



## Navigating the labyrinth of RI through a practical application — A case study in a cross-disciplinary research project

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### ABSTRACT

Responsible Innovation (RI) aims to enable research and innovation to take a more systematic approach to anticipating potential risks and consequences of planned research/innovative outputs. The Anticipation, Reflection, Engagement and Action (AREA) framework provides a flexible mechanism for organisations and researchers to align research and innovation with societal values, needs and challenges. However, its actual application may prove challenging for practitioners. In this paper, we describe how the AREA framework has been embedded in an interdisciplinary research project in the UK over the period of 2019–2021 through dedicated monthly RI workshops. To gain insights from this practice, we have collected qualitative data from discussions throughout the project and performed a systematic analysis of the logging practice itself. We discuss benefits and challenges associated with embedding an RI framework within an interdisciplinary research team, and present recommendations for future adoption of the AREA framework in a cross-disciplinary research setting.

### 1. Introduction

Responsible Innovation (RI) or Responsible Research and Innovation (RRI) (see [Owen and Pansera \(2019\)](#) for a discussion of the distinction between these) is expected to guide the practice and process of scientific research and innovation to ensure their alignment with societal needs, values and challenges. In the UK, the main funding council UK Research and Innovation (UKRI) advocates the adoption of the 'AREA' framework: the integration and embedding of capacities for Anticipation, Reflection, Engagement and Action — based on dimensions described by [Stilgoe et al. \(2013\)](#). The AREA framework is similar to the Dutch NWO-MVI (Dutch Research Council Platform for Socially Responsible Innovation) approach, which entails being 'proactive' and interdisciplinary ([Swierstra & Rip, 2007](#)), and the RCN (Research Council of Norway) that frames RI in terms of 'Look forward, Think through, Invite in and Work together' ([Egeland et al., 2019](#)).

However, although the AREA framework, as with other similar approaches in RI, is expected to provide an interpretive flexibility,

this lack of practical application guidance has made its application challenging in practice. In this paper we show how members of an interdisciplinary collaborative research project team worked together, to explore the establishment of an RI approach in practice, namely 'RI workshops'.

The fundamental aim of the RI approach is to ensure the societal soundness of the final products. RI should facilitate the development of a responsible process within an organisation/team towards such an outcome. We have seen work examining how involvement with stakeholders may lead to a more socially responsible product and reflecting how this process affects a team from within [Glerup et al. \(2017\)](#), [Lee et al. \(2019, 2019\)](#) and [Pansera et al. \(2020\)](#). However, most existing explorations have not discussed detailed case studies on *how exactly an RI approach is taken within an organisation or project team*. Given the diverse notion of an RI approach, these details are critical for us to establish a fuller understanding about how RI should be applied, what has worked and lessons learned. Our paper makes

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specific contributions to this aspect by documenting the process we took to develop the application of RI within an interdisciplinary and cross-institutional research project team, and presents critical lessons we have learnt from this process.

The contributions of this study are twofold: we report a systematic process of developing and applying ‘RI workshops’ in an interdisciplinary research project, and share the lessons we learnt through the process. To qualitatively monitor and analyse this developing and applying process, we collected and analysed the discussions that took place in each RI workshop, along with records of how the workshops affected the development of the project. Through a systematic analysis of the recording data, we identified the benefits and challenges associated with the application of RI in an interdisciplinary team and present a set of recommendations for applying RI practices in interdisciplinary research projects.

Our analysis shows the RI approach has been effective to (1) facilitate internal conversations, (2) deepen communications, (3) accelerate knowledge exchange, and (4) ensure inclusivity. Although the RI workshops were effective to bring together researchers from different disciplines and levels of RI experiences, there were challenges arising from the widely varying RI experience of participants, and in ensuring that the findings from the RI workshops were carried into the substantive work of the project. We recommend four key considerations for future practical adoption of RI approaches in research settings.

## 2. RI workshop – Our RI approach

### 2.1. Background

Our RI approach was developed under the context of a two-year research project funded by the UK Research and Innovation (UKRI), a major research funding body in the UK. The collaborative project brought together interdisciplinary expertise from three institutions and diverse disciplines, ranging from AI, psychology, mental health, RI and human computer interaction, with the aim to explore the key open question: *what causes people to trust, or fail to trust, existing online platforms and how is it possible to develop novel trust-building technologies to address users’ concerns?*

Algorithm-driven online systems are increasingly encountered in everyday life, making recommendations on what we might like, predictions about how we might act, and filtering information in websites offering services such as making bookings and job recruitment. This reliance on algorithms can give rise to uncertainties and tensions by users regarding how these algorithms arrive at their results and how data is used in sometimes life-changing decisions. These tensions can result in a breakdown of trust. Thus, a human-centred approach is greatly needed to produce technology and design principles that will foster user-algorithm trust. To this end, we assembled a team of frontier HCI, AI and digital mental health researchers to design and create two novel tools: (1) an *Algorithm Playground tool* that allows users to evaluate and critique algorithms used by online platforms, and (2) a *Mediation tool*, to engage users in dialogue and collective reflection with platforms in order to develop better trust of technologies.

The application of RI was built in from the onset because of the cross-disciplinary nature of the project and its exploration and building of trust technologies. An RI approach was intended as the means to integrate the inputs from different voices of diverse stakeholders, to ensure the development of technologies truly reflecting their needs.

### 2.2. RI workshops

To achieve this, we developed a format of monthly RI workshops, after three iterations of trial-and-errors.

This workshop involves a core project RI team, who meet monthly and constitutes (i) four *Team RI leads*, one from each of the four partner institution to champion RI practice in the research project and ensure

communication and shared understandings in each individual partner team, and (ii) a *Project RI lead*, whose responsibility was to champion the RI practice for the project and ensure critical knowledge transfer about RI practices and principles within the team, due to the varied levels of expertise in this respect. This has proven critical to the success of our RI practical applications and our co-development process. The Project RI lead is an existing team member of the lead institution, who has extensive experience in both RI research and training. Although the majority of the RI team had little practical experience with RI, our Project RI lead had played a pivotal role in ensuring all members developed a good understanding of RI principles through practice.

Our research project had four work packages (WP) which we list here because they are used later to identify roles in our discussion of the results:

- WP1 Responsible policy and practice, using an RI-based approach to establish a joint understanding of responsible trust and the relationships between policy and design;
- WP2 User-centred trust, for identifying user requirements for rebuilding user trust;
- WP3 Computational method for rebuilding trust, creating semi-automated mediation techniques and tools to recover from trust breakdown;
- WP4 A trust rebuilding tool: development of a software artefact ‘mediation tool’. Note that WP3 and WP4 were led by the same project partner organisation.

The background of the RI team is summarised in [Table 1](#).

At the start, given the interdisciplinary nature of the consortium and variability in experience of RI, we began with the step of ensuring all members had a good knowledge about what RI is and how to do RI, which was led by the project RI lead R5. After two iterations of piloting and related training, when we were confident that all Team RI leads were ready to practice RI logging for their team, we began to introduce ‘RI workshops’ as part of the project activity.

During each month, the Team RI lead from each team logged their RI-related activities onto an RI template (see [Fig. 1](#)). At the end of each month, the new logging template would be passed to the Project RI lead, who would coordinate an hour-long ‘RI workshop’ call with the local leads to discuss the activities and related RI issues.

During the workshop, each participant first reported their RI-related anticipation, reflection, engagement or act activities over the period, and other participants were given an opportunity to ask questions to stimulate a brief discussion about each team’s activities. This format provides a semi-structured format for sharing knowledge about a specific topic by all participants and also a sufficiently flexible space for stimulating conversations amongst participants and sharing of further experiences and observations.

Once this final RI practice format was established, we started to keep an audio recording of each of our monthly workshops as research data so that we could learn from this process, regarding the benefits of such practices and any further opportunities and challenges.

## 3. RI logging and data analysis

This paper makes a unique contribution to the community by presenting practical experiences gained through applying RI in an interdisciplinary research project, and through a systematic logging and analysis of how RI was applied throughout the project. This logging data includes two parts: (1) audio recordings collected in each RI workshop, and (2) the RI logging templates ([Fig. 1](#)) completed by each Team RI lead.

From October 2019 till December 2020, we collected audio recordings of seven RI workshops — September, November, December 2019,

**Table 1**  
 Researchers involved in the regular RI workshops and their background and RI expertise.

	Role	Expertise/Background	RI Experience
R1	WP2	Science, ethics and HCI	Some experience of RI including citizen participatory research, co-creation, and outreach activities
R2	WP3/4	AI and computer science	No RI experience prior to the project
R3	WP1	Computer science and HCI	Limited RI experience
R4	WP1	Computer science and HCI	Over 5 years experience of practising and researching RI
R5	WP1	Project RI lead	Over 5 years experience of practising and researching RI

### Activity Log Template

To be updated monthly:

- by the dedicated member of the WP RI lead prior to the RI workshop - activities and elements of these which can be constituted as RRI
- this will be sent with the agenda in a Google Doc to be filled in *before the RRI workshop*
- use bullet points/different lines to differentiate entries within WPs

Example

Activity Log				
	Relevant Milestone	Activity	AREA Plus Framework Category? <i>(Anticipate, Reflect, Engage or Act; if it fits under more than one please indicate this through the creation of multiple <b>Category</b> entries for same activity)</i>	
1	Stakeholder workshop	Setting agenda	Engage	Selection of multiple stakeholders from different professional backgrounds to ensure that we have a good, diverse perspective.
2	First Phase of citizen Juries	Conducted a citizen jury in Nottingham (+65s)	Anticipate Engage	We looked at scenarios with stakeholders to see what kind of interface they would/would not like to see in our prototype- these have been logged for data analysis & integration into the next development of the prototype.

Fig. 1. The RI Template: an activity log template for our monthly RI workshop, organised by the unit of activities to permit more flexibility for activity logging and reflection.

March, April, May 2020 and January 2021.<sup>1</sup> Each workshop lasted approximately one hour and all the recordings were professionally transcribed verbatim. We also collected the logging templates completed by each Team RI lead, which provided important background information to complement the discussions in the recording. A typical workshop involved four researchers, three of them as the Team RI lead (R1-4) from each individual research team and one of them being the Project RI lead (see Table 1).

We used the grounded theory to analyse our qualitative workshop discussion data and adopted the Thematic Analysis approach from (Braun & Clarke, 2006). The lead author carried out the first iteration of analysis of all the audio recording transcripts, and three co-authors discussed and confirmed the notebook together. In the following, we present key observations from our practice.

#### 4. Observations of RI in practice

The systematic data logging and analysis provided a unique opportunity for us to observe how the AREA framework is pragmatically interpreted and applied, and for us to observe what worked well with this collaborative RI approach, what worked less well, and what lessons we could share with the community.

To begin with, we have seen our research development had been influenced in important ways, including *better internal collaboration, deeper communication, more productive knowledge sharing amongst an interdisciplinary team and an increased consideration of external inclusivity.*

These benefits were observed from both our everyday project activities and sometimes discussions facilitated by the RI workshops.

##### 4.1. Facilitate internal collaboration

We anticipated that the application of the RI approach in the project would help us to foresee undesirable risks and increase the transparency and accountability of our outcomes. This internal collaboration could be observed both in everyday project activities and in discussions taking place in the RI workshops. Indeed, we observed through our self-reflections that the RI workshops could create a dedicated space to strengthen cross-team communications, which is crucial for knowledge sharing, efficient application of a user-led approach and better synergy between research teams.

As described in the previous section, the RI approach encouraged team members to reflect on the implications of actions (such as the design of certain user engagement activities or the design of the technological output), and make an anticipation of their design choices. In contrast to the regular bi-weekly project meetings, the monthly RI workshop allowed the Team RI leads from each team to collectively reflect how each action from each team may be relevant to the other teams and for the project as a whole. This was crucial for us to ensure that there was continuity between activities in each work package and that the cross-work package research activities were truly cooperative and led by empirical research.

For example, in the quote below, the technical researcher (R2) shared their concern about the validity of the initial user scenario they chose for their early prototype of the Mediation Tool. In particular, R2 raised potential legal issues that might be involved in the scenario in question (an e-recruitment scenario):

<sup>1</sup> The 2020 COVID-19 pandemic and change of personnel in the team has introduced some disruption in our RI logging.

“So we have especially been stuck for some time about two main questions because it was a big issue that needed a lot of discussion and a lot of brainstorming to answer. So first, it’s about the legal characteristics of candidates because the law forbids recruitment websites to ask many personal information and then we have been struggling with the question of justifying to display some characteristics that are forbidden and we are not supposed to ask and use”. — R2, workshop April 2020

As a result of these extensive cross-WP discussions, triggered by the reflections in the RI workshop, the technical team revised their initial design of the user scenario and avoided creating digital personas that may raise more legal debates in the process of mediating users’ perceptions of algorithmic fairness.

This example shows that reflection from the RI perspective in the RI workshops has not only helped us to identify the challenges that a team faced, but also surfaced the design rationale that was undergone by the technical team. This process was crucial for us to identify the need to bring in inputs from other researchers who were more familiar with the legal and design issues to suggest possible ways to overcome the challenges.

#### 4.2. Deeper communication

Our RI approach also encouraged deeper communication about the rationales behind our actions, and most importantly, permitted reflection and allowed agile intervention to address emerging issues. In addition, the RI workshops provided an opportunity for team members to critique and contribute to a reflection of this process.

For example, during an RI workshop, in response to how our technical team made a decision about choosing ‘chatbot’ as the starting point for our Mediation Tool prototype, the discussions brought in the inputs from the Advisory Group members by R1, regarding how the group members perceived the Mediation Tool should support. This discussion further led to expanded discussions in the regular project meetings, regarding how users’ perceptions should be taken into account in the tool design:

“Yes, they didn’t feel that any of the scenarios, there was a kind of mediation there,..Because of the dialogues, you know, it was more like the platform wants this and we’re trying even either explaining you why they want it, but they’re not letting you get in any options” — R1, workshop December 2019

“Yes, I wonder, whether at the next project meeting – [...] we could perhaps, if you’re happy to share this, [R1], just have a session or an agenda item to discuss this on the call?” — R5, workshop December 2019

As a result of these deepened conversations, the design of the Mediation Tool was re-planned, to avoid a ‘chatbot’-like user interface, which is distrusted by most stakeholders. Instead, the team chose a human-in-the-loop approach that allows more users’ inputs during their interaction with an AI-mediated mediation tool.

Discussions like this during the early prototyping were crucial for the technical team to rethink their initial designs, i.e. acting responsibly according to users’ inputs. The RI workshops played a critical role during technical discussions by bringing the interdisciplinary perspectives more closely together and facilitating a better communication of these different perspectives, and as a result, led to a more transparent design process that is more closely aligned with users’ needs.

#### 4.3. Accelerate knowledge exchange

Another benefit from an RI approach was the facilitation of cross-disciplinary knowledge transfer and better synergistic work between the different work packages. As mentioned above, the RI workshops enabled better communications and articulation of rationales and implications.

The workshops also provided an open space for team members from other disciplines either to ask questions as an outsider of the research discipline or contribute their expert knowledge. For example, the following quotes were provided by the technical team member R2, discussing their concerns about the RI aspect of their design, which nicely reflected how their participation in the RI process affected their design approaches:

“I guess this whole doing this Sandbox scenario thing has been very, very challenging[...]. So, obviously, for example, things like making sure that we actually comply with legal requirements and so on and don’t imagine that the e-recruitment scenario is going to be discriminating and and things like that, is an important aspect of responsible innovation” – R2, workshop April 2020

This demonstrates the critical value of cross-disciplinary collaborations which offered an opportunity for researchers from different disciplines to provide candid inputs and articulate the nuances of their specific methodologies. The following quote captures R3’s candid reflection about the challenges of working across disciplines:

“I wouldn’t raise that as a concern. I think I would raise it as this would be a much better way to ensure the communication, cross-group communication, because I’ve found that if we do retain a rapid communication pattern, practice, it’d be really helpful for everyone [...], I would definitely opt for a more agile kind of communication practice.” — R3, workshop December 2019

It is through these candid communications between researchers from very different research backgrounds that we identified key challenges and communication issues, for example, to achieve a balance between a user-driven approach and the need to achieve breakthrough computer science theoretical research. As a result of such practices, the team built up a closer relationship and better trust of each other’s research expertise and approach, all of which are critical for a cross-team and cross-disciplinary research to be truly effective, and for a user-driven development process to be more meaningful and successful.

#### 4.4. Ensure inclusivity

Inclusivity is core to our RI approach and this topic came up often in our workshop discussions. As summarised by our Project RI Lead, this practice made a crucial impact on the research findings we managed to achieve in the project, regarding how different populations might perceive trust of algorithms differently, and require supports differently.

“So we’re really having interesting discussions and this is because we have taken this inclusive approach, that this has really been allowed to emerge through reaching out to different people in regard to what is our role in all of those. [...] what becomes clear is they do bring very different understanding in some cases to their interpretation of the explanation. [...] So, I think that there will be a lot of interesting things that come out of it and we’re really looking forward to working through that more”. — R5, workshop April 2020



The RI workshops were also particularly instrumental for researchers to reflect on the inclusivity of the external stakeholders involved in our studies. In this quote, R1 talked about interactions with the advisory group — an external group of stakeholders who volunteered to help with ensuring internal project developments are user sensitive and thus user driven.

“... what we’ve been concentrating on is getting together with the advisory group for the co-creation activity. So when we engaged with the 16 to 25 year olds last Wednesday [...] we were very excited” –R1, workshop December 2019

Our researchers found it exciting and rewarding to interact with the younger user groups directly, who have been often left out of the design process of future technologies. This led to particular insights regarding how to develop trustworthy technologies for young people, in contrast to our separate focus on the older user participant group, the 65+, who have also been largely left out of the user-led technology design process, and our researcher reflected on how they had endeavoured to ensure the inclusivity of these participants at times when scheduling was a challenge:

“... the other thing related to the advisory group is that on the older group, there were some problems with the date, so we have to reschedule it and then they cannot do it that day either, so we have to leave it for January [...] So, actually, now I can put reflection as well” – R1, workshop December 2019

#### 4.5. RI workshops: A reflection on the method

The RI workshop format was developed through three iterations of co-creation, building on feedback and inputs from all RI leads championing the RI practices of their respective team. The resulting dedicated workshop format served a fundamentally different purpose than other project-related meetings and complemented them in several ways.

However, as reflected in our final RI workshop, this dedicated workshop space and involvement of only selected project members may have created a separation from the rest of the project team. When designing and developing the RI workshops, we carefully considered how to look at project activities through the RI lens and expected all discussions from the dimensions, such as engagement and act, would lead to direct impact on the rest of the project. Furthermore, the developments of the RI workshops were regularly reported by our Project RI lead in our bi-weekly remote project meetings and quarterly face-to-face project meetings (prior to the COVID pandemic). Although we did not deliberately set up a process to bring the outcomes from the RI workshop to the rest of the project, our RI leads have reflected that they have often found the RI workshop discussions useful and would thus report them back to their own teams’ regular meetings.

#### 4.6. Lessons learnt: Challenges of adopting RI

The adoption of RI in a cross-disciplinary team has not been without challenges. As summarised in our initial reporting, most of our Team RI leads involved in the practice had little or no experiences with the RI methodology. This can be a key barrier to a successful and meaningful adoption of RI. Thus, it was critical for us to have an in-house RI champion (i.e. our Project RI lead), who was an expert in RI-related research and a practitioner; and secondly, a strong leadership team who were committed to the RI approach from the onset.

The second challenge that we have recognised was to keep track of the impact of the RI approach. Despite the effort involved to ensure that RI discussions were carried to all team members, this was a success, owing to buy-in to the principles of RI. However, future adoption of our approach would probably need to be mindful of any potential gap of knowledge communication due to the set up of the RI reflection space and the rest of the project team, as mentioned by R3 in our final RI workshop:

“I think, I don’t know, but it’s just something, you know, if this is something that is happening within our little RI workshop, how does the discussions taking place, within these workshops, being infused to the rest of the team, you know, that’s something quite difficult for us to measure”. — R3, final workshop, January 2021

Related to this, a further open challenge we learned through our experience is retaining the continuity of RI, i.e. how to ensure that all the discussions taking place in a previous RI workshop and decisions made will be followed up and acted upon within a team/project. The RI workshop format was effective for us because the relatively small size of the research team and an established communication channel within each individual research institution, from the Team RI lead to their team members and vice versa. Again, this was raised by R3 in our last RI workshop:

“But I think that being able to have some kind of continuity, and being able to establish the process as a kind of an iterative process, like what agile methodology does [...] you said, you’re going to do this, and then the next meeting, see, that’s what you say you’re going to do about that, and how did it go, from kind of RI point of view? I think that’d be probably something nice to strengthen”. — R3, final workshop, January 2021

#### 4.7. Recommendations for future applications of RI

We recognise that the application of the RI approach can be challenging and our exploratory process of applying the AREA Plus framework by engaging all team members and taking a co-development process has led to some critical insights about key considerations for future applications of this framework within their teams or organisation. We make the following four recommendations:

1. Ensure a strong commitment of the RI approach from the leadership team and the majority of the research team: Several related previous efforts have also confirmed that the buy-in from the leadership team is critical to a successful application and integration of RI approach in a project (van de Poel et al., 2020). Our work has further shown that a deep embedding of RI approach through appointing designated project and work package RI leads goes a long way to ensure regular RI focused reflections and applications throughout a project.
2. Ensure sufficient RI knowledge is present in key team members in each work package to guide the initial adoption process and training of the team. In our initial iterations of developing RI adoption in the project, we struggled to establish a common understanding and uptake of the RI approach in a project that involves researchers from multiple disciplines and with varied degrees of knowledge about RI. A dedicated training session at the beginning of the project made a lasting impact on the team and strongly motivated researchers with little prior RI experience to be involved or take leadership roles.
3. Ensure a systematic process is established to keep track of the impact from an RI approach and avoid the creation of any gaps of knowledge communication. To our knowledge, our study is the first to systematically record and analyse the process of applying RI approaches in a multidisciplinary research project. The systematic analysis of the recording data and the follow-up reflection of each RI workshop provided tremendous inputs for our observation of what worked and what could be improved. Although such a practice may not be practical to all projects, the RI workshop logging template (see Fig. 1) that was produced by us in this process, which has been revised iteratively throughout the project, could provide a useful starting point, for projects to create an audit trail of discussions, reflections and actions.

4. Consider RI as a learning process for communication in the team, where RI-related activities are in a dialectic with other research activities and vice versa. As shown in our experiences, we underwent a trail-and-error process to get the RI application right, even though we had a strong in-house RI expert. We encourage research teams to be open minded about the RI adoption process and expect a journey involving iterative mutual learning. Furthermore, one other critical lesson we learnt from our experience is to bridge the gap between what takes place in a RI workshop and the rest of the project. The sharing of knowledge could be fragmented and ensuring mechanism are set up to facilitate regular communication within and across teams is crucial.

## 5. Conclusion

Our systematic approach to RI throughout an interdisciplinary research project and team provided a case study with evidenced “added value” of embedding RI in research. Through a principled approach of collecting and analysing the qualitative data generated during this process, we identified key benefits and challenges associated with embedding an RI framework. We conclude by presenting four recommendations for the community to apply the AREA framework in academic research setting, and we hope to continue our journey of assessing this principled method in different settings and exploring channels for addressing some of the identified challenges.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## References

- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.
- Egeland, C., Forsberg, E.-M., & Maximova-Mentzoni, T. (2019). RRI: implementation as learning. *Journal of Responsible Innovation*, 6(3), 375–380.
- Glerup, C., Davies, S. R., & Horst, M. (2017). ‘Nothing really responsible goes on here’: scientists’ experience and practice of responsibility. *Journal of Responsible Innovation*, 4(3), 319–336.
- Lee, E. A., Gans, N. R., Grohman, M. G., & Brown, M. J. (2019). Ethics as a rare bird: A challenge for situated studies of ethics in the engineering lab. *Journal of Responsible Innovation*, 6(3), 284–304.
- Owen, R., & Pansera, M. (2019). Responsible innovation and responsible research and innovation. In *Handbook on science and public policy*. Edward Elgar Publishing.
- Pansera, M., Owen, R., Meacham, D., & Kuh, V. (2020). Embedding responsible innovation within synthetic biology research and innovation: insights from a UK multi-disciplinary research centre. *Journal of Responsible Innovation*, 7(3), 384–409.
- Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy*, 42(9), 1568–1580.
- Swierstra, T., & Rip, A. (2007). Nano-ethics as NEST-ethics: Patterns of moral argumentation about new and emerging science and technology. *Nanoethics*, 1(1), 3–20.
- van de Poel, I., Asveld, L., Flipse, S., Klaassen, P., Kwee, Z., Maia, M., Mantovani, E., Nathan, C., Porcari, A., & Yaghmaei, E. (2020). Learning to do responsible innovation in industry: six lessons. *Journal of Responsible Innovation*, 7(3), 697–707.