Join Us to Optimize Health Through Cohort Research

Deliverable 5.1: An overview and critical view on ongoing initiatives that adapted RRI in their educational programs to stimulate engagement of citizens in science

Version 1.0

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 101006518.

Project Name	Join Us to Optimize Health Through Cohort Research (JoinUs4Health)
Project No.	101006518
Project Type	Coordination and Support Action
Project Duration	01/01/2021 – 31/12/2023 (36 months)
Project Website	https://joinus4health.eu/
Project Coordinator	Birgit Schauer (UMG)
Funded under	Grounding Responsible Research and Innovation in society with a focus on citizen science (SwafS-23-2020)
Work Package	WP5 Formal and informal science education
Deliverables	D5.1 Reports on ongoing initiatives that use educational training programs that teach RRI and aim to engage citizens in science
Version	1.0
Planned Date	Month 10 (October 2021)
Actual Submisison	01/12/2021
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Please cite this work as:

JoinUs4Health Consortium, 2021. JoinUs4Health: D5.1 Reports on ongoing initiatives that use educational training programs that teach RRI and aim to engage citizens in science (version 1.0), Erasmus Medical Centre, Rotterdam. Copyright Notice.

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Summary

This report covers deliverable D5.1 “An overview and critical view on ongoing initiatives that adapted RRI in their educational programs to stimulate engagement of citizens in science” as agreed in the grant agreement of the JoinUs4Health consortium (grant number 101006518). The aim of this deliverable is to report on ongoing educational initiatives, where programs or projects have been used to teach RRI and where these have been used to engage citizens, pupils and students in science at the European level.

To reach our aim, we conducted a literature search and consulted relevant stakeholders, in and outside the JoinUs4Health consortium, as well as NGOs and educational offices. Finally, we present the lessons learned from those existing educational programs.

Introduction

In the last decade, Responsible Research and Innovation (RRI) was introduced as a tool to help to reduce the gap between science and society. According to Schomberg *et al*. *"RRI is defined as a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products*" [1]. In other words, RRI aims to involve societal actors in the discussion of how the current strategy of science and innovation can help create a sustainable, diverse and inclusive society now and in the future. The RRI framework aims to realize these goals by focusing on improvement within five key themes: 1) Governance, 2) Education and open science 3) engagement, 4) gender equity and 5) ethics and integrity [2]. In this deliverable, we focus on a central part of the second theme: education.

Finding ways in which structural changes in research performing institutions can be facilitated and initiated is crucial to promote the sustainable implementation of RRI. With this purpose, teaching and learning activities are considered as an important tool to raise RRI awareness and for fostering these practices in the current and future scientists and stakeholders [3]. According to experts, involving RRI principles in education activities will not only encourage sustainable interactions between schools and other stakeholders. It will also encourage multidisciplinary, critical thinking and collaborative learning skills. In addition, it will make students more responsive and adaptive to changes in society [4].

Within the JoinUs4Health consortium, an EU funded project, we aim to foster the use of RRI to promote inclusive innovation and citizen engagements in science trough institutional changes, education, engagement and dissemination. This report covers deliverable D5.1 as agreed in the grant agreement of the JoinUs4Health consortium for work package "Education" (grant number 101006518). This deliverable serves to learn from previous projects related to this topic, such that this will hopefully benefit successful implementation of (new) educational programs amongst our consortium partners. Here we aim to provide an overview of selected, mainly European (ongoing) initiatives or projects that adapted RRI in their educational programs to stimulate engagement of citizens in science, and to critical review them. The results of this overview will also be used to learn from existing practices, identify key characteristics of successful programs, but also to understand the nature of barriers that comes with the implementation of these new initiatives. Finally, we will translate the yield of this search into policy recommendations for sustainable RRI implementation in education in a related deliverable (D5.2).

Methods

In order to get a good overview of the ongoing initiatives we firstly searched for scientific publications that described such initiatives. In consultation with relevant stakeholders such as consortium partners (e.g., the Dutch Patient Federation and Mijn Data Onze Gezondheid MDOG)), we also scrutinized grey literature including local citizen science initiatives, policy letters, websites, newsletters, summaries, evaluation reports and deliverables of previously funded citizen science projects, and checked references of relevant papers by hand for additional articles that could be of interest. Finally, we also went through the library of Europeans Commissions sources of funded programs for research and innovation (also known as CORDIS: The community Research and Development Information Service, https://cordis.europa.eu/project); In CORDIS, we screened titles and abstracts for potential projects of interest, based on project titles and abstracts, individual deliverables and published project results (search string in the supplement). In addition, we consulted RRI-tools.eu (https://rri-tools.eu/) for additional identification of projects and cross-checking with CORDIS.

A scoping review in biomedical literature of ongoing initiatives

To reach our aims, we first conducted a scoping review of relevant literature as published in biomedical literature published in scientific journals.

Search strategy

On March 22, 2021, we conducted a scoping review of the biomedical literature in Embase and Medline. We searched for studies that reported on initiatives that utilize educational programs for a sustainable engagement of citizens, or society as a whole, in science, published in any language since the inception of the database (1977 or 1946 respectively) up until March 22, 2021 (see **Table 1**). Full search strings for every database are presented in **Table 2**. We initially did not include 'RRI" in the search string for biomedical literature. At this stage, we wanted to cover as much as possible and historical definitions of RRI vary a lot. Instead, we complemented these results with dedicated RRI projects through a search in CORDIS and RRI tools. We included any study that reported on European initiatives that utilize educational programs, and details were systematically extracted by two reviewers. We primarily focused on European projects as these are most likely to generalize to and fit within existing educational infrastructure in institutions of collaborating consortium partners (such as the organization of primary and high school education, the BaMa structure, i.e. Bachelor-Master program, etc.). This was done in three phases, the title-abstract (TIAB) selection, the full-text selection and data extraction of the included articles. During this three-tier process, we followed guidelines for the Preferred Reporting Items for Systematic Review and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR).

Study selection

We imported all retrieved records into an EndNote (Clarivate Analytics) library. Two reviewers (Natalie Terzikhan (N.T.) and Silvan Licher (S.L.) screened all articles for eligibility, using the following inclusion criteria: (1) original research articles; and (2) articles that present or report on European initiatives to engage citizens with the design and implementation of science related projects. We excluded non-European initiatives, in addition to projects that aim to provide educational resources only without engaging citizens with the design and implementation of science in the project. We also excluded citizen science projects used citizens as data collectors only (solely contributory projects). [5]

Data extraction

Project characteristics were extracted from the included reports by two investigators (N.T. and S.L.), with discrepancies resolved by consensus discussion. Where possible, information was extracted on: affiliation of the first author, geographical location of the study's source population or institution, study setting (e.g., community, scholar, pre-university, university, postgraduate, third age university) project design and project aim (based on the research question, for example science communication, RRI, citizen participation, scholar training). We further planned to extract various characteristics of included project participants with a clear focus on diversity aspects, including the total number of participants, their age, gender and ethnic background.

Results scoping review of published biomedical literature

Among a total of 1580 retrieved articles, we identified 68 potentially eligible papers in the TIAB selection (flow diagram can be found in supplement). Ineligible papers included projects that primarily focused on science communication, concerned citizen science projects where citizens were used as data collectors only or were conducted outside Europe.

We included and extracted information from four projects that met the eligibility criteria of this review. Proposed characteristics that we aimed to extract were not systematically available in the identified reports, we therefore decided to describe the identified projects on an individual basis. These included one project from **Switzerland,** that leveraged public science events to engage scholars and students with science [6]. A **Spanish** project used a crowdsourcing approach to educate pre-university students about science, and also to stimulate them to pursue a career in science [7]. In the **Netherlands**, an educational program was focused on the coaching of citizens to stimulate patient and public involvement in science [8]. Finally the multicenter project **STARBIOS2 (2016-2020)** [9], a Horizon 2020 funded project that aimed to implement RRI by developing tools for RRI action plans for education, gender equality, public engagement, ethics and open access results and data. By learning from the feedback to these actions plans, STARBIOS2 facilitates the implementation of RRI in other research institutions. On the website https://starbios2.eu/

several guidelines and publications are shared, including **Guidelines for Implementing RRI in bioscience** (access report here), a report on **Science Education as a Trigger for RRI structural change** (access report here) (**Figure 1**), but also access to webinars and presentations, where lessons learned are discussed (**Figure 2**). One of the interesting achievements here are the implementation of mandatory RRI courses at the University of Slovenia (access article about the education experience of the University of Primorska, Slovenia: https://starbios2.eu/2018/education-rri-experience-university-primorska-slovenia/)

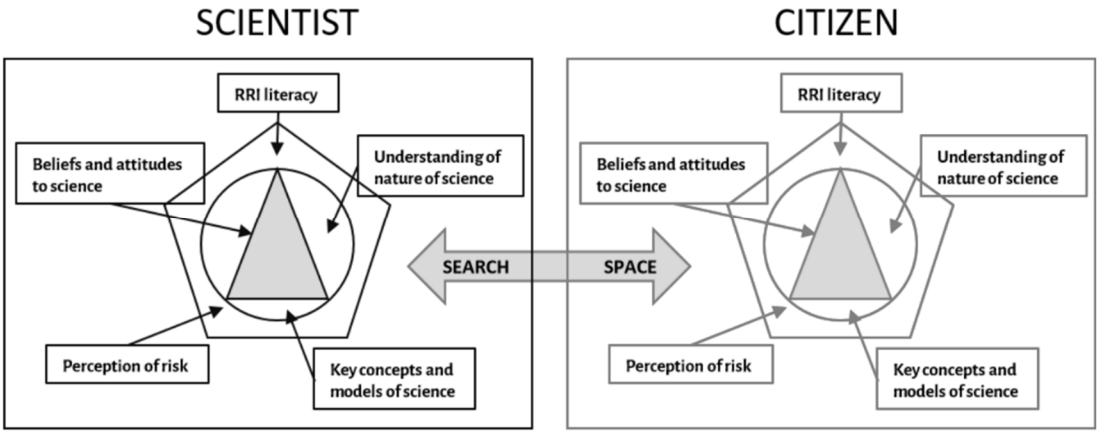


Figure 1. The inclusive communication model. Source: Science Education as a Trigger for RRI structural change (access report) Courtesy: Doris Elster, Tanja Barendziak, Julia Birkholz.

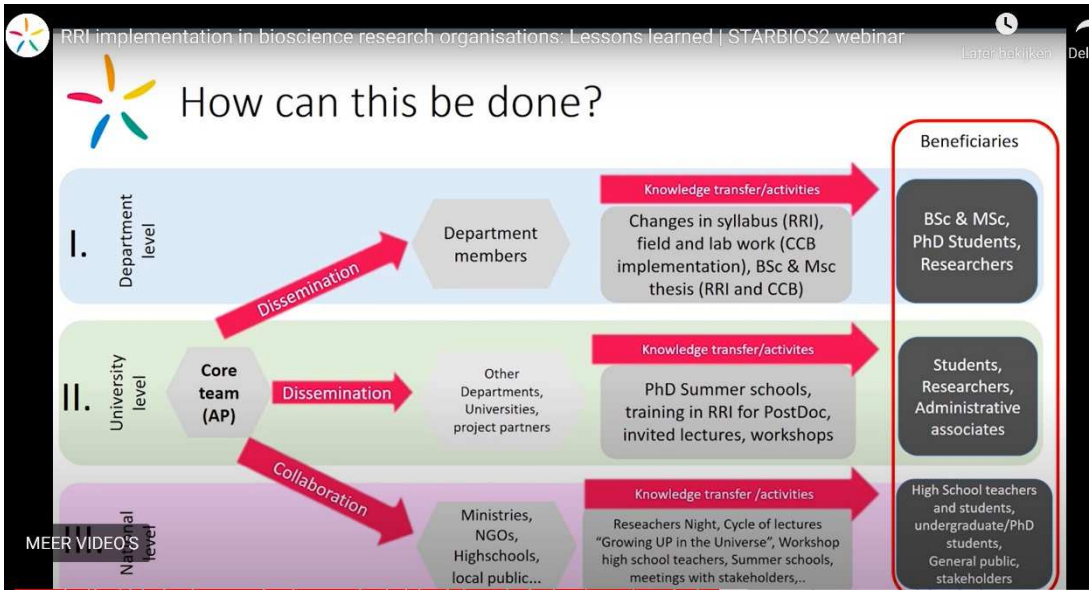


Figure 2. RRI implementation in bioscience research organisations: Lessons learned (STARBIOS2 webinar) https://www.youtube.com/watch?v=tnFSjL_lLJI&t=1776s

Grey literature

We supplemented the scoping review on published articles with a grey literature search. In consultation with involved stakeholders, we noticed that most ongoing educational programs run in local languages, limiting systematic appraisal of these projects in this review. We therefore initially

primarily focused on several initiatives in the Netherlands and later expanded to several EU projects searching for instance English websites available that are active and flexible to local differences across multiple European countries (like CORDIS and RRI-tools.eu). Based on this search within CORDIS, we identified 214 unique projects of potential interest. We found 85 results in RRI tools related to projects on science education. After TIAB screening and through cross checking of both CORDIS and RRI tools, we ended up with eight de-duplicated projects that met our inclusion criteria. In the next section, we summarize each of the identified projects based on the grey literature search.

1. **Irresistible [10]:** Is a EU funded project that aims to bring RRI into the classroom and engaging the youth with RRI in 10 countries including the Netherlands (Coordinator, University of Groningen), Finland, Germany, Greece, Israel, Italy, Poland, Portugal, Romania, and Turkey. It focuses on teacher training, combining formal (at school) and informal learning (museum, festival or science centre) focused on RRI. The partners have gathered a "community of learners" (schoolteachers, education experts, exhibition experts, and researchers) to develop 17 educational modules e.g. on healthy ageing, sustainability, and nanoscience; to test each of that in 5 to 10 classes in different countries. The idea was to use real life provocative research examples to encourage students' critical thinking and reflection (from [3]).
2. **INCENTIVE** [11]: INCENTIVE is a three-year program supported by the EU within the framework of the Horizon 2020 programme. Its aim is to demonstrate the potential of citizen science through the set-up of Citizen Science Hubs in 4 European Universities: 1) University of Twente (the Netherlands), 2) The Autonomous University of Barcelona (Spain), 3) the Aristotle University of Thessaloniki (Greece) and 4) Vilnius Gediminas Technical University (Lithuania). Through this, *"the project accelerates the transition of these institutions to more inclusive, open and democratic innovation and scientific governance, under the principles of Responsible Research and Innovation. The project seeks to deliver a legacy to European and international research institutes on how to create and operate their own Hub with the aim to secure a sustainable future"* [11], One of the Hubs was the University of Twente Citizen Science Hub which we described briefly below [12].

Figure 3. INCENTIVE goals
https://incentive-project.eu/about/incentive-goals/

3. **University of Twente the "SHAPING EXPERT GROUPS"** [13]:

The University of Twente has launched its vision and mission for 2030, with six shaping expert groups, including The Citizen Science expert group. Here, citizen science initiatives are connected, knowledge is shared, and new projects are supported. On the webpage, the ten principles of citizen science are shared, a citizen science conference was announced and made publicly available (Conference: [14]), and the **DesignLab** was promoted [15]. *"DesignLab serves as a gateway for private and social partners to solve societal problems. Through this, citizens and organisations get access to researchers and new innovations that put people first"*. DesignLab's ambition is to offer a starting point for citizen science initiatives.

Figure 4. The cover page of the "Futures magazine"; the new designlab magazine https://incentive-project.eu/about/incentive-goals/

The DesignLab focuses on three principles:

1) responsible design, 2) transdisciplinary research, and 3) citizen science. It bridges societal challenges with educational activities, research and practical outcomes.

The DesignLab had started several initiatives including TOPFIT Citizenlab consortium (end date 2022) [16, 17], where health care providers, patient organisations, insurers, companies and other knowledge institutes collaborate, and the Citizen Science Hub [12] where Citizen Science meet the EUs RRI principles. This Hub is part of the European project INCENTIVE as discussed above.

4. **Public Engagement at Utrecht University** [18, 19] – on the website of Utrecht University, public engagement activities are promoted by stating the following: Public engagement creates benefit to 1) the public by increasing understanding of the process and outcomes of science 2) the researchers by improving their communication skills and challenge their thinking 3) universities to become more inclusive and create more potential for positive profiling and funding and 4) to the society as a whole since it will enable informed choices. Several initiatives are presented on the website that vary from Science Festivals [20], children and science projects [21], citizen science projects [18] and public lectures and debates like the "Cultural Sundays" [22]. On the website, the **National Co-ordinator centre for Public**

Engagement (NCCPE) was also promoted, a UK based organisation that supports universities to engage with the public [23].

5. **The Science Centre Technical University Delft [24]:** TU Delft's share for citizen engagement to science looks very creative. On the website of Science Centre of the university, different activities are presented to engage young talents at early stages. A range or activities are included such as: 1) a scientific escape room, 2) a technical and scientific 'birthday party', 3) events and science festivals, 4) citizen science: becoming a researcher at WaterLab for water research [25] or 5) organising backstage tours at the campus. The education and citizen science projects aim to bring technique and science closer to basic and elementary school children. Besides the WaterLab, other projects are mentioned like scouting, or scientific workshops at schools.
6. **Junior Med School [26]:** The Erasmus Medical Centre in Rotterdam initiated The Junior Med School, where each year a selection of young students of the fourth and fifth grade of the elementary school get to learn more about medicine and practice scientific research for a short period of time. Schools get each year the opportunity to submit the names of two candidates for this program. The selected candidates are also eligible to enter Medical School after graduation.
7. **Dutch working group Citizen Science**: This working group was initiated by the 'Nationaal Programma Open Science' (Dutch national program open science [27]), which has three pillars 1) open access 2) open data and 3) citizen science. The working group started initially in 2019 by a workshop organized by the KNAW (The Royal Netherlands Academy of Arts and Sciences). Its aim was to create a network of Dutch citizen science initiatives and to generate quality standards. One of output of this working group is the "Citizen science in the Netherlands, Joint Knowledge and Forces" (access here), where also different cases of citizen science projects are described in Dutch.
8. **The Citizen Forum**: The aim of this project was to increase legitimacy of tough choices of healthcare reimbursement by involving citizens, obtaining information about patients' preferences and proposals for decisions that concern to the benefits package of the basic health insurance in the Netherlands [28].
9. **Citizen science for Public Health**: The aim of this project was to investigate whether citizen's engagement in knowledge production could contribute to produce inclusive health policy, using motivating examples from educational citizen science projects in the Netherlands [29].
10. **Citizen science lab – Leiden University** [30] – The aim of the Citizen Science Lab is to support scientists and citizens in the process of setting up and running citizen science projects. Citizen science lab not only supports citizen science projects but also investigates the motivation of citizens behind their participation in such projects, their impact on scientific

research, decision making and the society as a whole. The citizen science lab offers a big network on a local, national and international level and collaborate with for example the Citizen Science Cost Action, GlobeNL [31] and the European Citizen Science Association (described below).

11. **The citizen science Cost Action** aims to bundle capacities across Europe to investigate the impact of citizen science outcomes. It does so in order to highlight the potential of citizen science as an important factor of social innovation. It also provides resources like reports, books and other information material. The action has six international working groups:
    - ensuring scientific quality of Citizen Science,
    - develop synergies with education,
    - improve society-science-policy interface,
    - enhance the role of CS for civil society,
    - improve data standardization and interoperability, and
    - cross-WG-Synthesis and overarching measures.

12. **The European Citizen Science Association (ESCA)** has several aims including: "to become the central hub for citizen science initiative in Europe and to build a strong community, provide resources and educational material to increase the numbers of trained citizens". Citizens and scientists can engage by different means: 1) involving ECSA in their projects 2) joining working groups or suggesting a new one, 3) becoming a member and 4) by hosting an ECSA event. ECSA is also a member of several EU-funded citizen science projects [32], links in this reference [33], including:

Figure 5. Working groups of the ESCA https://ecsa.citizen-science.net/working-groups/

- "*COESO: Enabling strong growth of citizen science projects in the social sciences and humanities,*
- *CompAir: Using new technologies to measure local air quality, and work together with others to make local policy and social changes that will improve the quality of the air for all,*
- *Cos4Cloud: This project is developing 11 technological services to improve citizen observatories, helping them to increase the quantity and the quality of observations,*
- *EU-Citizen.Science: The platform for sharing citizen science projects, resources, tools and training,*

- *INCENTIVE: Establishing citizen science hubs in European research performing and funding organisations, to drive institutional change and ground responsible research and innovation in society,*
- *PANELFIT: Participatory approaches to a new ethical and legal framework for ICTs*
- *ROSiE: Identifies emerging ethical, social and legal challenges related to open science and citizen science,*
- *SEEDS: A project to empower teenagers in their own health and in STEM*
  SOCIO-BEE: Promoting more environmentally responsible behaviours and awareness of pollution by directly involving citizens,
- *StepChange: Exploring the potential of citizen science by developing five CSIs in the fields of energy, health and environment,*
- *YouCount: New knowledge and innovations to increase the social inclusion of youth at risk of exclusion through co-creative youth citizen social science.*

13. **The Living Knowledge Network [34];** Is the international science shop and community based research network. It fosters public engagement with all levels of the research and innovation process. The living knowledge network enables Civil Society Organisations to generate research ideas. Research is performed in response to societal questions and solutions are found by co-creation. On the website https://www.livingknowledge.org/ the 9th living knowledge conference is announced to be held in Groningen, the Netherlands from June 29 to July 1, 2022.. Besides the science shop concept, the Living knowledge network offers the Science Shop summer school, an intensive program with the focus on community based research. The living knowledge has attracted several EU funded projects including EnRRICH [35], InSPIRES, PERARES, SciShops. Some of these projects will be highlighted below:

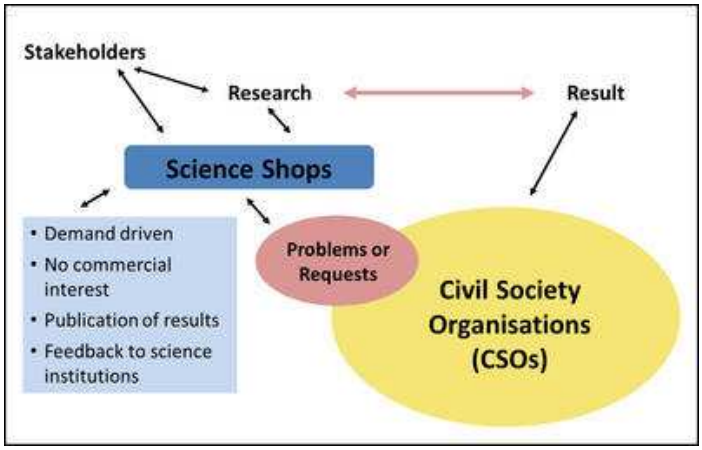


Figure 6. Science shops https://www.livingknowledge.org/science-shops/about-science-shops/

14. **ENRRICH [35];** Enhancing Responsible Research and Innovation through Curricula in Higher Education (2015-2017)**:** is one of the Living Knowledge platform projects. The Objectives are summarized in **Figure 7**. ENRRICH offers very important resources and deliverables of each of its working packages that included: 1) Identifying best practice, surveying needs and developing new course material in RRI, 2) Piloting RRI educational materials in higher education curricula, 3) Strengthening RRI in curricula through science workshops – good practice exchange and pilots, 4) Advance the uptake of RRI in academic curricula by utilising and developing the policy context at institutional, national and international levels to encourage this work, 5) Evaluation: Learning, stakeholder accountability, approaches, 6) Dissemination and 7) Report about the Conference on building RRI into curricula in Higher Education Institutions/Universities. Each of the deliverables within those working packages are worth considering to build RRI in educational curricula. In different policy briefs, the consortium partners summarized different recommendations for policy makers and future RRI projects.

Figure 7. The objectives of the EnRRICH project
MISSING????ENRRICH [35]

15. **HEIRRI [36]**; Higher Education Institutions and Responsible Research and Innovation: The project is described on the website of the Living Knowledge Platform as: "*HEIRRI is a European project, funded under the Horizon 2020 programme. HEIRRI aimed at starting the integration of RRI within the formal and informal education of future scientists, engineers and other professionals involved in the R&D&i process. The project has done a State of the Art Review and elaborated a Database gathering results from other EU funded projects on RRI, good cases and practices of RRI related learning and teaching. Results from this inventory represent the basis for RRI training programs and formative materials that are being developed, offering students the knowledge and skills to develop solutions to specific problems related to R&I. These materials are designed for different educational levels and formats (undergraduate, MSc, MD and PhD, summer courses and MOOC). Different stakeholders involved and/or affected by R&I participate in HEIRRI through online and offline activities debating on RRI learning. HEIRRI wants to stress the potential of RRI as a transformative and critical concept, while at the same time working with the six RRI «key aspects» identified by EC (societal/public engagement, gender equality, open access, science education, ethics and governance in R&I). The HEIRRI Consortium involves 9*

partners from 6 different countries, offering a global scope and wide expertise on RRI." Source.

16. **ENGAGE [37]**; Equipping the Next Generation for Active Engagement in Science (2014-2017): this project aimed to provide next generation students with the knowledge and skills to learn how to deal with socio-scientific issues and to foster informed decisions about that matter. The consortium included 11 countries and several project outputs are presented on CORDIS. **Figure 8** presents the strengths and weaknesses of Engagement as one of the figures presented in the ENGAGE report "Innovative Teaching for Responsible Citizenship: Policy Report" [38]".

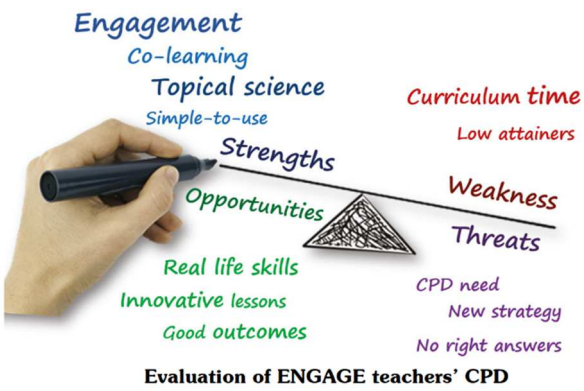


Figure 8. One of the policy reports of the ENGAGE project entitled: "Innovative Teaching for Responsible Citizenship: Policy Report" http://oro.open.ac.uk/46455/1/Policy%20final%202016%20April.pdf

17. **The national platform CitizenScience2Health [39]:** is an initiative of My Data Our Health Foundation (MDOG), which is committed to developing bottom-up solutions for chronic conditions. Citizen science plays a crucial role in this.

18. **FOSTER Plus [40];** Fostering the practical implementation of Open Science in Horizon 2020 and beyond): Foster aims to support a culture change, consolidate and sustain a training support network and strengthen the training capacity. The FOSTER portal is an e-learning platform that offers training researches of Open Science practices. The courses and resources (see image below) include: Introductory courses of RRI and open science, the application of RRI in companies, public engagement, research ethics and science integrity. In the image below you can find the RRI related resources as presented on the website. By

clicking on each resources, one will be redirected to the specific course page. Also events are presented including RRI related conferences and trainings.

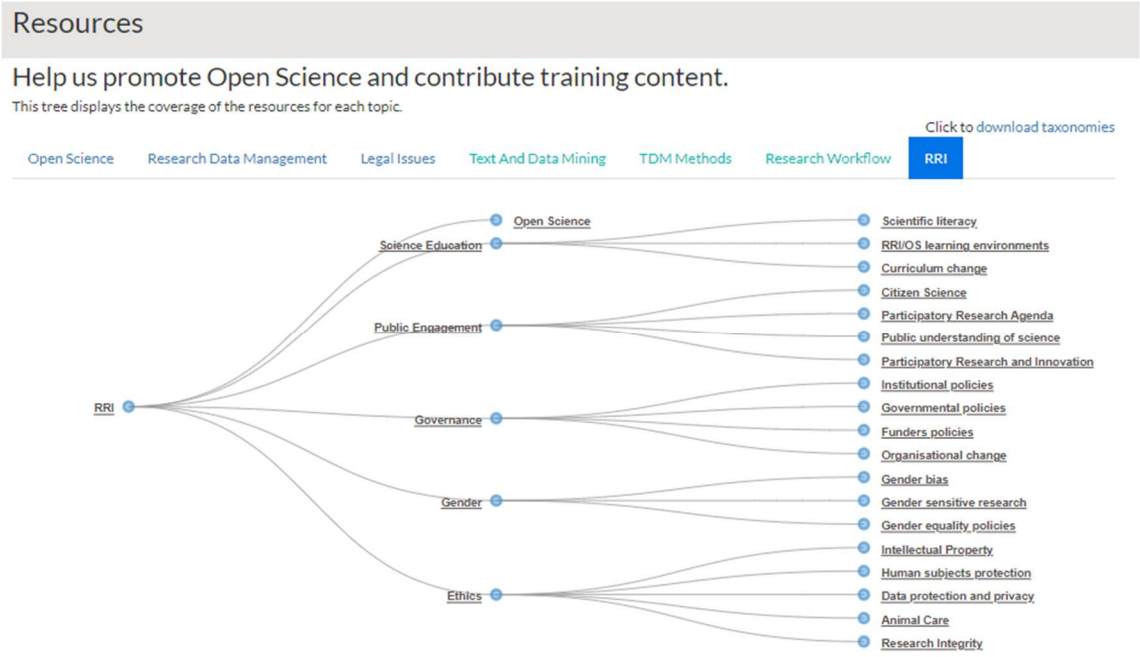


Figure 9. The RRI educational resources as presented on the website of FOSTER https://www.fosteropenscience.eu/resources

19. **Fit4RRI [41]:** is a H2020 funded project that aims to Foster improved training tools For Responsible Research and Innovation. The FIT4RRI project and the previously described project FOSTER are related. On the FOSTER platform training resources of FIT4RRI is presented. https://www.fosteropenscience.eu/fit4rri

20. **Open Schools for Open Societies [42]** (OSOS) (2017- 2020) https://www.openschools.eu/ is a consortium existing of 19 partners from 13 countries. It aimed to make schools hotbeds of innovation. The project aimed to provide schools the necessary support to undergo structural changes towards a more open, socially responsible learning atmosphere. OSOS claims to be the first to introduce the concept of open schooling, *"where schools, in cooperation with other stakeholders, can become an agent of community well-being. An open school is an engaging environment for science learning and makes a vital contribution to the community: student science projects meet real needs in the community outside school and draw upon local expertise and experience."*. The project website offers

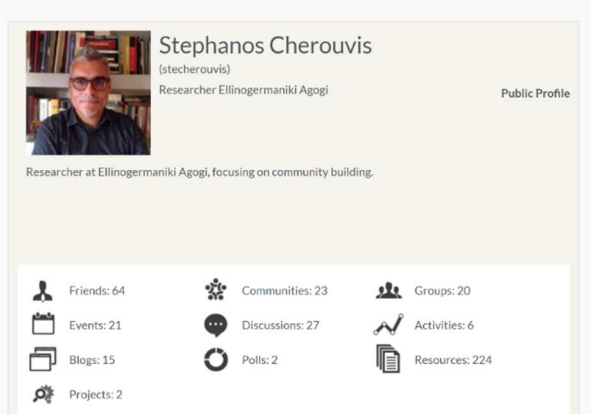


Figure 10. An example of a publicly available profile of a registered teacher on the Open School portal, with a summary of the internal activities and engagments https://portal.opendiscoveryspace.eu/en/osos-people?rid=4

deliverables and reports such as the open school model and roadmap, the support mechanism report and the assessment methodology report, shares inspiring projects and provides information on The Open School Portal. Interestingly on the portal several stakeholders ad projects can be identified categorised as: 1) Accelerators, 2) Communities, 3) Schools, 4) Teachers and 5) specific projects. Participating schools are presented on the worldmap, for which information can be filtered by country, name and level of openness, including the following levels: "enabled", "Consistent", "Integrated" and "Advanced". Interestingly, 2599 teachers/ users are registered on the portal. The profile is as presented in **Figure 10**

21. **RRI-Practice**; Responsible Research and Innovation in Practice [43] (2017-2021). Wageningen University in the Netherlands described this project as follows: *"RRI-Practice is a 3-year project under Horizon 2020. Its aim is to understand the barriers and drivers to the successful implementation of RRI both in European and global contexts; to promote reflection on organisational structures and cultures of research conducting and research funding organisations; and to identify and support best practices to facilitate the uptake of RRI in organisations and research programmes. The project will review RRI related work in 22 research conducting and research funding organisations and will develop RRI Outlooks outlining RRI objectives, targets and indicators for each organisation".* On the website of the project deliverables are offered like "the national and organisational conditions for implementing RRI" or "RRI roadmap targeted towards the EC", also many resources are available including Recommendations, Policy briefs, national workshop reports and expert opinions.

22. Open Science Hub Network: Empowering Citizens through STEAM Education with Open Schooling | OSHub Project | Fact Sheet | H2020 | CORDIS | European Commission (europa.eu) [44] Within OShub, local networks will be established to connect and engage schools and other stakeholders to jointly use research and innovation to build sustainable communities. It specifically focuses on communities that generally do not participate in research due to various barriers, such as minorities or less affluent citizens.

Discussion

In this discussion, we will highlight lessons learned from key past and ongoing educational programs on RRI and citizen science.

Lessons learned from existing educational programs

The JoinUs4Health project builds on several past and ongoing educational initiatives that aim to introduce RRI to research-performing organizations in a sustainable manner. Our scoping review aptly demonstrates that a limited number of projects is identifiable through scientific libraries. In contrast,

most ongoing projects are readily found by bringing together multiple sources of (grey) literature or 'informal' information, including consultation of stakeholders, organizational websites, (regional) policy letters, and *CORDIS*, which provides information on all EU-supported R&D activities.

The term "RRI" has first been coined ten years ago,[45] and has more recently been adopted by the European Commission as a key action of the "Science with and for Society" (SwafS) program. For this report, we conducted our search using key words like "RRI" and "citizen science". But it is important to realize that there are probably many more examples of initiatives that adopt RRI-like practices in the field without necessarily applying the labels RRI and citizen science, especially when the term is not used in its aims or mission, but the proposed actions do use similar principles. A good example of that is for instance the incorporation of open-ended questions that are being addressed through Project-based Problem Learning (PPL), with the engagement of multiple stakeholders and problem-solving methods in many educational curricula. Increasing the contribution of RRI to existing educational programs closes the gap between science and society in two (bidirectional) ways. First, by opening up parts of educational programs to different stakeholders such as citizens, the next generation of scientists and (university) students are directly connected to future partners at an early stage. By jointly educating these pioneers and stakeholders with basic principles of conducting science, they are acquainted with each other's roles and moreover learned how to contribute to the co-creation of science.

Based on the identified initiatives, we conclude that a lot attention went to the conceptualization and agreement of RRI implementation in educational programs over the past years. Results from our grey literature that cover projects from more recent years aptly demonstrate that many initiatives are taking place to implement RRI principles to educational practice.

On a European level, we observe that EU funded projects boosted the availability of RRI toolkits, guidelines and even complete (online) courses for targeted education of RRI principles across various levels of educational attainment. We highlight two motivating examples that lower the bar for RRI implementation in education. First, the FOSTER training portal provides a toolkit with essential courses that can assist learners to put RRI into practice (ref: https://www.fosteropenscience.eu/node/2750). Second, complementary RRI Training programs and formative materials are provided by the Higher Education Institutions and Responsible Research and Innovation (HEIRRI) project for different educational levels, ranging from undergraduate, MD/PhD to summer courses and MOOCs. Educative principles are based on problem-based learning and supported by multimedia materials.

More locally, we observe that the advances and benefits that are brought forward by these European developments are gradually arriving at individual universities across Europe. Albeit not complete, our search does indicate that many universities now have adapted their vision and mission to include

terms like “open science”, “engagement” , “societal impact” and “citizen science”. However, it remains unclear whether RRI approaches are systematically incorporated in their planned educational programs. That is not surprising, since most still struggle with implementing RRI into their own knowledge-making processes and educational programs due to its many conceptualizations and the diversity of approaches through which RRI can be put into practice. We therefore strongly recommend the formation of an expert European working group that aligns and summarizes all of these (partly overlapping) implementation strategies, recommendations and (piloted) educational programs (also proposed previously in one of the evaluation reports of the Living Knowledge Network; **Figure 11**).

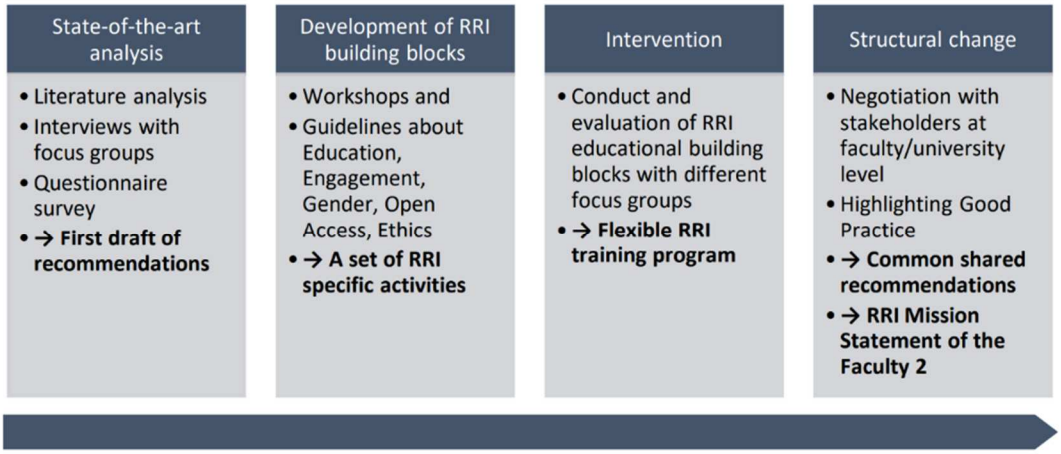


Figure 11. Roadmap for structural change at the University of Bremen. Source: Science Education as a Trigger for RRI structural change (access report here)

This could serve as a consensus statement rather than advocating for yet a new way of implementing RRI. To inform this envisioned working group on the educational part, – we firstly identified key lessons learned from RRI implementation in existing educational programs. In our second deliverable (D5.2) we also conclude with a set of recommendations for researchers, policymakers and alike to integrate RRI in educational programs. In this way, we envision to equip a new generation of scientists with tools incorporating RRI as a core competency.

Table 1. Search strategy review on (ongoing) initiatives that utilize educational programs for citizen science

Database searched	**via**	**Years of coverage**	**References**	**After de-duplication**
Embase	Embase.com	1971 - Present	1283	1253
Medline ALL	Ovid	1946 - Present	932	231
Other sources: Google Scholar			100	96
Total			**2318**	**1580**

Table 2. Search strings

Medical libaries
Embase- 1283 refs
('citizen science'/de OR 'citizen scientist'/de OR ('community participation'/de AND ('science'/de OR 'health science'/de)) OR (((scienc* OR scient*) NEAR/3 (citizen* OR public)) OR ((research) NEAR/3 (citizen*)) OR

((engage* OR attitud* OR literacy OR communicat* OR participat*) NEAR/6 (public OR communit*) NEAR/6 (scienc* OR scient*))):ab,ti,kw) **AND** ('school'/exp OR 'curriculum'/de OR 'curriculum development'/de OR 'education program'/de OR (curriculum* OR ((educat*) NEAR/3 (program*)) OR cours* OR MOOC OR school* OR universit*):ab,ti,kw)

Medline

(Citizen Science/ OR (Community Participation/ AND Science/) OR (((scienc* OR scient*) ADJ3 (citizen* OR public)) OR ((research) ADJ3 (citizen*)) OR ((engage* OR attitud* OR literacy OR communicat*) ADJ6 (public OR communit*) ADJ6 (scienc* OR scient*))).ab,ti,kf.) AND (exp Schools/ OR Curriculum/ OR (curriculum* OR ((educat*) ADJ3 (program*)) OR cours* OR MOOC OR school* OR universit*).ab,ti,kf.)

Grey literature

Google Scholar – 100 refs (first 100 refs were added)

"science|scientist citizen|public" curriculum|"education program"|course|MOOC|school|university

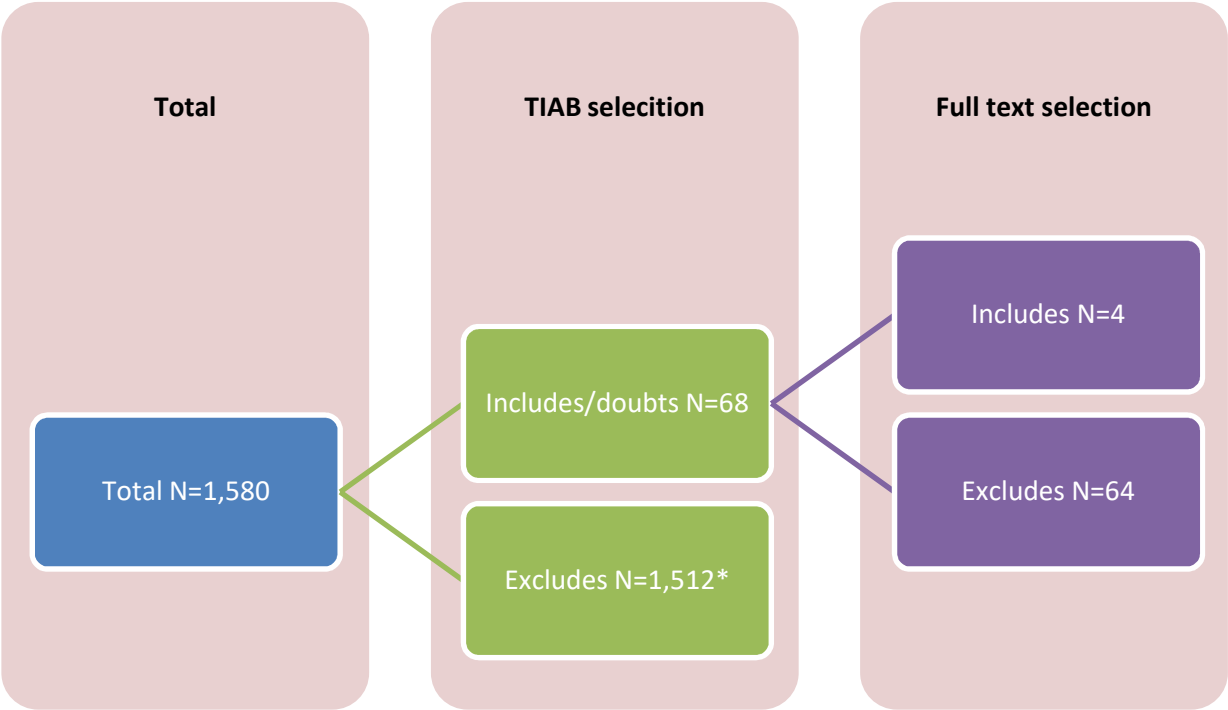
Preprint servers

MedRxiv and BioRxiv:

https://connect.medrxiv.org/relate/content/181

CORDIS

(/article/relations/categories/collection/code='pack' OR (/result/relations/categories/collection/code='deliverable' OR contenttype='project')) AND ('RRI' AND 'education')



Supplemental Figure 1. Flow chart of the scoping review to map ongoing initiatives that utilize educational programs for citizen science

TIAB= title abstract selection.
*including 13 duplicates

References

1. Schomberg, V., *A vision of Responsible Innovation, in Responsible Innovation.* R. Owen, Editor. 2013. p. 51-74., 2013.

2. Multiact.eu. *Responsible research and innovation - reducing the distance between science and society*. 2019; Available from: https://www.multiact.eu/2019/09/30/responsible-research-innovation-reducing-the-distance-between-science-and-society/.
3. Mejlgaard, N., et al., *Teaching Responsible Research and Innovation: A Phronetic Perspective.* Science and Engineering Ethics, 2019. **25**(2): p. 597-615.
4. tools, R. *How to integrate RRI in secondary education*. 2021; Available from: https://rri-tools.eu/how-to-stk-ec-integrate-rri-in-secondary-education.
5. Franzoni et al. 2021, Crowds, citizens, and science: a multi-dimensional framework and agenda for future research DOI: 10.1080/13662716.2021.1976627.]
6. Michel, C.R., G. Standke, and R. Naef, *Novartis School Lab: Bringing Young People Closer to the World of Research and Discovering the Excitement of Science.* Chimia, 2012. **66**(11): p. 832-836.
7. Maicas, S., et al., *Implementation of Antibiotic Discovery by Student Crowdsourcing in the Valencian Community Through a Service Learning Strategy.* Front Microbiol, 2020. **11**.
8. de Wit, M., et al., *Preparing researchers for patient and public involvement in scientific research: Development of a hands-on learning approach through action research.* Health Expect, 2018. **21**(4): p. 752-763.
9. Colizzi, V., et al., *Structural Transformation to Attain Responsible BIOSciences (STARBIOS2): Protocol for a Horizon 2020 Funded European Multicenter Project to Promote Responsible Research and Innovation.* JMIR Res Protoc, 2019. **8**(3): p. e11745.
10. Irresistable. *Irresistible: Engaging the Young with Responsible Research and Innovation*. 2021; Available from: http://www.irresistible-project.eu/index.php/en/.
11. EU. *INCENTIVE Citizen Science Hubs*. 2021; Available from: https://incentive-project.eu/.
12. Twente, U.o. *Citizen Science Hub at University of Twente*. 2021; Available from: https://www.utwente.nl/en/news/2020/11/855504/citizen-science-hub-at-university-of-twente.
13. Twente, U.v. *Citizen science, trengthening ties with society*. 2021; Available from: https://www.utwente.nl/en/organisation/about/shaping2030/organisation/seg-citizen-science/#citizen-science-strengthening-ties-with-society.
14. Twente, U.o. *Citizen Science Conference 20 November 2020*. 2021; Available from: https://www.youtube.com/watch?v=_90LEYN8kaQ.
15. Twente, U.o. *DesignLab*. 2021; Available from: https://www.utwente.nl/en/designlab/.
16. Twente, U.o. *TOPFIT CITIZENLAB*. 2021; Available from: https://www.utwente.nl/nl/techmed/onderzoek/topfit-citizenlab/.
17. Iedereenwetenschapper.be. *How Citizen Science is conquering the healthcare in Europe (Article in Dutch)*. 2021; Available from: https://www.iedereenwetenschapper.be/article/elk-persoonlijk-verhaal-heeft-wetenschappelijke-waarde.

18. University, U. *Citizen Science*. Available from: https://www.uu.nl/en/organisation/public-engagement-at-utrecht-university/finding-an-audience/citizen-science.
19. University, U. *Public Engegment*. 2021; Available from: https://www.uu.nl/en/organisation/public-engagement-at-utrecht-university/what-is-public-engagement.
20. University, U. *Science Festivals* 2021; Available from: https://www.uu.nl/en/organisation/public-engagement-at-utrecht-university/finding-an-audience/festivals-and-other-podia.
21. University, U. *Children and Science*. 2021; Available from: https://www.uu.nl/en/organisation/public-engagement-at-utrecht-university/finding-an-audience/children-and-science.
22. University, U. *The Cultural Sundays*. 2021; Available from: https://www.uu.nl/en/organisation/public-engagement-at-utrecht-university/finding-an-audience/public-lectures-and-debates.
23. NCCPE. *Naitonal Co-ordinating Centre for Public Engagement (NCCPE)*. 2021; Available from: https://www.publicengagement.ac.uk/.
24. Delft, T. *Science Centre Delft*. 2021; Available from: https://www.tudelft.nl/sciencecentre.
25. Delft, T. *The WaterLab*. 2021; Available from: https://www.tudelft.nl/scd/waterlab.
26. Rotterdam, E.U. *Junior Med School*. 2021; Available from: https://www.eur.nl/erasmusmc/onderwijs/junior-med-school.
27. NPOS. *Nationaal Programma Open Science*. 2021; Available from: https://www.openscience.nl/.
28. Bijlmakers, L., et al., *Increasing the Legitimacy of Tough Choices in Healthcare Reimbursement: Approach and Results of a Citizen Forum in The Netherlands.* Value Health, 2020. **23**(1): p. 32-38.
29. Den Broeder, L., et al., *Citizen Science for public health.* Health Promot Int, 2018. **33**(3): p. 505-514.
30. University, L. *Citizen Science Lab*. 2021; Available from: https://www.universiteitleiden.nl/citizensciencelab.
31. Nederland, G. *GLOBE Nederland*. 2021; Available from: https://globenederland.nl/.
32. ECSA. *European Citizen Science Association - Projects*. Available from: https://ecsa.citizen-science.net/projects/.
33. links, E.p. *ECSA projects*. 2021; Available from: https://coeso.hypotheses.org/; https://cos4cloud-eosc.eu/; https://eu-citizen.science/ ; https://eu-citizen.science/; https://rosie-project.eu/; https://seedsmakeathons.com/; https://stepchangeproject.eu/; https://eusea.info/platform/; https://www.youcountproject.eu/.

34. Knowlegde, T.L. *The Living Knowlegde Network*. 2021; Available from: https://www.livingknowledge.org/
35. Knowlegde, T.L. *ENRRICH: A Living Knowlegde Project*. 2021; Available from: https://www.livingknowledge.org/projects/enrrich/.
36. Knowlegde, T.L. *The Living Knowlegde: EnRRICH Resources: HEIRRI.*; Available from: https://www.livingknowledge.org/projects/enrrich/enrrich-resources/
37. ENGAGE, C. *ENGAGE: Equipping the Next Generation for Active Engagement in Science*. 2014-2017; Available from: https://cordis.europa.eu/project/id/612269/results.
38. Okada, A., *Innovative Teaching for Responsible Citizenship: Policy Report.* . 2016: The Open University.
39. Health, C.S. *Citizen Science 2 Health*. 2021; Available from: https://cs2health.nl/.
40. FOSTER. *FOSTER PLUS: Fostering the practical implementation of Open Science in Horizon 2020 and beyond*. 2021; Available from: https://www.fosteropenscience.eu/.
41. Fit4RRI. *FIT4RRI*. 2021; Available from: https://fit4rri.eu/.
42. Schools, O. *Open Schools for Open Societies*. 2021; Available from: https://www.openschools.eu/.
43. Authors, S. *Responsible Research and Innovation in Practice*. 2021; Available from: https://cordis.europa.eu/project/id/709637; https://www.wur.nl/en/project/responsible-research-and-innovation-in-practice.htm; https://www.rri-practice.eu/.
44. Hub, O.S. *Open Science Hub Network: Empowering Citizens through STEAM Education with Open Schooling*. Available from: https://oshub.network/; https://cordis.europa.eu/project/id/824581.
45. Owen, R., von Schomberg, R., & Macnaghten, P. (2021). An unfinished journey? Reflections on a decade of responsible research and innovation. *Journal of Responsible Innovation*, 1–17.
46. Cvitanovic, C., J. McDonald, and A.J. Hobday, *From science to action: Principles for undertaking environmental research that enables knowledge exchange and evidence-based decision-making.* Journal of Environmental Management, 2016. **183**: p. 864-874.
47. Kuhn, T., *The Structure of Scientific Revolutions*. 1962.