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25 Years of INGV's Education and Outreach: Bridging Science and Society

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Abstract

Over the past 25 years, the science outreach activities of the Istituto Nazionale di Geofisica e Vulcanologia (INGV) have evolved from individual efforts by scientists into organized initiatives led by teams at INGV. These efforts aim to enhance public understanding of the importance of geosciences and to promote a culture of prevention. Outreach efforts target schools and the general public through a range of activities, including guided laboratory visits, participation in national and international events, and the development of multimedia educational tools. An overview of our key activities is presented here, highlighting the role of geoscience in education and emphasizing the importance of equipping the next generation with an understanding of Earth system complexities. The overview also offers valuable perspectives on fostering children's awareness of geoethics to prepare them to address global challenges. In particular, the project with schools is one of the longest-running initiatives of the INGV Third Mission activities and has had a significant impact on local communities. Over the years, we have welcomed thousands of students, highlighting the importance of initiatives dedicated to schools, which are a strategic sector for the dissemination of geosciences.

Regarding selected outreach initiatives, we have conducted impact evaluation analyses to monitor efficacy and better refine our actions. Finally, in addition to the school project, a notable initiative includes an annual drawing competition for primary school students, which has collected over 35,000 drawings. This extensive dataset provides a unique opportunity to analyse how children's perceptions of geoscientific subjects have evolved over time.

Keywords: Geoscience disseminatio; Outreach activity; Educational projects; Children's drawings; Impact evaluation

Introduction

Science outreach has traditionally been driven by individual scientists aiming to raise public awareness of scientific concepts. However, as the need to reach a broader audience became increasingly evident, shortly after the founding of INGV, a dedicated group of researchers and technicians organized teams of part-time outreach operators. The mission was to promote scientific understanding, share knowledge, and communicate research findings, particularly regarding seismic and volcanic hazards.

In a world where citizens are expected to make informed decisions about their health and safety, scientific knowledge is crucial for managing uncertainty and making sound choices. This is particularly true for natural hazards, where there is growing recognition of the need to shift from a culture of preparedness in disaster response to one of prevention in disaster management. Achieving a culture of prevention requires responsible and balanced information, as well as education, to empower citizens. Public preparedness and knowledge of disaster management are essential resources for risk reduction. Consequently, this emphasis on scientific literacy fosters a positive perception of science within society.

Here, we present an overview of INGV's science outreach efforts, primarily aimed at schools and the general public. Our activities encompass a wide range of formats, including opening our laboratories for guided visits, participating in national and international events, producing educational videos, and creating multimedia tools [Nave et al., 2012; D'Addezio et al., 2014a, 2014b; D'Addezio, 2019]. Additionally, we collaborate with museums, academies, exhibitions, and scientific festivals, organizing interactive displays featuring experiments, models, and exhibits to facilitate the teaching and learning of geophysics [Nostro et al., 2005; Winkler et al., 2005; D'Addezio et al., 2015]. Additionally, we offer guided tours of our Institute's control rooms, which provide round-the-clock monitoring of seismic, volcanic, and tsunami activities throughout Italy.

A key aspect of INGV's educational and outreach efforts is the team's success, which stems from a close relationship and collaborative work between graphic

designers and research scientists. Over the past 15 years, graphic and visual communication have become essential tools for supporting outreach activities [Riposati et al., 2020].

Furthermore, during national and international events and festivals, as well as in projects with schools, INGV researchers and technicians lead educational and outreach initiatives focused on Earth sciences [Pessina and Camassi, 2012; Hunstad et al., 2013; Lanza et al., 2013; D'Addezio et al., 2014a, 2015, 2020b; Musacchio et al., 2012, 2015a, 2015b, 2019; Di Nezza et al., 2018].

A notable contribution to these outreach activities comes from the collaboration between INGV and the International Association for Promoting Geoethics (IAPG)[1], which has played a pivotal role in integrating geoethics into Earth science education and public dialogue [Peppoloni and Di Capua, 2016].

Our outreach initiatives also provide opportunities to study the impact of these activities on users. As part of our research approach, we have conducted impact evaluation analyses, and a summary of these evaluations, focusing on specific projects, is presented here.

Additionally, we have explored children's perceptions of science and scientists, as well as their views on planet Earth, its sustainability, and its future, by analysing drawings submitted by primary school students for calendar competitions. The results of these analyses offer valuable insights into how science is portrayed and whether it has fostered a shared understanding and a less stereotypical image of science. Furthermore, we aim to assess how environmental science and sustainable behaviours are being communicated to the next generation of global leaders.

1. INGV's Education and Outreach: An overview

The outreach and educational activities at INGV are primarily carried out by teams of mostly part-time scientists and technicians, with the main goal of promoting science education, with particular emphasis on volcanic and seismic hazards [Solarino, 2009; Nave et al., 2010; Pessina and Camassi, 2012; Rubbia et al., 2014; Piangiamore et al., 2015; Brasini et al., 2020]. This ongoing initiative is realized through the organization of various scientific dissemination efforts, targeting both schools and the general public. These activities are hosted at the main headquarters in Rome, as well as other INGV departments across Italy, from Milan to Catania, or at dedicated venues such as museums, science centers, and special event locations.

[1] https://www.geoethics.org (accessed 16 January 2025).

The following provides a brief overview of these initiatives, organized by type for ease of discussion, though many activities are interconnected and complement one another.
Over the years, we have produced editorial materials to support outreach activities, including free posters and pamphlets, which are also available online. These resources feature accessible information, visuals, and cartoons designed to appeal to a wide audience, including younger readers[2].

1.1 Educational activities for schools

Engagement with schools has been one of our earliest and most sustained outreach efforts [Burrato et al., 2003]. Over the years, INGV researchers have developed a variety of projects and initiatives, including conferences and in-school programs. These initiatives focus on core INGV research areas, such as seismology, volcanology, tsunamis, geomagnetism, aeronomy, and environmental science.
At several INGV locations, specific educational programs have been designed to provide students with an immersive experience. For instance, the INGV center in Rome annually hosts more than 1,500 students along with their teachers. INGV researchers and technicians welcome these students with enthusiasm and expertise, aiming to spark scientific curiosity and share knowledge about nature, science, and research.
During these visits, students not only interact with researchers but also engage in hands-on experiments and laboratory activities (Figure 1 and Figure 2). A highlight of the visit is the INGV Control Room, where seismic activity across Italy is monitored, along with early tsunami warnings in the Mediterranean, using cutting-edge technology.
Dedicated exhibition areas focus on topics such as plate tectonics, volcanic activity, and geomagnetism, providing students with a deeper understanding of these scientific phenomena. Additionally, high school and university students are also welcome to visit the scientific laboratories, where experimental research is actively conducted.
Since 2015, INGV has participated in the PCTO (Pathways for Transversal Skills and Orientation) program, formerly known as ASL (School-Work Alternance) [D'Addezio, 2021]. This program provides high school students with practical work experience, helping them develop both technical skills and an understanding of real-world work environments.

[2] https://www.ingv.it/comunicazione-e-divulgazione/educational (accessed 16 January 2025).

Figure 1. *Outcomes after the visit at the INGV headquarters in Rome. In the drawing created by Flavia, a third-grade student, the hands-on activity on seismic wave propagation is highlighted, with the researcher's explanation acting as a mediator for the learning experience. The illustration captures the interaction between the students and the researcher, emphasizing the practical and engaging nature of the activity.*

Figure 2. *Some of the activities offered to students include volcano workshops, exhibits on plate tectonics, and the "Laboratorio goloso" -tasty laboratory- focusing on the Earth's interior and seismic activity.*

The PCTO activities integrate traditional classroom learning with hands-on experiences, emphasizing practical skills alongside theoretical knowledge. The scientific pathway engages students using both traditional training methodologies and experimental approaches, placing special emphasis on integrating practical activities. These experiences have proven to be very effective for high school students, as they often involve developing manual skills and using software such as Excel, Word, and PowerPoint for focused tasks [Amici and D'Addezio, 2015].
In addition to our activities with schools, we are also committed to teacher training initiatives at both national and international levels. These programs aim to equip educators with the tools and knowledge needed to effectively teach Earth sciences, thereby promoting a broader understanding of geoscientific topics in the classroom [D'Addezio and Locritani, 2018].

1.2 Scientific dissemination activities organized by INGV

We organize scientific dissemination activities for special events held at INGV headquarters across Italy, as well as at museums, cultural centres, and other dedicated venues. The activities include a variety of events designed for both the general public and schools, such as seminars by researchers, guided tours of laboratories and seismic exhibitions, educational games, movies, debates, scientific theater performances, and concerts. Here is a summary of some of the key initiatives:

- ScienzAperta, a week dedicated to scientific information and dissemination, is an outreach initiative conceived and promoted by INGV since 2012. Its goal is to open the doors to the public and share with the community the places where research is conducted, through events held at various times and across different INGV venues [D'Addezio et al., 2014b]. The activities include a variety of events designed for both the general public and schools (Figure 3). Researchers are committed to ensuring that their activities are made accessible to society at large in a way that can be understood by non-specialists, thereby improving the public's understanding of science.
- Since 2008, INGV has been part of the European Researchers' Night, promoted by the European Commission as part of the Marie Skłodowska-Curie Actions (MSCA), which is the largest science outreach event in Europe. Science becomes a spectacle, with interactive workshops, engaging games, enlightening guided tours, exciting science treks, and compelling seminars and lectures, catering to all interests and levels of knowledge, so that everyone can immerse themselves in the fascinating world of research. INGV's participation has involved several venues, with European Commission-funded projects or in

collaboration with other projects, creating immersive experiences that bring the world of research to life.

- The "Parole per la Terra" initiative, launched by INGV in 2019, takes place throughout the country with the aim of spreading knowledge about earthquakes, volcanoes, the environment, and raising awareness of environmental protection and natural hazard mitigation. Every year, INGV's various sections offer a rich and varied program to bring the public of all ages closer to the world of scientific research through guided tours, educational workshops, lectures, and games.
- On World Earth Day, April 22, INGV participates in the "Villaggio della Terra" initiative in Rome. The "village" is usually visited by thousands of people and hosts more than 600 events over the course of several days. Additionally, 17 multimedia squares are dedicated to the individual goals of the United Nations' 2030 Agenda for Sustainable Development, featuring meetings, workshops, exhibitions, and events hosted by many organizations that join the event each year. INGV researchers engage the public in geosciences, helping them discover the deeper workings of our "home" through exhibits, workshops, and games for children aged 5 to 99. Another important annual initiative is the Settimana del Pianeta Terra (Earth Planet Week), a national geoscience festival launched in 2012 that focuses primarily on Earth sciences. INGV participates by organizing various geoevents, involving the public in educational activities and fostering a deeper understanding of Earth sciences.
- Recently, INGV has collaborated on events for World Ocean Day, established by the United Nations to raise awareness among citizens about the impact of human actions on the ocean, a resource fundamental to the preservation of life on Earth. These events involve the national scientific community engaged in the study of the ocean and climate. INGV organizes formats in which science and art immerse visitors in the marine environment, allowing them to learn more about this extraordinary resource and the actions that can be taken to contribute to its conservation.
- The "Giornata Nazionale dello Spazio" (National Space Day), established by the Italian government in 2021, provides a platform to raise public awareness of the benefits of both science and technology in space. INGV participates in this event by organizing activities that demonstrate how satellite observations are essential for monitoring the Earth's climate, volcanic activity, tectonic movements, space weather, and other natural phenomena. These activities are designed to engage people of all ages, helping them understand how space science contributes to public safety, environmental protection, and resource management.

Figure 3. *The Open Day programs at the INGV headquarters in Rome include guided tours of laboratories, seminars led by researchers, exhibitions, educational games, and visits to the INGV Control Room.*

1.3 Science outreach through exhibitions and science festivals

INGV manages museums dedicated to geophysics and volcanology, including the Reale Osservatorio Vesuviano, the Museo Geofisico di Rocca di Papa, and the Museo di Duronia (Figure 4). Additionally, INGV collaborates in the scientific management of the Museo Laboratorio delle Scienze della Terra in Ustica and the Volcanological Museum in Nicolosi. At these museums, INGV organizes both permanent and temporary scientific exhibitions and installations [Pagliuca et al., 2007; Avvisati et al., 2015; D'Addezio et al., 2015]. INGV also manages the Volcanological Information Centers of Vulcano and Stromboli, located in the Aeolian Islands (Italy), where visitors can explore information related to volcanic activity and the surrounding environment (Figure 4).

Figure 4. *In the figure an historical image of the Reale Osservatorio Vesuviano, one of the rooms of the Museo Geofisico di Rocca di Papa, and the exterior of the Volcanological Information Center of Stromboli. These locations play a central role in INGV's outreach activities, offering visitors valuable insights into the history, research, and monitoring of volcanic and seismic phenomena.*

In addition to managing these museums, INGV cooperates with other institutions to create self-designed exhibitions featuring experiments, models, and displays aimed at teaching and learning geomagnetism, plate tectonics, seismology, seismic hazards, and other topics for special events. These exhibits are also featured during special events such as the Festival della Scienza di Genova[3], an annual international event that, with an average of 250,000 visits, is one of the most significant science events organized in Italy. Since its inception in 2004, INGV has been a key participant, organizing temporary exhibits on various geophysical topics [Nostro et al., 2005; Winkler et al., 2005; Nave et al., 2012; D'Addezio et al., 2013; D'Addezio, 2019]. During the two-week festival, INGV's exhibitions attract an average of about 5,000 visitors weekly. In addition to the exhibits, INGV organizes a range of activities such as workshops, lectures, and special events, including theatrical performances designed to engage audiences with scientific concepts in creative ways [Soldati et al., 2024]. Workshops, lectures, and special events were also held as part of the National Geographic Science Festival in Rome and Futuro Remoto in Naples. Additionally, a variety of activities, including seminars, educational courses, conferences, and meetings, have been organized on sporadic occasions, often initiated by individual researchers or small groups.

1.4 Editorial products for science outreach

To further support its outreach efforts, INGV produces a variety of editorial materials, such as books, posters, and pamphlets, available both in print and online. These materials, designed to be visually engaging and accessible, feature images, infographics, and cartoons that simplify complex scientific concepts for a wide audience, including young readers [Cirillo et al., 2021]. These resources play an important role in ensuring that scientific information is accessible to all (see footnote 2).

2. Outlines on Research Applications

2.1 Appreciation surveys and visitor feedback on INGV's outreach activities

Over the years, INGV has collected valuable feedback through appreciation surveys completed by visitors from various audience groups. These surveys have provided

[3] https://www.festivalscienza.it/ (accessed 16 January 2025).

essential insights into visitors' profiles, satisfaction levels, emotional responses, learning outcomes, and areas for improvement. INGV's experience with visitor feedback spans a range of activities, from permanent exhibitions —such as the historical building of the Osservatorio Vesuviano located on Vesuvius volcano [Avvisati et al., 2015; Avvisati and Uzzo, 2000] — to temporary exhibitions, itineraries, and projects [Lanza et al., 2013; Rubbia et al., 2014; Musacchio et al., 2015a, 2015b; D'Addezio et al., 2016; Amici et al., 2018; D'Addezio, 2019]. The surveys analyse several factors, including the demographic profile of visitors, the effectiveness of educational activities, and the motivations behind participation in outreach events. Over time, these surveys have provided useful information on the enjoyment and effectiveness of various outreach initiatives, contributing valuable data on how well the activities resonate with different audiences [Nave et al., 2012; Lanza et al., 2013; D'Addezio et al., 2014b; Rubbia et al., 2014; Musacchio et al., 2015a, 2015b]. To reach diverse audiences, INGV distributes tailored questionnaires for adults, youth, and other stakeholders. These questionnaires assess participants' experiences during the activities and are an efficient, cost-effective method for collecting feedback. They offer anonymity to respondents while allowing for quick data collection. In the early stages, paper-based surveys were used, but over time, these evolved into digital formats for greater ease of use and wider accessibility. Despite their advantages, the survey tool has limitations, including the rigid structure of many questions and the potential for carelessness or inaccuracy in responses, which can affect the reliability of the data. The feedback gathered through these surveys is crucial for improving the effectiveness of science communication in INGV's outreach activities. It helps identify strengths and weaknesses in how scientific content is presented, guiding future improvements. These surveys also support the development of a more systematic approach to designing and implementing outreach programs in similar contexts.

Generally, the feedback from the public has been positive, with visitors expressing interest in the continuation of these outreach activities. However, the key question remains: how effective are these initiatives in terms of increasing knowledge? This remains a challenging issue to evaluate, as it depends on various factors, including participants' background knowledge, expectations, and individual approaches to learning. It is difficult to measure this impact immediately after a single experience, and any knowledge gain is likely to become evident only over the long term. In fact, evaluating outreach activities and the feedback received presents significant challenges, especially when assessing their long-term effectiveness. While immediate positive feedback helps measure engagement, it offers limited insight into the lasting impact on participants. Furthermore, exploring the long-term effects on children's and adolescents' understanding of scientific concepts would shed light

on how these messages are internalized and whether they continue to engage with science beyond the outreach activities. A more comprehensive evaluation framework, such as follow-up surveys or interviews conducted months or years later, could provide valuable insights into whether these activities inspire sustained interest in science, deepen curiosity about the natural world, or influence future STEM-related choices. However, such longitudinal evaluations are complex and resource-intensive, requiring careful planning and extended data collection. The main goal of INGV's outreach activities is not to provide in-depth scientific teaching but rather to help the public understand the experimental nature of Earth sciences, foster curiosity, and encourage people to ask questions about the world around them.

To move beyond the perception that public engagement activities are merely "goodwill exercises with no measurable rewards," there is a growing need to develop performance indicators for these initiatives. For example, adopting rating models and standardized questionnaires across all INGV events would be beneficial. This approach would allow for the creation of a common database for comparative analysis, providing more consistent data that can be used to evaluate and enhance the effectiveness of future outreach activities. Moreover, standardizing the questionnaires would help expand visitors' knowledge within the context of informal scientific learning and improve the overall impact of INGV's educational efforts.

2.2 Earth sciences in calendars created by children

INGV's outreach projects with schools include the creation of calendars featuring student artwork from an annual competition aimed at primary school children. Each year, schools eagerly participate by submitting drawings related to Earth science topics [Rubbia et al., 2015; D'Addezio, 2020a]. Over the years, we have collected more than 35,000 drawings. This extensive and unique dataset provides a valuable opportunity for analysis and comparison, especially by examining the themes and subjects across different competitions. It represents the first comprehensive national comparison of primary school children's drawings from across Italy, spanning over a decade. The analysis offers insights into how children's understanding of geoscientific subjects has evolved over time. It also helps assess how science is portrayed, and whether it has fostered a shared understanding and reduced stereotypes.

As the first task, we compared the drawings from the 2011 competition, *Scienziato anche io! La Scienza e gli scienziati visti dai bambini* (I'm a scientist too! Science and scientists from the children's point of view), with the drawings from the 2021 competition, *La Scienza in crescita, immaginare la scienza del Futuro!* (Growing

Science, let's imagine the science of the Future!) [D'Addezio and Besker, 2024a]. We observed similarities and significant differences over the 10 years separating the two datasets. Although the scientist is still generally depicted as a man, we noted a significant increase in the representation of female scientists in the 2021 dataset (Figure 5). The study considered and compared a wide range of variables, including the representation of researchers, the presence of stereotypes, gender diversity, and the scientific fields depicted.

Figure 5. *In the first analysed datasets of children's drawings, the scientist is still predominantly depicted as a man, although in the most recent dataset, there is a notable increase in the representation of female scientists.*

Although progress has been made, the path toward greater inclusivity in science remains ongoing. Targeted projects addressing gender stereotypes could be useful, such as highlighting female role models in STEM and showcasing successful women in science to inspire girls and challenge outdated perceptions [Cianetti and Melini, 2020]. Hands-on activities, workshops, and non-judgmental spaces for exploration are fundamental for building girls' confidence in science. Additionally, using inclusive language in educational materials and promoting mentorship programs can help foster a supportive environment.

The percentage of inventions in the 2021 dataset showed a notable increase, possibly reflecting greater confidence in the potential benefits of science. Several wide-ranging inventions focused on the environment, indicating a growing ambition to address climate change and pollution.

Considering the growing interest in environmental topics, we began analysing

children's perceptions of planet Earth, its sustainability, and its future by comparing drawings collected for the 2009 calendar, *La Terra di domani è oggi nelle mie mani* (The Earth of tomorrow is in my hands today), with those from the 2022 calendar, *Un futuro a misura di Pianeta* (A future sized for the Planet) [D'Addezio and Besker, 2024b]. How have perceptions of environmental themes evolved among Italian primary school children over time? We observed a more positive approach to environmental issues, particularly in the drawings of girls. These positive attitudes are expressed through the search for solutions, actions aimed at resolving problems, or sustainable behaviors.

Children expressed concern about pressing global issues such as urban, ocean, and marine pollution, as well as waste production, management, and disposal. Pollution and waste emerged as the main themes in the drawings.

There has been an increase in the depiction of inventions aimed at solving environmental problems, suggesting a growing confidence in the potential benefits of science and technology (Figure 6). This shift may also reflect the ongoing communication efforts by the scientific community. In fact, the positive progression of awareness about climate change over the years can be seen as a sign of increasing positive attitudes toward science and recognition of the importance of scientific knowledge and its cultural significance.

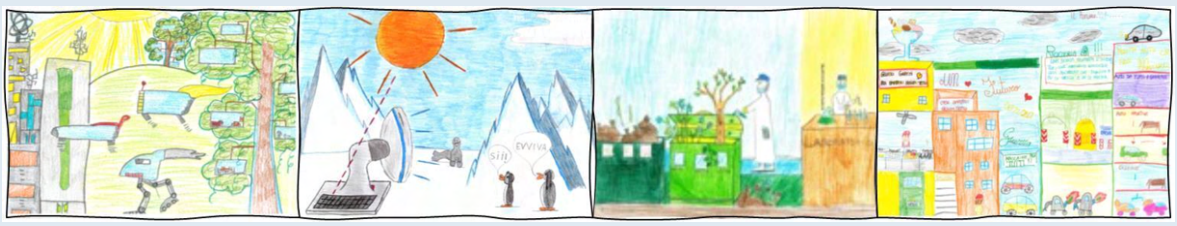

Figure 6. *In the second analysed datasets of children's drawings, over the years, there is a noticeable increase in awareness of climate change issues. Additionally, there is a growing use of children's inventions to propose solutions to environmental problems.*

Conclusion

The scientific outreach activities organized by INGV, including exhibitions, events, workshops, school projects, and themed initiatives, have played a significant role in raising public awareness and promoting the understanding of science, particularly Earth

sciences, among diverse audiences. The variety and scope of these activities—ranging from annual events to international initiatives—have enabled INGV to engage a broad spectrum of the public, from young students and families to experts in the field. The analysis of these outreach activities has highlighted how both permanent and temporary exhibitions, along with interactive learning experiences, have positively impacted the public's scientific awareness. These initiatives have also contributed to promoting a more inclusive and less stereotypical image of science and scientists. Visitor feedback has shown increasing appreciation for these events, suggesting that the public is becoming more engaged with topics such as environmental sustainability, climate change, and technological solutions to global challenges. One critical aspect is the long-term effectiveness of these activities, and further exploration is needed to assess their lasting impact. However, despite the progress made, much work remains to be done in breaking down gender stereotypes in science and encouraging greater female participation in STEM fields. Furthermore, the analysis of children's perceptions of the planet's future highlights growing confidence in scientific and technological solutions, coupled with a clear awareness of the environmental challenges facing the world.

In conclusion, INGV's outreach activities have had a positive impact in promoting a deeper understanding of Earth sciences and fostering a more open and inclusive scientific culture. The results from visitor surveys and the analysis of children's drawings suggest that these projects not only stimulate interest in science but also contribute to creating a more informed and responsible citizenship regarding global and environmental issues. However, to ensure a lasting impact, it is essential to continue refining methodologies for evaluating the effectiveness of these activities and further integrate science, art, and education, strengthening the role of science as a tool for understanding and driving change for future generations.

As an outreach community of scientists, we can make substantial progress in strengthening our presence in the territory through traditional methods (meetings, teacher training courses to support Earth Sciences education, visits to labs and control rooms, etc.) and multimedia tools to communicate geosciences to a wide, even non-specialized, audience, starting with children. Science communication serves not only as a tool for risk mitigation but also as a means to promote the study of science and encourage it as a potential career path for students. A long-term commitment to educational programs is essential.

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