# Addressing Dual-Use Potentials in Chemical Research and Innovation

*by Jan Mehlich*

**Responsible Research and Innovation (RRI) is a concept that describes approaches and strategies to addressing and tackling risks and dual use potentials of research and development (R&D) activities that have significant societal and environmental impact [1]. Built on a scientifically rigorous foundation of RRI knowledge and expertise, the translation into applied and practical contexts such as chemical R&D is underway [2]. Here, a framework for integrating environmental and ecological ethics dimensions into chemists' scientific integrity and good scientific practice guidelines is suggested under the umbrella of RRI.**

The proposal is rooted in the following premises that are explained in the subsequent sections:

1. Normative (ethical, legal, social, environmental) implications of design decisions in research and innovation contexts are framed and assessed in discourses that take place between involved stakeholders such as researchers, designers, managers, entrepreneurs, regulators, and (sometimes) civil society.
2. There is no one right solution for ethical challenges and dilemmas, but the final judgments are the result of a deliberative discourse process.
3. Dual use potentials of chemical R&D are identified and, to certain degrees, controlled through well-conducted discourses.
4. The role of chemical experts in R&D is to inform these discourses with chemical knowledge while, at the same time, being receptive for the normative assessment of "what is at stake."
5. Fulfilling this role is a skill that can and should be acquired during tertiary education.

In this feature, I illustrate how the interdisciplinary integration of normative discourse competence into chemical R&D processes at the academic and the corporate level greatly informs and improves the efforts to tackle dual use issues by empowering chemists to represent ethical, societal and environmental dimensions in their assessments. I show that the key to making good (ethical) choices in chemical R&D is not theoretical knowledge of ethics but practical discourse skills that arise from RRI training.

## Premise (1): Research and Innovation as a Discourse Arena

Chemists—here defined as practitioners and experts with a degree in chemistry or chemical engineering—work in interdisciplinary teams of people with diverse backgrounds and different views. In both academic science and corporate R&D, the daily activities of chemists include planning, designing, aligning, and communicating research as well as defining and negotiating research purposes, goals, and directions. While, certainly, being oriented towards the virtues of good scientific or engineering practice including objectivity, truthfulness, scepticism, and an immunity against other non-scientific interests such as fame, power, or money, the work that chemists do is inherently normative. That means that choices made in the research or innovation process, from major plans down to the level of distinct design choices, are embedded in and informed by a framework of societal, cultural, ethical, and legal norms and value propositions [3]. Why are we doing what we do? What is the envisioned innovation good for? Who benefits from it? What are the impacts and the risks? These questions cannot be answered solely on scientific-analytic grounds but are posed and answered in a research or innovation team. The diversity of such teams may, sometimes, make the process of finding answers more complicated and tedious since different team members have very different perspectives. Technical considerations may clash with economic interests; monetary margins may conflict with the material requirements for a suitable design; or the proposed solution may not be in line with the preferences and needs of users. Yet, it is the diversity that is required to elaborate the best outcome: While a team of scientists or engineers would quickly identify the best possible research plan, the other stakeholders contribute important information and views that allow constructive critique and refinement of these plans. Being challenged by critical scrutiny from non-scientific and non-technical actors involved in research and innovation is a key necessity for the success of a new technology, a new process, or a new material.

Discourse, here, means the process of communication and deliberation concerning issues related to a shared activity. It neither means quarrel or fight, nor flat information sharing. A discourse situation may occur formally in team meetings, in labs, at conferences or business consultations, or informally among team members during coffee breaks, at lunch, or on the corridor

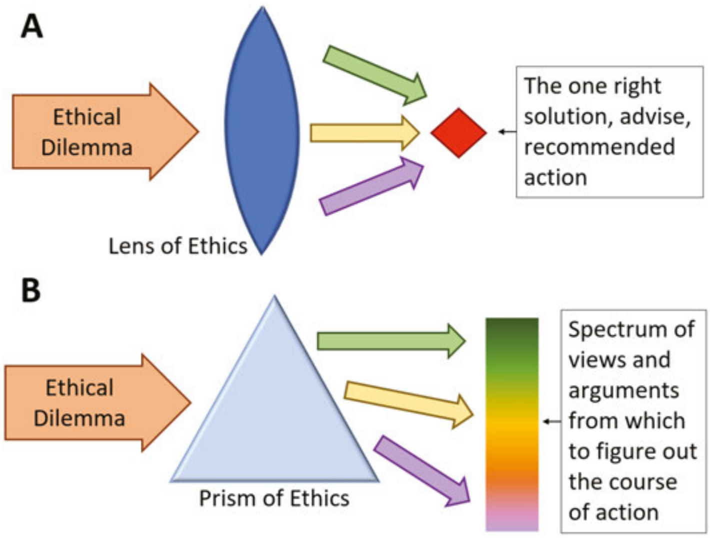


Figure 1: (A) Ethics as a lens focussing on the one right solution. (B) Ethics as a refracting prism yielding a spectrum of viewpoints.

between labs and offices. Written correspondences, for example via email, may qualify as discourse, too. What makes a conversation a discourse is the seriousness and rationality with which viewpoints are verbalised, arguments are brought forward, feedback is received, others are listened to and taken seriously, and decisions and conclusions are actively sought for. Some discourses stay on a cognitive level: What is the problem at hand, what knowledge do we have about it, and which solution does this knowledge suggest? Other discourses revolve around norms and values: What shall we do? What is at stake? How do our choices affect a value X (with X = safety, justice, integrity, sustainability, *etc.*) [4]? It is important to note that the scientific-technical experts such as chemists are not only involved in the cognitive discourse part of R&D (figuring out the best pathways towards the research goal), but also in the evaluative and normative discourse elements. Choices can only be made properly when the facts are on the table: What are our options? What are we able to do? What are the risks? It is the linkage of these two discourse types that usually leads to the best decisions. Before going into further details on this, and to avoid misunderstandings, it is important to point out the role that ethics plays in the discourse process.

### Premise (2): The Role of Ethics

The parlance of *ethical implications* or *ethical dimensions of research and innovation*, sometimes, evokes impressions of having to do with moral philosophy or theoretical principles. This worry can be dismissed here. While, admittedly, some conflicts and dilemmas related to scientific progress and technological innovation may be solved with the help of applied ethics expertise, what is suggested here is a very pragmatic and practicable concept of normativity. It covers all aspects related to norms and values that go beyond ethics and morality. Law, culture, society with all their facets of the life world are pervaded by implicit and explicit norms.

Ethics, then, comes into play neither top-down from some moral gatekeeper (a philosophy, a religion, a tradition, or a political council, for example), nor bottom-up from an ever-repeating case-based exploration. What is ethical—that means what is the *right* or *good* thing to do—is the result of a deliberative discourse process in which the discourse participants represent their value commitments truthfully and find overlaps and mismatches. With facts and norms on the table, it is possible to employ principles of fairness, rationality, and inclusiveness in order to figure out what is right or good.

This process is often referred to as *wide reflexive equilibrium [5]*: In a well-conducted discourse, when the hierarchies are flat and the feedback loops are intact, when no voice is excluded and no argument is stronger merely out of power (of the speaker) or rhetoric lure, the result may qualify as an ethical maxim or judgment after it went through several cycles of scrutiny, feedback, and refinement. This constructivist approach to ethics stands in contrast to ethical realism (the view that ethical guidance comes from either the world as it naturally is, or from a transcendental entity such as a god), and to ethical non-cognitivism (the view that no rational process but only intuition, emotion, or an anything-goes attitude can yield ethical insights).

This approach to ethics has important consequences for the meaning of discourses on ethical and other normative dimensions of research and innovation. Participants cannot rely on ready-at-hand orientations in the form of guidelines, codes, or even rules or commandments. At the same time, norms and values are not random or relative but are constituted by the social and cultural lifeworld in which the discourse is situated. With other words: Ethical orientation doesn't require any form of ethics expertise (for example, a degree in philosophy) or specific knowledge (for example, on the definition of human dignity, or competing principles of justice). Being an aware and open-minded member of society is sufficient. It also means that the expected result of a normative discourse cannot be *the one correct conclusion*—as convenient and attractive that may appear—but the clarified *spectrum of views* within which the most plausible and convincing one must be identified (Figure 1).

### Premise (3): At the Crossroads

*Dual use* means that besides intended gains and advantages, new technologies or processes may have adverse effects or are utilised for other than the intended purposes, sometimes anticipated, sometimes surprisingly, sometimes totally unforeseen. The question is, at what time in the development process did these pathways towards appreciated usefulness and unwanted risk open up, and whose decisions lead to that? The chemist knows many strategies and assessment methods to avoid negative impact of new materials, substances, and processes: risk assessment, life cycle assessment, toxicity analyses, environmental impact assessment, and others. Yet, these cover only a small fraction of the factors that play a role in dual use contexts [6].Textbook examples for dual use cases in chemistry are Frans van Anraat's trade of thiodiglycol for the Iraqi regime in the 1980s, claiming that it was intended for the local textile industry while it was actually used as the precursor for the chemical weapons mustard gas and nerve gas [7], or Arthur Galston's synthesis of 2,3,5-triiodobenzoic acid (TIBA) as a fertilizer that became famous as *Agent Orange* after its defoliation properties at higher concentration was exploited by the US military in Vietnam [8]. While van Anraat was convicted of complicity in war crime, ever since denying any responsibility for the creation and application of chemical warfare agents, Galston throughout his lifetime endorsed the duty of chemists to keep guard of the usage of their own findings. This, to many, seems like an unfulfillable demand. Too hidden and complex are the decision-making pathways that lead to misuse or dual use. The more basic the chemical research that leads to it is, the less responsibility the chemist has and the bigger the impact of other interests (meant are, supposedly, economic, political, or monetary interest) are, so the claim.

Certainly, the responsibilities for dual use risks are of the collective rather than the individual type. Yet, that doesn't mean that individual actors such as the scientific-technical developers of innovative technologies can hide behind this concept and are ridded of all responsibility. Dual use potentials spring from the earliest stages of technoscientific development and, thus, can be comprehended and considered in prototype designs and even in research plans. While the space here is not sufficient for going into the details of a very complex endeavour (key words: value-sensitive design, open innovation, design thinking, ethical vision assessment, *etc.*), one central point shall be highlighted: The identification of dual use potentials cannot be done by scientific-technical staff alone, but is always a task for multi-stakeholder teams that deliberate on the purposes and implications of R&D projects from different perspectives. When knowledge of use cases, of environmental and societal impact, and of the normative stakes is at hand, R&D activities can be aligned and adapted so that an envisioned future becomes more and misuse or unintended side effects become less probable.

### Premise (4): The Role of Chemists

As claimed above, chemists *qua* their expertise (as opposed to *qua* them being concerned citizen, which they are as well, of course) play an indispensable role in such discourses [9]. Premise (1) describes that good arguments consist of a factual element (knowing correctly *what is*) and a normative element (figuring out *what ought* and what value is at stake). One option would be that chemists can inform a discourse only on *what is*: Knowledge of chemicals and materials, of processes and their scalability, of toxicity and environmental impact, or of options for storing, transporting, using, recycling, or disposing chemicals. Yet, in practice, this can hardly be the case. This information is usually contextualised in an application that is more or less clearly pronounced. That means, purposes and expectations (*what ought*) are known. When being asked about the options, a chemist will usually align the information with the values that are believed to be tangent to the decision that is to be made. Now, there are two possibilities: Either the chemist promotes one value and suggests the best solution for it, or she enquires about the value proposition of other stakeholders and delivers the solution that fits best. The former is the case, for example, when sustainable or green chemistry approaches avoid toxic chemicals claiming that environmental safety is the relevant value. The latter is the case when chemists inform a public panel on $CO_2$ sequestering about the economically most feasible solution in case the panel asks for profitability, and on the environmentally most sustainable solution when the panel asks for environmental integrity as the central value.

Pielke suggested another attitude, the *honest broker*, as the ideal communicator type among scientific and technical experts in multidisciplinary settings [10]. This type would try to stir a constructive discourse by setting the science or engineering possibilities and the value propositions into perspective. That requires to understand both and to see the connections between the two, for example, what the choice of material for an industry-scale production process has to do with world market, sustainability, social justice, or regulation (in case, say, a mineral has to be mined in a developing country). Laying out the possibilities and the consequences of choosing one or the other results in above-mentioned spectrum (see Figure 1). The chemist will seldom be the one deciding over the values that are prioritised or promoted. But the chemical expertise has the power to clarify how values are affected in practice. Thus, it may be claimed that it is part of chemists' professional responsibility to share their insights with decision-makers in a way that empowers them to make a good decision.

## Conclusion: Responsibility by Training

If we take the previous premises seriously, we wish to educate chemists skilled in multi- and interdisciplinary collaboration and communication. *Responsible chemistry* would not be reduced to meaning scientific integrity and good professional conduct in the sense of not cheating, not plagiarising, and not mixing scientific interests with other (potentially conflicting) interests. Most of all, it would be understood as the competence to represent societal interests and environmental needs in one's daily practice. Chemists have a particular perspective upon what would count as *good* progress or a *good* innovation: One that works, that exhibits useful functionality and that exploits characteristics and properties of purposefully modified matter. Other stakeholders define *good* innovation and progress differently. The responsible chemist will listen to these perspectives and figure out how to preserve the value creation in terms of chemical functionality and, at the same time, create value in the societal, environmental, ethical, and economic sense.

We have seen that the key to these value co-creation processes is effective multi-stakeholder discourse. In most contemporary academic research and corporate innovation endeavours, the chemical competence is embedded into an infrastructure that provides such discourse opportunities. What is needed is training [11]. Partly, discourse competence requires methodological and practical experiences. Partly, and perhaps more importantly, discourse performance depends on guts and courage. A course on *Responsible Chemistry*, thus, must be a practical course in which attendees are actively engaged in team work on ethical and societal challenges arising from chemical R&D work. Challenge-based learning approaches would be best suited to design proper syllabi. In this way, the future generation of chemical innovators forms the skills that are necessary for dealing with dual use potentials and figuring out the best option to proceed with.

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