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Enabling a Smooth Transition: Responsible Chemistry Competencies for the European Green Deal

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Abstract: Chemists are a vital part of the research and innovation (R&I) landscape. With their expertise they shape progress and, thus, society. In order to live up to this responsibility, it is suggested to prepare young chemists for their future role as innovators with proper training. Here, it is important to go beyond the good scientific practice dimension of research integrity and add discourse performance and value assessments to the outline of a 'responsible chemistry' course. This becomes especially relevant in view of changing demands on chemical research and innovation as envisioned by the European Green Deal through its Horizon Europe funding scheme. This paper outlines the necessity of preparing chemists for the requirements of a green transition R&I policy and shows what that would mean for 'ethics in chemistry' education.

Keywords: Environmental ethics · European green deal · Responsible chemistry · Research integrity

Jan Mehlich combines his educational background in chemistry and applied ethics with his research in science, technology and innovation ethics. With experience in accompanying research in nanomedicine, green chemistry, and digital technologies, at his current position at the Center for Life Ethics at the University of Bonn, his academic focus is on the role of scientific-technical experts in normative innovation discourses, on strategies of empowering these actors to participate skillfully in those discourses, and on options for integrating environmental- and ecological-ethical knowledge into the research and innovation process. Among his teaching activities are courses on science and technology ethics, innovation management, critical thinking, and discourse performance.

1. Introduction

Undoubtedly, chemists due to their expertise are among the main drivers of innovation. Having studied this creative science in one of its forms – academic, pure, applied, or contextualised in business or management – chemical scientists, researchers, engineers, economists, lawyers, or regulators, populate innovation teams in corporations, offices in agencies, or councils and advisory groups in legislative institutions. Equipped with chemical knowledge, they develop and test new products and processes, discuss and implement regulations concerning environmental impact of substances, or pave the way for sustainable chemical progress in political decisions. More often than not, they realise that this chemical knowledge is but one element of a larger pool of insights and decision factors. While in the context of agencies and political organs, chemical expertise has an obvious normative dimension – the question of *what is the best thing to do* with the chemical topic at hand – the research and development (R&D) context of chemical innovation has a more hidden socio-ethical layer. In recent years, various academic and applied communities have grown a significant interest in *responsible research and innovation* (RRI):[1,2] Technology assessment is no longer simply about the risk of malfunctions in technical devices but about constructively accompanying the technology design process,[3] the sociology of technology is no longer an armchair activity but interested in concrete interventions on laboratory floors,[4] and technology ethics matured from discussing science fiction in the early debates of nanotechnology into a practice-oriented interdisciplinary effort to enable value co-creation.[5,6] Proponents of RRI do not get tired pointing out that responsible agency in scientific research and technology development is not a matter of having heard an ethics class at university, but of attitude, practice and performance.[7]

At the same time, since the bio- and nanotechnology debates in the early 2000s, attempts have been made to integrate ethical reflections and knowledge into R&D processes. First, larger EU-funded research projects had to address ethical, legal, and social implications (ELSI) or aspects (ELSA) in accompanying research projects.[8] The RRI approach since the early 2010s responded to the criticism that the ELSI approach was too academic and gave the normative discourse around technology development a more corporate touch.[9] In its latest communications around the Green Transition policy and the European Green Deal, the European Commission attempts to do nothing less than tackle climate change and other detrimental environmental developments by supporting research that addresses (and, perhaps, solves) ecological, economic and societal challenges.[10,11] Here, the ethical and other normative (legal, cultural, social, *etc.*) dimensions are intrinsically interwoven into the very design of a research agenda: In order to get funding, researchers need to show what challenge they have identified, how the research helps tackle it, and in which way the proposed solution meets ethical values such as fairness, justice, biodiversity, or social security.

This may seem like a lot to bear for chemists. While feeling competent in the area of toxicity studies, life-cycle assessments, and classical risk assessments, chemical experts may have difficulties in making a connection between their work and questions of environmental justice, climate justice, biodiversity, or fair land-use. Yet, it is their down-to-earth design choices in (chemical) innovation during the design and scale-up processes that have a significant impact on these aspects. With the above mentioned practice-oriented approaches to technology ethics, chemists can certainly be empowered to make ethically sound

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choices in their research and innovation work. This paper illustrates the urgency and possibility to equip the future generation of chemists with normative discourse skills through adequate responsible chemistry education in order to meet the requirements of green transition programs such as the European Green Deal.

2. The European Green Deal and Responsible Research and Innovation

The European Green Deal (EGD),[12] an initiative launched in 2019 by the European Commission, represents a comprehensive package of policies designed to support the European Union towards climate neutrality by 2050. It includes:

- *Fit for 55 Package*: This legislative package serves as the concrete translation of the Green Deal's climate ambitions. The overarching objective is to ensure all EU policies seamlessly align with the ambitious goal of achieving climate neutrality by 2050.[13]

- *EU Strategy on Adaptation to Climate Change*: Recognizing the inevitability of some climate change impacts, this strategy focuses on building a climate-resilient Europe by 2050. R&D-relevant areas of action include enhanced data collection and sharing policies, and nature-based solutions to help climate resilience and protect ecosystems.[14]

- *EU Biodiversity Strategy for 2030*: This strategy tackles the critical issue of biodiversity loss in Europe, aiming to achieve a reversal by 2030. Key actions within this strategy include expanding protected land and sea areas and restoring degraded ecosystems by reducing pesticides use.[15]

- *Farm to Fork Strategy*: This strategy aims to transform the EU food system into a sustainable model by 2050.[16]

- *European Industrial Strategy*: This strategy aims at supporting the industry as the acting force in the green and digital transition. It emphasizes three key principles: Sustainability, circularity, and environmental protection.[17]

- *Circular Economy Action Plan*:[18] Decoupling economic growth from resource use is crucial for achieving climate neutrality. This action plan outlines over 30 measures promoting circular practices in various sectors, including:
  - Sustainable product design: encouraging the design of products with a longer lifespan, easier repairability, and recyclability.
  - Circular production processes: promoting efficient use of resources and minimizing waste generation within production systems.
  - Empowering consumers and public buyers: raising consumer awareness and encouraging sustainable purchasing practices.

By addressing these points, the action plan targets specific industries with high resource consumption, such as electronics, plastics, textiles, and construction. Especially relevant for the chemical research and innovation context are:

- *Clean, Affordable, and Secure Energy*: As 75% of the EU's greenhouse gas emissions stem from energy use and production, decarbonizing the energy sector is a critical step towards climate neutrality. The EU actively supports the development and deployment of technologies for cleaner energy sources such as offshore wind and hydrogen.[19]
- *EU Chemicals Strategy for Sustainability*: Adopted in March 2021, it outlines a long-term vision for a safer and more sustainable chemicals industry.[20] Key goals include:
  - Enhanced protection of human health.
  - Strengthening industry competitiveness.
  - Supporting a toxic-free environment.

This brief overview illustrates that the EGD policy will have a significant impact on the European R&D landscape. For example, the Horizon Europe program since 2021, in the six clusters and five partnerships of its pillar II, refers directly to the EGD goals in its calls. Grant applicants need to illustrate how their research designs and outcomes address the ecological, economic, and/or societal challenges that the call intends to tackle. It is important to notice that all these challenges have genuine ethical character: Their communicated dimensions of sustainability, resilience, competitiveness, or solidarity are manifestations of ethical values such as freedom, justice, dignity, or integrity. Tackling these challenges means to develop or design innovative solutions (devices, processes, strategies) that support value commitments or mediate between value clashes. With other words: EGD-oriented research and innovation has a direct ethical call.

3. The Role of Ethics for a Successful Green Transition

Speaking of ethical implications or dimensions of research and innovation often brings to mind moral philosophy or theoretical principles. However, while some conflicts and dilemmas related to scientific progress and technological innovation may indeed benefit from applied ethics expertise, the approach suggested here is a pragmatic and practical concept of normativity. This concept encompasses all aspects related to norms and values that extend beyond ethics and morality, including law, culture, and society, with their implicit and explicit norms.

Ethics, in this context, does not originate from a top-down moral authority (such as a philosophy, religion, tradition, or political council) nor from a bottom-up case-based exploration. Instead, determining what is ethical – what is *right* or *good* – results from a deliberative discourse process. In this process, participants truthfully represent their value commitments and identify both overlaps and discrepancies. With facts and norms laid out, it is possible to determine what is right or good as long as principles of fairness, rationality, and inclusiveness are respected. This approach to argument exchange and refinement is often referred to as *wide reflexive equilibrium*.[21] In a well-conducted discourse, where hierarchies are flat, feedback loops are intact, no voices are excluded, and no arguments prevail solely due to the power or rhetorical skill of the speaker, the outcome can be considered a valid and accepted ethical judgment.

In this context, discourse refers to the process of communication and deliberation regarding issues related to a shared activity. It does not imply heated emotional discussions, quarrels, or mere information sharing. Discourse can occur formally in team meetings, labs, conferences, or business consultations, as well as informally among team members during coffee breaks, lunch, or in the corridors between labs and offices. Written correspondence, such as e-mails, can also qualify as discourse. What distinguishes a conversation as a discourse is the seriousness and rationality with which viewpoints are expressed, arguments presented, feedback received, and others are listened to and taken seriously, with an active pursuit of decisions and conclusions. Some discourses focus on the cognitive level, addressing questions like: *What is the problem at hand? What knowledge do we have about it? What solution does this knowledge suggest?* Other discourses revolve around norms, and values, asking: *What should we do? What is at stake? How do our choices affect values such as safety, justice, integrity, or sustainability?*

This approach to ethics has practical consequences for the conduct of discourses on the ethical and other normative dimensions of research and innovation. Participants cannot rely on pre-existing guidelines, codes, rules, or commandments for direction. However, norms and values are not arbitrary or relative; they are shaped by the social and cultural context of the discourse. In other words, ethical orientation does not require formal ethics expertise (such as a degree in philosophy) or specific knowledge (such as the definition of human dignity or principles of justice). Instead, being an aware and open-minded member of society is sufficient. Moreover, the goal of a normative discourse is not to arrive at a single correct conclusion–though this may seem convenient and attractive–but to clarify the spectrum of views and identify the most plausible and convincing standpoint within that range.

The ethical pillar of RRI, in this view, cannot be adequately addressed with reference to codes of good scientific practice or research integrity. It demands from the researcher or innovator an active and open-minded stance in the discourses that occur around R&I activities. It is impossible, for instance, to lay out the ethically demanded directions for research projects under the EGD umbrella (for example, the Horizon Europe 2021-2027 program). The involved researchers need to be empowered ('to be made able') to anticipate, comprehend, and specify the (environmental-)ethical implications of research and design choices and to represent these insights in communications with other stakeholders (for example, their organisation's or corporation's CEO, the management, the clients, or the general public). These efforts pay off in the form of better innovation. Then, ethics is no longer dismissed as an acceptance generator (as in, for example, the current phenomenon of green washing) or as an innovation inhibitor creating obstacles in the path towards a better future. Rather, in this practical and pragmatic understanding, it supports intrinsically ethical R&I agendas such as the EGD.

4. The Role of Chemists

Chemists – defined here as practitioners and experts with degrees in chemistry or chemical engineering – work in interdisciplinary teams comprising individuals with diverse backgrounds and perspectives. In both academic science and corporate R&D, chemists engage in planning, designing, aligning, and communicating research, as well as defining and negotiating research purposes, goals, and directions. Good scientific practice guidelines ensure that researchers comply with the virtues of good scientific or engineering practice, such as objectivity, truthfulness, scepticism, and immunity to non-scientific interests like fame, power, or money. What is more important in the RRI context at hand, however, is the ability to represent ethical dimensions of R&D, not theoretically, intellectually, or overly abstract, but through the very concepts they are familiar with. As pointed out above, in the European research and innovation landscape, EGD-oriented projects will demand from researchers and innovators that dedicated values are addressed and fostered through research and technology design. In the following, three examples are presented that show how an ethical amendment of common concepts and practices can greatly support the vision of RRI for the EDG.

4.1 *Sustainable and Green Chemistry*

According to the common understanding of sustainability, processes that do not deplete, do not harm the environment, and can be maintained over a long period of time may be labelled sustainable. In the terminology of the triple-bottom-line definition of sustainability (that is the most often cited definition),[22] sustainability is found where the interests of environment, economy, and society overlap. Sustainable and green chemistry efforts, according to contemporary textbooks, apply this definition when they intend to reduce pollutant footprints, substitute toxic with non-toxic chemicals, or get rid of depletable resources such as fossil fuels. However, there are clear limitations to the interpretation of sustainability as mere environmental friendliness or as a matter of interest satisfaction, especially when economic interests have the power to outweigh everything else. Biodiversity, climate justice (in short: the fair distribution of risks stemming from climate change), epistemic injustice (the fact that indigenous knowledge, even though profound, does not find its way into sustainability discourses), and other environmental-ethical considerations are not adequately represented by current sustainability concepts.

Research on technologies supporting the EGD are expected to apply a sustainability approach that encompasses a wider range of ethical aspects. Suggestions for how that could work have been made, for example, by aiming for value co-creation rather than interest satisfaction.[23] In this way, sustainability discourses (such as those in innovation teams) operate on the safe ground of an established framework that is enriched by a more holistic approach to sustaining desirable processes into the future.

4.2 *Ethical Risk Assessment*

R&D efforts in the context of the EGD benefit from integrating key concepts and concerns from climate and environmental ethics into forward-looking risk-assessment approaches in research and R&I policy.[24,25] To date, mandatory risk-assessment and life cycle assessment protocols focus almost exclusively on technical parameters such as functionality, safety, (non-)toxicity, or the biodegradability of substances. As risk management is moving towards inclusion of normative (ethical, legal, societal, and cultural) dimensions (see, for example, ref. [26]), researchers and innovators can analyse the impact of their R&I work not only in terms of substance and device properties but also in terms of ethical values such as global justice, environmental justice, biodiversity, and animal welfare, among others.

In practical terms, enhanced models of risk communication aid researchers in disentangling the complexities of normative risks. Along the lines of the risk escalator model of the International Risk Governance Council (IRGC), ethical risks and their handling become more apparent.[27] While complexity-induced risks may be cognitively solved with more and better research (and the discourse on best practices and methods), the ethical dimensions of uncertainty-induced risks (in which the impact on a particular value is not clear) and ambiguity-induced risks (where affected value commitments clash) require different forms of discourse (evaluative, normative) with different outcomes (risk trade-offs rather than statistical or probabilistic risk assessments). Chemists knowing these advanced approaches to risk discourse are better equipped for professional agency that contributes to reaching EGD goals.

4.3 *Chemists as Communicators*

When being asked to contribute chemical expertise to research and innovation processes, chemists tend to understate their competences as 'merely' scientific. As knowledge exponents, they feel safe explaining the chemistry behind processes and products. As such, they often remain neutral on critical decisions: With their scientific input, someone else will surely be able to figure out the right way. More seldom, but observable, are researchers and scientists promoting one specific path forward as the best solution for a problem. This type of communicator is not more helpful than the former since it disregards the possibility of misjudging what the problem precisely is or what values are at stake when deliberating on a remedy.

Pielke has shown that other, more effective, ways of science communication are possible.[28] Calling the first abovementioned type pure knowledge exponent and the second one advocate, he proposed a third type, the arbiter. This scientist or engineer would first ask decision-makers for their value proposition and then suggest a solution fitting that goal. The most effective communicator would be the honest broker who stirs a constructive discourse, scrutinizes value commitments, anticipates negative drawbacks of strategic choices on these commitments, and is actively involved in the discourse on stakes and values (and not merely on the relevant facts).

Same as most performative skills, science communication can be trained. Exposing young chemists to communicator styles such as those pointed out by *Pielke* will likely change their professional attitude and their understanding of responsibility. Chemists are never merely scientists. As respected and effective discourse participants, their epistemic authority can reach much further than the lab.

5. Conclusion: Responsible Chemistry as Ethics-in-Chemistry Practice

In view of the demands on chemical R&D supporting EGD objectives, our goal should be to educate chemists skilled in multi- and interdisciplinary collaboration and communication. Responsible chemistry supporting the EGD should not merely be understood as scientific integrity and good professional conduct, such as avoiding cheating, plagiarism, and conflicts of interest. Above all, it should encompass the ability to represent societal interests and environmental needs in daily research practice. Chemists have a particular perspective on what constitutes good progress or innovation–one that works, exhibits useful functionality, and exploits the properties of purposefully modified matter. However, other stakeholders may define good innovation and progress differently. A responsible chemist listens to these perspectives and seeks to balance chemical functionality with societal, environmental, ethical, and economic value creation.

Effective multi-stakeholder discourse is key to these value co-creation processes. In most contemporary academic research and corporate innovation efforts, chemical expertise is embedded within an infrastructure that facilitates such discourse opportunities. What is needed is proper training. This training requires both methodological and practical experience, and perhaps more importantly, it requires courage and confidence. A course on *Responsible Chemistry* should therefore be practical, actively engaging attendees in teamwork on ethical and societal challenges arising from chemical R&D work, introducing the application of advanced approaches of sustainability, risk, communication, and other elements of daily research conduct. Challenge-based learning approaches are best suited for designing effective *syllabi*. This way, the future generation of chemical innovators will develop the skills necessary for addressing EGD goals in their work and determining the best path forward.

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