NOTE #5

Science education as a trigger for RRI structural change

By Doris Elster, Tanja Barendziak, Julia Birkholz

RRI IMPLEMENTATION IN BIOSCIENCE ORGANISATIONS

GUIDELINES FROM THE STARBIOS2 PROJECT

Andrea Declich with the STARBIOS2 partners

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In this section, approaches and experiences at the University of Bremen illustrate how effective structural change processes can be triggered by science education. The RRI implementation and its associated structural change process pose a major challenge for research institutions. Future researchers and university students should acquire knowledge and skills to work responsibly during their academic experiences and training. Critical awareness and social responsibility are not additional skills to be casually patched onto research and innovation processes but should be a general attitude of researchers (Colizzi et al., 2019). To put RRI issues into practice in the Bremen context RRI should be fostered and developed through science education in a whole institution approach.

The University of Bremen is a relatively young university in Germany with 12 faculties and about 20,000 students. Faculty2 Biology and Chemistry is a partner in the STARBIOS2 project with the goal of developing a tailored Action Plan for the negotiation of a RRI mission statement. A Core Team with science educators as central agents is set up and the important stakeholders of the faculty (dean, vice dean, and members of the quality management) as well as representatives of students, doctoral students and researchers are involved in this process (Elster, 2016).

In the Horizon 2020 framework RRI is built on the following key dimensions: *Societal Engagement* and *technology transfer* focus on the promotion of the engagement of all societal actors in the R&I process; *Gender* aims at favouring gender equality within research institutions as well as in the R&I content; *Science Education* aims to provide future researchers with news capacities for attracting children and youth to science and technology; *Open Access* focuses

on making research and innovation transparent and accessible through making Open Access a reality; and ***Ethics*** aims to ensure high quality research results and ethical standards (Von Schomberg & Von Schomberg, 2013). The RRI mission statement of Faculty2 should refer to these key issues acknowledging the need for RRI to be critical, transformative within its environment, anticipative of future needs, inclusive and gender sensitive, reflexive about its actions, and responsive to trying new approaches and knowledge. For the implementation of these goals a complex roadmap (Figure 1) comprising four stages is set up (Elster et al., 2016).

In stage 1, we perform a comprehensive state-of-the-art analysis. It includes an analysis of literature and RRI research programmes. Based on this, we derive a theoretical model for the analysis of research projects and develop interview guidelines. We conduct the interviews with representatives of the focus groups of students, doctoral students and researchers. The results form the basis for a questionnaire survey. Based on the results of the interview and questionnaire surveys, we derive a list of criteria for the implementation of the RRI issues. It forms the basis for the first recommendations for the development of a RRI mission statement for the department.

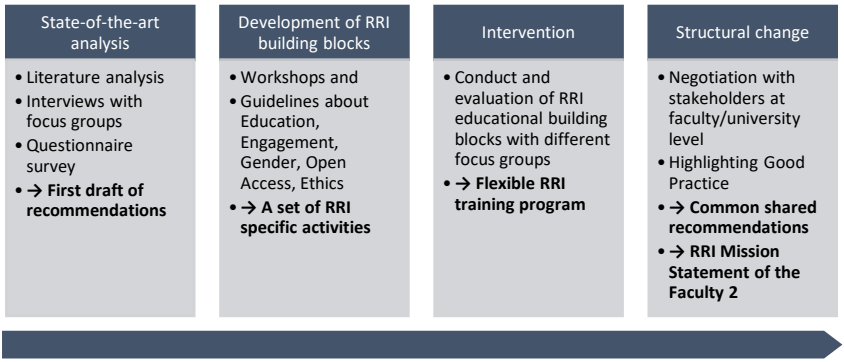
In stage 2, we develop different RRI educational building blocks and activities. They are based on a communication model and a theoretical model to promote RRI literacy. The RRI educational building blocks comprise reflective activities as well as RRI modules and workshops.

In stage 3, the RRI educational building blocks are tested and evaluated by the representatives of the different focus groups of students, doctoral students and researchers. They evaluation findings form the basis for a broad-based and flexible educational training program.

In stage 4, the evaluation of the RRI training programs as well as the results of the initial analyses lead to the derivation of RRI Key specific recommendations for the Faculty2. They are summarized

in the Booklet of Recommendations and form the basis for an in-depth negotiation process. The aim here is the RRI mission statement of the Faculty2.

Figure 1. Roadmap for structural change at the University of Bremen (Elster et al., 2016).



Educational concepts to promote RRI

Science education has an important role to educate the future scientists and university students. What scientists do, how they work, innovate and make decisions are important subjects for contemporary science education. While science and technology develop, science education needs to renew itself and work along with the developments in science and technology. New developments and technologies are very often controversially discussed in society. Therefore, a useful model for the processes of **communication between researchers and the public** is needed. It forms the basis of educational and didactical interventions.

In the case of the University Bremen new educational models should trigger the raising of awareness of RRI issues and an inspiring and fruitful structural change regarding RRI issues. As a consequence, within the Starbios2 project new educational concepts are developed at the level of students' individual training

by **RRI reflective activities**, **RRI modules** as inspiring practices, and **RRI in the curricula of academic programmes**. In addition, further events and outreach initiatives programmes are reported.

A communication model between researchers and the public

Our communication model is based on the Common Ground Theory based on Bromme (2000) and the Model for Communication about Biotechnology based on Ben France and John K. Gilbert (2006). In everyday communication, interaction partners encounter different perspectives. The question of how mutual comprehension arises in the case of different perspectives or knowledge especially in the expert and layman communication. The Common Ground Theory postulates that every act of communication presumes a common cognitive frame of reference between the partners of interaction called the common ground. All contributions to the process of mutual understanding serve to establish or ascertain and continually maintain this common ground (Bromme, 2000). "Two people´s common ground is, in effect, the sum of their mutual, common, or joint knowledge, beliefs, and suppositions" (Clark, 1996: 3).

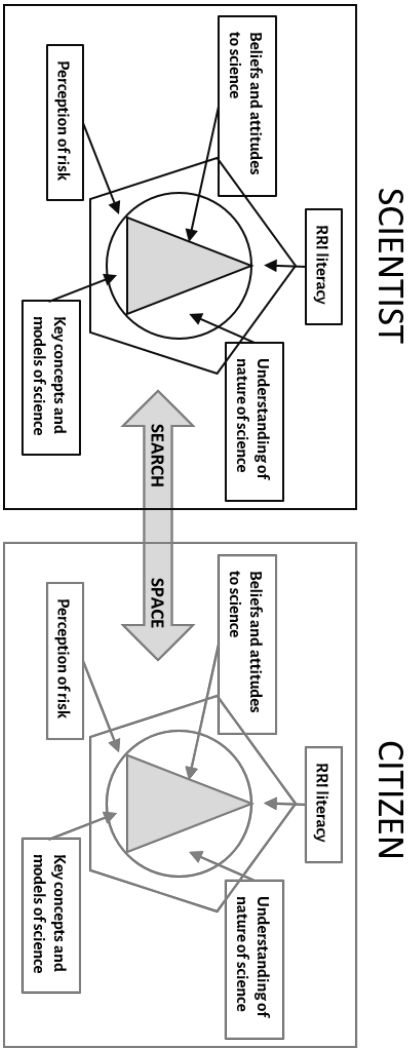
Researchers in the field of biosciences face the challenge to persuade "the public" of the rightness of their case, whilst "the public" is trying to argue a sceptical, or even contrary case. A model that might be of use in any field where technological controversy takes place was set up by France and Gilbert (2006). They took the idea of a communicating community, defined as relatively coherent social group engaging in communication with itself. The authors differ the biotechnology communities and the public communities. Each of the communities has a certain "view" on biotechnology that is made up of four "dimensions": their understanding of the nature of science and biotechnology; understanding of the key concepts and models used in biotechnology; perceptions of the nature of risk; and beliefs and attitudes about biotechnology.

Similar to Bromme´s definition of a "common ground" (Bromme, 2000) France and Gilbert (2006) define a "search room" as a virtual

arena where the "views" of the communities of scientists and the public communities are exchanged. "Where there are elements of the views that are in common to the two, communication is possible. Where there is no commonality, the degrees of understanding reached must be used to construct a mutual understanding that may evolve into an agreement exchange" (France & Gilbert, 2006: 2).

Within our Starbios2 project in Bremen we have to expand this model in respect to the RRI issues. Firstly, we defined a *RRI literate researcher* is a person who 1) perceives sensibly to detect questions related to RRI issues related to societal engagement and technology transfer, gender, ethics, open access publications and science education; 2) who is willing to apply its knowledge of RRI issues; 3) who actively acts to disseminate RRI issues in the context of research and the research institution. Secondly, we expanded France and Gilbert´s four "dimensions" by a fifth dimension, the RRI literacy. And thirdly, we extended the model which specifically focused on biotechnology to a more comprehensive view on biosciences. Our inclusive communication model is summarized in Figure 2.

Figure 2. The inclusive communication model for biosciences



Promotion by RRI reflective activities

The promotion of critical thinking is considered one of the key issues of good scientific RRI education. Students and researchers should be encouraged to critically question what is good and conscientious practice within their scientific domain. They should be aware of societal needs and that research is not oblivious towards societal values.

Reflexive capacities are crucial for understanding the role and responsibilities of research. Therefore, students and researchers should be aware of the interrelationship of their own research with other areas of science. The goal is to open the view to collaborate and coproduce knowledge with researchers as well as professionals outside their own fields and with interested citizens.

Within the Starbios2 project a series of reflective activities in respect to the societal engagement, contextualization of research, publication open access, gender in research, diversity team management, ethics in science communication are developed, tested and evaluated. They are summarized in the RRI toolbox at the local website[27]

RRI modules as inspiring practices

In the context of Starbios2 at University of Bremen the concept of raising awareness of RRI issues through RRI educational building blocks is based on the Citizen-SIP educational model. The model is based on Problem-based Learning (PBL) in socio-scientific contexts (SSC) and Inquiry-based Science Education (IBSE) with a specific focus on Citizenship Education (CE). Problem-based learning stands for self-determined and discovering learning, action-oriented teaching, interdisciplinary learning and self-evaluation. Participants learn to analyse a topic or question, to find and use suitable sources of information, and finally to compare, select

[27] (https://blogs.uni-bremen.de/starbiosbremenenglish/).

and implement solutions. Socio-scientific issues (SSI) are open-ended, multifaceted social issues with conceptual links to science (Sadler, 2011). PBL in socio-scientific contexts in authentic research projects as "real-world scenarios" offers powerful opportunities to develop critical thinking on the nature of science and its implications (Lederman et al., 2014). IBSE is an appropriate educational instrument to acquire process skills and an adequate view of the Nature of Science (Capps & Crawford, 2013) as well as a meaningful understanding in a societal context. Citizen Education takes into account the moral and social function of education at a socio-political level.

RRI in science education requires that students have creative thinking and problem solving skills. RRI deals with dilemmas and uncertain situations where students' arguments are as important as the scientific facts. Examples of RRI modules developed at the University of Bremen are "Promotion of Risk Literacy in Regard to Nanotechnology", "Wake up – Sensitisation of adolescents for the stem cell donation for leukaemia patients", and "Biodiversity loss and climate change in the Wadden Sea". These modules are developed in doctoral and master studies in cooperation of scientists, science educators and teacher candidates. The modules are evaluated in in-service trainings, pre-service education and schools.

RRI in curricula of the bachelor's and master's programmes

University students as nascent researchers should acquire knowledge and skills needed to work responsibly during their academic experiences. In their academic development, ideas and concepts of RRI should be fostered and developed throughout the formative process of education. Traditional academic hierarchies should be modified to enhance the voluntary participation and debate among the students. In an atmosphere of openness and trust, students should be encouraged to draw their own conclusions and provide valuable contributions to the debate.

The integration of research and teaching can provide valuable ways of enhancing student learning experiences. Nevertheless, the linking can be challenging and the understanding of a "research-based education" and "research-informed teaching" within and between disciplines is diverse. The "nexus" of research and teaching is influenced by the departmental structural arrangements for organising research and teaching activities, and a potential gap in making connections between staff research outputs and students´ learning when this research is too far ahead of the undergraduate curriculum to be accessible to students (Jenkins, 2004). Graffiths (2004) and Healey (2005) distinguish five "Research-informed teaching" approaches:

- Research-led (RL): Students learning "about" the research of others.
- Research-oriented (RO): Students learning about research processes.
- Research-based (RB): Students learning as researchers.
- Research-tutored (RT): Students learning through critiquing research.
- Scholarship of teaching and learning (STL): Enquiring and reflecting on teaching and learning.

In the bachelor's Biology programme and in the different master's programmes at the Faculty2 all five approaches of research-informed teaching are offered. They provide different avenues for RRI learning. Whereas during the bachelor's programme different concepts, ideas, relevance and aims of research and RRI are discussed (RL and/or RO), the integration in research groups and writing of the bachelor theses offers the possibility of students learning as researcher (RB). That allows them to relate RRI processes in the own field and the role of responsibility in these processes. Especially within the associated modules "interdisciplinary key qualifications" students learn about criteria for good research and ethical issues in scientific writing.

In the master's programmes of biosciences students focus on the specific topics of their fields of research and research-tutored (RT) learning may be at the core. Science chats and master seminars

allow doing and experiencing dialogical reflection on research and innovation (STL) and a perspective with the wider society.

RRI in the curricula of PhD programmes

Most of the reflective activities developed in Starbios2 projects are targeted to PhD students and young researchers. When doing more or less self-reliant research the application of RRI issues is important. The assessment of possible societal impacts of one´s own concrete research activities as well ethical issues of research receive increased importance. The goal is to propose adoptions to better align a research project with societal needs, values and expectations.

A good practice example at the University of Bremen is the Graduate School Nano Competence – Research, Mediation, and Design. This interdisciplinary graduate school combines the expertise of natural sciences and humanities, aiming a ten lightening society about the applied aspects of nanotechnology (https://www.nano.uni-bremen.de/).

Especially in the doctoral programme of Science Education RRI is reflected and RRI issues like socio-scientific issues and contexts, how to deal with gender and diversity as well as ethical questions are fields of investigation in doctoral studies.

Further outreach events

There are different possibilities to bring scientists and/or scientific questions in direct connection with the societal needs. One example is the citizen science project "My Ocean Sampling Day (MyOSD)" of the Max Planck Institute of Bremen. It is a global scientific campaign to analyse marine microbial biodiversity and function, taking place during the solstice on June 21st. The goal of the MyOSD citizen initiative is to involve citizens, school classes, and teachers in the research process. Supported by scientists and equipped with the MyOSD Sampling Kit and a Smartphone APP which they can use to collect marine microbes and important environmental data, they help lead scientists to get a better understanding of the world's oceans and their microbial biodiversity.

One fruitful example is the Open Campus Day in Bremen. According to the motto "Science for You and Me", the Starbios2 Core Team presents and discusses topics of genetic engineering and its future. Participating children are offered hands-on activities, such as DNA isolation from strawberries and construction of DNA models with pearls. In addition, a reflection activity on future topics of genetic engineering is offered such as "Should mammoths be brought to life?" or "Green genetic engineering as a solution to global hunger?".

From the Booklet of RRI Recommendations to the RRI Mission statement

Responsible Research and Innovation (RRI) represents a contemporary view of the connection between science and society. The goal is to create a shared understanding of the appropriate roles of those who have a stake in the processes and products of science and technology, scientists as well as educators and the general public. It is estimated that a shared understanding and mutual trust will lead to safe and effective systems, processes and products of innovation (Sutcliffe, 2011).

To reach these goals at the Faculty2 of University of Bremen a complex road map (Figure 1) has been developed with science education as core elements. Educational building blocks, reflective activities, RRI modules, and curricula enrichment for bachelor´s, master´s and doctoral programmes have been reflected and further developed. A non-line RRI toolbox tailored for Faculty2 needs was set up. Based on formative evaluation of RRI activities, a broad literature analysis, interviews and a faculty-wide questionnaire survey the Booklet of Recommendations "Towards a Sustainable and Open Science – Enhancing Responsible Research and Innovation in the biosciences at the University of Bremen" (Elster, Barendziak & Birkholz, 2019). It will now be discussed and negotiated. Together with the on-line RRI toolbox it will form the sustainable outcome of the four-year-long process of RRI structural change and development of a RRI mission statement tailored to the Faculty2.

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ABOUT THE STARBIOS2 GUIDELINES

This guideline aims to help readers formalize and trigger structural change aimed at introducing appropriate RRI-related practices to their own organisations. This is not a series of prescriptions, but an itinerary of reflection and self-interpretation addressed to different actors within the biosciences. To support this itinerary of reflection and self-interpretation, the document provides...

- a description of a general RRI Model for research organisations within the biosciences, that is a set of ideas, premises and "principles of action" that define the practice of RRI in bioscience research organisations,
- some practical guidance for designing interventions to promote RRI in research organisations in the Biosciences, putting into practice the RRI Model,
- a set of useful practices in implementing the structural change process,
- and information on particular STARBIOS2 cases and experiences, as well as materials, tools and sources, are also provided in the Appendix and in the Annex.