Responsible & Sustainable Innovation

Introduction to a new concept

Karsten Krüger[†]

Alba Molas[†]

Laureano Jiménez[†]

[†]Universitat Rovira i Virgili, Tarragon(Spain)

Citation: Krüger, K. & Molas, A. (2021) Responsible, sustainable Innovation (ReSI) Introduction to the Concept. Barcelona/Tampere/Warsovia

This paper is only electronically available. It can be obtained at the website of http://www.dia-e-logos.eu

This publication is based on the results of the project RRIL Responsible Research & Innovation Learning. It is co-funded with support from the European Commission.
RRIL-project nº 2018-1-ES01-KA203-050890.

Este informe se elabora y difunde como contribución a la 3ª Conferencia Mundial de Educación Superior, organizada por la UNESCO del 18 al 20 de mayo de 2022, con el fin de mejorar la contribución de las instituciones y los sistemas de educación superior de todo el mundo, en el marco de la Agenda 2030 para el Desarrollo Sostenible, su promesa de no dejar a nadie atrás, y con la mirada dirigida hacia los futuros de la educación. El contenido de esta publicación no expresa necesariamente las opiniones de la UNESCO ni de sus Estados.

Introduction

In the Erasmus+ project Responsible Research and Innovation Learning (RRIL) a team formed by 3 universities and 2 private social research centres worked out three learning modules on core topics of Responsible Research and Innovation (RRI): public engagement or cooperation between diverse innovative actors; gender (and social vulnerability); and innovative ethics. These three modules are complemented by this introduction to the concept Responsible & Sustainable Innovation.

We enriched the concept of RRI with the topic of sustainability as our studies on the degree of implementation of RRI in the universities of the countries covered by the project Finland, Poland and Spain showed that

a) RRI has a low implementation degree in all three countries as a concept. But in all three countries, the basic principles of RRI as public engagement, gender equality, science education, open access, and ethics are present in the public discourse on science and are in different degree integrated in the structures and processes of the university as such. However, their integration in the concrete research and innovation activities is still a gap.
b) RRI has not become a general guiding vision of university policies. In the recent years, the main guiding vision has become the Sustainable Development Goals (SDGs) similar as for the European Union and its member states.

As the basic principles of RRI as also present in the SDGs, the RRIL project team has decided to integrate both in one concept called Responsible & Sustainable Innovation.

However, similar to RRI also the SDGs runs the risk to be only present in the official discourses without an effective integration in the research and innovation practice. Facing the big sustainable challenges which the humanity is facing actually, our project sustains that sustainability must must be the reference point of all responsible innovation activities. To contribute to the anchorage of responsibility and sustainability in innovation based on scientific research, RRIL has developed and offers a training programme for Responsible & Sustainable Innovation for researchers, technicians of local authorities and university staff. It is expected that the training programme will support the orientation of university processes to the SDGs and to responsible innovation.

In the article we will not present the learning programme, but the basics of the concept of Responsible & Sustainable Innovation.

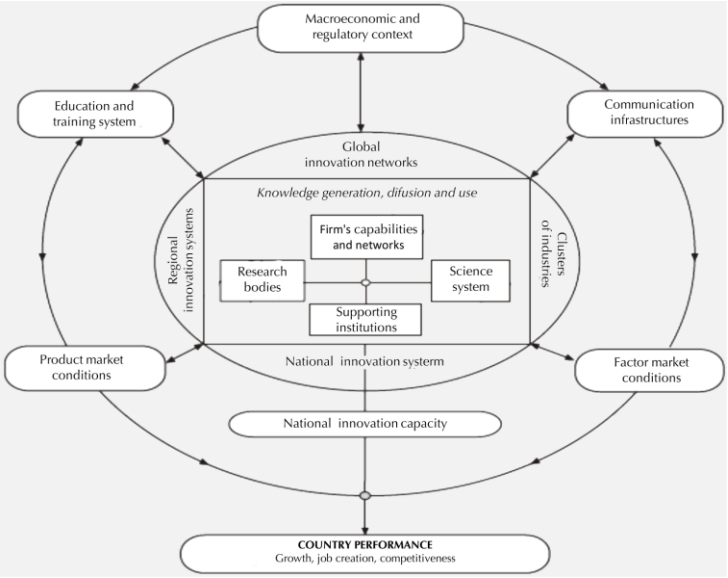
Changes in the innovation systems

In spite of that 'innovation' has been discussed still in the 19th century and at the beginning of the 20th century (see Tarde, Schumpeter and Ogburn), the term gains more social scientific relevance from the beginning of the 1960s on.[1] Fruit of this effort was the research on national innovation systems of the OECD. Later this term was diversified in regional, local and sector innovation systems.

The fact that the term 'innovation' –often reduced to technological innovation – has become one of the main catch words in politics and social science is related to several social changes as e.g.

a) In the post II World War period, the innovative capacity of a nation was perceived as the crucial factor for the competitiveness of national economies. This is why public investment in science and innovation became more important. Through competitive public funding, the aim is to guide the innovation system towards concrete objectives as e.g. the big societal challenges in the EU research programme H2020.
b) Innovations are increasingly based on scientific knowledge (historical frontrunners were the chemical and pharmaceutical industry. Another mire recent historical example is the nuclear energy. Actual examples are genetics, biotechnology and nano-technology more recently).
c) Cooperation between academic, scientific and business entities is increasing. This is reflected in the presence of business representatives, but also other social entities in the supervisory bodies of academic and scientific entities or in political advisory bodies.

Figure 1: National Innovation System



Source: OECD (1999) Managing National Innovation Systems. Paris

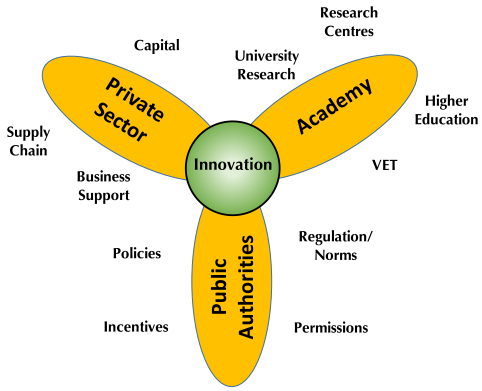
These consideration, especially the last one, were reflected in different works in turn of innovation processes and its configuration as national innovation systems [Nelson 1993 and Lundvall 1992] or idea – innovation networks [Hage/Hollingsworth 2000] among others. One main point of the

[1] See for instance the publication of 1962: National Bureau of Economic research (Ed.) The Rate and Direction of Inventive Activity: Economic and Social Factors. Princeton.

analysis was the change of the knowledge production systems. These were characterised by the separation between scientific knowledge and technological knowledge. It was a by-product of the industrialisation process, in which the national states governed the science system, meanwhile the generation of technology forms part of the private business: the market (see Stichweh 1984). Naturally, this separation was somehow diffused as the example of the predecessor of the actual Max-Planck-Institute – the Kaiser-Wilhelm-Institute – shows. It was an institute of basic research, but mainly private funded and in some parts oriented to practical application in industry but also military.

This consideration of the separation the knowledge production between academia, enterprise and government as steering agency was the point of departure of two main concepts as results of the analysis of innovation systems: the mode 2 of knowledge production (Gibbons et al 1994) and the triple helix (Etzkowitz & Leydesdorff 1995). We refer here to the triple helix approach.

Figure 2: Triple helix model



Source: own drawing

Etzkowitz & Leydesdorff (1995) observed that, at least since the 1970s, this differentiation regrets and the coordination between both spheres of knowledge production increased with a relevant role of governments. This gave place to new organisational arrangements as research centres in universities, strategic alliances between enterprises and new steering mechanism of the whole system, with a more relevant role of business e.g. in the distribution of public funds for research. Scientific knowledge generation became more and more an economic factor. However, it must be underpinned that this was not a quasi-natural evolution but a political intended process as the analysis of the research policies of the European Union and its predecessors, and that this strategy started in the 1960's. The triple helix approach was fruit of social science observation, but also a policy to promote the cooperation between this three area to increase the innovation capacities of national, regional and local economies.

The structural dynamics of the innovation systems did not stop with the triple helix model, but evolved to a quadruple helix model (see e.g. Carayannis & Campbell 2009) as the civil society claims for a more relevant role in the innovation process.

The origin of this claim, probably can be traced back to the 1960s with the growing conscious about ecological and nuclear risks, which has its expression in the social movements against atomic energy, but also for a more ecological production of food and other goods. The ecological movement is a good example, how scientific knowledge are first used as a defensive initiative to

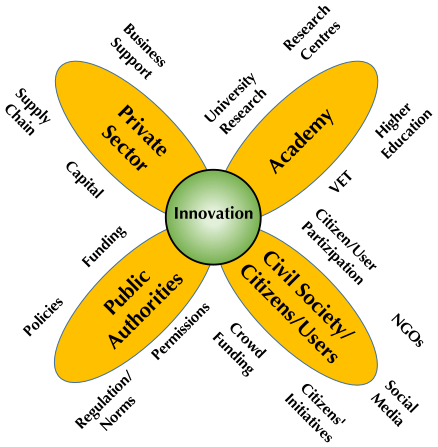
avoid ecological disasters becoming later a proactive movement promoting, for instance, first ecological agriculture and production.

Within this general societal changes generates series of citizens' initiatives and Non Governmental Organisations all over the world, which became active actors in the innovation processes. The emergence of the Internet makes this area still stronger e.g. through the use of social media or crowd funding.

However, the main works on the quadruple helix did not refer to this aspect of the changes in innovation systems, but maintains the focus on the economic beneficially innovation processes. For this reason, the triple helix process and the quadruple helix are rarely applied to social or political innovation processes in others sphere than economy or technology development.

In a nutshell, the innovation systems evolved from a system with two clearly differentiated knowledge production areas (science and technology/market) constitute in the course of the industrialisation and the forming of national states, first to a closed innovation system with closer coordination between science, business and government and later to a more open innovation system with multiple actors and a higher participation of the civil society, but also of other types of actors as the education systems and press media.

Figure 3: Quadruple helix model



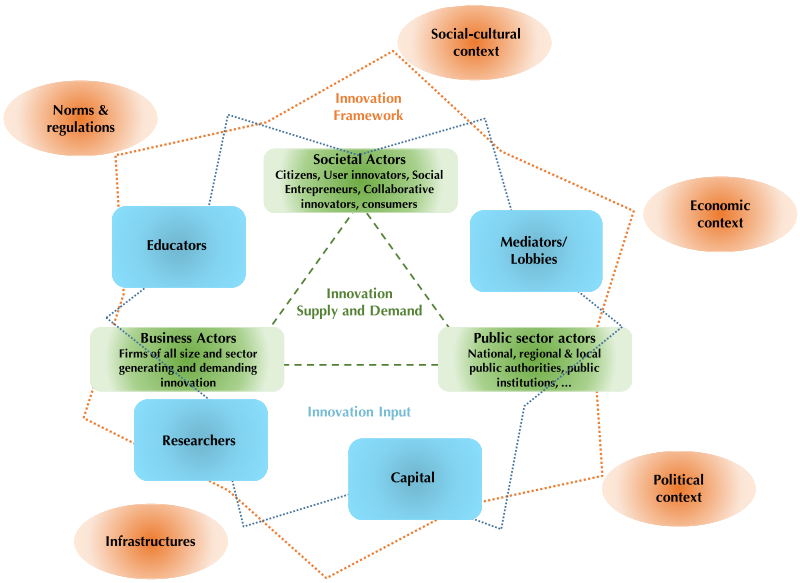
Source: own drawing

The approaches of triple and quadruple helix, as well as innovation and technology studies sustain that innovation are not linear processes but complex processes with several loops in which a wide range of actors with different often contradictory interests are involved. The figure 4 reflects the complex actors' configuration and its embeddedness in the social-cultural and economic context and the influence of the respective infrastructures, governmental policies and the normative and regulative framework. The figure only resumes a part of the configuration or others, which are playing a more and more relevant role in the innovation processes. This figure does not include the different geo-political dimension of innovation processes. Only for the European Union, there are the local, regional, national and the EU level to take into account.

The quadruple helix model draws a picture of open innovation processes, in which several actors are intervening in the different stages of the non-linear process. This has a conceptual nearness to

new innovation concepts as user-innovation or open innovation, which are focused mainly on business innovation.

Figure 4: Actors constellation in modern innovation systems



Source: Warnket et al. (2016: 33)

User innovation has emerged as an alternative to the traditional firm-centric model. In the traditional model, product and service innovations are created in firms in a 'closed' way using patents, copyrights and other forms of protection to prevent imitators [see Hippel 2005: 2]. In contrast, 'user innovations' are open processes in which the producer of the good or service is cooperating with the user to create an innovation. Users could be individuals, companies or organisations that expect to achieve benefits by using the new product or service. The producers in turn expect to make profit through the sale of the product or service.

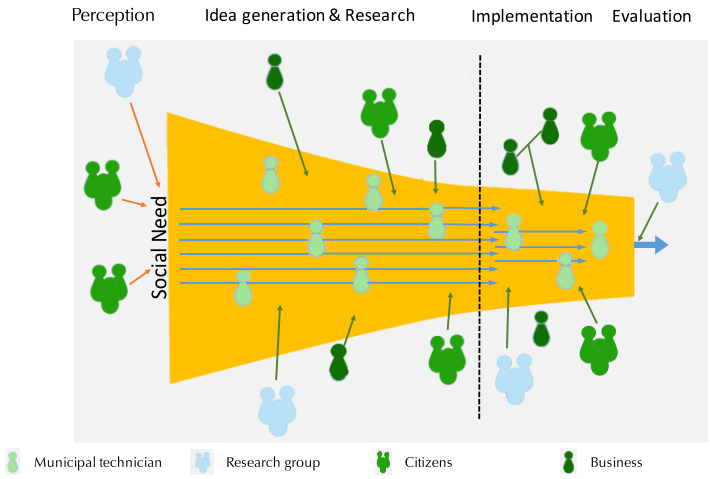
Examples of this type of innovation, mentioned by V. Hippel, can be found in the machinery industry, which designs and produces machinery on demand for instance for oil refining industry [Enos, 1962] or the chemical industry [Freeman, 1968]. Other examples are the construction of scientific instruments [v. Hippel, 1988] and sports equipment [Shah, 2000]. The increase in data processing capacity and Internet capacity has reinforced this model, allowing, for example, a better coordination with the users but also among the users. This is a social innovation process of the same innovation process that also affects the work organisation of the company in general [von Hippel 2005: 2]. Von Hippel speaks of the increasing democratisation of innovation processes, which implies important changes in the behavioural patterns of users and producers [see v. Hippel, 2005: 17].

‘Open innovation' is another concept that speaks of substantial changes in innovation processes. The indicates a shift from closed, internal business innovation processes, in which new ideas are generated exclusively within firms, to more open processes, whereby firms capture new ideas that have been generated in their environment and give them the same relevance as internally generated ideas [see Chesbrough 2006: 1]. Referring to a number of studies in economic and business history [*Lamoreaux et al. 1999;* Lerner 2000; Mowery 1983], Chesbrough argues that open innovation has been the dominant model until the emergence of corporate R&D labs. The

emergence of such labs changed innovation processes profoundly by imposing the closed model, whereby firms integrated R&D into their vertical structures by linking it to their internal processes of product development, manufacturing and distribution. However, over time, anomalies appeared in this model that favoured the re-emergence of the open model as an alternative, especially in high-tech based economic domains with their alliances, networks and intermediate markets [Arora et al. 2001]. The re-use of open models is related to the emergence of new business models that are not only focused on the internal processes of developing, manufacturing and distributing new products, but also on the development of new forms of commercialisation through licensing, joint ventures and spin-offs. It is also related to structural changes in innovation systems, which is reflected in the growing relevance of intermediaries [see Nooteboom 1999] and intermediate markets, through which functions that were previously performed in-house are carried out.

Similar trends can be observed in regional and local innovation projects based the participation of the citizens through consultation processes, living or social labs among other. The figure 4 is an adaptation of common schemes to visualise open innovation processes in business. We take here as point of departure the formulation of a social need by the citizens, supported by evidence of social research. The respective public authorities conduced the innovation process first at the stage of idea generation and research.

Figure 4: Social open innovation in the public sphere



Source: own drawing

At this stage, besides the team of the public authority and the academic research team are participating citizens through different means steered by the public authority. But also other intervention of NGOs or citizens' initiatives among others in the deliberation process is possible, as well as the cooperation of enterprises or alliances of enterprises. But it is the public authority, which filtered the different idea to have some feasible proposals among they can select for implementation. This stage could be again supported by research groups (e.g. creation of impact scenarios) and would be again open for public deliberation and the intervention of enterprises. At the end of this process, the impact of the implemented will be evaluated, probably by a research team, but also by the citizens. This is an ideal-typical model but the widespread of living labs and social labs in urban innovation projects indicates that the role of the citizens gains relevance

although that often the usual subjects – high-educated people, especially students – are participating in these processes.

Implication for the science system: towards Responsible Research

The changes in the innovation systems has naturally implication on the science system.[2] Academic research processes never were only oriented towards scientific interests, but always had a political component. However, what we now observe is the increasing relevance of economic interest in the science system itself.

At least since the beginning of the industrial era, public authorities intervened in the science system through public funding, especially the parts related to the military environment. The interest of companies in scientific research is not new either, as the example of the Max-Planck Society and its predecessor the Kaiser-Wilhelm Society – funded in 1911 shows[3]. These interrelationships were especially relevant in the chemical sector. So the cooperation between academia, business and government is anything but not new. But it has become actually the main model for steering innovation systems at different geopolitical level, at least in Europe.

This is observable in the continuous reform process of the governance structure of universities across Europe, mainly in line with principles of public management. We take here the example of the public funding of research. The share of unconditional public funding decreased in the last decades due to the introduction of performance based and competitive based mechanism of public funding (Bolli et al 2016 and Wiener et al 2020) and third-party funding, including European or national research funds, private funding or collaboration with practitioners tended to increase (Link, K. & Müller, B. 2020). In a nutshell, the share of funding, which is allocated through competitive procedures, has grown and makes these centres, like universities, more dependent on this type of funding. This implies that the decision on the scientific agenda is not taken –probably never has been - on the basis of purely scientific criteria, but on political and economic criteria. The funding mechanisms can be broadly classified as follows:

- Entities or researchers receive a certain amount of funding without setting any specific objective and they decide on the orientation of their research;
- Someone with financial capacity (national or regional governments including the EU, public research funding agencies or philanthropic organisations) decides on the priority areas and the entities or researchers receive funding by submitting proposals to generally competitive calls (for public entities an example is the European Framework Programmes as Horizon 2020 and for philanthropic organisation an example is the Bill Gates Foundation);
- Entities with commercial interests decide to invest directly in research projects in cooperation with research entities

[2] But not only for the science system, but also for the political system as it is reflected in the literature about governance. We want call here the attention to the question of the democratic legitimisation of the intervening actors especially to the problem of lobbism of enterprises, entrepreneur associations, but also of non-governmental organisation. In the background stands the question who is legitimised to speak in the name of others.

[3] For instance, the Kaiser Wilhelm Society was financed cooperatively by industry and the state
See https://www.mpg.de/195494/Kaiser_Wilhelm_Society and https://www.mpg.de/history_mpg

On the other hand, the priority setting of the scientific agenda never has been only be guided by scientific criteria being also object of social bargaining processes within the academic community and funding public authorities. In the actual innovation systems, it is more evident that different priorities criteria are applied among scientific excellence is only one besides economic, political and military consideration.

These changes - the more pronounced focus on political and business interests and their financing - produce some dilemmas:

- in the social field, some decisions raise the dilemma between the objectives of the intended innovation and its possible impact as e.g. an increase in inequality of access to knowledge, the negative impact on social equality or not respecting the ethical principles of the European Union. The case of the vaccine research or the effective treatment of Covid 19 highlights this dilemma: A research centre works on a vaccine receiving public funding, which is then made available to society at production cost en benefit of the society or commercialised to increase the profits of the collaborating company and its shareholders.
- In the field of research itself, the dilemma of opportunities arises, given, for example, that the choice of a type of project is often a consequence of the interest of a particular company, which tends to reduce then the capacity of a research centre to carry out other research of greater social interest or greater innovative potential.
- Innovation processes could produce additional unexpected and undesired results that could lead to social rejection if not well mediated with society and stakeholders

To avoid and mediate these dilemmas, one answer is the concept of Responsible Research and Innovation (RRI) to guide the processes of public funded innovation (see Schomberg 2011).

In the previous section, we have already mentioned that the participation of the civil society in innovation processes can be traced back, at least to the 1960' with the contest again the use of pesticides in agriculture and the nuclear energy. In the following decades, innovation processes encounter more and more social response. Beside nuclear energy, genetics, biotechnology and nano-technology can be mentioned as contested fields. This does not refer only on the scientific and technological development, but also on the implementation of technological solutions as wind energy and solar energy parks taking examples only from the energy field. This is not only due to the very particular interest of people, which are directly negatively affected for instance of the building up of big wind or solar energy parks. It is also a question of the structural configuration: for instance, in the case of energy system, if the preferred option is highly centralised energy systems or pushing more decentralised systems.

This rest 'economic' efficiency on the large public investment in innovative technologies, which requires large public and private investment. It conduced to policies emphasising the participation of actors from the civil society in the innovation processes with the aim of increasing social acceptance of innovations. For the same reason, more emphasis is placed on the transparency of the processes.

On the other hand, RRI can also be considered as an answer to the changes in the science system itself and its changing function within society, which has been conceived as the transition from academic to post-academic science (Nowotny et al 2002 and Ziman 1996). Post-academic science is characterised by the overlapping of research, development and application. Traditional concept of science, is based on a separation of the generation of scientific knowledge and its application in the 'real' world, which, in principle, does not add any new value to the scientific knowledge.

The role of scientific experts is to advise to take the best way, to assure the transfer of scientific knowledge to society, the so-called third mission.

But this model is not very useful in the actual situation of high uncertainty, in which action, especially political action, could not be conceived any more as the application of a previously established plan, but more as the continuous measuring of the impact of the 'provisional and revisable' projects and the search for the unintended consequences so that the project can be adapted and revised. Neither politics or scientific are not any more unquestionable all knowing and all deciding authorities. The citizens gain protagonism in these processes of searching for solutions becoming co-researchers and co-decision-makers. Many science areas, which in the past have been area only of interested of a certain of persons (academics), became public affairs in which the citizens play an increasing role.[4] The pandemic and the respective discussions about the solutions to take is an example, but it shows also the risk of these changes increasing the mistrust not only on the politicians, the enterprise, but also the scientific experts.

Although responsibility in research and innovation has been discussed for a long time, RRI is a concept genuinely developed by the European Commission at the end of the 2000's for the governance of the science and technology complex from part of the political instances.

In social sciences, the term 'governance' has been discussed for years as a tendency to complement or substitute, depending on the perspective, the traditional processes of representative democracy. Under the perspective of governance, the EU initiated in the late 1990s and early 2000s a reconfiguration of its political framework which was later set out in the Lisbon treaties. In the (publicly funded part of the) research and higher education system, these changes are reflected in strategies to enhance public-private cooperation and especially in the growing influence of private actors in the regulation of the research system. As, according to the European Union's own analysis, these changes have not yielded the desired results - increasing the innovative capacity of the European Union - concept of RRI is outlined in the 2010s to guide research and innovation systems in an open manner through rules of conduct.

A central element is to improve the engagement of society (or its different societal actors) in research and innovation processes by moving from the closed triple helix system (Etzkowitz & Leydesdorff 1995) formed by government, companies and universities/ public research centres to an open quadruple helix system (Carayannis & Campbell 2009) in which different actors representing society are more relevant. This has its expression in RRI and its inclusion in the Horizon 2020 research framework programme to mainstream European public funded research. RRI represents the European strategy for: a) increasing the social acceptance of research and innovation in European society by involving non-academic societal actors at all stages and complying with ethical principles; b) bringing research and innovation closer to European society by involving various actors and developing the policy stream science with society, for example as a citizen's science; and c) implementing the principle of equality, especially with regard to gender.

According to an 'official' definition by the European Commission (2014), RRI "*means that societal actors work together during the whole research and innovation process in order to better align both the process and its outcomes, with the values, needs and expectations of European society*". RRI is an ambitious challenge for the creation of a Research and Innovation policy driven by the needs of society and engaging all societal actors via inclusive participatory

[4] This reflection is based on the article Bammé, A. (2021) especially pages 286-289.

approaches". RRI means an ambitious challenge applying research and innovation policy oriented towards society's needs and involving all social actors through inclusive participatory approaches.

It is in this context, where the development of RRI must be placed, but also in the context of the profound changes in innovation systems. Another objective of this policies is to increase the transfer of the results of scientific research into products and services, which are ready for the market and accepted by society. For this reason, RRI has been developed, focusing on the quality of the innovation processes themselves by defining six domains of responsible action:

- Public engagement (Inclusiveness) not only of companies, but of society in general, that means civil society organisations. In other words, the aim is to push forward the already described trend of opening up the whole process to society in general.
- Gender equality takes up a basic principle of modern European society, namely the equality among all person and specially between gender, which has prevailed over the past 50 years. It is a question of integrating this principle not only with regard to the research team and decision processes, but also in its contents of research and innovation.
- Science education, which reflects the principle of distributing scientific and technological knowledge as wide as possible in society by transmitting scientific and technological curiosity and knowledge to young people.
- Open access to scientific and technological knowledge pursues the same objectives as the previous point but focused here on greater transparency in the processes of knowledge production. In principle, it is in contradiction with the objective of increasing the commerciality of knowledge
- Ethics is probably the central theme of this concept, which itself derives from changes in the system or from the basic principles of the science-technology system. It is a question of defining the cardinal points which should guide the European science and technology complex. The definition of ethical references for research is the central point for defining responsibility.
- Governance refers to how the scientific and technological complex should incorporate the parameters defined above at the level of the system and at the level of each of the institutional actors. The aim is to make these parameters the standard for research and innovation processes

Following Owen et al. (2012), this concept has its origins in earlier works in the Netherlands, the UK and the US in the areas of technology advice [Rip et al. 1995; Schot & Rip 1996; Guston & Sarewitz 2002], anticipatory governance [Karinen & Guston 2010], socio-technical integration, governance from within (midstream modulation) [Fisher et al. 2006; Fisher 2007; Schuurbiers & Fisher 2009; McGregor & Wetmore 2009] and public and stakeholder participation [Stirling 2005; Wilsdon et al. 2005; Sykes & Macnaghten 2013].

Schomberg (2011) described in more detail the concept responding o the questions 'why' and 'how'. Regarding the 'why' he considers that:

a) At the beginning of a research-innovation process its social impact cannot be appreciated due to the long duration of the development process.
b) Correspondingly, the ethical implications are difficult to predict, so that when the ethical and social implications can really be seen, the development of technology is already so advanced that it is difficult to change the trajectory of its development.

c) New technologies must respond to social needs and values in order to be accepted. Some of the problems of their acceptance, such as violating ethical, legal and social norms, could already be dealt with at the beginning of development.

In other documents '*A report on Responsible Research & Innovation'* worked out by Sutcliff (2011) and his team for the DG Research and Innovation, European Commission, the following 'why's' are mentioned:

1. Not to miss again significant new technological trends, as has happened with genetically modified organisms. That is why it is important to involve citizens in the discussion about these new technologies. As shown by the technologies of genetically modified organisms or nuclear energy, some new technologies create a strong rejection in society - generally expressed through non-governmental organizations acting in the field - based substantially on the mistrust of the intentions of the actors involved in the process of generation and implementation of these technologies. To reduce possible rejection of new technologies, a wide variety of actors must be involved in the innovation process by creating relationships of trust between the different actors.
2. Preventing other disasters such as asbestos, chlorofluorocarbons (CFCs), etc., and avoiding unintended consequences and irreversible consequences
3. Innovation processes are increasingly complex, disruptive and global, but it must be ensured that they are for the benefit of society.

Both documents advocate early social intervention or the principle of proactive governance to prevent an invention from failing for its social unacceptance. This could help to address and regulate its positive and/or negative impact at an early stage. Sutcliff [*ibidem*] specifies that the aim is to create a flexible and adaptive system for the anticipation of unintended consequences and to address the social, ethical and environmental aspects of innovations. Both claim for more participation by diverse societal actors - not only companies - in order to improve, from the beginning of the process, the possibilities of acceptance of the envisaged innovations.

Regard to the 'how', Schomberg [2011] distinguishes between the product and the process, which should reflect the principles of a deliberative democracy[5]. In the product dimension, he insists that they must be ethically acceptable (according to the EU's charter of fundamental rights and product safety). They must also be sustainable by meeting the respective EU requirements. And they must be socially desirable, for example, by contributing to improved quality of life or gender equality. All this is summarised in the principle that goods and services must be designed and assessed according to the reference standards, i.e. achieve a high level of environmental and human health protection, sustainability and social desirability.

This should be reflected in the inclusivity of innovation processes, which should be multidisciplinary counting with the active participation of stakeholders so that inventors become more responsible for social needs and social actors become co-responsible for the innovation process by making constructive contributions to the defining of socially desirable products and services.

[5] Deliberative democracy means, following Velasco, J.C. [2009: 75] "*designates a normative model - a regulatory ideal - that seeks to complement the notion of representative democracy by adopting a collective political decision-making procedure based on the active participation of all those potentially affected by such decisions, and which would be based on the principle of deliberation, involving the argumentation and public discussion of the various proposals."* (own translation)

Different RRI documents proposed several action dimensions to introduce full accountability into innovation processes from their inception. For instance, the RRI-Tools project [https://rri-tools.eu] speaks about anticipation, reflexivity, deliberation, inclusion and responsiveness/sensitivity [see Couza et al. 2017].

Reflection and critical thinking are at the heart of scientific research and should be part of any innovation process based on scientific knowledge. It is about reflecting on the motivation, basic assumptions, purposes and possible consequences of action: This also refers to the diverse and often contradictory interests, contradictions and uncertainties inherent in any innovation process, and how to manage them. This means that reflection on innovation must be part of the process.

Anticipation refers to the estimation of the impacts and forecasting of desired and undesired consequences of the envisaged innovation and how they affect different social groups and individuals. The key to anticipation is to ensure that the consequences of the innovation itself and its possible outcomes are taken into account and that these considerations are reflected in the process design itself (see https://www.orbit-rri.org/resources/keys-of-rri/). This means asking about the consequences and impact of innovation and is therefore closely related to the process of reflection.

Transparency is one of the basic requirements for innovative responsibility and confidence building. Although the link between transparency and trust is not automatic, without transparency, social trust and legitimacy cannot be achieved. Transparency is not only about making the methodology and the results open to the public, but also announcing the actors, who are involved in the process, their interests and their opinions.

Inclusive deliberation means including a broad and diverse spectrum of actors and audiences in the deliberative process at different stages of the process. In line with the model of the innovation system in the form of a triple or quadruple helix, it is assumed that various societal actors will participate in the different phases of the innovation process and in the reflective and anticipatory deliberations.

Owen & Pansera (2019) describe the dimensions and goals in the following table 2:

Table 2
Dimensions of responsible innovation

Dimension	Description	Goals
Anticipation	- Articulating and reflecting on potential intended and unintended applications, impacts and interactions. - Articulating plausible outcomes, risks and associated uncertainties. - Asking 'what if?' questions, considering contingency, what is known, what is likely, plausible or possible. - Searching for alternative scenarios and options	- Critical engagement with visions and promissory statements of expected impacts. - Better understanding of sociotechnical and innovation pathways and scenarios. - Better understanding of potential impacts, risks and interactions. - Increasing resilience. - Better capacity and basis for robust and legitimate decision making.
Reflection (1st and 2nd orden)	- Reflecting on underlying purposes, motivations, values, what is known, what is uncertain, areas of ignorance, assumptions, motivations, commitments and ethical dilemmas.	- Better understanding and articulation of motivations and purposes. - Articulation of tacit assumptions, commitments, areas of ignorance and uncertainties.

Table 2
Dimensions of responsible innovation

Dimension	Description	Goals
	- Reflecting on norms, socio-political contexts, agendas, institutional practices, behaviours and epistemologies	- Critical and ethical engagement with broader dimensions of research and innovation. - Alignment with social values. - Better capacity and basis for robust and legitimate decision making
Inclusive Deliberation	- Opening up the visions, purposes, processes and emerging impacts of innovation to inclusive deliberation - Inviting, engaging and deliberating early and iteratively with a diverse range of stakeholders and publics in innovation agenda setting and practice. - Creating more socially robust knowledge and support for legitimate decision.	- Engaged stakeholders and publics. - Raising debate. - Understanding of different framings. - Identifying opportunities for innovation. - Making visible assumptions, commitments and intended impacts. - Participation in agenda setting and defining societal challenges. - Equitable decision making. - Better capacity and basis for robust and legitimate decision making..
Transparency & Openness	- Open and free access to and communication of data, results, purposes, risks, uncertainties, applications and implications to facilitate inclusive deliberation.	- Transparency. - Equitable access to knowledge and reducing information and power asymmetries. - Supporting informed debate. - Better capacity and basis for robust and legitimate decision making.

Fuente: Owen y Mario Pansera (2019)
Note: Owen & Pansera include also a file on responsiveness, which we excluded here as it was treated before.

Towards Responsible & Sustainable Innovation (ReSI)

One of the weaknesses of RRI is that it is very process-focused, leaving aside the point of reference of responsibility. The only reference to the human rights and ethic standards valid in the EU is not enough. We propose here to take the UN's sustainable development goals as a reference. These goals are the result of decades of political work and have been adopted by all UN member states by 2015. Also the European Union (EU) has taken them as a reference point for designing its work programme for the years 2020 to 2027, for example, in the **'green pact'**.

The relevance of the objectives of sustainable development to scientific based innovations can been show through the dilemma that medical research is facing. It is well known that there is a current trend to personalise medical care and medication. This is just one example that medical research including pharmaceuticals is focusing on the more lucrative segments of the market. These are more located in the north hemisphere despite the fact that more than 90% of avoidable deaths globally occur in south hemisphere. The unequal impact of climate change, pollution and pandemics can be seen in many indicators, which show that poor neighbourhoods are more affected than rich ones (see for instance the impact of the Covid 19). Another example of the dilemma is the actual dispute between the EU and the pharmaceutical enterprises, which have developed and patented the vaccines. In spite that the EU and some national governments have co-funded the research, in which public research centres have participated, the benefits are exclusively private.

However, both examples bring up the question how they are related to sustainability. One main reference of the SDGs is the so called Brundtland Report of the year 1987 (UN 1987), elaborated for the UNO. It defines sustainable development as follows: "*Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities*."

From academic side, this definition has received critics as ambiguous or vague. But this seems the case of the vast majority key terms used in the intersection of academy and policy. It is this lack of clarity, which has enabled it to become a catch-word used in different environments. However, the policies of sustainable development – including the so called Millennium Development Goals (MDGs) - has shown reduced effectivity in the 1990's and 2000s (see Arsel 2020: 10). For this reason, a next step was taken with the elaboration of the 2030 Agenda for Sustainable Development and the respective Sustainable Development Goals (SDGs). Without going into the debate about the adequacy of the 2030 Agenda to achieve full sustainability, a resume would highlight the following key elements:

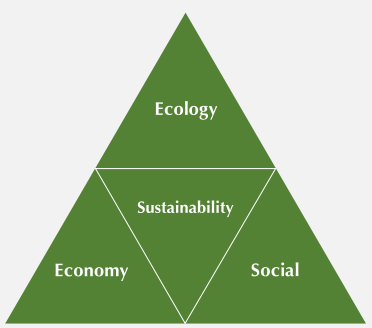
- Living without harming the environment, that means living within limits.
- Understanding the interconnections among economy, society, and environment.
- Equitable distribution of resources and opportunities.

It assumes that

- humanity can have neither an economic nor social well-being without the environment.
- these domains of ecology, economy and social are interwoven
- it requires actions, which work in all three domains under the overarching perspective to maintain alive the ecosystem Earth (see Dawe & Ryan 2003: 1459).[6]

Figure 5

Dimension of Sustainability



[6] Some works and initiatives consider or add others domains, e.g. the institutional (Spangenberg et al. 2002; Turcu 2013), cultural (*Soini & Birkeland 2014*), technical (Hill & Bowen 1997), religious-spiritual (Burford et al 2013) and global domain (Raskin et al. 1998). Without going into the discussion of the the relevance of these other domains, our article centred on the interrelation between socio-economical and ecological sustainability as the fundament of the fair transition to a sustainable Europe.

In other words, this interpretation of sustainability is a modell of three interconnected domains: ecology, economy and society, which can be operationalised as follows:

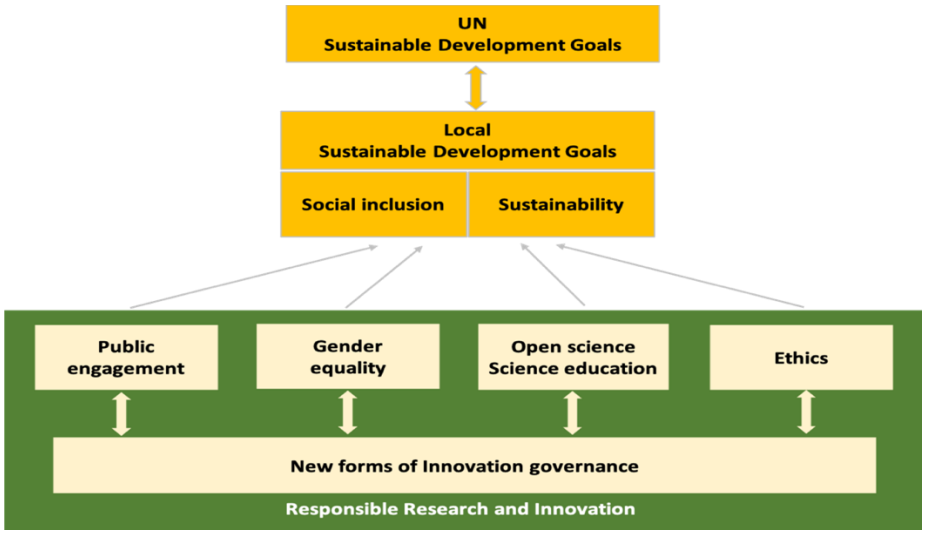
- Environmental sustainability is the ability to maintain rates of renewable resource harvest, pollution creation, and non-renewable resource depletion indefinitely without degradation of the environment.
- Economic sustainability is the ability to support a defined level of economic production indefinitely without environmental degradation.
- Social sustainability is the ability of a social system, such as a country, to function at a defined level of social well being indefinitely without environmental degradation.
- To which we could add an operational definition of the interrelation between economic sustainability and social impact in the sense that sustainable economic policy must be oriented to an equal distribution of the social benefits and loss overall related to environmental risks.

The EU has integrated this sustainability model and the sustainable development objectives in its strategies already in the 2000s. This aspect is reinforced in the design of the strategy for the years 2020-2027 in which the Green Deal and the just transition to a sustainable economy is a central element For this reason, we believe that it is appropriate to link responsible innovation to the SDGs as a reference point to guide responsible action in the domains established in the RRI concept. In the following figure 4, in which we have brought together open science and education for science in a single domain, we express the contribution of the RRI to the SDGs.

It must be highlighted that gender equality and social vulnerability become much more relevant as both are also SDGs.

The implementation of principles of responsible & sustainable innovation must address three level regard universities: the university as such, the individual researchers and the research groups.

Figure 6
Responsible Sustainable Innovation: Integration of SDGs and Responsible Innovation



Our empirical research on the implementation of RRI in universities and research organisations shows, the top-down strategy is nor very fruitful. At the universities, top down strategies face the

problem that universities are incomplete organisation in the sense that hierarchical decision processes have even, in the most hierarchized universities, considerable limits due to the relative autonomy of the university units (faculties, departments, institutes etc.) and the lectures regard teaching and researching. The effective implementation of internal policies required a high degree of consensus among the people in charge of the university, its units and the lectures.

But it is also true that the European Universities follow, in general, a code of conduct and have implemented procedures and guidelines for gender mainstreaming and ethics in research. And in general, European universities promotes public engagement, which is also required by European research programmes as H2020.

But our empirical research in Finland, Poland and Spain and other research on the topic indicates that the concept of RRI is hardly known at the level of individual researchers and research groups. However, this does not imply, that researchers and research groups do not follow intrinsically principles of public engagement, gender equality and research ethics. But there is a broad margin to improve its effective implementation in the daily project development activities.

However, as modern science based innovation is not an individual work, but a collective task, the responsibility for responsible & sustainable innovation lies not only in the individuals but also in the innovation teams, which must assure e.g. that:

- stakeholders from outside the project team are involved in the innovation process and that the affected citizens will have a voice;
- gender will not only treated in terms of 'head account', but also integrated as a transversal dimension of innovation. This is especially relevant for the just transition to a sustainable Europe, affecting not only gender but also other socially vulnerable groups.
- the data obtained and treated in the course of the project are anonymized,
- the privacy of data including big data is assured,
- maintain ethic principles in science based innovations
- take into account how the science based innovation affects the achievement of the sustainable development goals and sustainability in its three dimension: ecological, economic and social.

These are only some few example of aspects of responsible & sustainable to take into account in science based innovation processes.

Presentation of the online programme

Departing from this concept of Responsible & Sustainable Innovation, the project develops a online learning programme, which could be used also for blended and presence learning. The aim was to full a observed gap in learning offers detecting that there is no substantial attempt observable to develop continuous higher education programmes supporting the implementation of this concept and the respective reorganisation processes in universities, research centres, research and innovation oriented enterprises and public authorities like cities or regional governments.

Due to the relevance of cities for the achievement of the Sustainable Development Goals, the programme focused on urban social innovation and on the knowledge fields Energy and Economy) in four sections: introduction to Responsible & Sustainable Innovation, public engagement, gender equality and ethics based on interactive real-problem approaches. It was co-

created with practitioners from higher education institutes, municipalities and other local organisation.

The ultimate goal of the programmes is to empower actors through the learning process to participate actively in the implementation of ReSI principles in their organisation, the research & innovation network and urban innovation processes. It is intended to help users implement specific actions on a particular topic – public engagement, gender, and ethics in research & Innovation -such as designing and putting in practice a plan to generate structural change in an institution, selecting a participatory method to conduct an activity, or deciding in which open repository should be published the data and results of a project.

Objective

The program aims at helping practitioners to understand and analyse the dynamics of science-based innovation processes and the integration of principles of responsible and sustainable innovation focusing on public engagement, gender equality and innovation ethics. The program aims at helping the students to understand the dynamics of public engagement, the relevance of gender equality for the research processes and the tools for apply innovation ethics in science based innovation processes.

It provides the students with insight so that they can (a) reflect on their research and innovation already in early career stage; (b) anticipate intended and unintended consequences of their activities; (c) apply criteria of open science making transparent the intention of the research and innovation, the actors involved and their particular interest; and (d) involve the main stakeholders including the citizens in the deliberation processes from the beginning to the end of the science-based innovation process.

Structure and content

Course: Introduction to Responsible & Sustainable Innovation (ReSI)

The course introduces in Responsible & Sustainable Innovation, which anchored the concept of Responsible Research and Innovation (RRI) in Sustainability and the Sustainable Development Goals. The students will learn about

- the transformations of the innovation system towards quadruple helix configuration.
- the dilemmas, which academics must face, and how the concept of Responsible Research and Innovation have academics orientations to face these dilemmas.
- the need to anchored RRI in Sustainability and the Sustainable Development Goals. proposing the concept of Responsible & Sustainable Innovation (ReSI).

Based on this concept, the courses of public engagement, gender equality and innovation ethics has been developed. All three modules take as thematic reference points: economy, energy (including mobility) and urban development. The last topic indicates that the program insists in the cooperation with municipal public administrations and policy makers considering cities as crucial to achieve the Sustainable Development Goals.

It consist in:

Introduction.
Lecture1: Changes in Innovation Systems.
Lecture 2: Multi-actor configuration and open innovation.

Lecture 3: Answer to innovation dilemmas: Responsible Research & Innovation.
Lecture 4: Responsible Research and Innovation.
Lecture 5: Towards Responsible & Sustainable Innovation.
Lecture 6: ReSI in practice.

Course: Public Engagement in Responsible Research and Innovation

The course of ***public engagement*** aims at helping students to understand and analyse the dynamics of public engagement in the context of responsible research and innovation and its central elements. The students will be able to critically assess the strengths and weaknesses or advantage and disadvantages of public engagement in enhancing responsible research and innovation. The course insists in the relevance of public engagement for the implementation of the gender perspective and principles of innovation ethics already at the beginning of the innovation process. Students will work on a particular country/region innovation process case and analyse the major challenges and opportunities of public engagement of universities in transforming an innovation process to meaningfully respond to social, economic and political problems and come up with strategic and feasible solutions.

It consist in:

Introduction.
Lecture 7: Public Engagement in Responsible Research and Innovation.
Lecture 8: Innovation and Innovation Models.
Lecture 9: Conceptualising Dimensions of Public Engagement.
Lecture 10: Commercialisation of Research and Innovation and Public Engagement.
Group Exercise and Learning Diary: Developing sustainable public engagement strategy.

Course: Gendered Responsible & Sustainable Innovation (ReSI)

The course of ***gender equality*** aims to enable participants to integrate the dimension of gender equality and social vulnerability in science based innovation projects based on quadruple helix configuration, especially with the participation of municipal public administration and policy makers. Through the example of economy and technology (energy and artificial intelligence), it will arise the awareness of gender bias in science and innovation processes. The module insists in the interrelation with public engagement and innovation ethics to achieve the implementation of the gender perspective in science based innovation processes. It will reinforce the competences of the participants (defined in terms of knowledge, capacities, responsibility and autonomy) to integrate the gender and social vulnerability perspective in innovation projects and to evaluate and monitor their impact on gender equality and social vulnerability.

It consists in:

Introduction.
Lecture 11: Gender Bias in Economic Research.
Lecture 12: Gender Economics and Sustainability.
Lecture 13: Gendered ReSI (including gender bias in energy and technology innovation).
Lecture 14: Gender ReSi in Cities (with reference to energy use and mobility).
Lecture 15: Gender Mainstreaming and Doughnut strategy.
Group Exercise and Learning Diary: Gendered Responsible & Sustainable Innovation.

Course: Ethics in Responsible and Sustainable Innovation

The course of ***innovation ethics*** aims to enable students to introduce the ethical perspective in science based innovation processes, particularly in the fields of economy and energy with the focus on sustainability. It provides an overview of various tools, approaches, and methodologies such as the precautionary principle, International Standard ISO 26000, Value Sensitive Design, and participative technology assessment. It will arise the capability of the students to use in their projects, campaigns, or any other endeavours these and other tools reinforcing the ethic dimension of the innovation activities in close relation to public engagement and gender equality. It is based on the premise that to ensure social relevance and acceptability of any innovation, its impact should be evaluated at the early stages of the research process, including its possible unintended and unexpected consequences. Monitoring the innovation process could be enabled by sharing authorship and responsibility of the results with relevant social groups (citizens, policymakers, entrepreneurs, educators, etc.) who should be involved in all stages of the process while respecting the principles of gender balance.

It consist in:

Introduction.

Lecture 16: Tools to ensure societal relevance and ethical acceptability of RRI outcomes.

Lecture 17: Corporate Social Responsibility.

Lecture 18: Smart City & Responsible Technology.

Lecture 19: Just Energy Transition.

Group Exercise and Learning Diary: Ethics and General programme

The programme used video presentation to introduce to the topic and subtopics, web texts, video with experts (generally from external sources), individual exercises (e.g., quizzes and open questions), participants' learning journals, and group works (e.g., simulation of project development, interviews with experts among others) using holistic approaches combining public engagement, gender and ethic. Each course includes group exercises for its specific topic, so that they can be used separately, but maintaining the holistic approach.

Competencies

The programme aims that the participants will acquire competences defined, following the EQF 2018, as knowledge, skills and responsibility and autonomy. Here we will limit the exposition to the general competences of the programme. However, In the description of the courses, the competences are defined in more detail for public engagement, gender and innovation ethics.

Knowledge

EQF – Learning outcomes linked to knowledge
Level 6 (Graduate):
advanced knowledge of the field of work or study, involving a critical understanding of theories and principles.

Level 7 (Postgraduate: Bologna Master or other higher education postgraduate programmes (Formal and informal):

highly specialised knowledge, some of which is at the forefront of knowledge in the field of work or study, as the basis for original thinking and/or research.

critical awareness of knowledge issues in a field and at the interface between different fields.

The objectives are to:

- understand the dynamics of modern innovation systems.
- understand the principles of Responsible Research and Innovation and the relationship between public engagement, gender equality and innovation ethics.
- know the importance of responsible innovation in enhancing the social acceptance of research and innovation.
- understand the relevance of sustainability and sustainable development goals as anchors for responsible innovation (Responsible & Sustainable Innovation).
- understand the relevance of principles of responsible & sustainable innovation for the fair transition towards a Sustainable Europe and World.
- realise the relationship between public engagement, gender equality and innovation ethics and its relevance to achieve societal sustainable impact[7] of science based innovation projects.

Skills

EQF – Learning outcomes linked to skills

Level 6 (Graduates):

advanced skills, demonstrating innovation, required to solve complex and unpredictable problems in a specialised field of work or study.

Level 7 (Postgraduate: Bologna Master or other higher education postgraduate programmes (Formal and informal):

specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields.

The objectives are to acquire skills of:

- critically assessment of the challenges, dilemmas and opportunities of modern innovation systems (e.g., triple and quadruple helix configurations).
- implementation of ReSI principles in particular innovation processes.
- To assess innovation process from the perspective of responsible and sustainable innovation, especially in the dimension of public engagement, gender equality and innovation ethics.
- to apply critically the key principles of RRI: reflection, anticipation, openness and inclusive deliberation in own research and innovation.

[7] Sustainability is here and in the following sections used the three pillar model of ecological, economic and social sustainability, which is also the point of departure of the EU sustainability strategy (e.g., the Green Deal).

Responsibility & autonomy

EQF – Learning outcomes linked to Responsibility & autonomy
Level 6 (Graduates):
manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts.
take responsibility for managing professional development of individuals and groups.
Level 7 (Postgraduate: Bologna Master or other higher education postgraduate programmes (Formal and informal):
manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches.
take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams.

The objective is to strengthen responsibility and autonomy to:

- adopt and develop innovative mind-set based on ReSI principles.
- commit to understand the concept and importance of ReSI in making research and innovation responsive to societal problems.
- appreciate the concept of ReSI and the role of public engagement, gender and ethics to achieving sustainable goals.
- promote principles ReSI in innovation projects to improve the quality and sustainable relevance of the results.
- Identify and understand sustainable risks of science based innovations.
- Design and implement strategies to reduce sustainable risks.

The course can be consulted at canvas and used by other higher education providers to reinforce principles of responsible & sustainable innovation not only at the organisational level of universities, research centres and municipalities, but also in the research and innovation processes

Resume

We present here our concept of Responsible & Sustainable Innovation bringing together Responsible Innovation and Research (RRI) and Sustainable Development Goals.

We argue that the development of RRI is framed within the profound changes in innovation systems in which post-academic research, based on a closer cooperation between public research organisations, business and society, becomes much more relevant.

We sustain, based on empirical research of its implementation in higher education systems in Finland, Poland and Spain, that the RRI has had little impact on research and innovation systems and even less in the daily research practice and innovation processes.

RRI has also been criticized as it maintains a certain ambiguity regarding its points of reference. However, we sustain that both the dimensions of responsible innovation: anticipation, 1st and 2nd order reflection, inclusive deliberations and transparency and the RRI domains: public engagement, gender equality (social vulnerability), science education, open access and ethical principles are very relevant even more in post-academic research.

Next, we propose to link responsible innovation to the Sustainable Development Goals, which also guide the European Union's current strategies for a just transition towards a sustainable society and economy proposing the concept of Responsible and Sustainable Innovation. We argue that sustainability must become the anchor of innovation ethics and guiding principle of research and innovation in this Anthropocene crisis.

This was the point of departure to elaborate a learning programme not only focused on higher education institutes, research centres and their researchers, but also innovation practitioners from municipalities considering that cities are crucial actors to achieve the Sustainable Development Goals in a responsible way.

Literature

- Arora; A & Fosfuri, A., & Gambardella, A. (2001). Markets for Technology: The Economics of Innovation and Corporate Strategy. Cambridge, MA: MIT Press.
- Arsel, M. (2020). The myth of global sustainability: Environmental limits and (de) growth in the time of SDGs. Institute of Social Studies. Working Paper No. 662. Rotterdam
- Bolli, T. & Olivares, M. & Bonaccorsi, A. & Daraio, C. & Garcia Aracil, A. & Lepori, B. (2016) The Differential Effects of Competitive Funding on the Production Frontier and the Efficiency of Universities. Economics of Education Review, 52, 91-104.
- Burford, G., Hoover, E., Velasco, I., Janoušková, S., Jimenez, A., Piggot, G., ... & Harder, M. K. (2013). Bringing the "missing pillar" into sustainable development goals: Towards intersubjective values-based indicators. Sustainability, 5(7), 3035-3059.
- Carayannis, E. & Campbell, D.F. (2009) 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem. International journal of technology management, 46(3-4) 201-234.
- Chesbrough, H., (2006) Open Innovation: A New Paradigm for Understanding Industrial Innovation. Chesbrough, H., Vanhaverbeke, W., & West, J. (Eds.). (2006). *Open innovation: Researching a new paradigm*. Oxford
- Council of the European Union (2008).Conclusions on the definition of a "2020 Vision for the European Research Area. Retrieved 05/06/2021 at https://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/intm/104434.pdf (Links to an external site.)
- Couso, D., Simarro, C., Perelló, J., Bonhoure, I. (2017).10 ideas to include the RRI perspective. in STEM education. Retrieved 05/06/2021 at https://ddd.uab.cat/pub/infpro/2017/222612/RRI-SFY.pdf
- Dawe, N. K., & Ryan, K. L. (2003). The faulty three-legged-stool model of sustainable development. Conservation biology, 17(5), 1458-1460.
- EC (2012) Responsible Research and Innovation. Europe's ability to respond to societal challenges. Available at https://op.europa.eu/en/publication-detail/-/publication/2be36f74-b490-409e-bb60-12fd438100fe/language-en [online 24/11/2020]
- Enos, J. L. 1962. Petroleum Progress and Profits. Cambridge
- Etzkowitz, H. & Leydesdorff, L. (1995) The triple Helix – University-Industry-Government Relations: A Laboratory for knowledge based economic development. EASST Review 14: 14-19
- Guston, D. H. & Sarewitz, D. (2002) Real-time technology assessment; in Technology in society, 24(1-2) 93-109.
- Fisher, E. & Mahajan, R. I. & Mitcham, C. (2006) Midstream Modulation of Technology: Governance From Within. Bulletin of Science, Technology & Society 26(6): 485-496.
- Fisher, E. [2007] Ethnographic Invention: Probing the Capacity of Laboratory Decisions; in NanoEthics 1(2) 155-165
- Freeman, C. 1968. Chemical Process Plant: Innovation and the World Market. *National Institute Economic Review* 45, August: 29–57.
- Gibbons, M. & Limoges, C. & Nowotny, H. & Schwarztman, S. & Scott, P. & Trow, M. [1994] The New Production of Knowledge: the dynamics of science and research in contemporary societies, London.
- Hage, J. & Hollingsworth, R. [2000] A strategy for analysis of idea innovation networks. TUTS - Working Papers 5-2000; Berlin.
- Hill, R. C., & Bowen, P. A. (1997). Sustainable construction: principles and a framework for attainment. Construction Management & Economics, 15(3), 223-239.
- Karinen, R. & Guston, D. H. (2010) Towards anticipatory governance. The experience with nanotechnology. In: Kaiser, M. (Ed.) Governing Future Technologies. Nanotechnology and the Rise of an Assessment Regime. Dodtrecht. 217–32.
- Link, K. & Müller, B. (2020) Multiple-party funding: tensions and related consequences for academic research in Europe. Review of Managerial Science (2020) 14:417–445.

- Lamoreaux, N. and Sokoloff, K. (1999). 'Inventive Activity and the Market for Technology in the United States, 1840–1920', National Bureau of Economic Research,Working Paper No. 7107.
- Lerner, J. (2000). '150 Years of Patent Office Practice', National Bureau of Economic Research, Working Paper No. 7477.
- Lundvall, B.-Å. (Ed.) (1992), National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. London
- McGregor, J. & Wetmore, J. M. [2009] Researching and Teaching the Ethics and Social Implications of Emerging Technologies in the Laboratory; in Nanoethics 3(1) 17-30.
- Mowery, D. C. (1983). 'The Relationship Between Contractual and Intrafirm Forms of Industrial Research in American Manufacturing, 1900–1940', Explorations in Economic History, 20(4): 351–74.
- National Bureau of Economic research (Ed.) The Rate and Direction of Inventive Activity: Economic and Social Factors. Princeton.
- Nelson, R. R. (Ed.). (1993). National innovation systems: a comparative analysis. Oxford
- Nooteboom, B. (1999). Inter-Firm Alliances: Analysis and Design. London.
- Nowotny, H., Scott, P., & Gibbons, M. (2003). Introduction: 'Mode 2' revisited: The new production of knowledge. Minerva, 41(3), 179-194.
- Owen, R. & Macnaghten, P. & Stilgoe, J. [2012] Responsible research and innovation: From science in society to science for society, with society; in Science and Public Policy. 39/ 6: 751–760.
- Owen, R., & Pansera, M. (2019). Responsible innovation and responsible research and innovation. In Simon, D.; Kuhlmann, S., Stamm, J. & Canzler, W. (Eds) Handbook on Science and Public Policy. Cheltenham. 26-48.
- Raskin, P., Gallopin, G., Gutman, P., Hammond, A., & Swart, R. (1998). Bending the curve: toward global sustainability (Vol. 8). Stockholm.
- Rip, A. & Misa, T. & Schot, J. (1995) (Eds.) Managing Technology in Society: the Approach of Constructive Technology Assessment. London.
- Schomberg von, R. [2011] Introduction; in Schomberg von, R. (Ed.) Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields. Luxembourg. 7-15.
- Schot, J. & Rip, A. (1996) The past and future of constructive technology assessment. Technological forecasting and social change. 54(2-3) 251-268.
- Schuurbiers, D. & Fisher, E. [2009]. Lab-scale intervention. EMBO report 10(5) 424-427.
- Shah, S. 2000. Sources and Patterns of Innovation in a Consumer Products Field. Working paper, MIT Sloan School of Management.
- Soini, K., & Birkeland, I. (2014). Exploring the scientific discourse on cultural sustainability. Geoforum, 51, 213-223.
- Spangenberg, J. H. (2002). Environmental space and the prism of sustainability: frameworks for indicators measuring sustainable development. Ecological indicators, 2(3), 295-309.
- Stichweh, R. (1984) Die Entstehung des modernen Systems wissenschaftlicher Disziplinen. Frankfurt.
- Stirling, A. (2005) Opening up or closing down? Analysis, participation and power in the social appraisal of technology; in: Leach, M. & Scoones, I. & Wynne, B. (eds) Science and Citizens: Globalization and the Challenge of Engagement (Claiming citizenship); London. 218–31.
- Sutcliffe, H. [2011] A report on Responsible Research & Innovation. Brussels
- Sykes, K. & Macnaghten, P. M. (2013) 'Responsible innovation- Opening up dialogue and debate'. In: Owen, R. & Heintz, M. & Bessant, J. (Eds) Responsible Innovation. Managing the responsible emergence of science and innovation in society. Chichester. 85-107.
- Turcu, C. (2013). Re-thinking sustainability indicators: local perspectives of urban sustainability. Journal of Environmental Planning and Management, 56(5), 695-719
- UN (1987) Report of the World Commission on Environment and Development: Our Common Future. New York. Accessible at ttps://digitallibrary.un.org/record/139811
- von Hippel, E. 1988. The Sources of Innovation. Oxford.

- Von Hippel (2005) Democratizing Innovation. Cambridge/London.
- Velasco, J. C. (2009). Democracia y deliberación pública. Confluencia XXI. Revista de pensamiento político, 6, 70-79. Retrieved 05/06/2021 at https://digital.csic.es/handle/10261/23050 (Links to an external site.)
- Warnke, P; Koschatzky; K.; Dönitz, E. et al. (2016) Opening up the innovation system framework towards new actors and institutions. Fraunhofer ISI Discussion Papers Innovation Systems and Policy Analysis No. 49. Available at ttps://www.isi.fraunhofer.de/content/dam/isi/dokumente/cci/innovation-systems-policy-analysis/2016/discussionpaper_49_2016.pdf [online 24/11/2020]
- Wiener, M., Maresch, D., & Breitenecker, R. J. (2020). The shift towards entrepreneurial universities and the relevance of third-party funding of business and economics units in Austria: A research note. Review of Managerial Science, 14(2), 345-363.
- Wilsdon, J. & Wynne, B. & Stilgoe, J. [2005] The Public Value of Science. London.
- Ziman, J. (1996). " Post-academic science": constructing knowledge with networks and norms. Science & Technology Studies, 9(1), 67-80.