspective of science, limiting the ability of citizens to choose their own role in science-society co-creation.

(2) A significant number of projects have openly acknowledged the merits of **collaborative decision making**. Efforts to **promote and sustain a dialogue between science and society**, e.g., through the creation of appropriate spaces,

have been identified as enhancing society participation and science-society co-creation.

(3) Another result of our analysis concerns the importance of **science communication** for the enhancement of public trust in science, indicating that there are still several questions that need to be addressed in order to fully understand how communicating science enhances the public's trust in its results. These questions relate to the source of science communication, the gender dimension and representation of science communicators (i.e., the perception of scientific results as less trustworthy when communicated by scientists of different genders), and the content of the scientific message that needs to be transmitted to increase the public's trust.

(4) Our analysis also revealed that **Responsible Research and Innovation (RRI)**, **science education** and **open science** may have a significant impact on trust in science and should be further employed as tools for promoting trust in science.

(5) The thematic analysis concluded with the **various challenges** faced by previous projects in their attempts to implement strategies that directly or indirectly enhance societal trust in science. These challenges pertain to (1) the diversity of public engagement, (2) the (un)availability of science representatives, (3) the public's availability and motivation, and (4) the quality of scientific methods and results.

In addition to the qualitative thematic analysis of the selected EU project documents, a cross-project meta-analysis took place that identified the key stakeholder categories to be used in future project activities. The findings demonstrated a geographical imbalance between EU countries participating in 'trust-in-science' related projects, as well as increasing participation of social sciences and decreasing participation of the arts and engineering sciences in trust-building.

Our combined analysis leads to the conclusion that the examined EU-funded projects have made significant contributions to the enhancement of public trust in science within Europe by studying, promoting, and organising several actions related to **public engagement, science-society co-creation, science communication, science education, open science and RRI in general**. Nevertheless, we highlight the need to further develop these strategies and assess their precise impact on trust in science within VERITY and its sister projects.

The future actions of the VERITY project within the various Work Packages, such as the Systematic Literature Review on public trust in science, the report on the strategies, methods, and tools to tackle societal mistrust in science, the focus groups, and the vignette study, will be largely guided by the findings of this report and the identified action points.

This report will also contribute to the development of the VERITY recommendations for Stewards of Trust for tackling mistrust and strengthening the open science and science citizen co-creation of Research and Innovation.

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS/ABBREVIATIONS

Abbreviation	Explanation
AI	Artificial Intelligence
CS	Citizen Science
EC	European Commision
EU	European Union
OS	Open Science
RQ	Research Question
RRI	Responsible Research and Innovation
STEM	Science, Technology, Engineering, Mathematics
WP	Work Package

Table 1. List of acronyms/abbreviations

GLOSSARY OF TERMS

Term	Explanation
Stewards of trust	The organisations and persons responsible for guiding societal trust in science and facilitating science-society co-creation. Their responsibility emanates either from their official mandate and mission, or from their de facto power and influence.
Ecosystem of trust	The conceptual space within which societal trust in science is constructed, negotiated, enhanced or reduced, as well as science-society co-creation and open science are sought.

Table 2. Glossary of terms

1. INTRODUCTION

This deliverable is the outcome of '1.2. Analysis of results and outputs of EU projects', for 'WP1: Getting insights on mistrust in science and challenges to science society co-creation' of the VERITY project. It presents a summary and analysis of the results of previous EU funded projects that dealt – directly or indirectly – with the issues of trust in science and science-society co-creation. For the purposes of this task, researchers from the VERITY project consortium examined documents showing project results or policy recommendations from several carefully selected previous European Union (EU) projects, in order to review and systematise their results with respect to the enhancement of public trust in science within the EU and beyond.

In particular, the three main objectives of our analysis are the following:

I. To review and systematise the results of previous projects regarding the issues of public trust in science and science-society co-creation.
II. To examine what kind of tools these projects used and present their main findings.
III. To identify the most important shortcomings and barriers in these approaches.

Our methodology for achieving these goals was largely based on thematic analysis – a widely used qualitative research method. Our thematic analysis included the examination of documents from 59 previous EU projects, of which 41 contributed to the derivation of five key themes:

1. The spectrum of the public's roles in science-society co-creation
2. Collaborative decision making and public trust in science
3. The importance of science communication strategies
4. Responsible Research and Innovation (RRI) as a means of promoting trust in science
5. Barriers, challenges, and strategies to overcome them

Each one of these themes is presented in detail in Section 3, in which relevant passages from the studied documents are given in support of these themes, as per the standard methodology of thematic analysis. In Section 4, a cross-project meta-analysis follows where the five derived themes are combinedly discussed, along with a presentation of quantitative results that emerged from our thematic analysis. The discussion in this fourth section aims to bring together the results of our research for this task and present to the EC a collective picture of the work carried out in the examined projects.

2. METHODOLOGY

The systematization of the results from previous EU projects was completed in five stages, as illustrated in Figure 1, and was largely based on the method of thematic analysis. Thematic analysis is a widely used research method for identifying, analysing and reporting patterns or themes within a specific set of qualitative data, with the aim of providing a rich description of the data and a detailed account of a particular aspect or aspects of interest (Braun & Clark, 2006, 2012). In this report, the aim of our analysis is to review and systematize the results of previous EU projects in order to assess the extent to which these projects have been effective in enhancing societal trust in science and science-society co-creation, as well as to identify the presence of possible shortcomings and barriers towards the achievement of this goal.

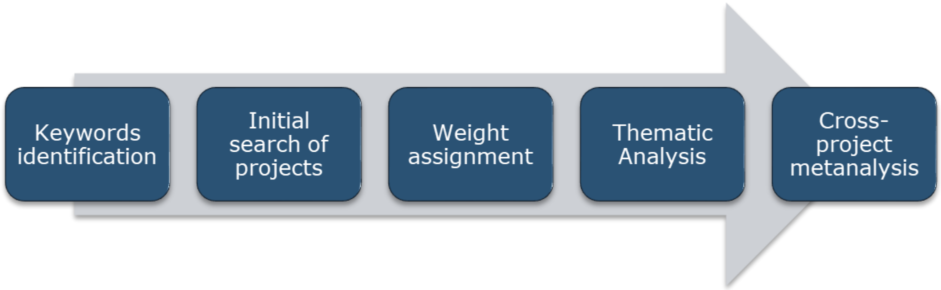

Figure 1. The five stages of our methodology

The first stage of our methodology was to define a set of criteria and keywords based on which we would then proceed to construct a list of potentially relevant EU projects that are likely to have had a direct or indirect impact on the enhancement of societal trust in science and the promotion of science-society co-creation. After careful consideration of various aspects of these research themes, we defined a set of keywords addressing the following concepts:

a) trust in science
b) collaboration
c) co-creation
d) responsible research and innovation (RRI)
e) research ethics
f) research integrity
g) benefit sharing

Based on these keywords we conducted a preliminary search of previous framework programmes and EU calls and decided to explore EU projects from the two most recent EU framework programmes, namely, Horizon 2020 and Horizon Europe. The choice of these two framework programmes was based on the fact that they cover the most recent programming periods (2014 – 2020, 2021 – 2027) of the European Commission (EC) and include calls directly concerning the co-creation of scientists and the public (H2020 – Science with and for Society, H2020-SwafS-2018-2020) and the enhancement of public trust in science (HE – Societal trust in science, research and innovation, HORIZON-WIDERA-2021-ERA-01).

The second stage in our methodology was to conduct an initial search in the CORDIS database[1] in order to derive a preliminary list of potentially relevant projects from these two framework programmes and specific calls. The search was conducted using the available filters in the CORDIS search tool by selecting Horizon 2020 and Horizon Europe in the 'Programme' category and typing 'SwafS' and 'WIDERA' in the 'Call ID' category, returning an initial list of 476 projects. The preliminary relevance of these 476 projects for the purposes of this deliverable was assessed by the authors of this report by scanning the titles and short descriptions of each project. The completion of this second stage resulted in a combined list of 175 projects from the H2020 - SwafS programme (n = 161) and the HE - WIDERA programme (n = 14).

For the third stage of our methodology, the list of 175 projects was disseminated to all partners for further screening based on an additional set of commonly agreed criteria. During this stage, a researcher from each participating organisation was assigned to a subset of the projects for which they were responsible to assign a weight factor (1-3), capturing the relevance of each project to the objectives of this deliverable, as follows:

- Weight = 1: the project is irrelevant to the objectives
- Weight = 2: the project is indirectly relevant to the objectives and any one of the following themes: trust in science, collaboration, co-creation, RRI, research ethics, research integrity, benefit sharing.
- Weight = 3: the project is highly relevant to the objectives and any one of the following themes: trust in science, collaboration, co-creation, RRI, research ethics, research integrity, benefit sharing.

All researchers were instructed to assess the relevance of the projects to the main objectives of the deliverable based on the extent to which the projects engaged with what we call the five different 'machines' of trust in science, namely, research ethics, research integrity, benefit sharing, co-creation, and science communication.

In order to eliminate personal bias in determining the eligibility of each project to be included in the thematic analysis for this deliverable, all projects were also independently screened by a researcher from UCLan Cyprus. As a result, each of the 175 projects received a weight factor assignment from two independent researchers. A cross comparison of these assignments was then carried out to determine the eligibility of each project to be included in the thematic analysis as follows: a project was considered to be eligible for the thematic analysis only if (a) it had received a 3-3, a 3-2, or a 2-2 weight assignment and (b) the project has produced at least one deliverable summarizing some of its results (preliminary or final) and/or providing specific recommendations and guidelines for certain actions related to the various machines of trust (e.g. recommendations to research performing organisations (RPO's) for implementing RRI practices, specifications of citizen science actions, guidelines for open science practices etc.). The implementation of these additional inclusion criteria resulted in the final list of

[1] https://cordis.europa.eu/projects/en

59 eligible EU projects, which were examined to produce this report through thematic analysis. For each one of these 59 projects, one or two publicly available documents (deliverables or articles) summarizing the results of the projects and/or providing specific recommendations and guidelines for certain actions related to the various machines of trust were then identified in order to derive the data for the thematic analysis. Of the 59 eligible projects analysed, 41 contributed to the derivation of the five key themes to be discussed in the following section. Annex 1 presents the complete list of the 59 studied projects along with the corresponding documents examined in the thematic analysis. The 41 projects used for the derivation of themes are marked with an asterisk. It is worth noting that none of the current EU projects from the HE-WIDERA call was included in the final list, since these projects are relatively recent and have not yet produced any considerable results to be analysed.

In sum, the final list of projects considered for the thematic analysis in this deliverable was determined on the basis of the following inclusion criteria:

- EU projects from H2020-Swafs call and HE-WIDERA call related to the broader issues of trust in science and science-society co-creation.
- Relevance to the objectives of this report as captured by a weight factor.
- Existence of a document/deliverable summarizing final or preliminary results of a project and/or providing specific recommendations and guidelines for certain actions related to the various machines of trust.

The first three stages described above, closely resemble the standard process of a systematic literature review where a set of inclusion and exclusion criteria is carefully selected in order to identify a certain body of literature for further analysis based on given research objectives.

The next and fourth stage of this task was to analyse the content of the identified documents of each project based on the method of thematic analysis. As defined by Braun and Clark (2006), thematic analysis is a step-by-step approach that helps researchers identify patterns and meanings in qualitative data, which in our case were derived from the results of the selected projects and include project deliverable reports, interview transcripts, and scientific articles. Typically, thematic analysis proceeds in six steps which can be schematically presented as follows:

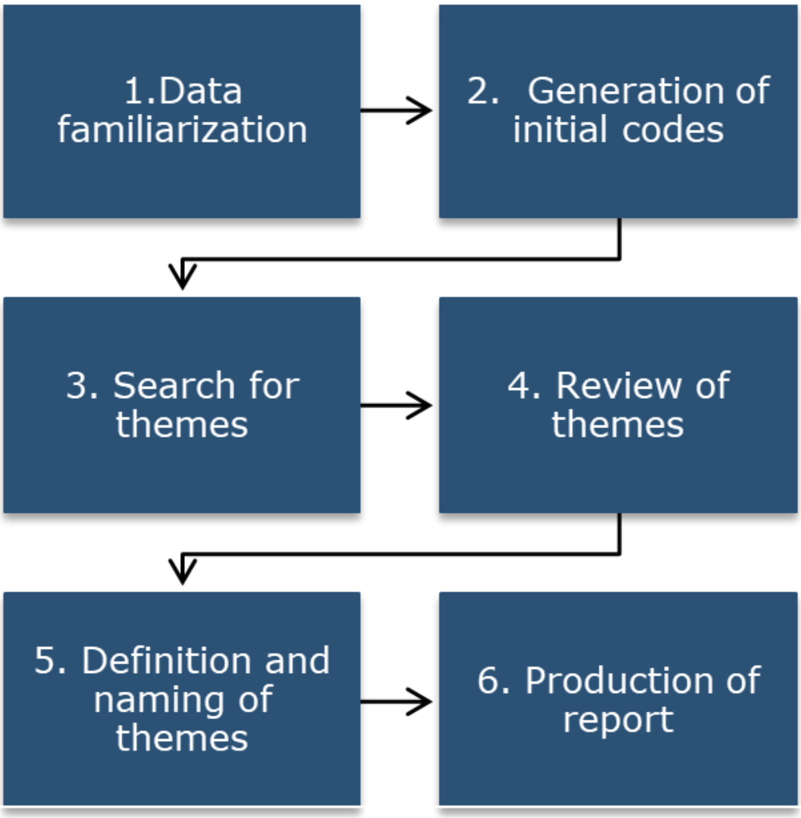

Figure 2. The six steps of thematic analysis

Once the list of 59 EU projects was finalized and the corresponding documents identified, the available texts from the projects were disseminated to five researchers from the five participating organizations for their familiarization with the available data (Step 1) and the generation of the initial codes of the thematic analysis (Step 2). In a thematic analysis codes are used to identify instances of the data that are related to the central research objectives and are of particular interest to the analysts. In practice, the coding process captures 'various segments of the raw data or information that can be assessed in a meaningful way regarding the phenomenon' under consideration (Boyatzis, 1998, p.63). Thus, in order to assess the extent to which previous EU projects have been successful in enhancing public trust in science via machines of trust, the researchers collaboratively produced relevant codes for which each researcher was responsible to identify corresponding excerpts from the documents they were assigned. Table 3 illustrates the codes used for the present thematic analysis, along with a brief description of each code.

After the identification of passages related to each one of the produced codes from the documents under consideration, the authors of the present report studied the coded passages in order to extrapolate the most important *themes* related to the two main areas of interest, i.e. the enhancement of trust in science and the promotion of science-society co-creation (Step 3). Theme development was based on the analysis of the coded passages in order to derive broad and overarching questions, issues and concerns the analysed data. A theme captures something important about the data in relation to the research question and represents some level of patterned response or meaning within the data set' (Braun & Clark, 2006, p.82). The aim of the present thematic analysis is therefore, to identify possible patterns within the coded data in order to derive useful insights from previous EU projects regarding possible actions for the direct or indirect enhancement of public trust in science via the aforementioned machines of trust of science, i.e. research ethics, research integrity, benefit sharing, co-creation, and science communication.

Code	Description
Science-Society co-creation	Collaborative forms of innovation between scientific and societal entities/stakeholders
Trust/Mistrust in Science	Means to motivate the value of trust in scientific outcomes and findings
Impactful Collaborative Work	Organisational or business relationships or interactions, which add value
Responsible research	Research approaches that anticipate potential implications to society
Governance	Authorities preventing negative impacts of research/innovation
Ethics in RRI	Consideration of human rights and ethical standards for social relevance of research/innovation
Gender Equality	Consideration of under-representation of women and how the gender dimension is integrated in research/innovation
Open Access	Transparency and accessibility of scientific resources
Citizen Participation	Joint participation of all social actors, i.e. researchers, industry, policy makers and civil society
Science Education	Tools and knowledge to better support the preparation of future scientists, researchers, and innovators

Research Integrity	Ways to actively adhere to principles and standards (e.g., codes of ethics)
Research Ethics	Guidelines on how scientific research should be conducted and disseminated
Science Communication	Ways to inform/raise awareness about science-related topics & scientific results
Benefit Sharing	Fair and equitable sharing of benefits from research/scientific outputs
Proposed Mechanisms	Proposed solutions to approach any of the areas of interest (trust in science, research ethics, responsible research, etc.)
Application Area	Implementation of solutions to approach any of the areas of interest in specific application areas (education, business, governance, health, etc.)
Challenges / Barriers	Challenges or barriers to the implementation of solutions regarding any of the areas of interest
Key Stakeholders	Specific stakeholders involved in the implementation of solutions regarding any of the areas of interest

Table 3. Codes of thematic analysis

The analysis of the coded text by the authors resulted in the identification of the following five themes to be discussed in the following section:

1. The spectrum of the public's roles in science-society co-creation
2. Collaborative decision making and public trust in science
3. The importance of science communication strategies
4. Responsible Research and Innovation as a means of promoting trust in science
5. Barriers, challenges and strategies to overcome them

After jointly defining the five themes of the thematic analysis the text containing the discussion of the five themes (Section 3) was co-produced by the authors of this report (Step 6).

Finally, the fifth and last stage of our methodology was to conduct a cross-project meta-analysis of our findings (Section 4), in which we summarised the most important findings of our thematic analysis and derived a set of quantitative results that emerged from our analysis regarding the countries in which these projects were located, the scientific fields with which they were associated, and the various groups of stakeholders they engaged.

3. THEMES AND FINDINGS OF THEMATIC ANALYSIS

The five themes derived from thematic analysis highlight, in our opinion, the most important aspects of the analysed documents in terms of the relationship between the public and science, the ways in which European citizens participate in scientific activities, the role of society in decision making and shaping the course of scientific research, the importance of how scientific achievements are communicated, and finally, the various challenges in developing and sustaining public trust in science via various approaches and actions, such as targeted outreach activities. Each theme is developed below and presented in detail with the support of corresponding passages from the analysed text in our thematic analysis.

3.1. THE SPECTRUM OF THE PUBLIC'S ROLES IN SCIENCE-SOCIETY CO-CREATION

Citizen science and science-society co-creation is one of the eight ambitions stated in the Open Science policy of the European Union: 'The general public should be able to make significant contributions and be recognised as valid European science knowledge producers'. Furthermore, one of the aims under the Horizon Europe programme is to 'engage and involve citizens, civil society organisations and end-users in co-design and co-creation processes and promote responsible research and innovation.'[2] It was also the focus of one of the five strategic orientations in the Horizon 2020 – Science with and for Society Work programme ('Strategic orientation 4. Exploring and supporting citizen science'), and naturally, many EU projects funded under the SwafS call engaged with and promoted citizen science actions.

As outlined in the SwafS Work Programme, citizen science is envisioned as 'linked with outreach activities, science education or various forms of public engagement with science as a way to promote Responsible Research and Innovation'[3]. This suggests that the term covers a broad range of activities and ways in which members of the public can engage with scientific activities, either in more passive roles, for instance, as recipients of the produced scientific knowledge, or in more active roles, as decision-makers with regards to the use of science in society or as co-producers of scientific knowledge. This broad range of citizen science and co-creation activities was clearly captured by the analysed texts of

---

[2] The EU's open science policy: https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science_en

[3] Horizon 2020 Work Programme 2018-2020, 16. Science with and for Society: https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-swfs_en.pdf

the examined EU funded projects, elucidating the first key theme of our analysis regarding the wide spectrum of the roles of the public in science:

> *The term "co-creation" broadly designates any coming-together of different actors in a joint activity that leads to a mutually beneficial outcome. However, within this broad definition, co-creation could take many different forms and follows a range of goals – ranging from actual democratization to mere democratic tokenism. (SCALINGS)*

Thematic analysis of EU projects showed that **the roles that citizens occupy can be thought to exist within a spectrum, where, on the one end, one finds a completely passive role of citizens as the spectators of scientific achievements, and, on the other end, one finds more active ways of citizen participation in the co-production of scientific knowledge**:

> *Science outreach activities (e.g. exhibitions) are at one end of the spectrum of Citizen Science while interactive workshops are at the other". (DITOs)*

The most extreme form of passive citizen participation in science concerns science communication activities in which citizens engage with science by merely receiving information about the progress of science, its methods, and its overall impact on society:

> *The EU-funded GlobalSCAPE project will contribute to a more comprehensive picture of science communication by focusing on science communication professionals working in non-Western countries and in regions where science communication can be challenging or under-valued. (GlobalSCAPE)*

> *Citizen Science is starting to be understood as the new paradigm for science communication, which is the core of the NEWSERA project. Improving the quality and effectiveness of science communication in CS projects is one of our main objectives. (NEWSERA)*

Less passive forms of citizen participation concern various activities in which the public is engaged in science educational events, such as citizen consultation sessions:

> *CONCISE sought citizens' viewpoints and analysed the responses obtained during the consultation to determine exactly how they viewed the issues under debate and use the findings to produce good practice guidelines for science communicators, educators and policymakers. (CONCISE, Article 1)*

Science-related interactive events such as the ones organized by the DITOs project are also less passive forms of citizen participation:

> *The majority of DITOs events were interactive (only counting workshops, science cafés, the bus, and gaming competitions). Online events vary in their degree of level of interaction while exhibitions and conferences are typically more unidirectional. (DITOs)*

More active citizen science activities are those in which members of the public make more or less substantial contributions to the production of scientific knowledge as co-researchers through participation. Consider for instance participants in medical research:

> *Patients started to be engaged not only in a passive role but as co-researchers. Patient engagement should not be limited to interviews or conversations, but rather should entail a series of cooperative endeavors. (MULTIACT)*

Participation in other scientific activities, such as data collection and data processing, is another form of active co-creation:

> *A central component of the DITOs approach is the notion of the Citizen Science escalator of public engagement. It suggests a hierarchy within a broad range of activities, from a perhaps mostly passive consumption of science (e.g. listening to a presentation or partaking in an exhibition) to more engaging activities such as hands-on experienced-based workshops and activities involving data analysis and goal-driven search for facts and hypotheses. (DITOs)*

Active citizen participation in science can also include decision-making by the citizens, such as co-creating the research design framework. In addition, active participation of the public in evaluation processes can be achieved by ensuring, for instance, the compliance of a research project with existing ethical guidelines and the fair dissemination of its results for shared benefits:

> *Participants involved in the operational working process of R&D&I activities differ from those involved in evaluation processes. Contributing to programmes design or implementation involves a different engagement than participation in evaluation, where the contribution focuses on compliance with ethical frameworks, regulations and procedures. (ProETHICS)*

> *In general, citizen engagement and stakeholder engagement activities range from the inclusion of citizen representatives on steering committees to the development of partnerships with targeted community groups to the employment of citizens that lived the experience relevant for performing the CSH (i.e., mental health patients, trained and hired to support care and research activities). (INCENTIVE)*

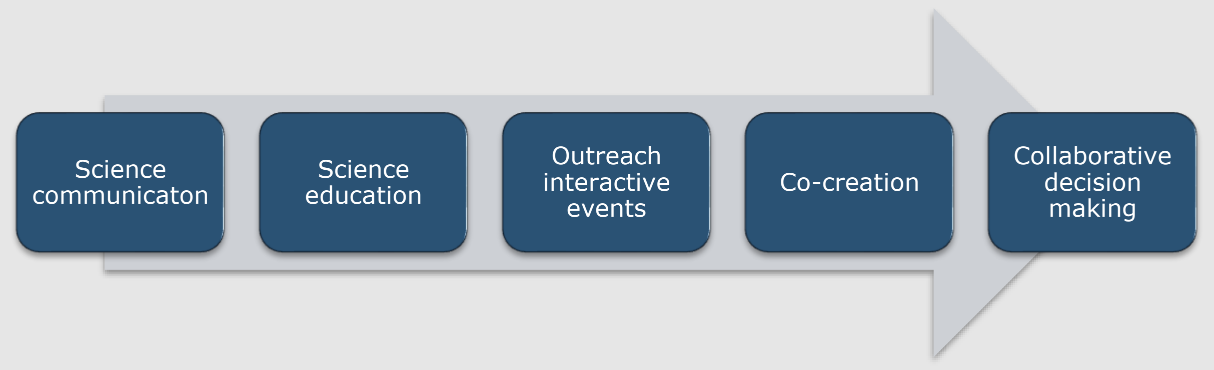

Figure 3. The spectrum of roles in citizen participation

Figure 3 illustrates the spectrum of roles in citizen participation, from more passive forms of participation (left) to more active ways of public engagement in science (right). **This wide spectrum of the roles the public plays in citizen science and co-creation actions, highlighted in the above examples, raises important questions regarding the allocation or sharing of power and communication between scientists and the public in citizen science projects.** There seems to be a consensus that the enhancement of trust in science requires more than simply providing detailed information about scientific results and science education to the public; it requires that the public be given greater agency as scientific citizens to achieve co-creation:

> *Traditional ways of tackling the knowledge and trust deficit by providing more information to the public have failed to deliver results. In fact, crises and controversies that question the authority and reliability of science, such as BSE (or "mad cow disease") and GMO (genetically modified organisms), have only further undermined public trust […]. The solution proposed was to promote more public engagement with science, following a "dialogical model" (CONCISE, Article 2)*

> *There is a need for greater outreach to civil society to better explain results and impacts and the contribution that research and innovation can make to tackling societal challenges, and to involve them better in the programme co-design (agenda-setting) and its implementation (co-creation). (SPARKS)*

> *To make science communication really effective, it is crucial to consider the role of the public and increase the literacy of the audience, but also trust in science, building a constructive dialogue between scientists and the public. (QUEST)*

A number of projects have aptly highlighted the need to reconsider the ways in which the public is usually invited to participate in citizen science projects, as well as the expectations of the scientific community for the achievement of certain scientific outcomes via citizen science:

> *Citizens are called to constructively contribute to particular research projects and debates; they are called to exchange arguments, to take on a broader and more*

balanced view and to reach consensus whenever possible. As a result, citizens are ubiquitously expected to be interested, to be informed, to be engaged, to be active. (PROSO)

Moreover, sponsors and organizers of formal engagement processes command specific framing power that has to be scrutinized in the context of RRI. Even in the case of two-way deliberation we have to be aware that there is a power imbalance between the organisers of participatory activities and those taking part in a public dialogue event. (PROSO)

Another main conclusion of this report is that despite decades of experimentation in the field of participatory practices, essential questions still remain unresolved, as to why, how, with whom, and in view of what quality participatory processes are conducted. This puts into question how participation is justified, and what the goals and outcomes are to be targeted, but also the need to reconsider the nature and scope of the underlying ethical issues in each context of design or implementation of participatory processes. (ProETHICS)

Moreover, the participation of the public, needs to be approached responsibly with consideration of relevant values and ethical guidelines:

Often enough the potential participants may be unable to cope with the challenge of balancing chances and risks of emerging technologies that are far from concrete applications and peoples' daily experiences. From this perspective, the RRI discourse should pay attention to the risk of an engagement overdose. (PROSO)

…the need to embed public engagement in research institutions clearly emerges, so as to make it a permanent function of the organisation, by activating governance structures able to go beyond a dispersed and occasional approach to public engagement… Two main strategies can be identified:−Supporting researchers and staff to promote public engagement activities−Establishing new structures, norms, and services. (GRACE, Guidance document #2)

The above passages capture what may be seen as one of the most important findings of the present thematic analysis, namely **the need to further examine whether current practices of citizen science are imbalanced and unidirectional, in that citizens are often asked to actively contribute to scientific research but that the actual organisation of scientific research rarely provides them the opportunity or capacity to co-lead or co-design these initiatives, which in their vast majority are organized and led from the perspective of science representatives** (e.g. universities, science communication organizations, scientists themselves etc.). Thus, achieving greater trust through Citizen Science requires we find a way to activate and empower scientific citizens.

One of the aims of the VERITY project in the forthcoming tasks, especially in the organisation of focus groups with citizens, journalists and scientists (T1.3 – WP1) is to examine the extent to which citizens feel 'estranged' or 'incompetent' when asked to participate in scientific research and carry out activities that may have a more direct impact on the production of new scientific knowledge, and what they feel they need to take on a more active role.

3.2. COLLABORATIVE DECISION MAKING AND PUBLIC TRUST IN SCIENCE

The second key theme identified in the thematic analysis concerns the merits of collaborative decision making, a theme closely related to the idea of the spectrum of roles in the co-creation process, identified in the previous section. **Collaborative decision making has the potential to create momentum towards greater public trust in science.** Collaborative decision making is listed as one of the medium and long-term impacts of the Horizon Europe WIDERA work programme ('Increased collaboration with all stakeholders, including citizens in all phases of research and innovation, leading to more responsible R&I')[4] and is expected to have great impact on raising the levels of public trust in science. Empirical research shows that public involvement in science-related decision making (Barnett et al., 2007; Nwebonyi et al., 2022), as well as engaging citizens in science and organizing outreach activities (Bedessem et al. 2021; Krüger,et al. 2022) are associated with high levels of trust in science. The aims of our thematic analysis are therefore, 1/ to assess the various ways in which past EU projects promoted collaborative decision making, 2/ to examine the overall impact of organizing and running citizen science actions from the perspective of the scientific community, and 3/ to determine whether such actions may eventually undermine the public's trust in science.

To begin with, the conducted analysis revealed that **a significant number of projects have openly acknowledged the merits of collaborative decision making, especially with respect to the public's feeling of empowerment when asked to contribute and express their opinions about important science-related issues:**

> *Thus, during the event, citizens were able to contribute to the development of science-related issues, and they knew that their contribution would help to prompt specific practical actions to improve communication on socially relevant topics. The citizens' felt empowered by being asked for their opinion, which would then be transmitted to science communication stakeholders. (CONCISE, Article 1)*

Moreover, the involvement of the public in different stages of the scientific process has been formalised with concepts such as RRI and participatory research techniques and used within EU projects to achieve more inclusive research practices, where the public has an elevated role:

> *The Rome Declaration in 2014 made the case for RRI, stating "RRI requires that all stakeholders including civil society are responsive to each other and take shared*

[4] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2023-2024/wp-11-widening-participation-and-strengthening-the-european-research-area_horizon-2023-2024_en.pdf

responsibility for the processes and outcomes of research and innovation. This means working together in: science education; the definition of research agendas; the conduct of research; access to research results; and the application of new knowledge in society - in full respect of gender equality, the gender dimension in research and ethical considerations". (SPARKS)

The participatory design developed a dialogue with stakeholders over a number of rounds […], explored their experiences in practice, and jointly identified their informational needs. The interactive approach also allowed for further exploration of emergent themes. (EnTIRE)

Some projects also suggested various mechanisms for promoting and sustaining a constructive dialogue between representatives of science and representatives of society. This can be initiated by the projects themselves, i.e., by asking for input from local community representatives, and the public in general:

Ultimately, partners suggest that to make science events inclusive you need to go out and listen to your audience. It also involves immersing into the work of local organisations and community organisations and then design activities together. As noted above, local partnerships can provide gateways into new audiences. (DITOs)

…the BG [Botanic Garden] partners were generally able to engage the public in dialogue and co-creation processes, encouraging debate on the topic of food security. It was the view of most BG partners that when the public has a voice, they start to feel they are as responsible as the scientists, experts, and policymakers for the decisions which are being made about food security issues. These actions can also be seen as an achievement of an RRI dimension, especially on the relevant aspect of public engagement. (BigPicnic)

Another approach would be to create appropriate spaces that can encourage the public to contribute to the decision-making process. Such processes are often seen as complex, with decision making spaces being composed of sets of interconnected ecosystems, where different types of stakeholders, such as researchers, funding bodies, politicians and the public need to participate:

One of the most critical issues for the CONCISE partners was to promote a feeling of participation in an initiative with a global reach, as well as offer a space in which participants could express their proposals, demands and expectations of communication on the four topics. (CONCISE, Article 1)

…the current AI scene can be interpreted as an interlinking set of ecosystems consisting of numerous actors (including individuals, companies, civil society organisations, public sector organisations, states, international actors). (SHERPA)

However, the EnviroCitizen project identified an imbalance in the initiation, organization and funding of citizen science actions, which mostly come from the perspective of science representatives, and a tendency to target specific groups of people:

…we identified that the majority of CS [Citizen Science] initiatives were initiated and supervised by academic institutions and NGOs, with the majority of funding derived by the national governments and NGOs. (EnviroCitizen)

The latter results are in agreement with the type of CS initiatives identified, which in their majority were following the contributory, contractual, and collaborative approach, with "passive" contribution from citizens, rather than the co-created and collegial ones. (EnviroCitizen)

This fact raises some important questions regarding **the balance between members of the public and science representatives in the context of science-society co-creation and collaborative decision making**. If it is true that most citizen science initiatives are organized from the perspective of science representatives, leaving citizens in a mostly passive – but still engaging – role, it is important to examine whether passive participation and lack of decision-making power are associated with lower levels of trust when compared to more active roles in science-related decision making and the co-creation of scientific roles.

Moreover, given that there is a need to move towards more democratic forms of citizen science and co-creation, **it is possible that members of the public feel that they do not have the authority or the expertise to make important decisions about the course of scientific research** in certain areas and actively contribute to science:

Dialogue between researchers and stakeholders was more bi-directional than between researchers and the public, mostly due to the existing knowledge gap with the citizens. This could explain the mixed views of citizens regarding the actual need of their inputs in science. (ORION)

This common perception of science by laypeople as something 'above and beyond' one's capabilities may be the result of a lack of trust from the scientific community to the public, which was another recurring pattern in the analysed documents:

The legitimacy of engagement in research is frequently challenged by doubts in the competences of societal actors, including citizens, to meaningfully comment on scientific debates or even contribute to research. (PROSO)

I'm sceptical to including all sorts of people in the research and innovation processes. They do not have the right language and the right knowledge to participate on an equal footing. (ETHNA – Interviewers' views)

…engagement with citizen science is often limited by concerns over data quality. (EU-Citizen.Science)

These passages clearly indicate **a form of hesitancy from the scientific community to engage members of the public in more active forms of co-creation and collaborative decision making**. The reasons for this hesitancy are typically attributed to the 'knowledge gap' between scientists and laypeople, and the lack of the 'right language and right knowledge' to participate in scientific research with 'quality control' often cited as a major obstacle in using the public for the production and analysis of scientific results.

The fact that scientists are often reluctant to engage citizens in more active forms of citizen science may be responsible for further widening the gap between science and society, thus undermining a strong relationship of trust between the public and science as a whole. Thus, a hypothesis to be tested based on these findings would be whether citizens feel that scientists do not trust them to make decisions about scientific research, and if this leads to a lack of trust from citizens towards scientists to take important decisions that may affect their lives directly or indirectly. It is therefore paramount to examine the ways in which a long-term two-directional relationship of trust between the public and the scientific community can be built and sustained by developing a culture of collaboration between science and society, which, as aptly noted by the NUCLEUS project, cannot be limited in one-off events and actions, but rather, will be based on an ongoing dialogue between scientists, policy makers and the public:

> *In establishing new alliances and partnerships, the EN have shown that city-university collaborations should not be limited to events. Sustainable networks need an ongoing knowledge exchange between researchers, scientific institutions, local stakeholders and citizens from different backgrounds (e.g. different cultures, genders and age groups). (NUCLEUS)*

While the focus of the VERITY project is to examine, develop and sustain mechanisms for the enhancement of public trust in science, the main findings of the present section of our thematic analysis, indicate **that an additional effort could be made towards the enhancement of scientists' trust in the ability of the public to engage with scientific research in ways that go beyond the passive participation of laypeople in science outreach activities**. In sum, enhancing societal trust in science also means demonstrating to scientists the lay public is endowed with specific forms of knowledge and expertise that, when properly engaged, can improve study design. In addition, if the concerns of the public about the effects of scientific activity are taken into consideration during research, then the bearing, scope and societal impact of scientific results can be extended.

The establishment of this mutual relationship of trust between science and the public reflects the ambitions of the Horizon Europe WIDERA Work Programme for increased inclusivity: 'Europe-wide citizen science campaigns should aim to cover a majority, – and potentially all – ERA countries; involve citizens at different stages of the research cycle (e.g., development of methods, data collection, data analysis, evidence-based advocacy processes, testing and evaluation); be inclusive and make particular efforts to involve those from lower socio-economic groups; and aim to deliver a range of additional benefits such as increased scientific literacy, improved trust in science, improved social inclusion and employability, and improved capacity within the scientific workforce to engage with society.'[5]

3.3. THE IMPORTANCE OF SCIENCE COMMUNICATION STRATEGIES

The third major theme of our thematic analysis concerns the importance of science communication for the development and the sustainability of public trust in science. Science communication has received considerable attention in current scientific literature as one of the most efficient ways to enhance and sustain trust in science, since the effective communication of scientific achievements has been shown to be highly correlated with increased levels of trust in science from the public. In particular, several empirical results indicate that various characteristics of the message transmitted to the public, such as the presence of information regarding the scientific method on which a result was derived (Agley et al., 2021a), the communication of ethical implications (Hendricks et al., 2016), and the communication of high consensus levels (Chinn et al., 2016; Mann and Schleifer, 2020), positively affect the levels of trust in science by the recipients of these messages.

Science communication is also one of the topics considered in the Horizon 2020 SwafS Work Programme (Strategic Orientation 5. Building the knowledge for SwafS / Taking stock and re-examining the role of science communication), and as expected, several EU funded projects have attempted to increase the knowledge and understanding of science communication strategies.

The importance of science communication in shaping the public's attitude towards science has been implicitly and explicitly acknowledged by several projects. Indeed, science communication strategies encompass much more than simply providing to the public the scientific results per se; scientific communication is essential to the democratic process and to the empowerment of scientific citizens:

> *The need for thoroughly factual and carefully crafted science communication can no longer be ignored if we want citizens to participate fully and knowingly in democratic deliberations. The ENJOI's contribution to this overarching goal is the result of a multi-dimensional approach combining research and co-creation activities. (ENJOI)*

Moreover, the importance of training researchers to develop appropriate science communication skills is also often highlighted:

> *…we highlight the necessity to encourage science communication skills and purpose in early career researchers, as a way to Open Science, also to the nonexpert part of society. (GRECO)*

[5] Horizon Europe, Work Programme 2023- 2024, 11. Widening participation and strengthening the European Research Area (p.97-8)

science communication is a necessary precondition for public engagement, since it serves to raise the interest of people or specific stakeholders on science and to encourage them to get involved with science and technology as well as to create in research organisations an enabling environment for more advanced forms of engagement. Moreover, science communication is also expected to enhance the image of science and to attract young people to start scientific careers. (GRACE)

Thus, science communication needs to be considered as a core element for achieving public trust:

…the EU-funded GlobalSCAPE project will contribute to a more comprehensive picture of science communication by focusing on science communication professionals working in non-Western countries and in regions where science communication can be challenging or under-valued. (GlobalSCAPE)

Science communication is a core element of the citizen science process and a key focus of ParCos (Participatory Science Communication). Within the scientific literature science communication has traditionally been divided into two paradigms. The first view is as the one-way transmission of information from 'expert' scientists to the general public. Whilst other models view it as a dialogue and discussion between the public, experts and decision-makers. (ParCos)

Some projects have also identified a direct link between science communication strategies and the enhancement of public trust in science. In some cases, science communication is presented as a solution to a lack of public trust in science; in others, a lack of public trust is seen as a challenge to science communication:

The overall aim of NEWSERA is to demonstrate the virtues of citizen science as an inclusive, broad and powerful science communication mechanism that can allow to increase trust in science communication and, in turn, in science at large, while opening up science and innovation to the whole of society. (NEWSERA)

…lack of trust in science and scientists represents a key barrier for science communication to be able to engage the public, on the other side, science communication can play a key role in enforcing trust in science and scientists. (QUEST)

The PRO-RES project indicated that, when it comes to the issue of trust, the selected strategy for communicating a scientific message might be more important than the validity and the reliability of the results themselves:

… adverse outcomes are reported over favourable ones, which leads to a negative perception of scientific effects, consequently, resulting in reduced levels of confidence. This is all the more difficult for the non-specialist to understand, since it is not necessarily the practice of researchers that can be controversial, nor the result of the research that can be problematic, but rather the interpretation made of it by end-users, as shown by the recent controversy over the Milankovitch cycles

and climate change. This leads to the conclusion that mistrust in science could be more an issue of communication rather than the validity and reliability of the results. (PRO-RES)

In their report for building trust of scientific institutions, the PRO-RES project has also explicitly employed empirical results from a research study by Brion & Lount (2019) indicating that most participants believe that a culture of clear and transparent communication is essential for establishing trust, and that communication needs to be accurate:

In a research study seeking to establish what should be done to build trust in the organizational context, findings indicate that 82% of the respondents held the opinion that fostering a culture of clear and transparent communication was essential. However, 81% of the respondents also hinted that for trust to be established, the communication must be accurate regardless of whether or not it is unpopular (Brion et al., 2019)*. (PRO-RES)*

However, as aptly noted by the InSPIRES project, what is equally important to the accurate communication of scientific results is the effective communication of these results in a way that they are perceived as valuable and understandable to society:

…according to the Science Shop staff […] it is important to build a trust relationship between researchers and society – How can they benefit from each other? Expectation management is then one of the key words – What does society expect? And what can research deliver? Presenting academic results in a way so they are seen valuable and understandable to society is a most valuable skill. (InSPIRES)

Another major objective of the VERITY project is therefore to **delineate what counts as 'accurate and effective communication' for the development and the sustainability of a relationship of trust between the scientific community and the public**. Building on the findings of the systematic literature review to be carried out in WP1 regarding the factors affecting public trust in science (T1.1), the project will aim to deepen its understanding on current notions of science communication, and to view it as a powerful tool for the enhancement of public trust in science by identifying the most important characteristics of the messages delivered to the public when science is communicated.

These findings can then be used to construct a common science communication strategy across the EU on which science communicators will be trained, in accordance with the Horizon Europe's ambition to 'put a specific emphasis on science communication to make researchers capable to correctly and effectively communicate to the public, and to make research careers more attractive for young talents.'[6]

[6] Horizon Europe, Work Programme 2023-2024, 11. Widening participation and strengthening the European Research Area (p.120)

In doing so, we will always bear in mind another recurring pattern in our thematic analysis, namely, the diagnosis made by the GlobalSCAPE and RETHINK projects that **science communication is not a one-dimensional activity, but rather encompasses a range of strategies which may have different purposes, and, consequently, different effects**:

> *The needs of modern science communication cannot be pinned down to a one size fits all remedy but based on a review of existing literature, an array of factors have been identified that can help to inform best practice. These are: Evidence based practice, Applied and tested, Practice, Reflection, Quality, Content, Strategy, Evaluation. (GlobalSCAPE)*

> *This research shows that the science communication ecosystem is very complex and fragmented, including multiple types of actors of which a majority tends to perform one-way communication, wanting to inform audiences already interested in science about facts. (RETHINK)*

In a similar spirit, the NEWSERA project has also produced a list of science communication channels and strategies in their report. The main identified channels include academic and non-academic publications (journals, online science magazines etc.), conferences, citizen science and science communication events, traditional media, and social networks. The identified strategies are via direct contact with identified target groups, face-to-face interaction, online forum discussion, storytelling, via the communication and dissemination plan of a research project, and via co-creation approaches.

Our findings can also be used to enrich existing guidelines and good practices in science communication produced by previous EU projects such as ENJOI and QUEST:

> *Policy impulse to promote tools relevant to information producers dealing with scientific issues is of the greatest significance. Specific guidelines and good practices are to be made available to all actors involved in science communication production and dissemination. (ENJOI)*

> *The task aims to identify recommendations to create the framework conditions for incentivising quality communication of science and R&I to a wide public for scientists and research institutions, as well as across different media and communicators, focusing in particular on the QUEST research strands, i.e. journalism, museums, and social media. Also, actions focusing on public engagement are considered. (QUEST)*

Finally, another important finding of our thematic analysis, which was particularly salient in the report of from the QUEST project, concerns **the gender dimension in science communication. One of the most interesting findings in the focus groups activities with citizens in the QUEST project was the existence of bias in the perception of communicating skills by scientists, since female scientists reported**

lower levels of confidence in successfully communicating scientific results to the public:

Another interesting element emerged in QUEST focus groups concerning perception of communication skills by scientists, was that women seemed less confident than men in communicating science to the wide public. (QUEST)

What emerges is for instance that hardly any women scientists are highlighted in the popular science writings, men scientists are more likely to be speakers at events than women even after controlling for the gender and rank of the available speakers. (QUEST)

This is, in our opinion, a very important issue which relates to the greater issue of gender balance in science, and to which greater attention must be given. If female scientists feel less capable of delivering effective scientific messages to the public than their male colleagues, it is possible that, from the perspective of the public, female science communicators are seen as less trustworthy sources of information compared to male scientists. However, relevant empirical work on this issue from Reif et al. (2019) indicates that according to the respondents' evaluation in an online survey with experimental design, female experts explain scientific information slightly more comprehensibly than male experts, and viewing a stimulus featuring a female STEM expert as opposed to a male expert has a small positive and significant effect on perceived expertise, which is further related to trustworthiness. The VERITY project will examine further aspects of this issue in order to understand the reasons why potential female science communicators may feel less confident and assess whether the possible existence of this bias affects the perception of scientific results as less trustworthy when communicated by scientists of different genders.

The work to be carried out in VERITY is a further advancement of similar work done in the CONCISE project where participants in public consultations were asked about their preferences regarding the content and the format of scientific information they would like to receive, their preferred channels of communication, etc.:

The innovative nature of the CONCISE public consultations derives from the fact that participants were asked not only how they obtained scientific information and how they perceived it, but also how they believed the scientific content should be communicated. At the end of each round of the discussions, participants were asked, among other things, how they would like to receive information about a topic that they had discussed, the communication channels they preferred, the kind of information they would be looking for, and the type of format they found most useful. (CONCISE, Article 1)

The aim is to deepen our understanding of optimal ways of science communication for the enhancement of public trust in science, by turning engagement by scientists with the public into an opportunity to strengthen democratic processes, to empower scientific citizens, and to develop a balanced relationship between different stakeholders in science-related decision making.

3.4. RESPONSIBLE RESEARCH AND INNOVATION AS A MEANS OF PROMOTING TRUST IN SCIENCE

Responsible Research and Innovation (RRI) traditionally lies at the core of EU framework programmes, promoting a culture of aligning research and innovation practices to the values, needs and expectations of society within the EU and beyond (Von Schomberg, 2011). RRI is often referred to as an umbrella term incorporating six key dimensions: Public Engagement, Science Education, Open Access, Gender Equality, Governance and Ethics.[7] As expected, the RRI approach is also central to the Horizon 2020 SwafS Work Programme in various forms, and hence, many projects in our thematic analysis were directly or indirectly related to RRI practices. **In addition to the dimension of Public Engagement already highlighted in the previous themes, our analysis revealed that the two dimensions of Science Education and Open Science may also have a significant impact on trust in science and should be further employed as tools and means of promoting trust in science.**

Science education encompasses several formal and informal strategies aiming to increase the public's knowledge and interest in science, particularly amongst younger generations and females. Within the Horizon 2020 framework, science education has been promoted via innovative pedagogies to teach science (e.g. open schooling), and the encouragement of scientific institutions to be involved in the organization and implementation of activities promoting science education to the public.

Within our thematic analysis, we found that **several projects acknowledged the importance of formal and informal science education as a valuable tool for bringing the society closer to scientific research and cultivating the interest of younger generations in science**:

> *Based on the analysis of the selected articles, the main conclusion that can be obtained is the fact that education is the key in the process of getting not only in touch with scientific research, but also with the way its results have an impact in every day's (sic) lives. (ALLINTERACT)*

> *It has been recognised that if CS [Citizen Science] projects are appropriately designed, children can be involved actively in citizen science activities, in which they can both learn from and contribute to research. In particular, if such research is integrated into school curricula, their engagement can add significant value to formal education. Among the benefits of such integration for students, Shah and Martinez [2016] listed the instilment of community awareness, critical thinking,*

[7] A normative framework for RRI: the six policy agendas. https://rri-tools.eu/about-rri

problem solving, and practical experience, noting that hands-on experience is the most important aspect when the youngest students are involved. (Cities-Health)

We also found that **science education took several different forms**, indicating the variety of ways in which the public can be engaged in science and the wide spectrum of roles citizens can have. An interesting initiative came from the DITOs project, in which Science buses were employed as an attempt to bring science to the public in various locations, rather than waiting for the public to come to places where science is created and communicated. On the BigPicnic project, they explored the use of 'Science Cafés' to reach new audiences, which allowed them to achieve both public engagement objectives and to provide quality, formal and informal, science education. The ENRICH project developed 'Science Shops' for university students, relying on collaborative research efforts and a participatory ethos to embed education in society.

Projects created a mix of one-off and recurring events and workshops encouraging both citizen participation and science communication.

Another original initiative came from the ORION project, according to which 7,500 directly participated in its public engagement actions including one-day workshops, public dialogues, and Massive Online Open Courses (MOOCs):

While some ORION participants were engaged occasionally (e.g. respondents of the ORION benchmarking surveys) or attended short-scale ORION single events (e.g. one-day workshops), others participated extensively in immersive events (e.g. public dialogues) and over large periods of time (e.g. ORION MOOC trainings or co-creation actions). As a result, ORION has reached different degrees of impact regarding the different modalities of participation and engagement levels in the ORION activities. (ORION)

Projects MULTIPLIERS and PULCHRA directly engaged with open-school practices, such as science buses, to develop effective and innovative ways of bringing science closer to the public by taking into consideration the citizen's views and abilities:

…the concept of Open Schooling serves to build effective collaboration between science and society in efforts to increase the attractiveness of scientific careers, particularly for girls, enhance the scientific competence of citizens and in general improve formal and informal science education (MULTIPLIERS)

Open Schooling is one of the strategies to accomplish a new way of doing science that takes purposefully into consideration citizens' views and capacities. (MULTIPLIERS)

Open schooling (OS) is a flexible education mechanism that allows learners to learn where and when they want, often (but not always) physically away from a school and a teacher. (PULCHRA)

These actions clearly indicate the emphasis given on the Science Education dimension of RRI within the programmes we have examined in our analysis. There is an abundance of empirical evidence from current scientific literature suggesting that the level of education (Agley et al., 2021b; Pechar et al., 2018), the cultivation of a reflexive mindset (Achterberg et al. 2017; Hendriks & Jucks 2020), and the existence of a positive attitude towards science (Altenmuller et al. 2021; Gauchat, 2011) are all related to increased levels of trust in science. Thus, **actions taken with respect to science education within the Horizon 2020 SwafS framework programme were paramount in developing and sustaining societal trust in science**. VERITY will build on the current literature and the actions taken in previous EU projects to further understand those aspects of formal and informal science education that are most relevant for the enhancement of public trust in science.

Regarding the dimension of **Open Science**, this is a key strategic priority of the EU and occupies a central role both in the Horizon 2020 and the Horizon Europe framework programmes.[8] Broadly construed, Open Science encompasses several different practices in scientific research that together ensure the transparency and accessibility of scientific resources to all stakeholders, including the public. The eight ambitions of Open Science Policy of the EU include *inter alia* the openness of data, the openness of access to peer-reviewed scientific results (Future of scholarly communication), the research integrity & reproducibility of scientific results, the training of scientists in Europe in the development of the necessary skills to support and apply open science practices, and citizen science practices. In the Horizon 2020 SwafS Work programme, Open Science appears in various forms, e.g.: 'In the context of Open Science and Responsible Research and Innovation the European Commission therefore strongly supports the optimal open access to and re-use of research data' (p.16), 'The action should examine and map the ethical, legal and social implications/challenges as well as the research integrity issues related to Open Science, and consequently identify and analyse the necessary elements to support the integration of research ethics and integrity as structural component of Open Science' (p.52). Hence, as expected, projects engage with Open Science practices:

> *In order to achieve more transparency in research practices, research performing organizations should implement open science training practices. (FOSTER)*

> *This document […] starts with a checklist for OS [Open Science], that researchers may consider in various phases of their investigation. (GRECO)*

However, at the same time, it was widely acknowledged that **Open Science practices are often related to various worries regarding intellectual property issues, and possible conflicts with an organization's economic interests, or a scientist's career development**:

---

[8] https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science_en

The concept of open access can result in a conflict between open access and the company's economic health for most companies. (COMPASS)

"How is my Intellectual Property protected to prevent others from stealing or benefiting from my research if I make it open?" (GRECO)

The biggest discussion regarding Open Access within TNO was about Intellectual Property (IP) issues. (JERRI)

Within the current scientific literature, open science practices are clearly correlated with increased levels of trust in science (Rosman et al., 2022; Schneider et al., 2022; Song et al. 2022) indicating that **society highly appreciates transparent and openly accessible processes of creating new knowledge and technology**. However, regardless of open science practices, there is also empirical evidence that the levels of public trust in scientists affiliated with private companies are lower compared to scientists affiliated with public institutions, and that, similarly, research conducted with public funds is considered more trustworthy compared to privately funded research (Konig and Jucks, 2019; Critchley, 2008). It is therefore interesting to examine whether the adoption of open science practices in privately funded research suffices to increase the levels of trust in its scientific results, while at the same time maintains the financial interests of the organizations funding and conducting scientific research. A major challenge is thus to find ways of compromising the benefits of open science practices with the protection of intellectual property and the interests of scientists and RPOs, whether these are academic institutions or private companies conducting research and producing knowledge. This challenge will be assessed in the future actions of the VERITY along with the four main challenges identified in our thematic analysis to be discussed in the following subsection.

3.5. BARRIERS, CHALLENGES, AND STRATEGIES TO OVERCOME THEM

The last key theme of our thematic analysis concerns the challenges and barriers encountered by previous EU projects in their attempt to implement strategies that directly or indirectly enhance societal trust in science.

The careful consideration of the available documents from the examined EU projects in our thematic analysis revealed several barriers and challenges in terms of: (i) public engagement, (ii) availability of science representatives, (iii) the public's availability and motivation, (iv) the quality of methods and results.

Formal engagement spaces and strategies tend to attract certain types of participants, i.e. people with higher education and a pre-existing interest in science:

…favouring formal engagement spaces over more spontaneous and bottom-up initiatives brings a number of challenges for RRI processes. First, formal deliberation processes tend to attract certain participants; often those with a higher education. […] In short, formal engagement processes expect, to a certain extent, 'rational' participants. (PROSO)

The majority of citizens who participate in citizen science are well educated (Haklay, 2018) and finding ways of engaging less educated and less privileged participants is an important goal if citizen science genuinely wants to move towards involving everybody. There is a need to open up the range of voices, values and visions directing and shaping citizen science projects and to include wider societal perspectives. (ParCos)

…these opportunities for participation are often socially stratified. The lay participants in co-creation thus tend to represent only fragments of society (e.g. higher income, higher education, no migration background), even if the exclusion mechanisms at play are unintentional. (SCALINGS)

Further difficulties are related to the challenge of reaching people residing in geographically remote areas or in certain European countries, especially when it comes to public engagement activities:

It has already become apparent that some regions have more training offerings than others indicating a potential difference in value that certain nations place on science communication training. (GlobalSCAPE)

A possible strategy to mitigate this problem is to develop various mechanisms for reaching out to people in these areas and encourage the decentralization of actions funded by the EU, away from urban centres. The Science Bus initiation from the DITOs project is a nice example:

The DITOs bus reached the smallest number of participants. However, it did so in sometimes remote areas and places that may not have easy access to scientific museums or other citizen-science project spaces, and therefore increased the inclusiveness and reach of the audience. (DITOs)

The above excerpts clearly illustrate the major challenges in engaging the public in various science related activities, such as science education, science communication and citizen science. As already mentioned, **enhancing the public's trust in science requires bringing the public and the representatives of science closer, and hence, it is natural to expect that the promotion of public trust in science via similar actions will face similar difficulties.** However, it remains to be seen whether there are certain groups of people within the EU and beyond, which, for various reasons, tend to have lower levels of trust in science indicating that certain initiatives may need to be targeted. Indeed, the work currently undertaken for the purposes of T1.1 of the VERITY project (*Systematic literature review of factors affecting public trust in science*) indicates that there are certain common characteristics amongst people who have lower levels of trust in science. One of the aims of our project is therefore to identify these characteristics and ensure that all future actions and recommendations of the project will target certain social groups that have lower trust in science, while at the same time maintaining the necessary diversity in terms of the representation and participation of the public in the project.

The (un)availability of science representatives to engage in activities that bring science closer to laypeople and thus potentially enhance the public's trust in scientific results, often lacking the time and motivation to do so, is another challenge.

> *Many researchers agree that public engagement and science communication is not part of their task. (GRECO)*

Several projects have highlighted the fact that researchers often are not qualified to communicate the importance of their research to the public:

> *[…] Scientists lack training and skills to engage with the public and frequently do not see a value in engagement beyond dissemination activities. (PROSO)*

Some projects also highlighted the fact that in addition to the lack of time and motivation in some researchers, there are also funding limitations and limitations in structures and resources:

> *…the majority of CS initiatives reported that there were facing design and other implementation issues, primarily due to funding limitations. (EnviroCitizen)*

Nevertheless, the report of the RETHINK project indicates that many scientists do feel a responsibility to communicate and democratize science:

> *…many scientists do feel an intrinsic motivation and sense of responsibility to engage in science communication and want to democratize science. But they find it hard to reach out to new audiences […] which reproduces inequalities in access to knowledge. (RETHINK)*

Finally, the lack of time, motivation and training was not only observed in scientists, but also in journalists who could potentially communicate science to the public:

> *Studies about what discourages scientists and journalists from participating in science communication identified many challenges related to a lack of time, resources and skills. (ENJOI)*

The above passage indicates the need to provide the necessary resources to science representatives – whether these are scientists themselves or professional science communicators in journalism – to devote more of their time in bringing the public closer to science. Lack of time is often referred to as a major barrier in engaging with the public, however, the available time one has, is closely related to one's priorities which further means that researchers prioritize other things over the communication of their research to the public and their participation in science-society co-creation activities. Mitigating this problem means providing researchers with the necessary incentives to participate in public engagement activities by building the necessary structures to facilitate the democratization of science. A simple strategy would be for universities to reduce the teaching load of academics in exchange of public engagement activities as well as to find various ways of awarding researchers who deliberately participate in public engagement activities.

Moreover, several projects have also highlighted the fact that it is not only researchers that often lack the time and motivation to participate in co-creation activities, but also members of the public. This is the third type of challenge identified in our thematic analysis indicating a lack of motivation, time and sometimes skills to participate in science related co-creation actions:

> *It is noted that, despite strong motivations to continue participating, engagement can be disrupted if there are excessive time demands made. A study revealed that some participants felt their time was unappreciated and were uneasy in continuing engaging with activities that were too time-consuming (Rotman et al., 2014). (EU-Citizen.Science)*

> *The main challenge in organizing Science Cafes is to get enough people present. According to the coordinator of the UNIFI Science Shop it is difficult to do this only in the context of the Science Shop, because you need to develop a practice. (InSPIRES)*

> *One significant barrier that can influence the implementation of the OSS projects in various ways relates to time restrictions. Initially, time restrictions influence the duration of the implementation of the OSS projects in schools which cannot occur the entire school year. (MULTIPLIERS)*

We also observed that this lack of motivation from the public to actively engage in science co-creation activities is closely related to the so-called 'knowledge gap' between researchers and members of the public which in turn creates an overall difficulty in building fruitful collaborations between scientists and non-experts:

> *…other barriers are the lack of financial incentives and the feeling that the person belongs to a socio-demographic group that is underrepresented in the scientific community. (INCENTIVE)*

> *Language is key to communication and EN [Embedded Nuclei] and societal partners can too easily be confused by terminology: academics too, and our NUCLEUS partners and consortium a whole can also be guilty of at times, getting too theoretical and conceptual too quickly. (NUCLEUS)*

In addition, the lack of communication skills among scientists was linked to their inability to engage with the public over the long term:

> *Factors such as lack of support, poor communication and lack of understanding of audience and motivations are all cited as barriers to prolonged engagement and participation with projects and activities on a broad scale. (EU-Citizen.Science)*

> *While a number of initiatives have sprung over the last decade, existing engagement models suffer from limitations, the majority of them being unable to efficiently provide lay citizens with the skills and capacities to engage and have an impact in scientific and technological developments. (PRO-Ethics)*

The Pro-Ethics and ROSiE projects also identified the lack of mechanisms and the existence of various technical requirements as possible factors hindering the effective collaboration and communication between researchers and the public:

> *Yet, the mechanisms are still lacking for citizens to impact evidence-based processes for policymaking. (Pro-Ethics)*

> *For example, specific (technical) requirements may hamper broad participation in OS undermining epistemic pluralism (epistemic challenge) resulting in differentiation, injustice, and limited democratization of knowledge production (ethical implications), or researchers may possessively guard their research (due to what has been called "The Gollum effect"), which can substantially undermine sharing, accessibility, and transparency. (ROSiE)*

Therefore, if the public's trust in science is to be enhanced by bringing members of the public closer to the scientific practice, the proposed mechanisms and initiatives must find ways of motivating not only researchers and science communicators, but also members of the public that may feel completely unmotivated and estranged. Closing this gap between science and society is one of the most important challenges of the VERITY project in enhancing public trust in science.

Finally, the aforementioned limitations in terms of time, understanding, and motivation from the public also affect the continuity and sustainability of public engagement actions. Indeed, many projects reported that the continuous engagement of public in their initiatives was particularly challenging mainly due to the limited availability of time from the participants, mentioned on four different projects:

> *Participants cite feeling undervalued for their contributions as a cause of discontinued engagement (West and Pateman, 2016). / A study of audience motivations showed a large gap between intent to participate and actual participation with a project, with the critical difference being that individuals felt compelled to actively engage when the project aligned with their motivations (Rotman et al., 2014). This research also highlighted that motivations often developed when a participant was involved for long periods and developed relationships with the project team and other participants. (EU-Citizen.Science)*

> *In terms of continuous training, we already mentioned the risk of becoming a too burdening task for participants, in particular when such activities are too many, too frequent, too difficult to understand or if participation is de facto compulsory to keep contributing to the project. This is relevant as lack of time has been frequently mentioned in other CSHs as one of the main barriers. (INCENTIVE)*

Most reported initiatives are one-time events or events that exist only throughout the project lifetime, or the external, purposeful funding received. Very few of the initiatives have a long term impact or are designed in a way that allows certain sustainability (e.g., Zuchkerman, 2019). (MULTIPLIERS)

The **most important barrier in enhancing public trust in science, is identified as the possible presence of low-quality scientific research which might be accompanied by instances of scientific misconduct.** As with any other human endeavour, scientific practice can sometimes be erroneous and produce results that later turn out to be false, however, **this fact can be easily misinterpreted as evidence that science is often erroneous and thus, untrustworthy.**

For instance, some worries of low-quality research production have been highlighted by the ROSiE project in the context of Open Science. As highlighted by the projects examined article, open science undeniably has a wide range of benefits to science and society – especially in terms of the transparency of science – however, at the same time, it is associated with a number of worries regarding the quality of open data, data procurement (i.e. collecting, producing, clarifying, rinsing data that will be later made publicly available), and the interpretation of the openness of science from the public:

While increased access to information, knowledge, and evidence are obvious advantages, epistemic objections have been made. The first and easily accessible research results may be of low quality and even fake, as quality-assured and validated evidence takes much more time, resulting in OS bias or an OS divide. (ROSiE)

The PRO-RES project also acknowledged the possible presence of low-quality research due to the failure of governance structures in the implementation of RRI aspects, and the emphasis of scientific institutions on visible outcomes at the expense of policies that potentially increase the trustworthiness of scientific results. Moreover, the widely spread culture of 'publish or perish' in the scientific community often leads researchers to value the number of their publications more than anything, which may result in scientific studies of questionable quality:

It is found that the governance structures employed in the management of trust in scientific research have several profound failures. The first shortcoming is that while there are clearly defined policies governing research aspects such as ethics and accountability, there is poor implementation specifically as per research results (mis)usage (Stoett & Fox, 2016). Secondly, it is observed that the governance bodies in institutions such as universities put too much emphasis on visible outcomes at the expense of policies meant to ensure the trustworthiness of research in the scientific, political, and economic contexts. Besides, these governance bodies have not established spaces where controversies involving scientific research can be addressed with all due serenity. In that regard, there usually is confusion whenever cases of misconduct arise since the frameworks necessary for implementing corrective measures are inexistent. (PRO-RES)

This is in our opinion one of the most important challenges in enhancing public trust in science, namely, to communicate the message that while science is not infallible and there are indeed instances of low quality and erroneous scientific results, science remains an important source of trustworthy knowledge with clear benefits in certain specific social arenas.

4. CROSS PROJECT META-ANALYSIS

In addition to the five key themes presented in the previous section, the analysis of the selected previous EU projects has also allowed us to derive various qualitative and quantitative data which lead to some interesting observations.

To begin with, during the assessment of the selected documents from the 59 eligible projects for our thematic analysis, we found that five projects engaged with the issue of trust in science more directly than others. Of high importance are the efforts made by the CONCISE and the PRO-RES projects to deepen our understanding on the issue of trust in science. The CONCISE project produced – amongst other things – a detailed study on trust and mistrust in sources of scientific information:

> *This article aims to contribute to the discussion on the role of trust in science by addressing the specific issue of trust in sources of scientific information. We aim to explore the reasoning used by citizens to trust or distrust different institutional and individual actors that provide scientific information to the public*. (Rowland et al. 2022)

The article draws from the results of public consultations with citizens in Portugal and Poland on the topics of climate change and vaccines with a focus on citizens' perceptions of trust in several sources of scientific information. In accordance with evidence from the current scientific literature to be presented in D1.2 (*Review Paper of Scientific Literature*) of the VERITY project, their results indicate that the public's trust varies depending on the source of scientific information and it is affected by the topic's visibility.

The PRO-RES project produced a *Report on Rebuilding Trust of research institutions* (D6.1) in which the authors, – amongst other things – highlight mistrust in science might be more an issue of communication, rather than the validity of scientific results. Their conclusion is derived from the fact that the public seems to be often inundated with conflicting information, controversies, and information about the harmful effects of research, as opposed to the rare report of extraordinary scientific results. Other notable contributions to the topic of trust in science come from the projects SHERPA, ROSiE and NEWSERA. The SHERPA project actively promoted the enhancement of trust in Artificial Intelligence by developing a set of recommendations for the improvement of AI ethics and standardization for trustworthy AI. The ROSiE project made a substantial contribution to the enhancement of public trust by promoting responsible Open Science and showing how the lack of transparency and the failure to replicate scientific findings due to insufficient information can be harmful to the trustworthiness of science. Finally, the NEWSERA project offered a detailed analysis and evaluation of several science communication strategies, highlighting the central role of science communication for the enhancement of public trust in science, as already discussed in Section 3.3.

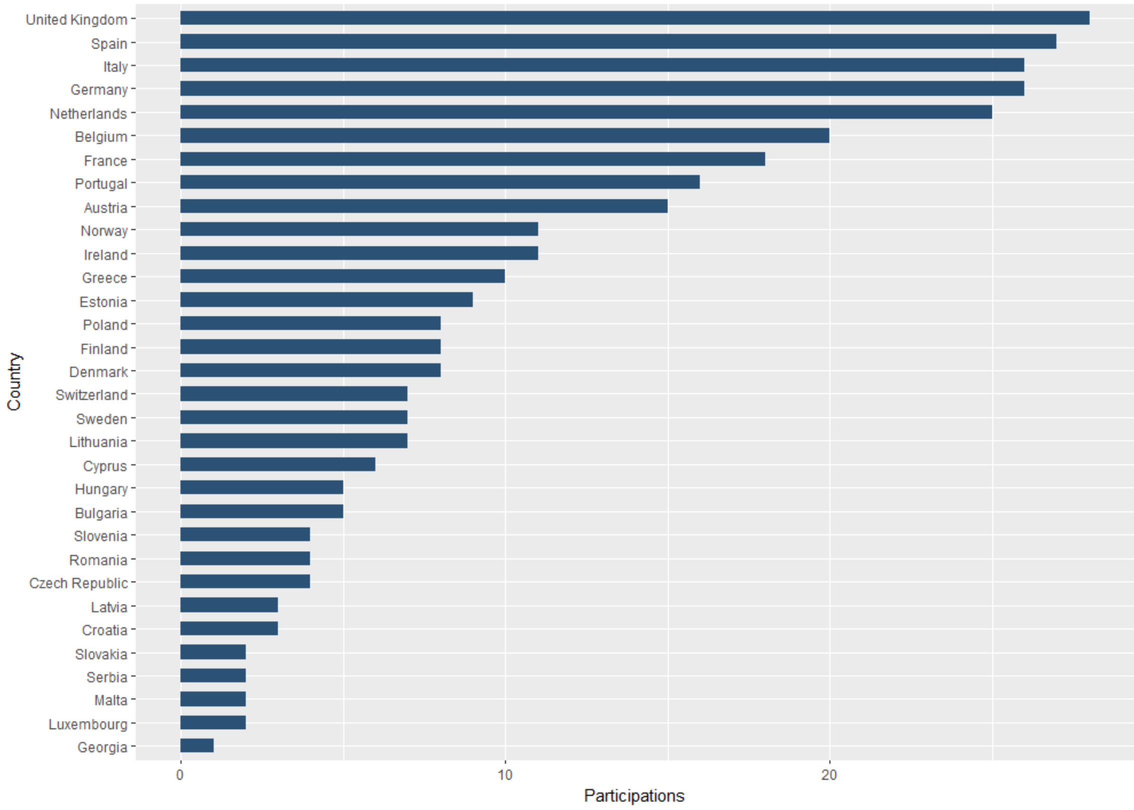

Figure 4. Participation of European countries in the examined projects

Another interesting fact that emerged from the conducted thematic analysis concerns the European countries that were engaged with the 41 projects from which the five key themes were derived. Based on the geographic locations of the partners involved in each one of these projects, we constructed a table indicating how many project participations come from each European country in which these projects were located (Figure 4).

The derived data indicates that from a total of 32 European countries involved in these projects, four countries (United Kingdom, Spain, Italy and the Netherlands) have at least 25 participations, whereas seven more countries (Belgium, France, Portugal, Austria, Norway, Ireland and Greece) have between 10 and 20 participations. All remaining countries have less than ten participations, with ten countries having less than 5 participations. Although our data are not conclusive – in that they only come from the 41 projects that contributed to the derivation of the five key themes of the thematic analysis – they can be safely interpreted as hinting towards the fact that the thrust of the previous projects' efforts towards the enhancement of public trust in science is perhaps disproportionally concentrated in the countries lying at the top of the chart. It remains to be seen whether this imbalance in the geographic location of these projects also reflects the levels of trust in science in these European countries.

Another important implication of our analysis concerns the various fields of science with which these projects are associated in the CORDIS database, as illustrated in Figure 5. While it is natural to expect that most of the projects within the 'Science with and for Society' programme would be associated with sociology and political science as part of their attempt to bring society closer to science, it is observed that very few projects are associated with physical sciences, and STEM in general. This fact can be interpreted as indicating that the selected EU projects for our analysis based on the seven key concepts highlighted in Section 2 (trust in science, collaboration, co-creation, responsible research and innovation (RRI), research ethics, research integrity, and benefit sharing) are mainly implemented by organizations specializing in the social and political sciences, with a focus on health and environmental science.

Another surprising fact is that only one project was associated with the field of philosophy, even though concepts such as Responsible Research, Research Integrity and Research Ethics are closely related to the broader field of ethics, which is one of the most important branches in academic philosophy.

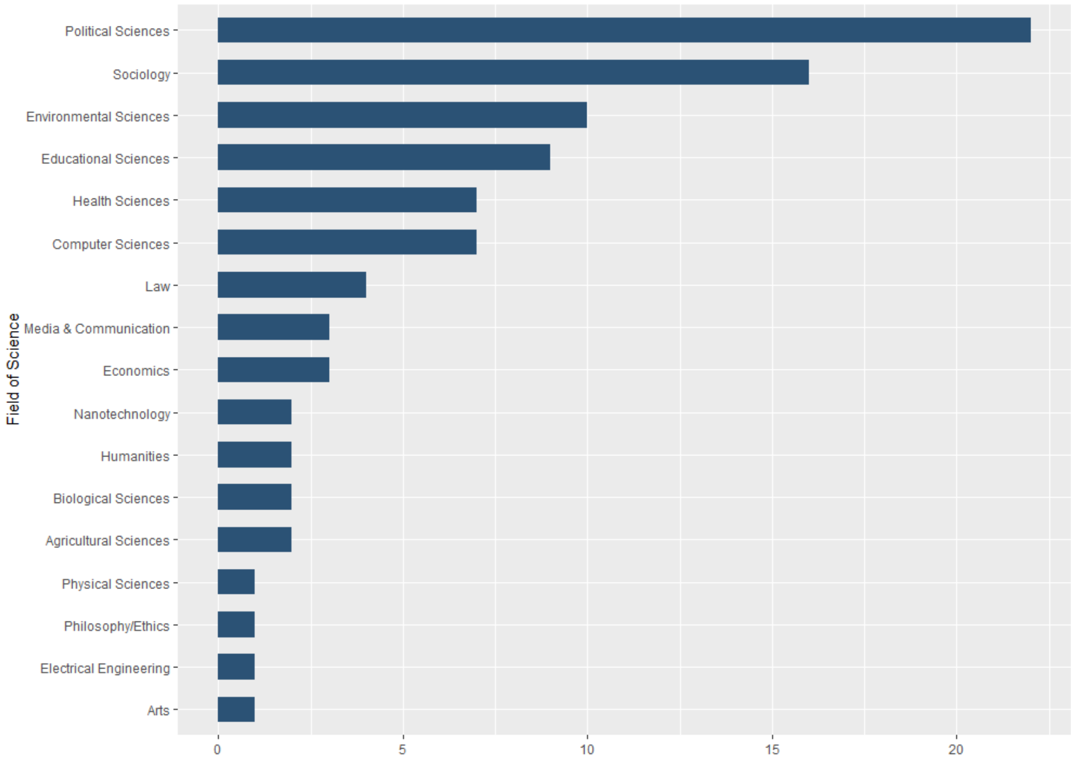

Figure 5. Scientific fields associated with the examined projects

Finally, during the analysis of the identified 59 EU projects within the SwafS call, we recorded the various stakeholders involved in each project in order to compile a complete picture of the possible stakeholders involved in the enhancement of public trust in science within the EU. The collected data indicates that there are four different categories of stakeholders (a) the policy sector, (b) the academic sector, (c) the private sector and (d) the third sector, each one contributing to the promotion of the trustworthiness of science in different ways.[9]

The four categories are summarized in Table 4, where various examples of each category are given in the corresponding columns. The major aim of WP2 ('Exploring the ecosystem of trust and building community') of the VERITY project is to clarify the different roles of these stakeholders in the ecosystem of trust in science and identify those stakeholders that can act as *stewards of trust* by actively promoting and sustaining high levels of public trust in science. This will be mainly achieved by developing a clear stakeholder engagement strategy and establishing the VERITY 'Advisory and Impact Board' which will be constituted by 15-20 stakeholder representatives, who will actively contribute to various activities of the project.

To conclude, the conducted thematic analysis of the examined EU funded projects resulted in five key themes, emerging from the efforts of these projects to – directly or indirectly – increase public trust in science within the EU and beyond. Each one of these themes represents a particular topic for consideration in the future actions of the VERITY and other similar projects. However, some additional interesting conclusions can be derived by identifying the ways in which these five themes are related to each other.

POLICY SECTOR	ACADEMIC SECTOR	PRIVATE SECTOR	THIRD SECTOR
• Policy makers • Politicians • Governments & Parliaments • The European Commission • Research Councils • R&I agencies • Research Funding Organizations • City councils / Municipalities • Ethics committees • Regulatory agencies (e.g. European Medicine Agency - EMA)	• Universities • Researchers • Public Research Institutions • Private Research Institutions • Teachers & Instructors • Curriculum Designers • Private and public schools • Scientific journals	• Private companies • Service providers • Health Industry • Product manufacturers • Science communicators • Journalists • Press / Traditional Media • Social Media	• Civil Society Organizations • Non-profit NGOs • Science Centres • Museums • The public • Young people • Students • European Citizen Science Association (ECSA)

Table 4. Stakeholder categories with examples

In particular, the wide spectrum or roles that citizens take when participating in co-creation and science communication actions (theme 1) is closely related to the conclusion derived in the second theme of our analysis, regarding the (in)balance of power and decision making in science co-creation activities. While most of the projects successfully organized

---

[9] The 'third sector' here represents the part of the society comprising non-governmental and non-profit organizations or associations, including charities, voluntary and community groups, cooperatives, etc.

and promoted public engagement activities, it is safe to say that the majority of these initiatives are produced from the perspective of science, limiting the ability of citizens to choose their own role in science-society co-creation. It is possible that this form of patronage from the perspective of science in deciding when and how the public participates in co-creation activities, affects both the trust of the public in science and scientific institutions, and the motivations of citizens to participate more actively in these actions. This fact is also related to the apparent lack of trust from the scientific community in the abilities of non-experts to participate in co-creation initiatives, undermining a bi-directional relationship of trust and mutual respect between the scientific community and the public.

Moreover, the strategies of science communication examined in theme 3 (The importance of science communication strategies) are closely related to the two additional dimensions of RRI that were identified in theme 4 (RRI as a means of promoting trust in science) as paramount to the enhancement of societal trust in science, namely, science education and open science. In principle, science education is a powerful tool for raising public awareness in the importance of science and for cultivating a positive attitude and interest e.g., amongst young people. Nevertheless, we stress that science education can – and should be used to – mitigate the lack of trust from the scientific community to the public highlighted above, by equipping non-experts with the necessary skills needed in order to make fruitful contributions both to the production of new knowledge as co-researchers, and to the decision-making processes regarding the aims and direction of scientific research. With regards to open science, an important challenge remains in finding ways of increasing the transparency of privately (and publicly) funded research with the economic and other interests of the researchers and organizations involved. More efforts also need to be made to optimize the ways in which open science practices are understood by the public both via science education and science communication.

Finally, a joint consideration of all five themes shows how the topics identified in the first four themes are linked to some of the challenges identified in theme 5 (Challenges barriers, and strategies to overcome them). The first identified barrier in theme five emerges from the fact that usually, the public is approached via various formal strategies and in predetermined spaces that seem to preclude the representation of certain groups of citizens. This problem is closely related both to the fact that citizens often feel estranged and inadequate when asked to participate in science outreach activities, and to the fact that these initiatives are almost exclusively designed and implemented by science representatives (themes 1 & 2). Given that citizens often lack the time and the motivation to participate in co-creation activities, it is safe to conclude that citizen participation in co-creation actions is stratified and often limited to people of higher education and people with a pre-existing intrinsic interest in science. It remains to be seen whether certain groups of people who tend to participate in co-creation activities also have higher degrees of trust in science, and similarly, whether unrepresented members of society have lower trust in science.

5. SUMMARY

The present report is the first deliverable of the VERITY project, and as such, it will be used to feed the future actions of the project for the enhancement of public trust in science. In this last section, the main findings of this report are summarised, along with the most important points of action for the VERITY project, as a result of this study.

Our thematic analysis resulted in five key themes, discussed in detail in Section 3. In short, the first theme concerned the wide spectrum of roles that citizens take when participating in co-creation and science communication actions: members of the public have been engaged in these projects in various forms, sometimes in a passive role as recipients of scientific information and education, and others in a more active way as knowledge co-producers. The second theme concerned the (in)balance of power and decision making in science co-creation activities: while most of the projects successfully organized and promoted public engagement activities, it seems that most of these initiatives are produced from the perspective of science, limiting the ability of citizens to choose their own role in science-society co-creation. The third theme concerned the importance of science communication for the enhancement of public trust in science, indicating that there are still several questions that need to be addressed in order to fully understand how communicating science enhances the public's trust in its results. These questions relate to the source of science communication, the gender dimension and representation of science communicators, and the content of the scientific message that needs to be transmitted to increase the public's trust. The fourth theme focused on two dimensions of RRI, science education and open science, that seem to be particularly relevant for the enhancement of public trust in science. Finally, the last theme that emerged from our thematic analysis concerned the various challenges faced by previous projects, that are likely to affect similar attempts by the VERITY projects and other projects under the Horizon Europe WIDERA call towards the enhancement of the public's trust in science. These challenges pertain to (i) the diversity of public engagement, (ii) the (un)availability of science representatives, (iii) the public's availability and motivation, and (iv) the quality of scientific methods and results.

As stated in Section 1, the analysis for the purposes of this deliverable was motivated by the following three main objectives:

Objective 1: To review and systematise the results of previous projects regarding the issues of public trust in science and science-society co-creation.

Objective 2: To examine what kind of tools these projects used and present their main findings.

Objective 3: To identify the most important shortcomings and barriers in these approaches.

Our qualitative analysis leads to the conclusion that the examined EU funded projects have made significant contributions to the enhancement of public trust in science within Europe, by studying, promoting, and organizing several actions related to public engagement, science-society co-creation, science communication, science education, open science and responsible research and innovation (RRI) in general. Nevertheless, we highlight the need to further develop these strategies and assess their precise impact on trust in science within the VERITY project and its sister projects.

To achieve this, we have identified the following outstanding issues and action points emerging from our research on the results of previous EU funded projects, and which will guide the future actions of the VERITY project:

- Examine the extent to which citizens feel estranged or incompetent when asked to participate in scientific research and co-creation actions.
- Examine whether passive forms of public participation and the imbalance in decision-making processes in co-creation actions are associated with lower levels of trust in science.
- Examine the ways in which a long-term two-directional relationship of trust between the public and the scientific community can be built and sustained by developing a culture of collaboration between science and society.
- Identify the ways in which the levels of trust from the scientific community in the abilities of non-experts to make substantial contributions to research can be increased.
- Delineate what counts as 'accurate and effective communication' for the development and sustainability of a relationship of trust between the scientific community and the public.
- Identify the most appropriate characteristics of the messages transmitted to the public in science communication.
- Examine the gender dimension of science communication, identify the reasons why potential female science communicators may feel less confident, and assess whether the possible existence of this bias affects the perception of scientific results as less trustworthy when communicated by scientists of different genders.
- Examine the aspects of formal and informal science education that are most relevant for the enhancement of public trust in science.
- Examine whether the adoption of open science practices in privately funded research suffices to increase the levels of trust in its scientific results, while at the same time maintaining the financial interests of the organizations funding and conducting scientific research
- Find ways of compromising the benefits of open science practices with the protection of intellectual property and the interests of scientists and RPOs, whether these are academic institutions or private companies conducting research.
- Identify the common characteristics of certain social groups with lower levels of trust in science and ensure that all future actions and recommendations of the project will target these groups, while at the same time maintaining the necessary diversity in terms of the representation and participation of the public in the project

- Identify ways of providing the necessary resources to science representatives – whether these are scientists themselves or professional science communicators in journalism – to devote more of their time in bringing the public closer to science.
- Identify ways of motivating not only researchers and science communicators, but also members of the public that may feel estranged and completely unmotivated to engage with science-society co-creation actions.
- Identify the best possible ways to communicate the message that while science is not infallible and there are indeed instances of low quality and erroneous scientific results, science remains the most trustworthy source of knowledge for the benefit of society.
- Clarify the different roles of the various stakeholders in the ecosystem of trust in science and identify the most appropriate stakeholders to act as stewards of trust by actively promoting and sustaining high levels of public trust in science.

The future actions of the VERITY project within the various Work Packages will be largely guided by the findings of this report and the identified action points. The Systematic Literature Review on public trust in science (WP1/T1.1) which is currently in progress, will provide a comprehensive overview of the current state of the art regarding the factors affecting the public's trust in science, and is expected to shed light on many of the topics highlighted above (e.g. on the characteristics of certain social groups with lower levels of trust in science). Similarly, the report on the strategies, methods, and tools to tackle societal mistrust in science (WP3/T3.1) will assess the impact of various strategies implemented for the enhancement of public trust as recorded in the current scientific literature, while the Social Network Analysis (WP1/T1.4) is expected to provide valuable insights on the role of social media as possible stewards of trust, by analysing a large volume of data from existing social media databases. Moreover, the work carried out in WP2 regarding the stakeholder mapping and the development of a stakeholder engagement strategy is particularly relevant to the identification of the most appropriate stakeholders and their role in the ecosystem of trust. Finally, of high importance to the achievement of the main goals of the VERITY project, are the various focus groups and the vignette study to be carried out within WP1 and WP3, since they will provide the researchers of the project the unique opportunity to directly engage with various stakeholders of the ecosystem of trust and listen their opinions on the trustworthiness of science. Currently, the focus groups with citizens in WP1 (T1.3) are planned to attract citizens from different social groups, scientists from various scientific fields, and journalists and science communicators, in order to build a complete picture of the different perspectives in the relationship between science and society. Accordingly, the focus groups with stewards of trust in WP3 (T3.2) will engage people with different backgrounds who have a responsibility of upholding and maintaining societal trust in science as a result of their position in the ecosystem of trust, with the aim of identifying the basic principles of the most appropriate strategy for each category of stewards of trust.

6. REFERENCES

Achterberg, P., De Koster, W., & Van der Waal, J. (2017). A science confidence gap: Education, trust in scientific methods, and trust in scientific institutions in the United States, 2014. *Public Understanding of Science*, *26*(6), 704-720.

Agley, J., Xiao, Y., Thompson, E. E., & Golzarri-Arroyo, L. (2021a). Using infographics to improve trust in science: a randomized pilot test. *BMC Research Notes*, *14*(1), 210.

Agley, J., Xiao, Y., Thompson, E. E., Chen, X., & Golzarri-Arroyo, L. (2021b). Intervening on trust in science to reduce belief in COVID-19 misinformation and increase COVID-19 preventive behavioral intentions: randomized controlled trial. *Journal of Medical Internet Research*, *23*(10), e32425.

Altenmüller, M. S., Nuding, S., & Gollwitzer, M. (2021). No harm in being self-corrective: Self-criticism and reform intentions increase researchers' epistemic trustworthiness and credibility in the eyes of the public. *Public understanding of science*, *30*(8), 962-976.

Barnett, J., Cooper, H., & Senior, V. (2007). Belief in public efficacy, trust, and attitudes toward modern genetic science. *Risk Analysis: An International Journal*, *27*(4), 921-933.

Bedessem, B., Gawrońska-Nowak, B., & Lis, P. (2021). Can citizen science increase trust in research? A case study of delineating Polish metropolitan areas. *Journal of Contemporary European Research*, *17*(2).

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), 77-101.

Braun, V., & Clarke, V. (2012). *Thematic analysis*. American Psychological Association.

Brion, S., Mo, R., & Lount Jr, R. B. (2019). Dynamic influences of power on trust: Changes in power affect trust in others. *Journal of Trust Research*, *9*(1), 6-27.

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Sage.

Chinn, S., Lane, D. S., & Hart, P. S. (2018). In consensus we trust? Persuasive effects of scientific consensus communication. *Public Understanding of Science*, *27*(7), 807-823.

Critchley, C. R. (2008). Public opinion and trust in scientists: The role of the research context, and the perceived motivation of stem cell researchers. *Public Understanding of Science*, *17*(3), 309-327.

Dierkes, M., & von Grote, C. (2005). *Between understanding and trust: The public, science and technology*. Routledge.

Gauchat, G. (2011). The cultural authority of science: Public trust and acceptance of organized science. *Public understanding of science*, *20*(6), 751-770.

Haklay, M. (2018). Participatory Citizen Science. In: Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J. & Bonn, A. (Eds), Citizen Science: Innovation in Open Science, Society and Policy. UCL Press.

Haywood, B. K., & Besley, J. C. (2014). Education, outreach, and inclusive engagement: Towards integrated indicators of successful program outcomes in participatory science. *Public Understanding of Science, 23*(1), 92–106.

Hendriks, F., & Jucks, R. (2020). Does scientific uncertainty in news articles affect readers' trust and decision-making?. *Media and Communication*, *8*(2), 401-412.

Hendriks, F., Kienhues, D., & Bromme, R. (2016). Evoking vigilance: Would you (dis) trust a scientist who discusses ethical implications of research in a science blog?. *Public Understanding of Science*, *25*(8), 992-1008.

König, L., & Jucks, R. (2019). Hot topics in science communication: Aggressive language decreases trustworthiness and credibility in scientific debates. *Public Understanding of Science*, *28*(4), 401-416.

Krüger, J. T., Höffler, T. N., & Parchmann, I. (2022). Trust in science and scientists among secondary school students in two out-of-school learning activities. *International Journal of Science Education, Part B*, *12*(2), 111-125.

Mann, M., & Schleifer, C. (2020). Love the science, hate the scientists: Conservative identity protects belief in science and undermines trust in scientists. *Social Forces*, *99*(1), 305-332.

Nwebonyi, N., Silva, S., & De Freitas, C. (2022). Public Views About Involvement in Decision-Making on Health Data Sharing, Access, Use and Reuse: The Importance of Trust in Science and Other Institutions. *Frontiers in Public Health*, *10*.

Pechar, E., Bernauer, T., & Mayer, F. (2018). Beyond political ideology: The impact of attitudes towards government and corporations on trust in science. *Science Communication*, *40*(3), 291-313.

Pieczka, M., & Escobar, O. (2013). Dialogue and science: Innovation in policy-making and the discourse of public engagement in the UK. *Science and Public Policy, 40*(1), 113–126.

Reif, A., Kneisel, T., Schäfer, M., & Taddicken, M. (2020). Why are scientific experts perceived as trustworthy? Emotional assessment within TV and YouTube videos. *Media and Communication*, *8*(1), 191-205.

Rosman, T., Bosnjak, M., Silber, H., Koßmann, J., & Heycke, T. (2022). Open science and public trust in science: Results from two studies. *Public Understanding of Science*, *31*(8), 1046-1062.

Rotman, D., Preece, J., Hammock, J., Procita, K., Hansen, D., Parr, C., ... & Jacobs, D. (2012, February). Dynamic changes in motivation in collaborative citizen-science projects. In *Proceedings of the ACM 2012 conference on computer supported cooperative work*, 217-226.

Rowland, J., Estevens, J., Krzewińska, A., Warwas, I., & Delicado, A. (2022). Trust and mistrust in sources of scientific information on climate change and vaccines: Insights from Portugal and Poland. *Science & education*, *31*(5), 1399-1424.

Schneider, C. R., Freeman, A. L., Spiegelhalter, D., & van der Linden, S. (2022). The effects of communicating scientific uncertainty on trust and decision making in a public health context. *Judgment and Decision Making*, *17*(4), 849-882.

Shah, H. R., & Martinez, L. R. (2016). Current approaches in implementing citizen science in the classroom. *Journal of microbiology & biology education*, *17*(1), 17-22.

Song, H., Markowitz, D. M., & Taylor, S. H. (2022). Trusting on the shoulders of open giants? Open science increases trust in science for the public and academics. *Journal of Communication*, *72*(4), 497-510.

Fox, O., & Stoett, P. (2016). Citizen participation in the UN Sustainable Development Goals consultation process: Toward global democratic governance. *Global Governance*, *22*, 555.

Tlili, A., & Dawson, E. (2010). Mediating Science and Society in the EU and UK: From Information-Transmission to Deliberative Democracy? *Minerva, 48*(4), 429–461.

Von Schomberg, R. (2011). Towards responsible research and innovation in the information and communication technologies and security technologies fields. *Available at SSRN 2436399*.

West, S. E., & Pateman, R. M. (2016). Recruiting and retaining participants in citizen science: what can be learned from the volunteering literature?. *Citizen Science: Theory and Practice*.

Wynne, B. (2006). Public engagement as a means of restoring public trust in science–hitting the notes, but missing the music? *Public Health Genomics, 9*(3), 211–220.

Yearley, S. (2005). What Does Science Mean In The "Public Understanding Of Science"? In M. Dierkes & C. von Grote (Eds.), *Between understanding and trust: the public, science and technology.* Routledge.

Zuckerman, S. (2019). Making Sense of Place: A Case Study of a Sensemaking in a Rural School-Community Partnership*, Journal of Research in Rural Education*, 35(6), 1–18.

7. ANNEX 1: EXAMINED PROJECTS

Project Acronym	Document
ACTION*	D6.4 Impact Assessment Report
ALLINTERACT*	Report 2: Initiatives which are making societal actors aware of the scientific research that led to the solutions they appreciate
BigPicnic*	D8.2 Final External Evaluation Report
CIMULACT	D5.3 – Report on the assessment of the impact of CIMULACT
Cities-Health*	Article: Citizen Science as Part of the Primary School Curriculum
COMPASS*	D4.3 Review and recommendations for revision of the Responsible Innovation Self-Check
CONCISE*	Article 1: CONCISE A standard for public consultation on science communication Article 2: Trust and Mistrust in Sources of Scientific Information
CROWD4SDG	D4.3. In-situ assessment report of citizen local interactions and self-reporting GEAR cycle 1
DITOs*	D5.3 Final Evaluation Report
ENERI	Article: What constitutes expertise in research ethics and integrity
ENJOI*	D1.4 How to support a healthy science communication environment
EnRRICH*	D6.2 Guidelines for embedding RRI in curricula
EnTIRE*	D2.3 Report of results from the stakeholder consultation
EnviroCitizen*	D4.3 Annual progress and management report
ETHNA*	ETHNA System project interviews
EU Citizen.Science*	D4.1 Guidelines and Recommendations
FEDORA	D3.2 Future-oriented science education manifesto
FIT4RRI*	D5.1 Guidelines on governance settings for RRI
FOSTER Plus*	D3.2 Recommendations on Open Science Training
GlobalSCAPE*	D5.1 Academic Gap Analysis
GRACE*	Guidance document #2 - Collection of experiences on Citizen Engagement Guidance document #3 - Collection of experiences on Science Education
GRECO*	D1.2 Practical guide to open science
INCENTIVE*	D2.3 Manual-for-Citizen-Science-Community-Building
InSPIRES*	D3.1 Results of the new SS 2.0 models
INTEGRITY	D3.2 Results of mapping current practice
JERRI*	D8.4 Summative evaluation
MICS	D1.3 Project Fact sheet
MULTI-ACT*	D1.6 Final version of the MULTI-ACT Patient Engagement
MULTIPLIERS*	D2.1 Report on Identified Good Practices and Needs Analysis
NewHoRRizon	D8.3 A guide to good practices for RRI
NEWSERA*	D2.3 Effectiveness of science communication in EU citizen science projects
NUCLEUS*	D5.5 Final Recommendations Institutionalised NUCLEI for RRI Guidelines
ON-MERRIT*	D6.4 Final Guidelines and Policy Recommendations
ORION*	D5.6 Final project's evaluation and quality report
ParCos*	D2.1 The Bristol Approach for Citizen Science
Path2Integrity	D3.1 Path2Integrity roadmap
PERFORM*	D2.2 Final protocol of tested methods to generate a transformative participatory educational process by using science and arts-based education approaches
PRINTEGER*	Article: Working with Research Integrity—Guidance for Research Performing Organisations: The Bonn PRINTEGER Statement

PRO-Ethics*	D1.2 Paper Manuscript on Participatory Practices
PRO-RES*	D6.1 Report on Rebuilding Trust of research institutions
PROSO*	D2.2 Societal engagement under the terms of RRI
PULCHRA*	D3.1 Report on the science education methods and approaches to be used
QUEST*	D4.4. Recommendations on Policies and Incentives for Quality Science Communication
REINFORCE	D9.2 Instruments and User Guide
RETHINK*	D5.3 Guidelines and recommendations for practitioners, policy makers and scientists
ROSiE*	Article: Open Science Knowledge Production: Addressing Epistemological Challenges and Ethical Implications
RRING	D2.3 Strategies to mobilise and promote RRING
RRI-Practice	D15.1 Implementing RRI: Comparison across case studies
SCALINGS*	D8.2: Roadmap
SHERPA*	D4.3 Final Recommendations
SISCODE	D6.2 Analysis of exploitable results and actions
SOPs-4RI	D1.1 Research Integrity and Quality Assurance Plan
SPARKS*	D4.4 Policy recommendations
SUPER_MoRRI	D6.1 Report on RRI added values assessment tools and methods
TechEthos	D3.3 Results-of-media-analysis
TIME4CS*	D5.1 Evaluation and Impact Assessment Plan
TRESCA	D1.3 Report with elaborated focus area descriptions and trending topic analysis
TRUST	Article: Promoting Equity and Preventing Exploitation in International Research
VIRT2UE	Article: Collecting and characterizing existing and freely accessible research integrity educational resources

* Indicates the projects from which the five themes in this report were derived.