



Responsible Research and Innovation in the
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Dr. Beverley Gibbs
Dr. Rider Foley
Prof. Paul Martin

The University of Sheffield, Western Bank, Sheffield. S1 3JD.

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Executive Summary

Responsible Research and Innovation (RRI) recently gained traction in science, engineering and technology (SET) policy in the European Union and United Kingdom and is currently an important initiative for both researchers and educators to consider as they pursue public funds. While attention is often paid to the implications of RRI in the research arena, fewer conversations have explored how this SET policy affects educational and curricular efforts within research-intensive universities.

This workshop was an opportunity for collaboration between the social sciences, arts, medicine, humanities, and various SET disciplines to consider whether and how we might support the emergence of RRI in curriculum design for SET undergraduates.

This document shares the efforts undertaken at a workshop that occurred at the University of Sheffield on 24 May 2016, which explored the benefits of, and strategies for, promoting “*RRI in the classroom*.” Participants were from multiple disciplinary and institutional positions with backgrounds in education, science policy, science and technology studies, biomedical ethics, engineering ethics, project-based learning, and humanities. The report establishes a theoretical construct for RRI and then explores how existing educational activities might be aligned with this new framework. It comprises:

- a opening statement on the motivations and structure of the workshop
- a description of the activities, outcomes and the subsequent dialogue
- a series of reflections, discussion points, and takeaways.

The report is accompanied by a list of the 40 classroom activities and learning outcomes generated during the workshop, and explores their connections to RRI ; they are included to offer examples of how educators understand an alignment between classroom activities, learning outcomes, responsible research and innovation and learning domains.

This workshop serves to support the on going conversations across the United Kingdom and European Union as the science policy initiatives incorporated in RRI are unpacked, digested and reinterpreted by educational and research communities.

Responsible Research and Innovation in the Classroom: A workshop report

Beverley Gibbs^{*1}, Rider Foley², Paul Martin³

1.0. Introduction

Academic institutions have, over the past two centuries, formed siloed, disciplinary structures that shape education and research (Klein, 1990). Transformations of thought and paradigm shifts occur within research disciplines, yet those transformations occur slowly over time (Kuhn, 1962). A lack of open communication channels and fora to share experiences and educational approaches between disciplinary-based academic units results in fragmentation and parallel efforts across the university (Bromme & Tillema, 1995). There is often near uniformity in the learning outcomes of students from similar disciplines at different universities, but disparate learning outcomes for students enrolled in different departments within the same college or university.

Such challenges have led to calls for reformation and rethinking of the contemporary university. Those calls have come in the form of advocacy for interdisciplinary scholarship and teaching that grew out of calls for reform in higher education (HE) and an academy that would produce graduates who are better equipped to serve the needs of society (Klein 2008). This call for interdisciplinary scholarship came as a response to claims that traditional bodies of knowledge were inadequate for sparking the reflection, renewal and judgment that is required in addressing complex and dynamic challenges such as poverty (Jantsch, 1972). Although he did not go so far as to suggest a pedagogical approach, Jean Piaget (1972) commented that as the epistemological frameworks associated with disciplines evolved, they would gravitate towards systems perspectives. Efforts to 'bridge' or 'leverage' disciplines have given rise to fields such as biomedical engineering, geophysical sciences or sustainability science, which in turn take on a certain quasi-disciplinary identity and create new journals, bodies of knowledge, and epistemic communities (Pfirman & Martin, 2010). Other reformation efforts have attempted to break down disciplinary models of education and research through cross-disciplinary appointments that force scholars and educators alike to transcend boundaries (Komiya & Takeuchi, 2006). Crow and Dabars (2015) argue that a new model of education needs to move beyond efforts that aim towards

¹ Department of Mechanical Engineering, University of Sheffield *Corresponding Author

² Department of Engineering and Society, University of Virginia

³ Department of Sociological Studies, University of Sheffield

inter- or cross-disciplinary and instead aim towards a reorganization of the university itself in a manner that transcends disciplinary boundaries. This can be seen in more revolutionary ideas of the ‘challenge-driven university’ in for example, the US, UK and Finland (The Economist, 2016). In a more evolutionary sense, efforts towards reorganization that cut across or “transcend” disciplines often result in pan-university initiatives that aim to bring together scholars from across campus.

At the same time, national policy agendas arise that seek to stimulate reformation in the higher education sector. Those national and regional- or state-based policies can influence the university through funding priorities, guidance documents, and perhaps most contentiously, systems of metrics that are taken to indicate performance and quality. Nations around the world are looking to leverage the funds allocated to universities as a means to advance political priorities, which include: educating the workforce, driving economic growth, addressing public health crises, and securing national defense. These political priorities express public values, as broadly defined by Bozeman (2007). For many universities, the institutional charter offers guidance as to their duties and responsibilities to the nation, state and community, which reflect the public values of the founders (Mero, 2011). Thus, public policy agendas and charters impose direct and indirect force in a top-down manner on both scholarship and curricula within the university.

This confluence of forces—bottom up faculty and staff curriculum development initiatives to top-down national policy and metrics—kindles efforts to reform the curriculum and prioritize scholarly collaborations between departments, faculties and universities. The challenge can be to measure and determine an appropriate response to the confluence of forces, especially in a world where the political winds can shift with the season. A contemporary case of this confluence can be observed where a top-down mandate from the European Union (EU) for the adoption of responsible research and innovation (RRI) in the Horizon 2020 funding program (Strand et al., 2015) is meeting bottom-up efforts for collaboration across disciplines around the governance of emerging knowledge domains, e.g. synthetic biology (Calvert & Martin, 2009). This supranational focus on RRI is blossoming at the same time as the United Kingdom deploys the AREA (anticipate, reflect, engage, act) framework (EPSRC, 2016). The science policy initiatives advancing RRI serve as the backdrop for this report.

This document shares the efforts undertaken at a workshop that took place at the University of Sheffield on May 24, 2016, which explored, “*RRI in the classroom.*” What follows is a brief statement on the motivations and structure of the workshop (section 2.0), a description of the activities, outcomes and the subsequent dialogue (section 3.0), a series of reflections, discussion points, and takeaways from the workshop (section 4.0). This workshop report is accompanied by a full listing of the 40 classroom activities, learning outcomes and their connections to RRI gathered and analyzed during the event.

2.0. Motivations and Structure

The national policy set out in Horizon2020 and in the AREA framework by the UK Engineering and Physical Sciences Research Council (EPSRC, 2016) are driving conversations about RRI in the EU and UK research communities. This agenda sets the stage for conversations about both the emergent concepts gaining political momentum under the moniker of RRI (de Saille, 2015; Rip, 2014) as well as the aggregation of scholarship that is being subsumed by RRI (Ribeiro et al., 2016). In research-intensive universities, such as the University of Sheffield, where scholarship and education are closely linked, there is a need to understand research policy implications in the context of the curriculum and ultimately within the classroom. At the University of Sheffield, this mantle was picked up by the ‘Public Value Sub-Group’, a committee with the remit to *“oversee the embedding of the concept of public value in existing core and operational activities”* that reports directly to the University Executive Board and is chaired by Professor Richard Jones, Pro-Vice Chancellor of Research and Innovation. The Public Value Sub-Group commissioned a working group to explore the strategic and operational opportunities and implications of the emerging RRI agenda. This ‘RRI Task & Finish’ Group (later, RRI Development Group) was a pan-university committee of research integrity professional staff, RRI researchers and already engaged academic leaders.

Professor Paul Martin, Head of Sociological Studies, was appointed to chair that effort, and served as the co-organizer for this workshop. The RRI group is charged with developing a framework that will enable the University of Sheffield to provide practical support to its research community on how to approach research through the holistic prism of RRI, and support them in applying for funding from UK Research Councils and the EU. This effort entails the bringing together of people from diverse institutions, faculties, and disciplines to explore how RRI fits within the University’s current governance structures and longstanding public value framework.

A commitment to public value is built into the foundation of University of Sheffield and the donations from local citizens made under the auspices that their contributions: i) bring higher education within reach of the child of the working man, ii) support local industry, iii) be a centre where the treatment of accidents and diseases be studied, and iv) bring standing to Sheffield within higher education (University of Sheffield, 2016a). Those public values continue to resonate today in the mission statements and goals set forth for the institution. In many faculties, such as the Faculty of Engineering and its nine departments, there are bottom-up efforts that reflect those values. For example, “Sheffield Robotics”, a multi-partner interdisciplinary research centre that positions ideas of responsible innovation at the heart of its agenda, an effort that is upheld as an exemplar for other research programs as a way to bring ethics into engineering research. Programs of this type promote the qualities codified in “The Sheffield Graduate Attributes” that describe graduates who are skilled and ethical

researchers, competent in applying their knowledge and skills, experienced in working with clients, communities and partners outside the University and citizens who respect diversity and have the cultural agility to work in multinational settings (University of Sheffield, 2016b). The workshop organizers drew motivation from these ‘responsible robotics’ activities and the University’s commitment to public values.

Frameworks of RRI, which are increasingly finding traction in policy and academic circles, bring in perspectives from ethics, ELSI (ethical, legal, and societal issues), public engagement, deliberative dialogue, and many others. Although a variety of RRI frameworks are emerging, what they share is a call for scientific and technical experts to *anticipate, engage, reflect* and *act* (AREA) framework. Practitioners in industry, government and community organizations as well as those in academic research are expected to include this AREA framework into their daily routines. This poses a direct challenge to educators preparing scientists and engineers for the future workforce. To this end: what is the responsibility for higher education in preparing scientists and engineers to be reflexive, anticipatory and engage with diverse stakeholders? How and when do educators introduce effective objectives to curricula that are traditionally dominated by cognitive knowledge and practical skills? Who has the capacity to stimulate new understandings of the normative objectives of both SET and RRI? Those questions guided the philosophy and design for the workshop structure.

To stimulate an open discussion, Dr. Foley carried forward arguments put forth by Stilgoe et al (2013) on an apparent lack of normative content in current RRI discussions. Foley argued for the framing of RRI to move beyond “good” processes (born from procedural justice) and put forth aspirations born from sustainability to guide the activities of the research enterprise (Foley et al., 2016). From this initial provocation, Prof. Martin opened the floor to discussion in plenary and then moved into a series of hands-on activities that sought to link the broader RRI framework to classroom activities. The design encouraged audience members to participate alone, in pairs, and in plenary through verbal and nonverbal means. While the opening of the workshop followed a traditional lecture format, the second half was designed to be multi-directional and interactive among the participants, see Appendix A.

Participants came from diverse disciplinary and institutional backgrounds including the University of Sheffield’s Department of Sociological Studies (3), Political Sciences (1), Faculty of Science (1), The Medical School (1), Faculty of Engineering (4), and School of Education (1). Additional participants traveled from the Centre for Biomolecular Sciences (1) and Institute for Science in Society (1) at University of Nottingham and Department of Social Sciences Health and Medicine (1) at King’s College London. The participants hold positions that connect to education of postgraduate (graduate student) science training, science and technology studies, biomedical ethics, engineering ethics, project-based learning, and humanities, see full participant list in Appendix B.

3.0. Report Out from Activities

3.1. Introduction and framing talk

After an initial introductions by all participants, Prof. Paul Martin opened with a brief statement about how the workshop was intended to be (1) an opportunity for collaboration between the social science, arts, medicine, humanities, and various STEM disciplines and (2) a space to consider whether and how we might steer innovation. The workshop was positioned in response to the AREA framework and as a space to explore its implications across the University on behalf of the RRI Steering Group. Thus, the workshop encouraged participants to learn from one another and share knowledge about our research and teaching practices. This event was a first step in sharing ideas, practices, and learning from one another.

Dr. Rider Foley's opening talk drew from two RRI frameworks: EPSRC's AREA model (EPSRC, 2016) and Stilgoe et al's (2013) model. This initial analysis tabled critiques of RRI as a 'tick box' exercise, e.g. stakeholder engagement as performed in nanotechnology (Delgado et al., 2011). He then moved away from the political instantiation of RRI and cast *rri* (un-capitalised) as a more principled approach, as articulated by Linder et al (2016). The deliberative-democratic processes of responsible innovation were encapsulated in dimensions of anticipation, engagement, reflexivity, adaptive action and coordination. To reach beyond processes, those dimensions were mapped against a set of justice-oriented principles derived from sustainability scholarship (Foley et al., 2016), see Figure 1.

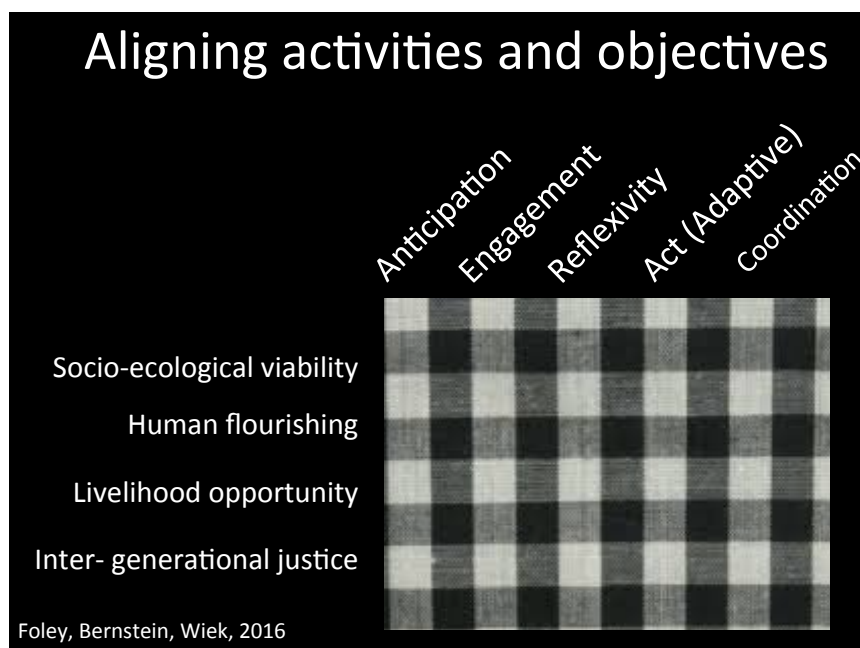


Figure 1. Framework aligning deliberative democratic processes with sustainability principles.

The second part of the opening talk shifted to the educational context. The framework (depicted in Figure 1) was applied to classroom activities and learning outcomes, and an explicit connection was made to the alignment between aspects of sustainability and process-based activities. The University of Virginia's curriculum (Johnson, 2016) were introduced as one model for infusing ethics into the heart of engineering education. The plenary talk was successful in stimulating a wide-ranging discussion that spanned connecting individual to collective ethics, scaling project and problem-based learning, drawing upon normative frameworks in the classroom, and integrating ideas from different disciplinary perspectives from across the university.

Faculty familiar with the existing ethics curriculum (in engineering, science and medicine) were struck by the need to move beyond individual modes of ethical action and code-following within professional communities to an ethical training that encourages students to engage with larger, macro-ethical questions (Herkert, 2005). One faculty member suggested that global challenges of sustainability resonate with students, especially international students that want to engage in real-world problem solving. One instructor felt that 'big picture' ideas were not tangible enough for their engineering students; others respectfully disagreed and felt that "inclusive" design can be taught by highlighting the relationship between a person's hand and the size of cell phones. Another participant shared a story about a student who confessed to lying awake at night worrying about the consequences of using different materials in battery storage devices and how those affected people and the environment.

The University of Sheffield's Engineering program admits c.1,400 students per year, so the question of building a program that supported problem-based projects with communities was raised and the scale of the effort detailed. A faculty member offered that dovetailing sustainability-based projects within existing project-based courses would be an opportunity to pilot such a program. The suggestion was made to consider corporate or external sponsors for such time-intensive, small-group projects.

To diversify who exactly is the instructor in engineering, science, or medicine coursework, one participant suggested that new institutional avenues be created for supporting instruction across schools via cross campus mechanisms to help build relationship between faculty. Others felt cross-campus instruction might be perceived as an unwanted intervention and, subsequently that the student's 'home' school would want to retain control of the curriculum.

Practical pedagogical considerations: some attendees have observed that the contribution of (for example) social scientists as subject experts in the political and ethical dimensions of technology to the teaching of engineers is complicated by the different teaching traditions that different disciplines brings, and the learning expectations of different cohorts of students – the translational work required is not insignificant. These are tensions that require continued thought and deliberation – it is not as straightforward as asking a social scientist to come and teach a module.

3.2. Lego Serious Play: Connecting human creativity and narrative

Dr. Stevienna de Saille, a postdoctoral scholar and trained facilitator with Lego Serious Play, facilitated this activity. She stated that Lego Serious Play is a formalized method for interacting with workshop participants and is intended to spur creative thinking and generate narratives about design processes and their outcomes. Each participant was given only six lego bricks and instructed to create a 'duck' in one minute.

Participants worked quickly to connect the bricks. One participant verbally protested the unfairness of the competition, but was assured the activity was not competitive. After a minute, participants held up their "duck" for the group to see. Each and every configuration was unique and the facilitator pointed to this as evidence for creativity. Participants then told a story of their "duck". Narratives ranged from descriptions to "mutant ducks", "shy ducks", 'rubber ducks', and "ducks from the dell".

This sharing of stories evolved into a discussion of how to use this activity in teaching design, creativity, and exploring the use of narrative. One participant reflected that the activity brings in different knowledge practices and allows people to tell stories. All stories, she expanded, are inherently different and allow the storyteller to bring themselves into the stories. The participant referenced the opening talk and how this activity was about putting human flourishing first, rather than celebrating the artifact. Many participants felt that the activity could 'open up' science and engineering education to allow students to interact differently in the design and building processes.

This line of thought led to reflections regarding when would be the 'right' time to teach ideas of responsibility in science or engineering. One person offered that students must know substantive, disciplinary content before introducing ideas of responsibility. Others disagreed and suggested that simple activities integrated throughout the curriculum offer opportunities to learn about ethical responsibility alongside disciplinary knowledge. To this end, Dr. Foley offered a story of bringing in his nephews (ages 6 and 7) via Skype to his classroom to explain their Lego creations. That exercise was designed to suggest that (1) ethics are taught through formal and informal lessons and (2) creativity and building are forms of human expression and not inherently "good" or "bad", rather ethical responsibilities are learned by engineer alongside technical skills. Others suggested ways to structure modules that made the move from the individual to the collective and back again through writing reflections and journaling.

Dr. de Saille shifted the conversation to activities with the actual curriculum design process as a means to infuse greater creativity and make connections between different parts of the programme-level curriculum and efforts by the RRI Development Group at University of Sheffield. At that session, the group developed a vision as to what RRI might mean within the University of Sheffield. Their bricolage of Lego sub-assemblies formed the basis of a distinctive vision statement that was further refined amongst senior academics. Overall, the discussion was robust, energetic, and lively.

3.3. Making connections: Teaching activities and assigning heart, head, and hands.

The Lego Serious Play activity offered a strong transition into the next activity, in which participants were asked to describe (1) a learning activity, (2) the learning outcome, and (3) its connection to RRI (or rri). A worksheet from the “Nano around the world” game (<http://www.nisenet.org/catalog/nano-around-world-card-game>) and the Lego Serious Play activity was offered as examples of activities that could be conducted in condensed formats, while the senior thesis from the University of Virginia was references as an example of an extended, longer-term activity (Johnson, 2016).

Participants worked individually and to describe learning activities, outcomes,, and their connections to RRI (or rri). When participants stopped writing, they were paired up and encouraged to share their activities. The room quickly erupted into a cacophony of voices. As the voices died down and the sharing concluding, participants were asked to post their worksheets up to the wall. They were given an opportunity to align their worksheet the framework presented in the plenary talk (Fig. 1) or near one of the vertical or horizontal dimension headers or outside of the framework, see Figure 2.

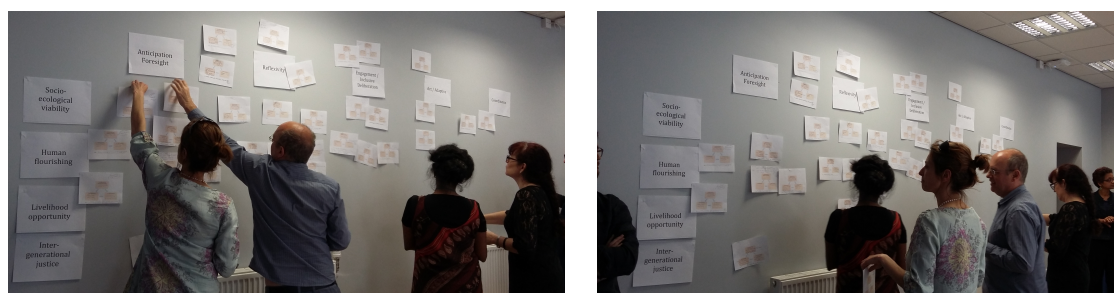


Figure 2. Participants work to post learning activities within the framework presented.

After participants posted their worksheets on the wall, they were given sticky notes with images of a heart, hand, and head. Those icons represented distinct learning domains with the heart representing the emotive/affective, hands as kinesthetic or psychomotor domain, and the head as cognitive (Krathwohl et al., 1964; Hannah & Michaelis, 1977). Evaluating the collected activities through the lens of learning domains was useful in exploring the balance or dominance of certain domains; previous studies of interdisciplinary pedagogy have found heavy reliance on the cognitive domain (Raine, 2009). Participants generated 40 worksheets with learning activities, learning outcomes, and connections to rri / RRI in 15 minutes. Appendix C records all of the activity worksheets that were generated. After posting the worksheets and assigning each a learning domain, participants stepped back and discussed what they had done. It was surprising that the participants were able to so readily grasp the activity and generate such a quantity of materials.

There was readily observable diversity in the learning domains, as well as in the alignment of worksheets to the framework. Quite a few worksheets were placed outside the framework (above or to the side). A few participants felt uncomfortable with matrix frameworks that expressed delineations between categories and, thus challenged the alignment exercise; this point is returned to and explored in the discussion. The exercise resulted in a broad distribution of learning activities exhibiting strong alignment with anticipation, reflection, and engagement, as well as the principle of human flourishing, see Table 2. Few learning activities aligned with act/responsive/adaptive category, and those that did drew from community-based projects.

	Anticipation / Foresight	Reflect / Integration	Engage / Inclusive / Deliberative	Act / Responsive/ Adaptive	Coordination / Polycentric	None
Not aligned with principle	4	4	6	-	-	-
Socio-ecological viability	5	3	2	1	1	1
Human Flourishing	6	5	5	2	-	1
Livelihood Opportunity	-	1	1	1	-	1
Inter-generation justice	1	-	1	-	-	-

Table 2. Alignment of learning activities with categories presented in the framework. Note: Participants aligned some learning activities with as few as none and as many as four categories, thus the rows and columns do not sum to forty.

Participants assigned learning domains for each learning activity, though not all learning activities were assigned learning domains. Participants readily assigned hearts, hands, and heads and categorized the learning domains employed by the activity and sparked a robust discussion (Figure 3). The exercise yielded a balanced distribution of learning domains, shown in Table 3 below. The activities built support for how students can coordinate, e.g. team building or communication activities. There was a concentration of activities designed to develop care for the future through emotive learning activities.

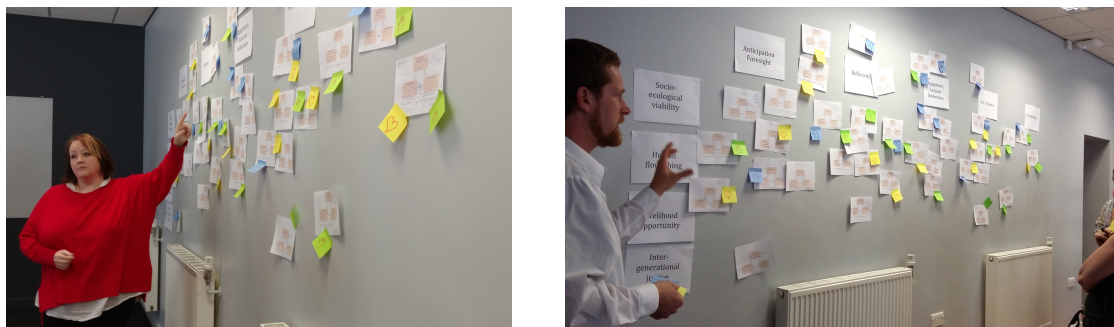


Figure 2. Participants assign learning domains to activities posted on the wall (left) and discuss the results of the exercise (right).

RRI Capacity	Heart (emotive)	Hands (kinesthetic)	Head (cognitive)
Anticipation	6	1	4
Reflection	2	4	2
Engagement	3	4	4
Act / Responsive	-	2	-
Coordination	-	-	1
Not assigned	2	1	-
Totals	13	12	11

Table 3. Alignment of learning domains with RRI capacities, as assigned by the participants.

Note: Participants assigned as few as none and as many as two learning domains, thus the table's rows and columns do not sum to forty.

In the discussion, quite a few people expressed an appreciation for the framework in its ability to bring together the normative and procedural dimensions of RRI. Others felt that they needed to consider how this framework directly (or indirectly) linked to the public value statements in their university's charter, but suggested that, on the face of it, there was strong resonance. One participant raised the point that the framework was human-centered and while they appreciated the "human flourishing" objective, they were less impressed by mere "viability" of socio-ecological systems, as this presupposed a human domination of the environment. They felt viability stood in stark contrast to flourishing and thus, equal weighting was not provided to both principles. Another participant critiqued Foley's presentation of "livelihood opportunity" as too "market-focused" and suggested that it be rephrased in a manner that recognizes ways of creating shared benefits without monetary exchange.

An observation was made that intergenerational justice was sparse, as compared to the other aims. This comment was responded to in two different lines of argument. One participant suggested that connecting current scientific practices or engineering research to long-term, intergenerational outcomes is a "bridge too far." Further, connecting mundane practices in the laboratory or engineering to such concepts is not readily intuitive or currently included in the curriculum. The comment was expanded in terms of how (i) routine practices are repeatedly performed and serve to structure future practices and (ii) that changing those social practices in an intentional manner is uncertain, at best. A second line of argument focused on intergenerational justice and the way in which the facilitators attempted to "enforce" strict boundaries between the categories. This argument arises from a classic critique of categorization among social groups and the restrictions those boundaries can impose (Lamont & Molnár, 2002). While that those critiques were heard, other participants pushed back on those points. They argued that matrix frameworks can be a heuristic for institutional priorities and organization, rather than means to enforce rigid boundaries.

3.4. Participant reflections and general discussion

The discussion shifted to the potential wider impact of this workshop in the University of Sheffield, whilst highlighting important, broader questions. One person stated that teaching outside one's own department raises the challenge of translation in the sense of how this workshop's engineering-oriented discussions might be brought into other disciplinary areas. That point was taken up and it was reported that the University's public value group is exploring questions of whether these multiple frameworks – specifically, RRI, research integrity and university values – fit together, or whether we should 'let a hundred flowers bloom'. Some expressed a concern that RRI is a transient "hoop jumping" mandate from the government and that considerable uncertainty lies ahead in the macro-policy landscape, both with the imminent reorganization of the UK's research governance landscape (BIS, 2016) and the possibility of UK's withdrawal from the European Union (now underway following the membership referendum of 24 June 2016). That point was rebutted in terms of thinking about RRI not as adding responsibility onto innovation, but expanding innovation options. As one participant stated, "it's not a hoop, it's not a burden, it's a way of opening up alternative innovation pathways." That argument was supported with the understanding that while RRI activities can be viewed as soft governance, perhaps there is a need to articulate how it is actually adding a lot of value to the core of the university.

The conversation shifted to specific opportunities and challenges within the University of Sheffield and questions involving how and whether RRI should become central to the University's mission or identity. There was some feeling that RRI built on Sheffield's existing identity, and as an institution that scaffolds innovation in a region. Thus, building upon the current appetite for thinking about the implications of RRI as a question of research integrity rather than a social science research question, and that this could be a distinctive attribute for the University of Sheffield.

In terms of research, a point was raised that postgraduates and post-doctorates have to learn quickly how to articulate the link between their research and the 'big picture'. Since funding applicants must demonstrate the connection of their research to its wider societal context and possible impact, applicants who fail to do so typically fail to receive funding. The connection to research led one participant to mention the Sheffield 'Crucible' project (University of Sheffield, 2013), and the aim to develop an understanding of "*the importance of developing a wider view of the world of research and the power research has to influence society*". Participants' thought that the connection to graduate student training was more self-evident and raised questions around how to scale RRI up and involve more senior academics. One participant who sits on a UK Research Council grant review panel - offered that a significant amount of the panel's time was spent talking about the ethical dimensions of research proposals and they suggested the framework presented in the workshop may serve as a structure to evaluate the ethical dimensions of grant applications.

4.0. Discussion

4.1. Reflections on the workshop

The workshop brought together a diverse group of people from within Sheffield, as well as other UK universities, to contribute their expertise to an exploration of how sustainability principles can be aligned with the process-oriented capacities put forth in the UK's AREA framework. To this end, the opening talk and the subsequent activities advanced such an alignment. While the workshop design offered participants an opportunity to contribute their expertise in curriculum design and pedagogy, it also allowed people to voice their critiques of the framework and highlight the challenges of bringing RRI into institutional practices, curricula, and research projects.

At Sheffield, Prof. Martin serves as a crucial link between the workshop and the University as an institutional connection to the Vice-Chancellor's committee. There are important relationships between the participants and their responsibilities for postgraduate research education, medical education, undergraduate engineering education, social sciences and the humanities. Connections made between workshop participants and their respective communities are critical for the healthy maturation of the ideas explored during the workshop. The outcomes by no means reached closure around those issues, but rather furthered existing efforts and conversations.

To be self-critical, as we seek to innovate in the curriculum, are we embarking on that responsibly? Were we anticipatory? Reflective? Engaged? Could we act? In this sense, the first point of reflection is that the workshop was very much focused on the perspectives of faculty and did not draw upon broader stakeholders such as students (under- or postgraduates). It would be important to engage students in deliberations on the reformation of the curriculum. Other stakeholders, not in attendance, included members of Sheffield's civic community that are indirectly connected to the university. To build upon the ideas from sustainability education that advance project and problem-based learning that is community-based (Wiek, Xiong et al., 2014), there is a clear need to include those voices in the early planning efforts. This would also be consistent with the University's idea of the 'Engaged Curriculum' (University of Sheffield, 2016c).

As an early effort towards community-building, the workshop did little in the way of envisioning alternative futures and implications of educational reform of this nature. Narratives of the future of the University of Sheffield, the interactions between faculty and connections to community and industry partners might offer inspiration for decision-making against an anticipatory knowledge landscape. Alternatively, given the state of educational reform and the issuance of the UK Government's 'white paper' on higher education (BIS 2016), there might be cause to explore if (and how) a greater diversity of outcomes could arise.

4.2. Questions remaining

Important questions remain including: What is meant by RRI in different disciplinary contexts and institutional settings? How can RRI be constructively reinterpreted for healthy alignment with disciplinary and institutional values? How can existing efforts be understood within the AREA framework or other RRI frameworks? How can science, research, medicine and education become entangled with explicit statements of public values or sustainability?

Those questions and others are being taken up by members of the Virtual Institutes of Responsible Innovation (VIRI) in research and academic pursuits around the world (VIRI, 2015). At Arizona State University, the home institution for VIRI in the United States, an effort is underway to create a School for the Future of Innovation Studies that aspires to re-think innovation in the pursuit of justice, freedom, and quality of life (Walker, 2015) is born from the Consortium of Science, Policy and Outcomes (CSPO), the Center for Nanotechnology in Society, and the leadership of Michael Crow. Concurrently, University of Twente and Utrecht University are bringing together science and technology studies (STS) scholars with engineers and nanoscale scientists through the NanoNextNL program (Rip & van Lente, 2013).

Other organizations, not just members of VIRI, are taking up similar efforts. For instance, faculty at Technical University–Delft developed curriculum and a series of videos, readings and learning activities designed to define and explain RRI (Kormelink, 2016). At Colorado School of Mines, the legacy of Carl Mitcham’s work on engineering ethics is expanding to connect engineering ethics education even more explicitly to issues of injustices with a workshop planned in New Orleans at the American Society for Engineering Education (ASEE, 2016). Across Europe, the HEIRRI project aims to *“....integrate the concept of RRI in the formal and informal education of future scientists, engineers and other professionals involved in the research and innovation process.”* (HEIRRI, 2016), and the ENRRICH project looks to develop capacity in staff and students to embed RRI in higher education institutes through engaging civil society organisations with co-produced research agendas (Living Knowledge, 2016).

4.3. Next steps

Participants agreed that while this workshop opened conversations, more work is needed internally at University of Sheffield to understand how the public value and RRI might align. And externally, there needs to be further discussions on connecting the ‘on-the-ground’ perspectives of educators and researchers to higher levels of management among national levels of university governance (Universities UK, 2016). There is a continued need to create spaces and times for more voices to enter the discussion and inform the debate on how RRI is interpreted and reshaped at universities across the United Kingdom and European Union.

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6.0. Appendices

Appendix A. Workshop Agenda

Responsible Research and Innovation in the Classroom	
University of Sheffield	
May 24, 2016	
13.00	Lunch served
13.15	Introductions (Paul Martin)
13.20	Plenary Talk (Rider Foley)
13.45	Plenary Discussion
	Guiding questions:
	1. How do you interpret or reframe the principles and processes underlying responsible research and innovation?
	2. What are challenges and opportunities that accompany the RRI agenda?
Break	
14.10	Activity 1. Lego Serious Play (Stevie de Saille)
14.25	Activity 2. Making Connections. Activities<>Outcomes<> RRI
14.45	Activity 3. Thematised and assess for gaps.
15.00	Plenary Discussion
	Guiding question(s):
	1. How does this fit into curriculum design? Who should teach these activities?
	2. When would RRI have most impact? Can it be taught to UGD? When?
	3. How do we build capacity and what does capacity mean here at Sheffield?
	4. What does 'RRI in the Classroom' mean for Sheffield and its ability to deliver public value?
15.45	Closing Remarks and Reflections
16.00	Workshop Close

Appendix B. Workshop participants

RRI in the Classroom : University of Sheffield, 24th May 2016

Attendees

Prof. Paul Martin (Chair), Department of Sociological Studies, University of Sheffield

Dr. Rider Foley, Department of Engineering and Society, University of Virginia

Dr. Beverley Gibbs, Department of Mechanical Engineering, University of Sheffield

Dr. Rob Howell, Assistant Faculty Director of Learning & Teaching (Enhancement),
Faculty of Engineering, University of Sheffield

Dr. Carmen McLeod, Centre for Biomolecular Sciences, University of Nottingham

Dr. Susan Molyneux-Hodgson, Department of Sociological Studies, University of
Sheffield

Dr. Trish Murray, Faculty of Engineering, University of Sheffield

Prof. Kate Pahl, School of Education, University of Sheffield

Dr. Warren Pearce, Department of Sociological Studies, University of Sheffield

Dr. Sujatha Raman, Institute for Science in Society, University of Nottingham

Dr. Stevie deSaille, Department of Politics, University of Sheffield

Dr. Rob Smith, Department of Social Science, Health and Medicine, King's College
London

Dr. Sandrine Soubes, Researcher Development Manager, Faculty of Science, University
of Sheffield

Dr. Pirashanthie Vivekananda-Schmidt, The Medical School, University of Sheffield

Appendix C. Teaching activities worksheets

Title	Learning Activity	Learning Outcome	Rri/RRI Connection	Domain	Notes
Rebuilding the Grid	Students reconstruct the energy grid, over time (using a timeline) to demonstrate how technologies gain momentum “Lock-IN”	Their knowledge of systems (socio-tech) To the history & future of electric infrastructure	Anticipate/Reflect Inter-generational justice	Head	
N/A	Molecules to nuclei: developing idea of a biobusiness	Impact of business model on: socio-ecological viability, human flourishing, livelihood opportunities	Anticipation	N/A	
Poetry workshop with girls → gaining control of mode/form	Reading existing poems	How poetry works	Understanding use of expression	Hand	Knowledge from group influences learning outcomes
Poetry Workshop with a group of girls in Rotherham → fundamentals of knowledge	Writing poetry/poetry workshop in a community	Drawing on existing reading/experience	Making sense in community context → Widening participation	Heart	Knowledge from life experience influences learning outcomes

Renewable Energy Supply Chains	MIT Press – release on solar energy innovation – only Requires “cheap, everyday, readily available” materials	Where do these materials come from? Who is impacted & how? (e.g. cobalt) - The Congo; conflict minerals.	Anticipation	Head	
STS Bootcamp for iGEM	- Develop solutions to ‘homelessness’ using synthetic biology - Design an interview schedule, pick a sample + think about analysis	Training in STS to conduct of iGEM project	Behind every rhetorical “social need” claim is the social world as experienced by the social actors	Hand	tried with Ugs from ~6 depts. In Uni
Social Accountability SSC	Collaboratively design focus of a project to benefit a local organization	Socio-Eco variability + viability Human flourishing	Anticipation Engagement Human flourishing Reflexivity Act	Hand	
Finding a host community for nuclear waste	- Read GDF policy - Power; decision making - Analyze language in policy document - Discuss contexts of production + challenges to implementation.	UK White Paper on Geological Waste Disposal (2014): Process, power, dynamics of decision making	Intra-gen. & Inter-gen justice Etc.	Heart and Hand	Not yet tried with MSE folk

MEC 408 – Industrial Marketing	Class discussion	- Role of engineering in globalization + impact of that	Human flourishing Livelihood opportunity Socio-ecological viability	Heart	
MEC428 Professional Responsibility of Engineers (blog) & reflective piece	-Identify Research topic -Apply ethical framework(s) - Publish -Solicit response -Write reflection on analysis + responses	A topical engineering issue/ethical dilemma	Anticipate Reflect	Heart	
MECH 425 “Design for A Sustainable Environment.”	Site visit + survey (Needsend; Parkwood Springs) - Consult stakeholders A proposal to sustainably develop Neepsend (eg transport, energy] Develop designs	A proposal to sustainably develop Neepsend (eg transport, energy]	Socio-ecological viability Anticipation / Engagement (?)	Head	
Multi-disciplinary chats	Discussion Group of multi-discipline students	Different approaches to problems talked by disciplines	Encourages thinking outside disciplinary boundaries	N/A	

Drugs + Prescribing	Understand benefit + challenges of the direct cost, resistance + environmental impact Intra generational justice	Human flourishing Inter-generational justice	Anticipation Engagement Reflexivity	N/A	
Stakeholder Mapping	Analyze case study on bicycles by a set of predetermined stakeholder groups	That social groups shape innovation.	“Initial” Engagement (People matter) Human Flourishing	Hand	
Opening The door	Read Missing Masses / Use worksheet to Analyzing Latour’s door/groom and the social and labour function of technology in society	How technologies affect human labor and what/how to grasp that relationship	Livelihood opportunity -- Reflexivity	Head	
Tech Fix	Apply Sarewitz and Nelson (2008) framework to their project.	If their own tech is an appropriate technical fix	Reflexivity	Head	
Building Responsible Innovation	Use examples, come up with important questions, design a process to consider questions	A process to manage/explore to unpredictable nature of their S&T.	L need to build capacity for such RI questions and understanding of how it might integrate into	Hand and Head	

			research.		
N/A	<p>Minds Inventor –</p> <p>Potential projects pitched to members of (re?) public</p> <p>Public vote</p> <p>Review committee of public</p> <p>Incorporate reflection in research application</p>	<p>A pitch ‘science lecture style’</p> <p>[cairing public evech?]</p>	Engagement	N/A	
Siting the Wind Turbines	<p>Role play as planning officer – decide on wind power in your region.</p> <p>Inputs – conflicting information (‘research’) + opposition from some stakeholders.</p>	<p>Experts also disagree</p> <p>Human flourishing?</p> <p>Justice</p>	Engagement	Hand and Heart	
Design Improved Cookstove for sub-Saharan Africa	How would you go about it?	The “Whole system” – inc. where to start	Anticipation + Engagement + Reflexivity	Hand and Head	

Poetry workshop with girls learning new skills / body of knowledge	Writing poems Reading them allowed	Understanding of Rhythms + language	Locate with literature courses at Sheffield	Head and Hand	Knowledge from poet influences learning outcomes
Poetry workshop with girls → practical criticism	Reading poems to each other	Whether their poem is any good	Learning to listen + appreciate	Head	
Poetry workshop with girls → re-imaging futures.	Writing poems	How language works Their hopes and fears	Linking to hope / utopia English at Sheffield	Heart and Head	Knowledge from school influences learning outcomes
Cultural Context of Civic Engagement aka Imagine	Writing poetry	Poems	Voice, including cultural context of civic engagement Aka imaging	Heart	
Global Policy Priorities	Consider a list of 'grand challenges' facing the world, and rank them in order of importance	Different groups of students rank the same challenges very differently	Enables students of public policy + administration to reflect on their place in the world.	Head	This is for social scientists! Sarewitz + Bozeman: Public Value Mapping
Global Policy Priorities	Consider list of 'grand challenges'	That prioritizing policy challenges is hard to do objectively.	Policy and STS should engage beyond expert groups	Head	For social scientists!

Evaluating	Evaluate/reflect either the process in “Building RI” or a live case study.	Ability to critically evaluate attempts to consider unpredictability of sci-tech w/in research	How do we know what outcomes of RI are?	Head	
Promises & Speculation	-Suggest a research activity -Explain why I should fund it -Produce a new unanticipated technology from two proposals	That sci & tech is promissory & unpredictable	Entry point for A.G. → Raises questions about how we deal with that	Heart	
Ethics Patient Structural Case Analysis	Identify an Ethical issue that applies to patient management	Human flourishing. ? Inter-generational justice	Anticipate Engage Reflexivity	Head	
‘Horror’/’Wow Stories of Research & Innovation	Using short video to tell a narrative (either good/bad) example of research/innovation	A story with an important message	Demonstrating/mobilizing students to at least want to explore applications of RRI	Heart	
Lego Serious play (1)	Use lego to build a model	A model which helps them tell a story in response to a question	How they think / what they think is being responsible	Hand	

Lego serious play (2)	Tell the story of the model to the other participants	Their own assumptions/values/cares, etc.	Inclusivity, everyone gets a change to tell their story	Heart (& Head/Hand?)	
Lego serious play (3)	Choose the most important part of the individual model and make a shared model from all of these	These insights to create a shared idea/model of something	Will end with a representation of what each person values most in response to the question.	Heart	
Lego Serious play (4)	Group discussion of everyone's answers, what's the "take-away" synthesis?	Different points of view, different contributions, different aspects beyond their own imagination	Can end in a plan of action which encompasses the values, etc. discussed	Head	
N/A	Designing "human" robot	Key characteristics of what it means to be human	Reflexive thinking	Hand	
N/A	Unknown game	Role of emotion in decision making	Critical view on [???	Hand and Heart	

N/A	Design an enhanced robot	Future humans	Anticipation of future technologies Reflect on social responsibility	N/A	
Building a SynBio Research Centre	In small groups, folk will: (1) Discuss a specific RC call for research centers, (2) consider who to involve, (3) come up with a focus + some big RQs	How to 'read' EPSRC project calls What factors need to be taken into account Aspects of organizational structure in scientific enterprises	How social + technical concerns are entangled, even (!) in basic research. Reflexivity	Hand	Tried out with MSc Bioengineering students. Process not outcome is important.