PROCEEDINGS OF SCIENCE

Education, Outreach and EDI in Education and Outreach

Ana Godinho *a,**

a CERN,
Geneva, Switzerland

E-mail: ana.godinho@cern.ch

This overview of education, outreach and EDI in education and outreach addresses the points below:
1) Citizens' attitudes to science and to scientists is overall positive, including as concerns trust in science and scientists. However, there is room for more engagement, especially regarding hearing directly from scientists.
2) Direct interactions with scientists have a measurable, positive impact on the public and on students. They increase the public's engagement with science and awareness of science's impact on society. For students, direct interaction with scientists improves their perception of and interest in science careers.
3) Effective education and outreach entails awareness of the range of diversity groups, how they intersect each other, and working with communities from the start of developing a project, valuing the knowledge and experience of diverse groups.

The European Physical Society Conference on High Energy Physics (EPS-HEP2023)
21-25 August 2023
Hamburg, Germany

*Speaker

PoS(EPS-HEP2023)019

1. Introduction

The terms "Education" and "outreach" are often used with different yet overlapping meanings, in different scientific disciplines, different countries (even continents), and communities. In this publication, the terms are taken to have the meanings described below, drawn from the author's experience and published literature.

"Outreach" refers to a range of activities aimed at informing, communicating with and/or engaging with audiences that are outside academia or research (often referred to as "non-technical audiences"). In anglophone countries, "science outreach" is often called "public engagement in science".

"Education" refers to activities aimed at facilitating learning about science in informal, out-of-the classroom contexts. Importantly, it is not curricular science education, and does not encompass training (e.g., of PhD students, of post-docs). Science education encompasses learning about both scientific concepts and about the process of science (not to be confused with the "scientific method").

There is a strong overlap between education and outreach, in terms of goals (e.g., both may have the goal to strengthen the STEM pipeline), the activities that are put in place (e.g., hands-on laboratory workshops both engage in science and foster learning) and the actors (e.g., research laboratories carry out both outreach and education).

A feature that distinguishes outreach from education is the target audience. Whereas the activities developed as outreach target all ages, education activities generally focus on young people and, by association, their educators (i.e., students and teachers).

Equity, Diversity and Inclusion (EDI) is as relevant in outreach and education as it is in science and research. If the goal of outreach and education is to instil a sense of belonging in science for all (with "belonging" extending from wanting to take up a career in science to feeling empowered to make sense of the science that shapes our lives), then education and outreach are vehicles to achieve this goal, but only as long as they ensure equitable access to and engagement with science [1].

Drawing from survey, research and practice-informed findings, this paper makes a case for continued and increased direct engagement of scientists with the public, through education and outreach. It presents key concepts to consider in carrying out inclusive science education and outreach, bringing values of equity, diversity and inclusion into the very first conception stages of an education or outreach project.

1.1 Citizens' attitudes towards science, technology and scientists

If the goal of education and outreach is to connect citizens of all ages with science and technology, then in assessing these areas it is pertinent to look at existing data on citizen's attitudes to science and technology, as well as trust in science and scientists. This paper presents data from the 2021 Eurobarometer [2], the 2020 Wellcome Global Monitor [3] and the 2022 Pew Research Centre survey [4].

1.1.1 EU citizens' attitudes to science and technology

The 2021 Eurobarometer on European citizen's knowledge and attitudes towards science and technology, carried out by the European Commission, describes the results of a survey of

37103 respondents in 38 countries, including EU Member States, EU enlargement countries, EFTA states, and the United Kingdom. The survey was conducted between 13 April and 10 May 2021, primarily through face-to face interviews [2].

When asked about interest in different issues/topics1, 82% of respondents said they were either very interested or moderately interested in new scientific discoveries and technological developments. This level of interest was slightly lower than that for new medical discoveries (86%) and environmental problems (89%), but higher than for culture & arts (77%), politics (71%) and sports news (59%).

Citizens were also asked about how informed they felt about these issues/topics. For most the level of "feeling informed" was lower than that of their interest, including for new scientific discoveries and technological developments, where only 66% of respondents felt informed. There is thus scope for outreach activities that can increase citizens' perception of "feeling informed" about science and technology.

Citizens are positive about the influence and benefits of science and technology. A total of 86% of respondents think that the overall influence of science and technology on society is positive (either very positive or fairly positive) and 53% of respondents think that science and technology benefit their lives.

The characteristics that best describe scientists are2: intelligence (selected by 89% of respondents), reliability (68%), collaborative (66%), honesty (58%). These match the qualities that citizens would like to see in scientists3: intelligence (50%), honesty (43%), reliability (39%), morality (34%), ability to work together (27%). These findings suggest that scientists are perceived in a positive light by EU citizens.

When asked which professional groups are most qualified to explain the impact of scientific and technological developments4, 61% of respondents considered scientists working in the public sector as amongst the most qualified, followed by 40% for scientists working in the private sector. Overall, scientists were considered more qualified than doctors (considered as amongst the most qualified by 29% of respondents), journalists (19%), environmental protection associations (16%), national governments (12%). Interestingly (and possibly surprisingly for many of us) people active on social media/blogs were considered amongst the most qualified for this purpose by only 6% of respondents. This finding seems to counter the ongoing and often deafening discussion about the impact of social media "bubbles" on knowledge of and attitudes to science and technology. As with all survey results, these findings should not be taken on their own, but compared with those of smaller-scale empirical studies on the role of social media in misinformation and disinformation around science.

On scientists' role in communicating with citizens, 51% of respondents considered that scientists do not spend sufficient time meeting people to explain their work[5]. This is mirrored in

[1] Eurobarometer question: In everyday life, we have to deal with many different issues, where we feel more or less interested. For each of the following, please indicate whether you are…

[2] Eurobarometer question: The following is a list of characteristics that can be associated with scientists today. For each characteristic, indicate if you think it describes scientists well or describes them badly

[3] Eurobarometer question: Please choose the three qualities that you think scientists should have

[4] Eurobarometer question: Among the following categories of people and organisations, which are the best qualified to explain the impact of scientific and technological developments on society?

[5] Eurobarometer question: Please indicate to what extent you agree or disagree: Scientists spend sufficient time meeting people like me to explain their work.

the Wellcome Global monitor, which detected a 19% increase in the public's interest in hearing directly from scientists about the research they were conducting between 2018 and 2020.

1.1.2. Trust in science and in scientists

The 2020 Wellcome Global Monitor, conducted as part of the Gallup World Poll by the Wellcome Trust (UK), includes results from representative surveys in 113 countries and territories carried out in 2020 and early 2021, with approximately 1000 adults aged 15 and older interviewed per country. As part of the 2020 survey, participants were asked about their trust in science [3].

The survey indicates that trust in science rose worldwide between 2018 and 2020: at the global level, respondents were more likely to place "a lot" of trust in science in 2020 (41%) than in 2018 (32%) and were more likely to place a lot of trust in science, compared to 20186.

Also compared to 2018, the increase in trust in science (32% trusted science "a lot" in 2018, and 41% in 2020) and scientists (34% in 2018 and 43% in 2020) was greater than for other groups, namely doctors (3% increase), journalists (1% increase), and national governments (3% increase).

Similar results were found by the 2020 German Science barometer [5] and the 2019-20 3M State if Science Index [6].

These findings are all the more significant since their collection and publication coincide with the start of the COVID-19 pandemic: a time when, faced with the novelty, complexity and devastating impact of the new coronavirus, the inner workings of the research process were publicly discussed, including disagreements between scientists, the limits of scientific knowledge exposed and issues of trust in scientists widely discussed. Some researchers claim that it seems reasonable to assume that the public disclosure of science-in-the-making, including the unprecedented international collaboration involved in understanding the virus and developing vaccines, may have helped secure trust at high levels.

Data on trust in science after 2021 is available for the USA, in the Pew Research Centre annual survey. The 2022 survey was applied to 10588 US adults in September 2022 [4]. A longitudinal comparison, beginning in 2016 shows a gradual increase in the percentage of US adults who have a great deal/fair amount of trust in science, peaking in April 2020 (87%) – thus similar to the findings of European surveys and the Wellcome Global monitor - and decreasing slightly to 77% in September 2022 (reaching the levels before the COVID-19 pandemic). Overall, however, two-thirds of US adults have confidence in science, and scientists are the third group of professionals in which US adults have a great deal/fair amount of trust, after medical scientists and the military. The data in the Pew Research Centre survey highlights a strong partisan divide in the levels of trust in science expressed by respondents.

1.2. The role of scientists in outreach and education (or why should scientists become involved in outreach and education?)

Scientists are one of several actors in outreach and education (Figure 1).

[6] Wellcome Global Monitor question: In general, would you say that you trust science a lot, some, not much or not at all?

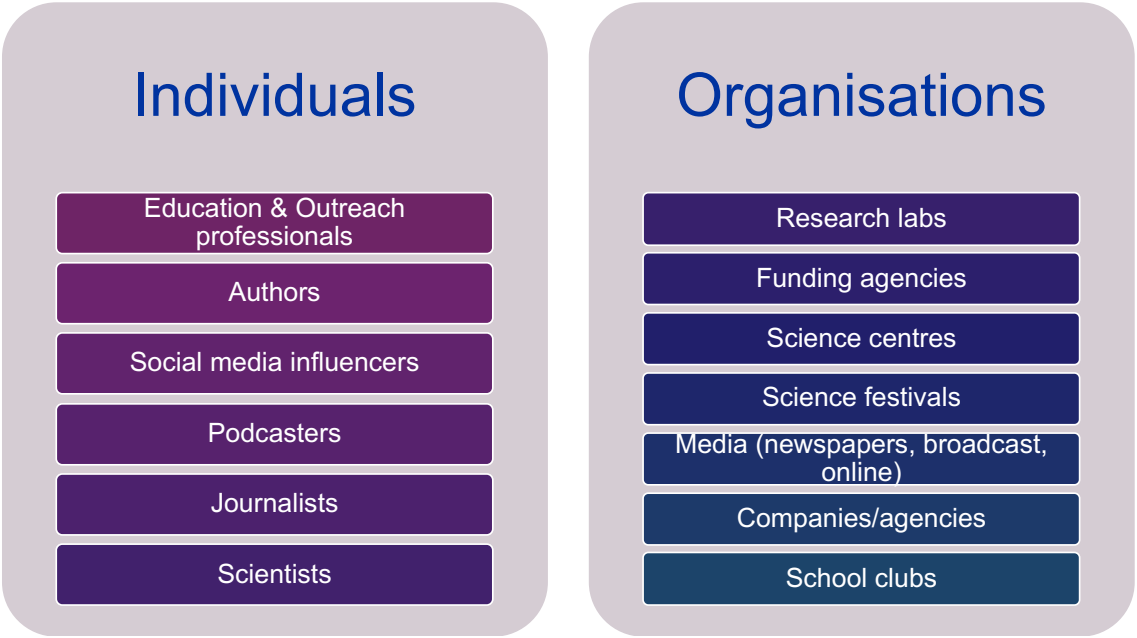

Figure 1. A non-exhaustive list of individuals and organisations that are considered actors in the fields of outreach and education.

The individuals in the left column either work as freelancers or within the organisations listed on the right. These organisations carry out both outreach and education – an example of the overlap between the two fields.

The surveys mentioned in the previous section suggest that there is a strong interest from the public (citizens) in hearing directly from scientists about the work they do. These findings are supported by empirical research. Studies of the impact of scientists' direct interaction with the public show significant positive effects on the public's levels of engagement with science [7], knowledge about science and the natural world, and understanding of the role of science in society [8].

Research also shows that the impact on students of meeting scientists includes students changing their perception of scientists from 'boring' and 'nerdy' to 'normal' and 'approachable' and gaining a broader understanding of the diversity of careers in science [9]. Evidence suggests that even short discussions with scientists about their everyday life can increase students' career aspirations [10].

1.2.1 Evidence from CERN's research

Evaluation of CERN's education and outreach programmes produce similar results to those in the literature. This section will present findings from the 2019 CERN Open Days (an outreach event for all ages) [11] and the CERN S'Cool LAB (a hands-on educational physics laboratory for secondary-school students and teachers) [12].

The 2019 CERN Open Days were effectively "delivered" by almost 3000 volunteers from the CERN community (physicists, engineers, students, administrative staff and others) who mediated the activities, guided visits to CERN facilities, demonstrated, explained and discussed their work with visitors.

Surveys of the visitors pre-, post- and three months after the Open Days showed an increase in the proportion of visitors that perceived the people who work at CERN to be engaging: 55%

pre-Open Days, 74% post-Open Days and 70% three months after the Open Days. In addition, 45% considered "Talking to people at CERN" as one of the reasons for going to the Open Days (in the pre-Open Days survey). After the Open Days, 58% indicated "having a conversation with people from CERN" as one of the main activities they carried out.

In open questions about the key memory of the Open Days, 16% explicitly mentioned members of the CERN community. The effect appears to be lasting, since in the sample of respondents three months after the Open Days, the same circa 16% was maintained [13].

"More impressive than the LHC is CERN's people."

"People at CERN like their work and like to talk about it."

"CERN does complicated things, but if you go there and speak with the CERN people, it isn't difficult at all to understand."

"The guide of guides […] was the absolute highlight and fulcrum of our trip […] Our experience at CERN was informed 100% by what he alone explained. […]"

In S'Cool LAB, a study of 509 high-school students from 13 countries evaluated a range of affective and cognitive outcomes on the students of participating in half-day hands-on sessions guided by tutors from the CERN community. The findings show that students' perception of tutors and the support provided by tutors (i.e., help in solving problems and a display of fascination for physics) is highly positively correlated with almost all outcomes such as interest, curiosity, enjoyment, physics self-beliefs, perceived cognitive activation (a measure of how students felt engaged in the tasks). In linear regression models, tutor support was by far the most important predictor for these outcome variables [14].

1.2. Equity, Diversity and Inclusion

Before addressing EDI in outreach and education (the focus of this paper), a few words on how outreach can contribute to changing the public perception of diversity in high energy physics.

Visitors to the 2019 CERN Open Days were asked how they perceive people who work at CERN: diverse, rather diverse, neither, rather similar, similar. A visit to the Open Days increased the proportion of visitors that perceived the community as diverse: from 42% before the Open Days, to 60% immediately after the Open Days and 55% three months after the Open Days [13].

1.2.1. Inclusive outreach and education

It is consensual that education and outreach need to have EDI at their core. There is an increasing body of research into EDI in outreach and education, also called "inclusive science communication". One of the goals is to establish guidelines for what is effective inclusive education and outreach.

The literature suggests that achieving diversity is not simply having a range of demographics in the audience. Similarly, inclusion is more that successful participation; it is ownership of that participation. In summary, EDI in education and outreach is intentionally working with diverse, traditionally excluded communities in all phases of developing a project.

When thinking about diversity groups, there is a tendency to focus on girls/women. However, there are many more diversity groups: indigenous people, immigrants, ethnic groups, linguistically diverse, persons with disabilities, developing nations, LGBTQIA+ communities,

religious groups, people with a low socio-economic status, and more. The groups with whom to collaborate will depend on where we are: geographically, culturally. It is not expected that all groups are addresses all the time; but it is important to be aware of the range of diversity groups [15].

Other aspects that inclusive science communication researchers have highlighted as important when thinking and developing outreach and education projects are:

- To remember that a person may belong to more than one group ex: a teacher may be a black single mother
- That it is good to interrogate how the experiences and cultural perspectives of researchers and education and outreach practitioners influence and shape how they approach their work (e.g., the presence of implicit biases)
- Education and outreach practitioners and researchers may belong to one of these diversity groups, and so should bring in their experience.

Whatever method is used for inclusive education and outreach, research suggests it should be underpinned by [1]:

- Community-engaged research – involve communities from the moment the project becomes an idea
- Co-creation – with the relevant communities
- Use culturally-relevant channels – informed by the engagement with the community
- Integrate lay expertise throughout all the phases of the project. Avoid tokenism.
- Accept engagement on the audiences' terms – be open to accept and act on different opinions and preferences expressed by the communities.

1.3. Conclusion

In 1952, the clinical psychologist and researcher, Anne Roe, said,

"Nothing in science has any value to society if it is not communicated, and scientists are beginning to learn their social obligations."

Since then, and especially since the 1980s in Europe, scientists in all research fields have been called on to communicate about their research.

In 2013, Sir Mark Walport, at the time Chief Scientific Advisor to the UK Government, said

"Science isn't finished until it's communicated. The communication to wider audiences is part of the job of being a scientist, and so how you communicate is absolutely vital."

These two quotes illustrate the evolution of the perception of scientists' role in outreach and education over the past 60 years. Over these six decades, there has been an evolution from calling on scientists to communicate, to inviting scientists to be reflective about how that communication is done.

Activities based on dialogue and debate with citizens, and greater citizen participation in research have flourished. More recently, the outreach and education community has begun

addressing how to make EDI part of these activities and of its practice, informed by empirical research.

References

[1] K.N. Canfield, S. Menezes, S.B. Matsuda, A. Moore, A.N. Mosley Austin, B.M. Dewsbury, M.J. Feliú-Mójer, K.W.B. McDuffie, K. Moore, C.A. Reich, H.M. Smith, C. Taylor (2020) *Science Communication Demands a Critical Approach That Centers Inclusion, Equity, and Intersectionality*, *Front. Commun.,* **5** (2) [doi: 10.3389/fcomm.2020.00002]

[2] Directorate-General for Research and Innovation (2021), *Special Eurobarometer 516 – European citizens' knowledge and attitudes towards science and technology*. European Commission [doi: 10.2775/303708]

[3] Wellcome Trust (2020) *Wellcome Global Monitor*.

[4] Pew Research Center (2022) *Americans Value U.S. Role as Scientific Leader, but 38% Say Country Is Losing Ground Globally*

[5] Wissenschaft in dialog (2020) *Science barometer 2020*

[6] 3M (2020) *State of Science Index - 2020 Global Report*

[7] K.A. Stofer, J. Rujimora, S. Sblendorio, E. Duqueney, M. Tatineni, G. Gauder. (2019) *Casual conversations in everyday spaces can promote high public engagement with science*, *Intl. J. Sci. Ed. Part B,* **9** (4) [doi: 10.1080/21548455.2019.1670882]

[8] D. Wormald (2018) *The impact of meeting scientists: a public engagement literature review*, Natural History Museum (London)

[9] K. Woods-Townsend, A. Christodoulou, W. Rietdijk, J. Byrne, J.B. Griffiths, M.M. Grace (2015) Meet the scientist: the value of short interactions between scientists and students, *Intl. J. Sci. Ed. Part B,* **6** (1) [doi: 10.1080/21548455.2015.1016134]

[10] K. Hochberg, J. Kuhn (2019) *What do scientists do? Increasing awareness of social and networking aspects in everyday activities of scientists*, *PriSE* **2** (1) [doi: 10.25321/prise.2019.849]

[11] https://opendays.cern/

[12] https://scoollab.web.cern.ch/

[13] D. Dvortzhitskaia (2023) Personal communication

[14] J. Woithe (2020) *Designing, measuring and modelling the impact of the hands-on particle physics learning laboratory S'Cool LAB at CERN - Effects of student and laboratory characteristics on high-school students' cognitive and affective outcomes, CERN-THESIS-2020-089*

[15] K. Judd, M. McKinnon (2021) A Systematic Map of Inclusion, Equity and Diversity in Science Communication Research: Do We Practice what We Preach?, *Front. Commun*. **6**:744365. [doi: 10.3389/fcomm.2021.744365]