



**The EnRRICH tool for educators:
(Re-)Designing curricula in higher education from a
"Responsible Research and Innovation" perspective**

Deliverable 2.3

Valentina Tassone and Hansje Eppink

Wageningen University

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Contact: Valentina.Tassone@wur.nl
Hansje.Eppink@wur.nl



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Table of contents

Introduction.....	3
1. An introduction to Responsible Research and innovation (RRI)	4
1.1 Definitions and features of RRI	4
1.2 Understanding “Responsibility” in RRI.....	5
2. RRI in higher education	7
2.1 An introduction to the EnRRICH Tool	7
2.2 Methods used for developing the EnRRICH tool.....	7
3. The EnRRICH tool: the pillars	9
3.1 RRI in higher education: a working definition.....	9
3.2 RRI in higher education: design principles	9
3.3 RRI competence	15
4. The EnRRICH tool: elements for module development.....	19
4.1 Articulate learning outcomes	19
4.2 Define assessment, teaching and learning methods.....	27
Appendix	30
Acknowledgements	32
References	32

Introduction

The Enhancing Responsible Research and Innovation through Curricula in Higher education (EnRRICH) project aims to support the embedding of Responsible Research and Innovation (RRI) in higher education curricula. The EnRRICH project wants to develop the knowledge, the skills and the attitudes of students and staff in European higher education to respond to the needs of society through Responsible Research and Innovation (RRI). This Deliverable 2.3 is a manual written within the context of the EnRRICH project, to introduce educators to RRI and to present the EnRRICH tool. The EnRRICH tool aspires to guide educators to (re-) design curricula in higher education from a RRI perspective. This preliminary tool will be applied and tested in the next months within the EnRRICH project and, based on that, it may be further refined.

The tool provides insights about what RRI in higher education entails, about principles to take into account when (re-)designing curricula, about specific RRI competencies to be acquired by higher education students, about concrete steps for setting RRI-driven learning outcomes and for choosing consistent assessment, teaching and learning methods, with a focus on higher education modules (a module in higher education is a single course, often part of a wider program). The EnRRICH tool does not aim to stimulate the development of new modules about RRI, though this could be possible. Rather, the tool can be used to refresh existing modules from a RRI perspective. Educators can, thus, take their existing educational practices as starting point.

Additionally, while providing guidance to educators, the tool does not aim to be prescriptive. Educators are invited to experiment with the tool and identify the best course of action for revitalizing their own educational practices, within their own context. Finally, while the manual provides some possibilities to reflect on program development (i.e. a program is composed of various modules) through RRI lenses, it does not provide specific guidelines for revitalizing programs, as this goes beyond its scope.

1. An introduction to Responsible Research and innovation (RRI)

1.1 Definitions and features of RRI

Saying that research and innovation endeavours should be undertaken with a sense of responsibility, is something that not many would contest. RRI “intuitively feels right in sentiment, as an ideal or aspiration” (Owen et al. 2013, pp. 27). While RRI may be easy to endorse, however, it may also raise questions about what being responsible actually entails within scientific and innovation practices. Such questions cannot be taken for granted and do not have a single answer. The crucial role that RRI is asked to play, in response to the grand challenges that lie before us and to the evolving needs and values of society (von Schomberg, 2013; EC, 2013), call for a deep understanding about what a responsibly-driven research and innovation entails and about the capacities to be cultivated for fostering it. In the attempt to start familiarizing with RRI, hereby few definitions of RRI developed by key actors in the field. Those definitions, to be read in the following Textbox 1, are developed mainly with a policy, academic and technological context.

Textbox 1: Some definitions of RRI

“RRI should be understood as a strategy of stakeholders to become mutually responsive to each other, anticipating research and innovation outcomes aimed at the ‘grand challenges’ of our time, for which they share responsibility” (von Schomberg, 2013).

This definition is largely based upon a European Policy perspective.

RRI is “a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)” (von Schomberg, 2011, this definition is also adopted by EC, 2015).

This definition is largely based upon a European Policy perspective.

“Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present” (Stilgoe, et al., 2013).

This definition originates from insights developed within public debates concerning new areas of science and technology, with a special focus on UK.

“RRI is the on-going process of aligning research and innovation to the values, needs and expectations of society” (Rome declaration on Responsible Research and Innovation, 2014).

This definition is largely based upon a European Policy perspective.

“Responsible Research and Innovation is a dynamic, iterative process by which all stakeholders involved in the R&I practice become mutually responsive and share responsibility regarding both the outcomes and process requirements” (RRI tools project D1.1- Klaassen et. al., 2014).

This is the definition set by RRI Tools, a project funded by the European Union’s Seventh Framework Program. This project aims to develop a training and dissemination toolkit for fostering RRI.

The RRI performance depends both on the *processes* that promote RRI activities as well as on the *outcomes* that those processes have (EC, 2015). With regard to *RRI processes*, Stilgoe et al. (2013) elaborates a number of processes, called dimensions that can support RRI. Those RRI processes are: anticipation, reflexivity, inclusion and responsiveness. The RRI tools project (e.g. RRI tools project D1.4 – Kupper et. al., 2015) define similar RRI processes that includes not only the ones just mentioned but also other ones such as openness, transparency, diversity, adaptive change. With regard to *RRI outcomes*, von Schomberg (e.g. 2011) and the RRI tools project (e.g. Kupper, 2015) consider that RRI efforts and practices should address our societal challenges reflected in the ‘Grand Challenges’ (Lund Declaration, 2009), should foster engaged publics,

responsible actors and responsible institutions and should lead to ethically acceptable, sustainable and socially desirable outcomes.

In order to provide some guidance with regard to RRI within a policy context, the European Commission has specified a number of policy areas and action points relevant to RRI, called RRI Keys. The EC has defined, firstly, six RRI keys (EC, 2013). Later on the EC (2015) has suggested the inclusion of two additional RRI keys to support a comprehensive monitoring of RRI practices, for a total of eight RRI keys. The keys are meant to be taken into account when developing processes that promote RRI activities as well as when focusing on the outcomes of those processes. Those eight RRI keys are: governance, public engagement, gender equality, science education, open access, ethics, sustainability, social justice. A short description of each of those keys is found in the appendix 1.

1.2 Understanding "Responsibility" in RRI

The notion of responsibility can be approached differently depending on the perspective adopted (e.g. Grinbaum and Groves, 2013). From a *consequentialist* perspective, responsibility is mainly interpreted as *accountability* or liability. Within this perspective, first of all, the scientist or innovator is meant to be accountable, and therefore responsible, for the results of the practices undertaken. The goodness of one's scientific and innovation efforts depend on the outcomes. In this sense responsibility implies the capability to use past and present knowledge in order to understand, and at best to predict, the impact of one's endeavours. Responsibility is, thus, especially knowledge-based. A first inherent problem here is that when the outcomes of one's endeavours are negative and do harm, due to unforeseen events, the goodness of one's scientific and innovation efforts can depend only on the intention of the actor, scientist or innovator. But if the actor does not have full knowledge at the time of acting and his intention is not harmful, then the actor cannot be considered culpable for bad unforeseen outcomes either. Secondly, responsibility is related to one's individual specific role. So, for example, the role responsibilities of a scientist can be related to producing reliable knowledge. In this context acting right and ethically is about playing properly that given role, within the capacities and limitations once have. Obviously this conception of role responsibility does not include the virtue of a wider moral social responsibility towards mankind and the world (e.g. Grinbaum and Groves, 2013).

This notion of responsibility still present in our society, emerged in classical times and evolved over time, especially within the life context of people living close to one another and whose actions mainly impacted the immediate surroundings and rarely had irreversible impacts on the world at large and on the future (Owen et al., 2013, p. 36). Nowadays, we live in a globalized society characterized by an emerging complexity and severe grand challenges. The knowledge developed is contested, and while answering certain questions it also poses new queries and dilemma and adds to our sense of uncertainty. Outcomes of scientific and innovation practices do not evolve in a simple, linear fashion. Predicting with certainties possible impacts is difficult, if not impossible. And accountability for those impacts cannot be easily traced back. Additionally, scientific and innovation endeavours involve multiple actors. Knowledge is thus co-produced. Actions and implications are systemic, and therefore responsibility is not an individual affair based uniquely on role responsibilities of selected actors. Rather, it is a shared and collective process.

Given this, in line with various authors (e.g. Adam and Groves 2011; Grinbaum and Groves, 2013; Owen et al, 2013; Stilgoe, et al., 2013), it can be argued that the challenges of our time require a broader notion of responsibility, such as a *prospective* notion, that matches the complex society of today, that acknowledge the importance of knowledge while accommodating its limitations, that allows for a deeper reflection about

ways of doing and being and for the cultivation of social values and socially-relevant choices. From this prospective perspective the notion of responsibility includes new dimensions such as *care* and *responsiveness*, which are especially value-based and response-driven (e.g. Grinbaum and Groves, 2013; Jonas, 1984; Pellizzoni, 2004). The challenging conditions of our time call for human values that bring us back to our basic obligation to care for others and to permeate our endeavours with that sense of care, within and beyond any specific role one plays in society at a given point in time. As suggested by Adam and Groves (2011, p. 17) care “can provide us with ethical resources that can guide us in the face of uncertainty”. In this sense, responsibility requires a reflexive capacity, not only with regard to individual intentions but also in relation to our collective wants and needs and about the wider social significance of what our endeavours may accomplish now and in the future. Additionally, the urgency and severity of our grand challenges call for overcoming any sense of paralysis that can be experienced as a result of some factual limitations of an accountability-based approach. Societally relevant scientific and innovation endeavours may benefit from responsive actions. They may benefit from forward-looking activities such as developing foresight about plausible futures and consequences, but also they need to be responsive to new knowledge, changing public values, circumstances and societal needs while they emerge. This requires flexibility, in order to accommodate uncertainty. And it requires a process of on-going collaboration and experimentation.

2. RRI in higher education

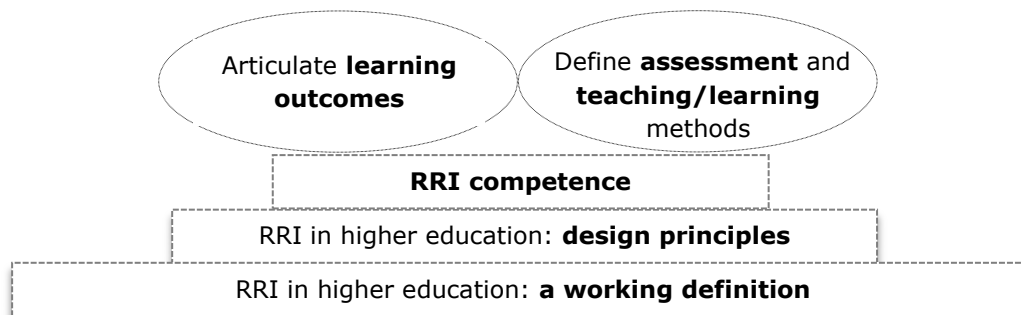
2.1 An introduction to the EnRRICH Tool

The EnRRICH (Enhancing Responsible Research and Innovation through curricula in higher education) tool has been developed with the intent to guide educators to revitalize curricula from a “Responsible Research and Innovation” standpoint. The tool has a number of components, namely it includes three pillars and two elements which are interconnected. See figure 1.

The three pillars provide the foundation for (re-)designing curricula through RRI lenses. The pillars are: i) a working definition of RRI in higher education, ii) design principles for embedding RRI in higher education and iii) RRI competence.

The two elements are built on the three pillars, and can further provide concrete insights for embedding RRI within higher education modules. The elements are: i) articulate learning outcomes, ii) define assessment, teaching and learning methods.

Figure 1: the EnRRICH Tool



2.2 Methods used for developing the EnRRICH tool

Before introducing the tool and its possible application, this section explains the methods of analysis used for elaborating the various components of the tool.

Current literature lacks to provide a *working definition of RRI in higher education* and possible *design principles* for facilitating the uptake of RRI in higher education curricula. Therefore, both components constituting the first two pillars of the tool for (re-)designing higher education curricula, have been developed through multiple steps. A first step consisted of defining the philosophical perspective taken for approaching RRI. More specifically, the working definition and design principles are grounded on a prospective notion of responsibility, without excluding elements deriving from a consequentialist notion (see section 1.2 in this manual). In a second step, existing RRI definitions (see textbox 1) have been studied. Those RRI definitions are also mainly taking a perspective towards responsibility that goes beyond individual accountability. Main aspects, related to those definitions, were distilled in the form of keywords describing features of RRI. This has led to the initial development of a possible working definition of RRI in higher education curricula and related design principle, which have been further developed in the next steps. So, a third step focused on integrating comments received by EnRRICH partners and advisors during two consultation workshops. The first consultation workshop was held six months after the start of the EnRRICH project, and the second one followed six months later. A fourth and last step, focused on analysing the RRI related promising

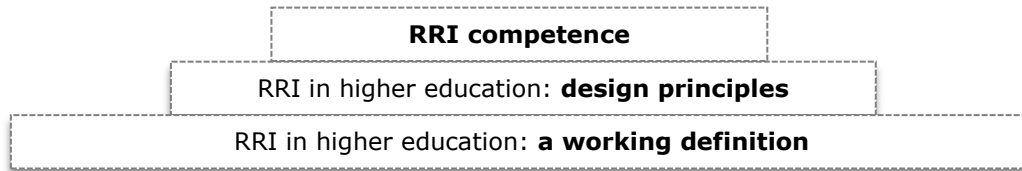
practices in higher education curricula in Europe, which were collected within the EnRRICH project (Living Knowledge, 2016). This analysis has provided additional elements for understanding RRI-related practices in the context of higher education. Based on the integration of those steps, a working definition of RRI in higher education and related design principles have been elaborated.

The EnRRICH tool introduces also a third pillar, the *RRI competence framework*. The tool can be considered a heuristic, developed with the intent to support educators to reflect about possible competencies that characterize a responsible researcher and innovator. Those competencies can be acquired by higher education students if there are to participate effectively in responsible research and innovation practices. In EnRRICH, the RRI competence framework comprises a set of capabilities, also called competencies. Each of those competencies is an interplay of knowledge, skills and attitudes, as indicated in the EnRRICH proposal. The RRI competence framework, part of the EnRRICH tool, has been developed through a few steps. A first step consisted of analysing few RRI definitions, as well as text from selected literature describing processes and capabilities needed for fostering RRI. More specifically, by means of qualitative content analysis the two authors, first separately and then jointly, have interpreted and coded the RRI definitions presented in textbox 1, as well as text from Stilgoe, et al. (2013, p. 1570-1573) and text from the RRI Tools Project (Kupper et. al., 2015, p. 19-38). The text in the papers by Stilgoe, et al. (2013) and RRI Tools Project (Kupper et. al., 2015), have been used as first reference point, as that text provides a description about RRI processes (and related possible capabilities). All this has led to the development of a very first possible set of RRI competencies. In a second step, this preliminary set of RRI competencies has been used as reference point for discussion with the EnRRICH partners and advisors. On this matter, two consultation workshops with EnRRICH core team were held six months and one year after the start of the EnRRICH project. Few individual consultation meetings with EnRRICH advisors were also organized. This has led to the further development of the set of RRI competencies, which are part of a RRI competence framework. A third step consisted of further refining this framework, and related competencies, by analysing promising practices of RRI in higher education curricula, which were collected within the EnRRICH project. A fourth and last step focused on integrating comments received by the participants of a workshop led by the authors and presenting the competence framework within the Living Knowledge conference held in Dublin in 2016. Based on the integration of those steps, a RRI competence framework has been developed.

Finally, the development of the *learning outcomes* and alignment aspects related to *assessment, teaching and learning methods* (the two elements of the tool) has been largely inspired by a workshop led by Dr. Declan Kennedy, University College Cork, in Ireland. The workshop was held for EnRRICH partners, on May 11, 2016. The insights gained during the workshop have been further developed by the authors, based on literature review, and adapted within the context of the EnRRICH tool.

3. The EnRRICH tool: the pillars

The EnRRICH tool is composed of *three pillars*, namely a working definition of RRI in higher education, design principles and competence.



3.1 RRI in higher education: a working definition

The EnRRICH tool, based on the analysis indicated in section 2.2, proposes the following (work in progress) definition of RRI in higher education”:

Fostering RRI in higher education curricula is about equipping learners to care for the future by means of responsive stewardship of scientific and innovation practices that address the grand challenges of our time in a collaborative, ethical, sustainable and socially desirable way.

3.2 RRI in higher education: design principles

There are three *key design principles* proposed in order to facilitate the uptake of RRI in higher education , namely:

- Education *for* society (*principle 1*)
 - Education *with* society (*principle 2*)
 - Education *to* whole persons (*principle 3*)
- Education for society (principle 1):

The adoption of RRI lenses within an higher education context calls for a reflection on the purpose of education. Given the explicit aim of RRI to align scientific and innovation efforts towards addressing societal challenges then, inevitably, educational endeavours need to be targeted to those challenges too. Education becomes then a means for equipping students to navigate the challenges of our time. “We have to enable students to address societal challenges and accommodate their solutions for the benefit of society” states the Lund Declaration background paper (2015, p.4). It is therefore crucial to provide students with opportunities to engage in educational processes and practices within societal challenges areas. The priorities set by the EU in terms of societal challenges to be addressed, also called grand challenges, are listed in textbox 2.

Textbox 2: EU societal challenges policy priorities, according to the EU framework program for Research and Innovation (EU, 2016)

- ✓ Health, demographic change and wellbeing;
- ✓ Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bio-economy;
- ✓ Secure, clean and efficient energy;
- ✓ Smart, green and integrated transport;
- ✓ Climate action, environment, resource efficiency and raw materials;
- ✓ Europe in a changing world - inclusive, innovative and reflective societies;
- ✓ Secure societies - protecting freedom and security of Europe and its citizens.

While educators can start here a reflection process about the purpose they consider their educational module (or program) can have and whether and how the topic they focus on is linked to societal challenges, there is a bigger question that may arise. Higher education modules (or programs) are also part of a bigger institutional, national and European education strategy. So the educators may wonder about the feasibility of embracing an "education *for* society" mentality, given the bigger higher education policy frame they will likely have to comply to. Here, it is provided a short reflection on this matter. While every national and institutional policy can provide own specific nuances when it comes to setting purposes of higher education, European countries largely use the Bologna process documentation as the reference factor for developing own national and institutional policy strategy.

The Bologna working group has indicated four main *purposes* of European higher education (Bologna Working Group on Qualifications Frameworks, 2005, pp.23-25). Those purposes guide higher education policies and practices within the countries that are part of the European Higher Education Area (EHEA). This means that the 47 European countries participating to the EHEA are committed to develop educational strategies and qualifications that are anchored on those purposes. Those purposes are: i) preparing students for the labour market, ii) preparing students for life as active citizens in a democratic society iii) personal development of students and iv) development and maintenance of a broad, advanced knowledge base. In appendix 2 a detailed description of those purposes can be found.

While the first three purposes especially focus on the student and the fourth is especially linked to society, all four purposes are interlinked (Bologna Working Group on Qualifications Frameworks, 2005, pp. 24). Those purposes point out that the needs of students and society should be central in higher education curricula. Those European higher education purposes do not explicitly focus on the grand challenges of our time, nor explicitly consider education as a mean for equipping students to care and to respond to those challenges. Additionally, when considering the three pillars of sustainable development, namely People, Planet and Prosperity, one could argue that the European higher education purposes do focus on people (especially students' development) and prosperity, but they overlook the planet and the planetary boundaries, to which societal challenges are often related to. Those aspects could be points to reflect upon at a European higher policy level, given the importance the European policy gives to RRI.

However, those European higher education purposes leave to educators room for integration of an "education *for* society" standpoint. Fostering students' employability, active citizenship and personal development implies educating students to work, to live and to develop themselves in the context they are in, which is a 21st society characterized by those grand challenges. Inevitably, living and working in our current

society requires the capacities to navigate those challenges as researchers, innovators and citizens of today and of the future. Furthermore, the last purpose is linked to society too. The advancement of knowledge in a broad range of disciplines is crucial for innovation and for society as a whole, as also indicated in the description of this purpose (see appendix 2). In this sense, education can fulfil this purpose by equipping students with the capacities for advancing (interdisciplinary) knowledge and innovation in society within the context of societal challenges.

Reflective questions for educators

- ✓ What do you consider to be the underlying purpose of your module (or program)?
- ✓ Does your module (or program) include an education *for* society standpoint? And in what way?
- ✓ Does or can your educational module (or program) address topics that are relevant for society?
- ✓ What are societal challenges that your module (or program) is directly or indirectly addressing or can address?

- Education *with* society (principle 2):

From an RRI standpoint science and innovation are not only meant to target societal challenges but also to meet societal actors' needs, values and aspirations, while tackling those challenges. The Rome Declaration on Responsible Research and Innovation in Europe (p.1), building on the Lund declaration and the Vilnius declaration and linked to the EU Charter of Fundamental Rights, call on all "stakeholders to work together for inclusive and sustainable solutions to our societal challenges". Research and innovation endeavours should, thus, be fine-tuned with societal actors, through for example processes of deliberation and collaboration among stakeholders.

This has at least one implication for higher education. That is, in order to prepare students for socially relevant endeavours, education needs to facilitate an interplay between academia and society. Education can connect students to real life societal contexts and needs, and encourage the experience of (inter- or trans-disciplinary & inter-cultural) collaboration. An education *with* society can allow students to understand and connect various scientific and societal knowledge fields, to develop socially-robust knowledge, skills and attitudes and to learn dealing with heterogeneous constellations of actors characterized by different perspectives, values and needs.

An example of how to organize the bridge between the academic and the societal worlds is provided by Science Shops. Science shops are facilities that can provide opportunities to engage students in praxis-oriented research and academic consultancy activities, as part of their curriculum, for and with civil society. A more detailed description about Science Shops can be found in Textbox 3.

Textbox 3: The example of Science Shops

Science Shops describe themselves as units providing independent, participatory research support in response to concerns experienced by civil society (www.livingknowledge.org). In some cases Science Shops are independent Non-Governmental Organisations (NGOs) but often they are part of a university. Their aim is to bring down barriers between science and society by creating fair and supportive partnerships with civil society organisations usually free of charge (Mulder et al., 2006). Civil Society Organisations can approach a Science Shop with a problem they are experiencing. Science Shop coordinators translate this problem into a research project and look for students and research staff to co-create in close contact with the civil society organisation solutions to their societal concerns. Students participating in the Science Shop projects do this under appropriate supervision (Mulder et al., 2006). The Science Shop projects are deeply rooted in society and often have an interdisciplinary nature. They provide students with authentic and interdisciplinary learning opportunities, grounded on real societal challenges. Here, the different strategies Science Shops are using to embed their activities into Higher Education curricula:

- Using a Science Shop project as a thesis topic (BSc, MSc and PhD)
- Integrate a Science Shop project in an existing course as a case study
- Creating a novel course (or practical period) connecting students to Science Shop projects, and awarding credits for this course

When it comes to the concrete pedagogical application of an education *with society* principle within curricula, and specifically within modules (or programs), educators could approach this in a variety of ways depending on the topic they teach, on the aim of the module (or program), on the opportunities offered within their institutions, etc. Especially based on the analysis of RRI promising practices in higher education collected within the context of the EnRRICH project (Living knowledge, 2016) we have distilled two main pedagogical approaches educators could take, namely a *light approach* and a *deep approach* to education *with society* in curricula.

A *light approach* consists of exposing students, in the classroom, to given knowledge and cases focusing on addressing societal concerns, academically and with societal actors. For instance, within the classroom, students could be exposed to concepts, methods, case studies, etc. and could be asked to reflect on rationale, ways, possibilities and implications of addressing current challenges while taking into account societal actors values and needs. Students could learn about deliberative methods and dialogic tools. They could practice role plays in order to exercise collaborative skills, and could design and evaluate an hypothetical inter-disciplinary project for tackling a certain issue in a participatory way. They could, also, benefit from a lecture by a civil society representative or by site visit and excursions to get a close sense of facts, perspectives and experiences of stakeholders.

A *deep approach* consists of engaging students in authentic learning processes at the cross-road between the classroom and society. For instance, students could identify or be presented with a specific problem faced in real-time by certain actors in the world and be asked to address it academically and collaboratively. Students could work in inter-disciplinary teams, benefit from supervisions of academic experts and experiment with using scientific knowledge to respond to the needs and values of the stakeholders engaged. They can practice the art of collaborating and negotiating with key societal and academic actors and develop solution-oriented capacities. Differently than in the light approach, students here are engaged collaboratively with other actors in real-time and real-life applications in-between academia and the rest of the world.

An example of application of a light and a deep approach is presented in textbox 4. The two approaches do not exclude each other. For example, one can think of exposing students to case studies to encourage understanding, reflection and learning (light approach) and then engage the same students in addressing collaboratively a specific

query commissioned by a certain stakeholder and provide an academic advice to address it (deep approach)

Textbox 4: Example of practices in curricula

A Light approach: *Example from a course on "Current population issues and urban demography" at Vrije Universiteit Brussel (Living knowledge, 2016. RRI promising practices and case studies)*

Learning activities:

This course is based on fundamental issues in demography and relates to current events. The starting point is a study of recent basic reports and referenced articles. Urban demography is a fixed part of the course, with the city of Brussels used as an observation ground. Students visit social organisations or certain districts in Brussels, staff members of those organisations give lectures. Particular attention is dedicated to organisations that are collecting and working on data that is used in demographic studies. Students should collate the acquired knowledge in a critical research design on population issues. They look up the most appropriate available secondary data to answer the formulated research question. Next, they visit a data producer and a data user of population related research, in order to sharpen their critical data reflection.

Learning assessment:

Oral exam (40%): Individual oral presentation of the group work

Research project (60%): Written reporting

A Deep approach: *Example from a course on "Transdisciplinary Project", Leuphana University of Lüneburg (Living knowledge, 2016. RRI promising practices and case studies)*

Learning activities:

This is a two-semester research based learning project. Semester one deals with: Identification of societal problems with various actors from different societal fields and cooperative problem framing, building of a transdisciplinary team and development of a research plan. Semester two deals with: Implementation of the research project, including dissemination of outcomes.

Students learn to collaborate in transdisciplinary teams, they collaborate with actors from different fields of practice and engage in mutual learning processes. Within their projects, students pass through all three phases of transdisciplinary sustainability research:

- Identification of a case/problem, formulation of a research question, building of a transdisciplinary team (phase A),
- Working on the research questions in the team with different stakeholders (phase B)
- Preparation of results for societal and academic use and publication (phase C).

Learning assessment:

At the end of the first semester the student groups submit a research design and an essay that focuses on an individually selected aspect of the transdisciplinary research process, including experiences from an experiential case encounter (1-day working in the field). Furthermore, in a compulsory but not graded reflexion dialogue between each student and the lecturers the learning process is reviewed. At the end of the second semester the student groups submit a final report that consists of a scientific paper presenting process and a brochure (or similar) including results and recommendations for practitioners.

Reflective questions for educators

- ✓ Does or can your institution facilitate an interplay between academia and society? And in what way? (e.g. Science Shops)
- ✓ Does or can your educational module (or program) equip students to address grand challenges academically and collaboratively with societal actors?
- ✓ Does or can your educational module (or program) take a light or a deep approach to education *with* society? And in what way?
- ✓ Does or can you use activating learning activities (e.g. role-play, group discussion, project work, excursion) in your course set-up? And which ones?

- Education to “whole” persons (principle 3):

Framing responsibility not only as accountability, but also as care and responsiveness has implications for the type of learning to be fostered within higher education. It requires a learning that not only focuses on acquiring and on applying given knowledge, but that also focuses on developing value-oriented and response-oriented capacities. This implies that the students need to learn and to develop across multiple domains. A number of authors have explored domains upon which learning can be fostered (e.g. Bloom et al., 1956; Krathwohl et al., 1964). The EnRRICH tool distinguishes three domains that appear to be crucial for facilitating RRI, namely the *cognitive*, the *affective* and the *physical* learning domains. *Cognitive learning* is approached here as *learning to know*. Cognitive learning is needed in order *to know and to understand* the complex issues of our time, to navigate uncertainties, to apply the knowledge acquired, to experiment with and to evaluate new solutions for addressing those issues in society. However, learning about RRI also includes learning within the *affective domain*, which is approached here as *learning to be*. *Affective* capacities are needed too, as nurturing a sense of care and stewardship, collaborating, cultivating a sense of responsibility, social attitudes and values are not merely intellectual exercises but a *way of being and of relating* to ourselves, to others and to the planet. Additionally, learning about RRI include the *physical* (or psycho-motor) domain, approached here as *learning to do*. This is especially related to the tangible and physical expressions of our cognitive and affective capacities, of our knowledge and attitudes and implies for example appropriate communication skills, use of equipment in laboratories, etc.

The possibility to embed those cognitive, affective and physical learning dimensions depends on the educational topic and related academic field, on the specific aim and type of modules (and programs), etc. Those dimensions which are now introduced here, will be discussed further in the section dealing with the articulation of the learning outcomes (section 4).

Reflective questions for educators

- ✓ Does your module (or program) allow or can allow for learning across various dimensions (cognitive, affective, psycho-motor)? And how?
- ✓ What do you consider to be a possible added value of fostering learning with the various domains, in the context of your module (or program)?
- ✓ What do you consider to be a possible challenge related to fostering learning with the various domains, in the context of your module (or program)? And how could you tackle that challenge?

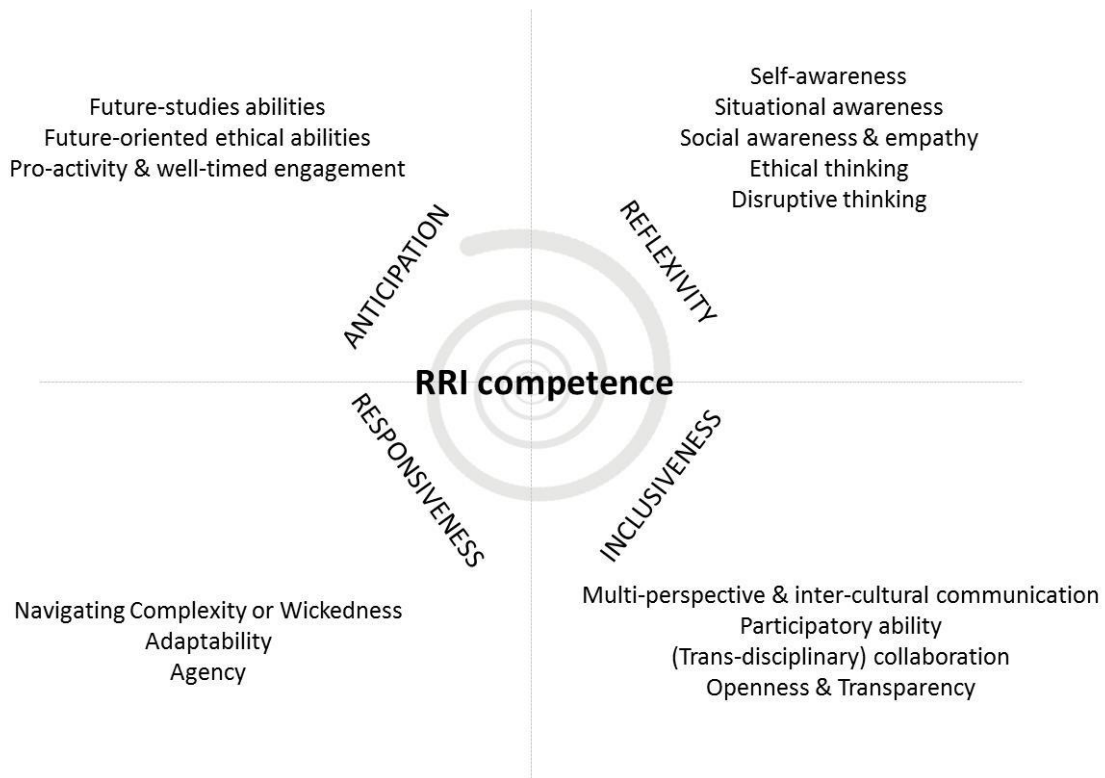
3.3 RRI competence

When considering the prospect of equipping students as responsible researchers and innovators, educators may wonder about what are the specific capabilities, or competencies, that need to be acquired by higher education students if there are to participate effectively in responsible research and innovation practices. In order to address this question, and based on the analysis indicated in section 2.2, the EnRRICH tool introduces a RRI competence framework (see figure 2). This framework has been developed with the intent to guide educators, towards the goal of equipping students to be responsible researchers and innovators. The notion of competence evolved over time and gained increased attention in the EU within a professional and educational context (e.g. Mulder et al., 2009). Also, it has been explored within a normative and societal context (e.g. sustainability) by various authors (e.g. Barth et al., 2007; Gardiner and Rieckmann, 2015; Rieckmann, 2012; Wals, 2010; Wiek et al. 2011).

In the EnRRICH tool the RRI competence is defined as an overarching and multi-dimensional competence enabling responsible research and innovation. The RRI competence comprises a set of capabilities, also called competencies. Each of those competencies is an interplay of knowledge, skills and attitudes (including values). The competencies are articulated across four dimensions or quadrants namely anticipation, reflexivity, inclusiveness and responsiveness. The proposed competencies do not mean to be exhaustive nor prescriptive. While each of the proposed competencies stands on its own within a certain dimension, those competencies and dimensions are also interlinked. The lines between them are blurred. Those various competencies can mutually reinforce each other, even when they appear to be overlapping or in contradictions within and across dimensions. The dynamic interactions among competencies and dimensions can help building the overarching and multi-dimensional RRI competence and can enable RRI. The framework is built considering that RRI is a complex matter that can be related to diverse educational contexts, diverse societal challenges, diverse scientific and innovation fields, diverse subjects areas and diverse actors. The proposed set of competencies attempts to embrace this complexity and diversity, and is thus context-independent. In practice, the set of competencies that are conducive to RRI in a specific concrete situation depends on the particular context within which one is situated.

Therefore, the RRI competence framework proposed here is meant as a *guide*, a heuristic, for educators. The relevance of the various competencies depends on the specific focus and aim of modules (and programs) within curricula. So, within a specific topic and module (or program), some competencies can be more applicable than others. It can also be, for example, that a different or more specific nuance need to be given to a specific competence. So, while using the framework as a guide, educators are invited to personalize its application within the specific educational, scientific and societal context they are in.

Figure 2: A RRI competence framework



A description of each of the competencies (in terms of knowledge, skills and attitudes) within each domain, as introduced in the RRI competence framework, can be found in textbox 5.

Reflective questions for educators

Take the RRI competence framework as starting point for your reflection about possible students' competencies fostered or to be fostered within your existing or to be developed module (or program):

- ✓ What insights do emerge?
- ✓ What are RRI related competencies you focus or could focus on, within the context of your module (or programme)?
- ✓ What challenges do you foresee when wanting to foster development of RRI competencies in students? And how could you tackle those challenges?

Textbox 5: Description of RRI relevant competencies within each domain

Dimension: ANTICIPATION

It includes competencies in anticipating societal challenges and future implications related to scientific and innovation practices

Future-studies abilities:

- *knowing and understanding concepts, methods and tools for exploring possible development of societal challenges in the future, for imagining possible futures, for exploring possible solutions to societal challenges and possible future implications and impacts of scientific and innovation practices (e.g. scenario analysis, forecasting methods, etc.)*
- *skill in anticipating possible futures, by applying future-studies concepts and methods*
- *holding a positive and engaged attitude towards anticipatory efforts, valuing anticipatory abilities*

Future-oriented ethical abilities

- *knowing and understanding ethical principles and resources in the context of short and long term projects and plans*
- *skill in engaging with ethical questions about the goodness of possible futures that scientific and innovation practices can bring into the world (e.g. the "to what end" questions) and in applying ethical principles and resources when engaging into anticipatory scientific and innovation practices*
- *holding a future-oriented ethical attitude, for example having a sense of care towards the future; valuing ethical principles for a just future*

Pro-activity & well-timed engagement:

- *knowing and understanding the meaning and practice of pro-activity, barriers and supportive factors*
- *skill in being pro-active and well-timed when engaging into anticipatory processes and practices, early enough to be constructive but late enough to be meaningful*
- *holding a receptive attitude towards ones surrounding, and valuing pro-activity*

Dimension: REFLEXIVITY

It includes competencies in reflecting about context, ways of framing, ways of knowing, ways of doing, and ways of being in relation to the work of science and innovation and societal challenges.

Self-awareness

- *knowing and understanding oneself, and tools to reflect about own actions, assumptions, norms, values and ways of framing*
- *skill in reflecting about own actions, assumptions, norms, values and ways of framing*
- *holding a positive constructive attitude towards self-reflection*

Situational awareness

- *knowing and understanding the context within which one's scientific and innovation efforts, and related societal challenges, are situated*
- *skill in reflecting about contextual factors*
- *holding a receptive attitude towards one's surroundings and contextual aspects*

Social awareness and empathy

- *knowing and understanding social values, cultures and perspectives, and related tools for reflecting on those values and perspectives*
- *skill in reflecting about and acknowledging social values, cultures and perspectives*
- *holding a social and emphatic disposition, respecting social values*

Ethical thinking

- *knowing and understanding tools to ethically evaluate and make judgements about perspectives, assumptions and endeavours for tackling societal challenges*
- *skill in ethically evaluating and judge perspectives, assumptions and endeavours for tackling societal challenges*
- *holding a caring and ethical attitude, valuing ethical thinking*

Disruptive thinking

- *knowing and understanding what disruptive thinking entails, and tools for fostering it*
- *skill in engaging with unconventional ways of thinking that challenge and go beyond current status-quo, ways of knowing and ways of framing.*
- *holding the courage to think disruptively, and valuing disruption*

Dimension: INCLUSIVENESS

It includes competencies in including, communicating with, collaborating with diverse stakeholders and the wider public within scientific and innovation practices and in relation to societal challenges.

Multi-perspective & inter-cultural communication

- *knowing and understanding concepts and tools related to perspective-taking and communication with people holding different perspectives and cultures*
- *skill in actively listening and communicating with the wider public and diverse stakeholders by being sensitive to different perspectives and cultures*
- *holding an attitude of respect and curiosity towards different perspectives and cultures, valuing diversity*

Participatory ability

- *knowing and understanding participatory methods for including voices of diverse stakeholders, also the wider public, minorities and silent voices, within science and innovation design and practices*
- *skill in engaging stakeholders and including their voices within design and practices of science an innovation*
- *holding a participatory attitude, valuing participation*

(Trans-disciplinary) collaboration

- *knowing and understanding concepts and methods for collaboration across disciplines, actors and various contexts*
- *skill in bridging disciplines, actors and various contexts, negotiating and co-operating towards collective goals*
- *holding an attitude of willingness to engage with and to bridge diverse disciplines, actors and contexts, valuing collaborative efforts*

Openness & Transparency

- *knowing and understanding tools and processes for sharing information about findings and practices in science and innovation and in relation to societal challenges, and understanding possible restrictions in sharing information (e.g. intellectual property rights, need to limit the circulation of sensitive data)*
- *skill in sharing information regarding findings and practices, while being mindful of possible restrictions*
- *holding an attitude of openness in sharing one's findings and processes, valuing transparency*

Dimension: RESPONSIVENESS

It includes competencies in coping with and responding to emerging challenges and to new knowledge, perspectives, public values, and norms through scientific and innovation endeavours

Navigating Complexity or Wickedness:

- *knowing and understanding (tools for exploring) complexities, and even wickedness, of emerging societal challenges and research and innovation endeavours*
- *skill in handling complex, or wicked, problems and make choices in spite of complexities, controversy and uncertainties*
- *holding a constructive attitude towards complexities or wickedness, overcoming any related possible sense of paralysis or overwhelm, tolerating ambiguity*

Adaptability:

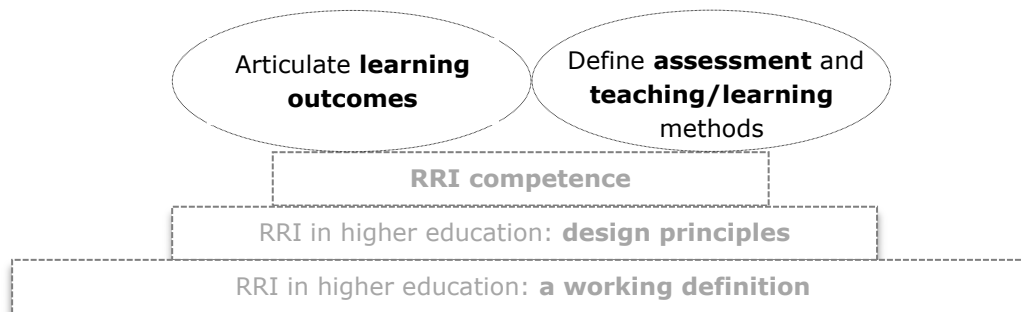
- *knowing and understanding tools and processes for identifying emerging challenges and changes in society, as well as for flexible and adaptable design and practices, in order to meet those changes and challenges*
- *skill in identifying emerging challenges and changes, and in revising views and adapting the direction and course of action of research and innovation design and practices, in order to respond to those challenges and change*
- *holding a flexible attitude towards challenges and changes, having the willingness to respond to them when they emerge*

Agency:

- *knowing and understanding the concept and practice of agency, including also supportive and hampering factors, in the context of societal challenges and scientific and innovation practices*
- *skill in initiating change and engaging with exploring new ways of doing*
- *holding an attitude of courage and commitment towards initiating change, believing in ones' ability to produce change through one's action*

4. The EnRRICH tool: elements for module development

This section introduces two key elements supporting development of modules from a RRI perspective. The elements discussed are: i) the articulation of the learning outcomes, ii) the choice of appropriate assessment and teaching/learning methods. Those elements are grounded on the EnRRICH pillars described in the previous section.



4.1 Articulate learning outcomes

Defining who articulates the learning outcomes

In order to discuss about how to articulate learning outcomes, first two different approaches that educators can take in their educational activities are presented. Educators can embrace an instrumental perspective or an emancipatory one in their educational activities focused on addressing societal challenges (Wals and Jickling, 2002; Jickling and Wals, 2008). The *instrumental perspective* is in line with transmissive and mechanistic mode of education. Within this perspective education is expert-driven. The educator is the expert transmitting knowledge, mainly in a linear manner. Educational activities focus, thus, on transmitting expert knowledge, prescribing given standards and pre-determined solutions to current societal issues. The student is a neutral or passive receiver that retains the knowledge provided. The *emancipatory perspective* is in line with social cognitive theory and socio-constructivist mode of education. As such, education is about providing space for autonomy and self-determination. Education is approached mainly as a process. Knowledge about societal challenges, capacities to tackle them or outcomes to be achieved are not only handed over, but they are developed also by reflecting on viewpoints, affective elements and through experience. Teachers act more as facilitators, or they are even co-learning with the students and possibly with other societal actors. Students are actively meant to engage in questioning and in developing design, practices and solutions to societal challenges and to experiment with that. See also figure 3.

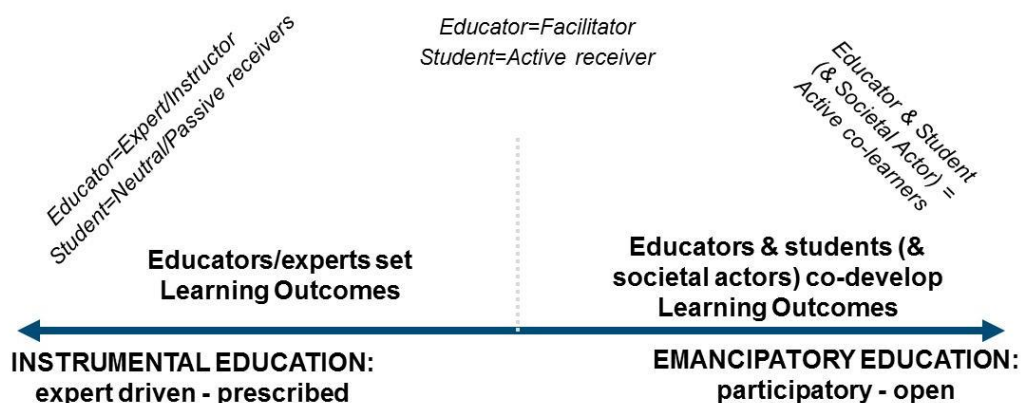
Before linking the discussion about those educational approaches to the articulation of learning outcomes, let us spend few words about what learning outcomes are about. Learning outcomes represent one of the building blocks for transparency within European higher education systems and qualifications. Articulating learning outcomes, also, can support the design of assessment strategies, teaching and learning methods within a specific module (or program). According to the Bologna working group on Qualifications Frameworks (2005, p.37) a learning outcome is "a statement of what a learner knows, understands and is able to do at the end of a period of learning". When taking a RRI perspective this definition appears adequate when it comes to covering the cognitive and psychomotor learning domains. This definition could be, however, less adequate to cover the affective learning domain. In the attempt to cover all learning dimensions, the EnRRICH tool considers that a *learning outcome* is "a statement of what a learner knows,

understands, *values* and is able to do at the end of a period of learning". This definition is identical to the Bologna working group definition, except for the fact that it adds the term "values" in the attempt to include the affective dimensions.

Defining appropriate learning outcomes is considered crucial for every module within the European higher education system. Learning outcomes should be written from a student-perspective, as those outcomes are based on what the student can achieve at the end of a module (e.g. Bologna Working Group on Qualifications Frameworks, 2005). One can argue that when educators articulate learning outcomes for students, they are actually adopting an instrumental perspective as they are prescribing standards to be achieved by students. From this perspective educators act as experts. While learning outcomes can be articulated from a student-point of view, they are educator/expert-driven or in other words they are developed according to what the educator consider to be relevant for the students. On the other hand, taking a full emancipatory approach when setting learning outcomes would imply to allow students, and possibly other societal actors students engage with, to participate in the development of the learning outcomes. This would mean that, for example, a feedback loop is implemented throughout a module in order to allow integration of feedback from students, and in case from other actors too, in the development of the learning outcomes.

A strategy could be, for instance, to discuss with students about appropriate learning outcomes within the context of a module and integrating the feedback when updating the module offered in the next round. When appropriate, feedback from societal actors, that students engage with, could also be integrated in this process. By doing so, in time, learning outcomes are co-developed by educators, students and in case also other stakeholders. This could be a feasibly strategy to apply, when wanting to adopt a more emancipatory perspective. Another strategy could be, for instance, to discuss with students about their appropriate learning outcomes while they join a certain module. The educator should then leave space to students for adjusting given learning outcomes or for creating new ones, based on students' needs and wants as they emerge throughout the module. The learning process is therefore open, and the learning outcomes can emerge while learning. Societal stakeholders could also provide inputs throughout the module based on their perspective and experience with the students. Such an approach calls for high flexibility on the side of the educator, the students, and the educational arrangements related to assessment, teaching and learning strategy, etc. Also, it is possible to think of a combination of an instrumental approach (i.e. the educator prescribes the learning outcomes), with an emancipatory approach (i.e. the students, and the societal actors when appropriate, participate in the articulation of the learning outcomes). So, learning outcomes are, partly, predetermined and prescribed by educators and, partly, they are co-developed by educators, students and societal actors.

Figure 3: Defining who articulates learning outcomes



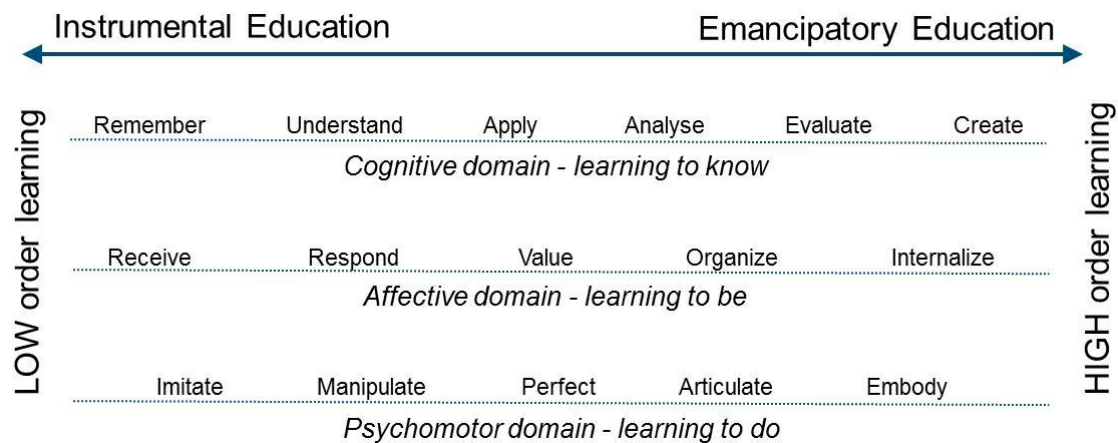
Understanding the character of the learning outcomes

For developing the learning outcomes, the EnRRICH tool considers three learning domains, namely the cognitive, affective, and psychomotor domains (see also “education to whole persons”, principle 2, previous section). In order to provide concrete examples of how to articulate learning outcomes within those learning domains, few taxonomies are taken into account in this manual. More specifically, the elaboration of learning outcomes within the cognitive domain is grounded on the taxonomy by Anderson and Krathwohl (2001) and by Krathwohl (2002), the elaboration within the affective domain is grounded on the work of Krathwohl, et al. (1964), the elaboration within the psychomotor domain is grounded on the work of Dave (1970). Those taxonomies build on the work of Bloom et al. (1956), which is widely recognized by educators within many subject areas (e.g. Marzano and Kendall, 2007). Those taxonomies consider learning as a process. They identify levels of learning within each domain, and consider that by building upon former learning (lower order learning) more complex levels of knowing, being and doing can be developed (higher order learning). The higher are the levels of learning the more they are consistent with a constructivist view of learning (e.g. Krathwohl, 2002). See Figure 4 depicting for each domain, according to the taxonomies just introduced, the various levels of learning expressed through verbs within each domain.

Before introducing details and examples about possible learning outcomes within each low or high level and each domain, let us go back to the discussion about instrumental and emancipatory education. *Regardless of who defines the learning outcomes*, the various high or low levels of learning (according to the taxonomies just introduced) imply a different type of learning engagement and processes. Low order levels imply expert driven and transmissive educational processes. The students receive information from the educator and replicate given knowledge, ways of doing and being. Higher levels imply more engaging and participatory educational processes. Students can engage in expressing their own capacities and can experiment with ways of thinking, doing and being. *So, learning outcomes that relate to lower order levels have an instrumental character and call for a type of education that is instrumental. On the other hand, learning outcomes that relate to higher order levels have a more emancipatory character and call for a type of education that is more emancipatory. See figure 4.*

All this, as said, regardless of who sets the learning outcomes. So, educators could set on their own learning outcomes (and therefore adopt an instrumental perspective in terms of who sets the learning outcomes) and still articulate learning outcomes that belong to either a low order learning (which calls for instrumental forms of education) or high order learning (which calls for a more emancipatory forms of education). The opposite could also be true. That is, educators and students could set jointly the learning outcomes (and therefore adopt an emancipatory perspective in terms of who sets the learning outcomes) and still articulate learning outcomes and engage with learning process that belong to either a low order learning (which calls for instrumental education) or high order learning (which calls for a more emancipatory education).

Figure 4: Domains of learning for articulating learning outcomes according to their instrumental or emancipatory character



It needs to be clarified that while an education *to* whole persons is considered crucial in the EnRRICH tool when (re-)designing curricula from a RRI perspective, *the application of the taxonomies used here is not prescriptive*. Educators may need to comply to other taxonomies that are suggested by their own institution, or may just be interested or attach more value to other taxonomies (e.g. Marzano and Kendall, 2007). While this manual, and the EnRRICH tool, are attempting to provide a concrete guidance to educators also in terms of writing learning outcomes, it is not the purpose of the tool to identify a best taxonomy or to prescribe a right taxonomy. Rather, the ambition of the EnRRICH tool is to stimulate educators to consider the possibility of a whole person approach when revitalizing their educational work through RRI lenses.

Guidelines for articulating learning outcomes

Broadly speaking, whether the learning outcome is developed with or without student participation and whether has an instrumental or emancipatory character a written learning outcome can start with an opening phrase like: *'After successful completion of this module students are expected to be able to.....'*. This starting phrase is followed by an *action verb*. The *action verb* used is related to the level, or complexity, of learning (low level or high level). It should be specific and clear. It is suggested to avoid the use of actions verbs which are rather general like 'know', 'be familiar with', 'be acquainted with', etc. The action verb is then followed by the *object of the verb*, which provides clarification about the verb, and is followed by some words that provide the *context* of the learning outcome. The RRI competence framework (introduced in the previous section, figure 2) can be used as inspiration when defining the object and the context of the learning outcome. The RRI competence framework includes a set of competencies that can be acquired by higher education students if there are to participate effectively in responsible research and innovation practices. Grounding the learning outcomes development into the RRI competencies can ensure the development of RRI-driven learning outcomes.

So in short, a written learning outcome is a statement, possibly embracing a cognitive, affective and psychomotor domain, including a number of components:

- ✓ a starting phrase: e.g. *After successful completion of this module students are expected to be able to.....*
- ✓ + an *action verb*
- ✓ + the *object* of the verb & the *context* (the *RRI competence* can be used as inspiration for defining the object and context)

Some examples about how to develop possible RRI-driven learning outcomes, within each of the various domains of learning, are provided in tables 1, 2 and 3. In those tables, for each domain, and for each level of learning within each domain, there are indicated related action verbs (which are not exhaustive but only offer an impression of verbs that can be used), and examples of possible RRI-driven learning outcomes (grounded on some aspects of RRI competencies). When looking back at the RRI competence framework already introduced in figure 2, and when using this for inspiration when developing learning outcomes, one can note that the set of RRI competencies proposed especially point towards the development of learning outcomes that are related to higher order learning. Nevertheless, the lower levels could still be relevant within certain contexts or just as a first step towards more complex forms of learning which could be for example facilitated at a later stage within the same module or in other modules within a program.

The examples provided in the tables 1,2 and 3, attempt to provide a general sense of how to develop learning outcomes. In practice, however, the description of a set of learning outcomes within a module depends on a number of factors. It depends on the topic addressed, on the specific objectives of a module and the wider aim of the program within which a module is developed. Also, it depends on the specific target, for example a first module offered to Bachelor students can be different than a module developed for students in the last phase of their Master program, or can be different than a module supporting PhD candidates. Additionally, while the different cognitive, affective and psychomotor domains are handled here separately, and may be handled separately also in modules, in practice those domains are interconnected. For example, in order for a Master student to acquire a future studies ability, that student needs to acquire the knowledge about various concepts and future study methods (cognitive domain), to acquire the skills for using those methods (cognitive and psychomotor domain) and to have a positive attitude towards anticipatory learning (affective domain). Furthermore, generally speaking, a single module can hardly incorporate whole persons learning outcomes for the all set of RRI competencies. In other words, a single module cannot be expected to embrace the depth and richness needed for forming a responsible researcher and innovator. This should not discourage educators. Educators, interested in (re-) designing higher education modules can use the EnRRICH tool as inspiration, and consider the integration of some aspects of the RRI principles and of one or more RRI competencies (or just some aspects of the competencies) to revitalize own module from a RRI perspective. In order to foster further reflection about the use of set of learning outcomes within modules Textbox 6 provides some examples of set of learning outcomes for hypothetical modules.

Table 1: Example learning outcomes – cognitive learning domain (*based on the taxonomy by Anderson and Krathwohl, 2001; and Krathwohl, 2002*)

Level of learning	Example action verbs	Example RRI-driven learning outcomes
Remember: recall information, without necessarily understanding it	Arrange, collect, define, identify, label, list, enumerate, order, name, recall, recognize, quote, reproduce, select, state, etc.	After successful completion of this module students are expected to be able to: <ul style="list-style-type: none"> list participatory methods for including voices of diverse stakeholders in decision-making processes (<i>related to participatory ability</i>) name European fundamental rights according to the EU charter (<i>related to social & emphatic disposition</i>) define what a complex system is according to complexity theory (<i>related to navigating complexity or wickedness</i>)
Understand Construct meaning of instructional messages	clarify, restate, describe, explain, summarize, discuss, review, illustrate, associate, defend, conclude, differentiate, convert, extrapolate, map, match, construct, indicate, etc.	<ul style="list-style-type: none"> discuss about the issue of transparency in science and innovation practices (<i>related to openness & transparency</i>) describe emerging challenges in society related to the increase of global population (<i>related to adaptability</i>) review a range of self-awareness tools according to their objective (<i>related to self-awareness</i>)
Apply Use learning material in a new context	Apply, assess, choose, demonstrate, develop, discover, employ, examine, experiment, find, modify, operate, practice, estimate, prepare, solve, use, implement, etc.	<ul style="list-style-type: none"> apply scenario analysis techniques to explore possible outcomes of park management strategies (<i>related to future-studies abilities</i>) assess the transdisciplinary character of selected multi-stakeholders partnerships in the health sector according to transdisciplinary principles (<i>related to transdisciplinary collaboration</i>) examine power dynamics among stakeholders engaged within the assigned project (<i>related to participatory ability</i>)
Analyse Break down information or material into its components, seeing relationships and the overall structure.	Differentiate, discriminate, distinguish, break down, categorize, compare, connect, analyse, debate, distinguish, investigate, point out, question, relate, separate, deconstruct, integrate, etc.	<ul style="list-style-type: none"> compare different future-studies methods and point out differences, strengths and weakness (<i>related to future-studies ability</i>) integrate ethical principles in the development of long-term strategies to address food security issues (<i>related to future-oriented ethical thinking</i>) question assumptions and perspectives adopted in traditional youth education (<i>related to disruptive thinking</i>)
Evaluate Make judgements based on criteria and standards	Appraise, argue, assess, convince, decide, choose, evaluate, grade, rate, defend, revise, judge, justify, measure, forecast, relate, validate, value, monitor, test, etc.	<ul style="list-style-type: none"> choose appropriate communication tools for communicating with different stakeholders in order to uncover their needs and wants (<i>related to multi-perspective and inter-cultural communication</i>) critically appraise the possible short- term and long-term socio-economic and environmental impact of Dutch mobility policy (<i>related to future-studies abilities</i>) judge the effectiveness of decision making strategies within different social and team contexts (<i>related to situational awareness</i>)
Create Put elements together to form a novel, coherent whole or make an original product	Generate, design, produce, construct, arrange, vision, compose, assemble, create, develop, formulate, generate, invent, make, hypothesize, plan, organize, originate, prepare, propose, build, set up, argue, establish, etc.	<ul style="list-style-type: none"> create a real-life project to address academically a sustainability local concern (<i>related to agency</i>) develop an academic advise to answer a specific interdisciplinary challenge faced by a civil society organization (<i>related to transdisciplinary collaboration</i>) compose a conceptual framework, by integrating existing concepts and theories, for analysing the complexities or wickedness of selected societal challenges (<i>related to navigating complexity or wickedness</i>)

Table 2: Example learning outcomes – affective learning domain (*based on the taxonomy by Krathwohl at al., 1964*)

Level of learning	Example action verbs	Example RRI-driven learning outcomes
		After successful completion of this module students are expected to be able to:
Receive willingness to receive information	Listen to, aware of, perceive, retain, experience, alert to, sensitive to, show tolerance of, accept, attend, etc.	<ul style="list-style-type: none"> Accept the inclusion of voices of minorities into policy design (<i>related to participatory ability</i>) listen to discussions about social values and needs with an open mind (<i>related to social awareness & empathy</i>)
Respond active participation in own learning	Reply, answer, react, perform, show interest, contribute, follow along, approve, cooperate, etc.	<ul style="list-style-type: none"> show interest in reflecting on own beliefs related to the ability to produce change through one's own action (<i>related to agency</i>) react constructively to feedback and evaluations about own performance (<i>related to self-awareness</i>)
Value Ranging from simple acceptance of a value to expression of a commitment	respect, accept, attain, assume, appreciate, pursue, support, challenge, participate, be devoted to, etc.	<ul style="list-style-type: none"> respect different perspectives and cultures when communicating to others in team work projects (<i>related to multi-perspective and inter-cultural communication</i>) appreciate anticipatory thinking when engaging into research activities to tackle societal challenges (<i>related to future-studies abilities</i>)
Organise relate a new value to those one already holds and bring it into an internally consistent philosophy	select, judge, decide, integrate, reconcile, relate, identify with, recognize, balance, compare, etc.	<ul style="list-style-type: none"> recognize own responsibilities in order to tackle societal challenges (<i>related to self-awareness</i>) decide about possible course of actions in project development in spite of ambiguities (<i>related to navigating complexity or wickedness</i>)
Internalize Articulate one's own values and belief systems and operate consistently with them	Practice, internalize, embody, display, act, continue to, carry out, change, complete, manage, solve, reconcile, show, etc.	<ul style="list-style-type: none"> display a sound ethical attitude and behaviour during project work, e.g. no plagiarism, ethically handling sensitive data, etc. (<i>related to ethical thinking</i>) reconcile diverse and divergent viewpoints within a multi-stakeholder process (<i>related to trans-disciplinary collaboration</i>)

Table 3: Example learning outcomes – psychomotor learning domain (*based on the taxonomy by Dave (1970)*).

Level of learning	Example action verbs	Example RRI-driven learning outcomes
		After successful completion of this module students are expected to be able to:
Imitate Observe the behaviour of another person and replicating that behaviour	Copy, follow, repeat, replicate, reproduce, match, etc.	<ul style="list-style-type: none"> reproduce steps for effective use of forecasting tools, through software, in the field of landscape development (<i>related to future-studies abilities</i>)
Manipulate performing certain actions by following instructions and practising skills	Act, build, execute, perform, enact, use, implement, etc.	<ul style="list-style-type: none"> act pro-actively according to pro-activity principles during team work exercises (<i>related to pro-activity</i>)
Perfect carrying out a task with expertise, and demonstrating actions to others	demonstrate, master, show, be precise, calibrate, etc.	<ul style="list-style-type: none"> demonstrate mastery in the use of various communication techniques for different audiences (<i>related to multi-perspective and inter-cultural communication</i>)
Articulate Coordinating and adapting a series of actions and skills in different and new contexts, and using alternative tools	Adapt, construct, combine, create, customize, modify, formulate, etc.	<ul style="list-style-type: none"> adapt steps in laboratory experiments to take into account emerging research findings and social needs (<i>related to adaptability</i>)
Embody Performing actions with ease, in a natural and intuitive way appropriate to the context	create, design, display, invent, manage, facilitate, etc.	<ul style="list-style-type: none"> facilitate meetings in a transdisciplinary context (<i>related to (transdisciplinary) collaboration</i>)

Textbox 6: Examples set of learning outcomes within hypothetical modules

RRI- driven learning outcomes can be combined in various ways within a module. A possibility is that a module focuses on deepening one specific competence. For example, an hypothetical module on communication science for students at the end of their Bachelor studies, and focusing on deepening one competence say enhancing “multi-perspective and inter-cultural communication”, can include learning outcomes like:

After successful completion of this module students are expected to be able to:
(in between brackets the learning domain is mentioned)

- describe concepts and methods of communication for social change, and for different audiences/ stakeholders and different cultures (*cognitive learning domain*)
- design communication activities for facilitating social change, targeted to various audiences and cultures (*cognitive learning domain*)
- apply selected communication method and activities for social change, targeted to various audiences and cultures (*cognitive and psychomotor learning domain*)
- demonstrate verbal and non-verbal communication capabilities when interacting and communicating with various audiences and cultures (*psychomotor learning domain*)
- respect different viewpoints and perspectives when interacting with various audiences and cultures (*affective learning domain*)
- compose a conceptual framework of communication for addressing a selected societal challenge, consisting of an integration of well-chosen concepts, methods and activities, for different audiences and cultures (*cognitive learning domain*)

Another possibility is that a module embraces two or more competencies features. For example an hypothetical module on transdisciplinary project development, for students at a Master program level, and focusing on few RRI competencies, could include some learning outcomes like this:

After successful completion of this module students are expected to be able to:
(in between brackets the learning domain is mentioned, together with a main competence addressed)

- develop as a team an academic interdisciplinary advice to answer a specific challenge faced by civil society organizations (*cognitive learning domain, related to transdisciplinary collaboration*)
- facilitate meetings in a transdisciplinary context (*psychomotor learning domain, related to transdisciplinary collaboration*)
- show a collaborative attitude and the willingness to include diverse disciplines and actors viewpoints (*affective learning domain, related to transdisciplinary collaboration*)
- adjust, with a team, and in interaction with representative(s) from civil society organizations, formulated project goals and plans when and if necessary (*cognitive learning domain, relate to adaptability*)
- display a sound ethical attitude and behaviour , e.g. no plagiarism, ethically handling sensitive data, etc. (*affective learning domain, related to ethical thinking*)
- appreciate reflective learning and self- reflection of own perspectives, responsibilities, beliefs in relation to personal functioning as a team member within a collaborative project s (*affective learning domain, self-awareness*)
- demonstrate mastery in (verbally) presenting and communicating the developed academic interdisciplinary advice to an academic and civil society audience (*psychomotor learning domain, related to multi-perspective and inter-cultural communication*)

Reflective questions for educators

- ✓ Who (the educator, the students, the societal actors) is articulating or can articulate the learning outcomes of your module? What is the strategy?
- ✓ What can be relevant learning outcomes that are or can be set within the context of your module, taking into account possible feedback received, and in line with the specific RRI competencies you are focusing on?

4.2 Define assessment, teaching and learning methods

The description of learning outcomes can support the design of appropriate assessment, teaching and learning methods. Assessment methods focus on assessing the learning process of a student and assessing whether a student has met the learning outcomes. The teaching and learning methods are the methods the teacher and the students engage with in order to meet the learning outcomes. Different learning outcomes can require different assessment, teaching and learning methods. It is suggested to work towards consistency and proper *alignment between the character of the learning outcomes chosen and the assessment, teaching and learning methods*. Aligned modules support and target well the achievement of the learning outcomes (e.g. Blumberg, 2009). It is recommended to take into consideration alignment aspects, regardless of who sets the learning outcomes. Whether the educators develop learning outcomes on their own (instrumental perspective) or jointly with the students, and if appropriate with the societal stakeholders (emancipatory perspective), they need to consider that there is a connection between the character of the learning outcomes, the teaching and learning methods selected and the assessment done at the end.

Fig. 5 attempts to provide some general ideas about possible assessment, teaching and learning methods that can be consistent with learning outcomes that have an instrumental or emancipatory character or that sits in between. The assessment, teaching and learning methods indicated are not exhaustive but only offer an impression of possible methods to be adopted. The main intention here is to support reflection about the value of alignment. For example, consider the following learning outcome within a module: *“reconcile diverse and divergent viewpoints within a multi-stakeholder process” (high order learning within the affective domain)*. Assessing the students, for example, through multiple choice questions and engaging the students in one lecture on “communication and negotiation” as teaching and learning activity may not fully serve the achievement of that learning outcome. On the other hand, assessing the students, for example through performance assessment by peers and teacher and engaging in workshops and project work as teaching and learning activity (which are also more in line with higher order learning) could serve better the purpose of that learning outcome. Figure 6 provides few concrete examples of aligned learning outcomes, assessment, teaching and learning methods. Figure 7 attempts to summarize key steps for articulating learning outcomes and defining assessment, teaching and learning strategy.

Finally, it needs to be pointed out that educators may find challenging to assess, by means of a grade, some learning outcomes as for instance the ones related to the affective domain. For example, some may experience challenging or even questionable to grade students’ attitudes of respect towards other cultures, or students’ democratic values and their appreciation towards participation, or students’ sense of care toward the future, etc. However, the fact that it is challenging or even questionable to quantitatively measure and grade some learning outcomes anchored in RRI competencies, this does not mean that those learning outcomes (and related RRI competencies) do not count. Still, educators can engage in fostering teaching and learning processes and methods that do support students’ development as whole persons and the articulation of a variety of learning outcomes based on RRI competencies.

Figure 5: Examples of few assessment, teaching and learning methods within the context of low or higher order learning

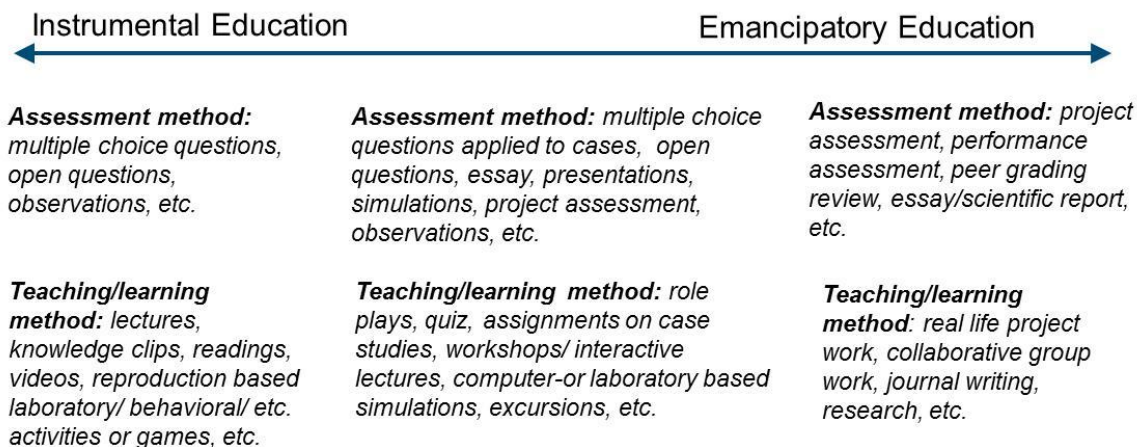
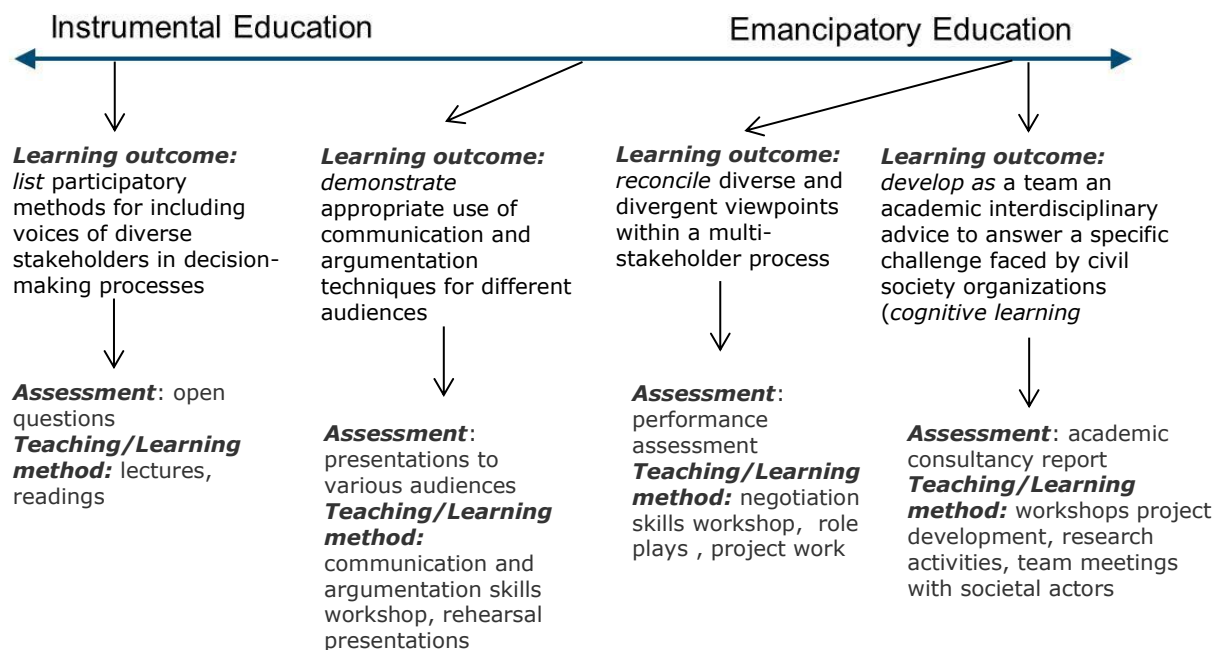


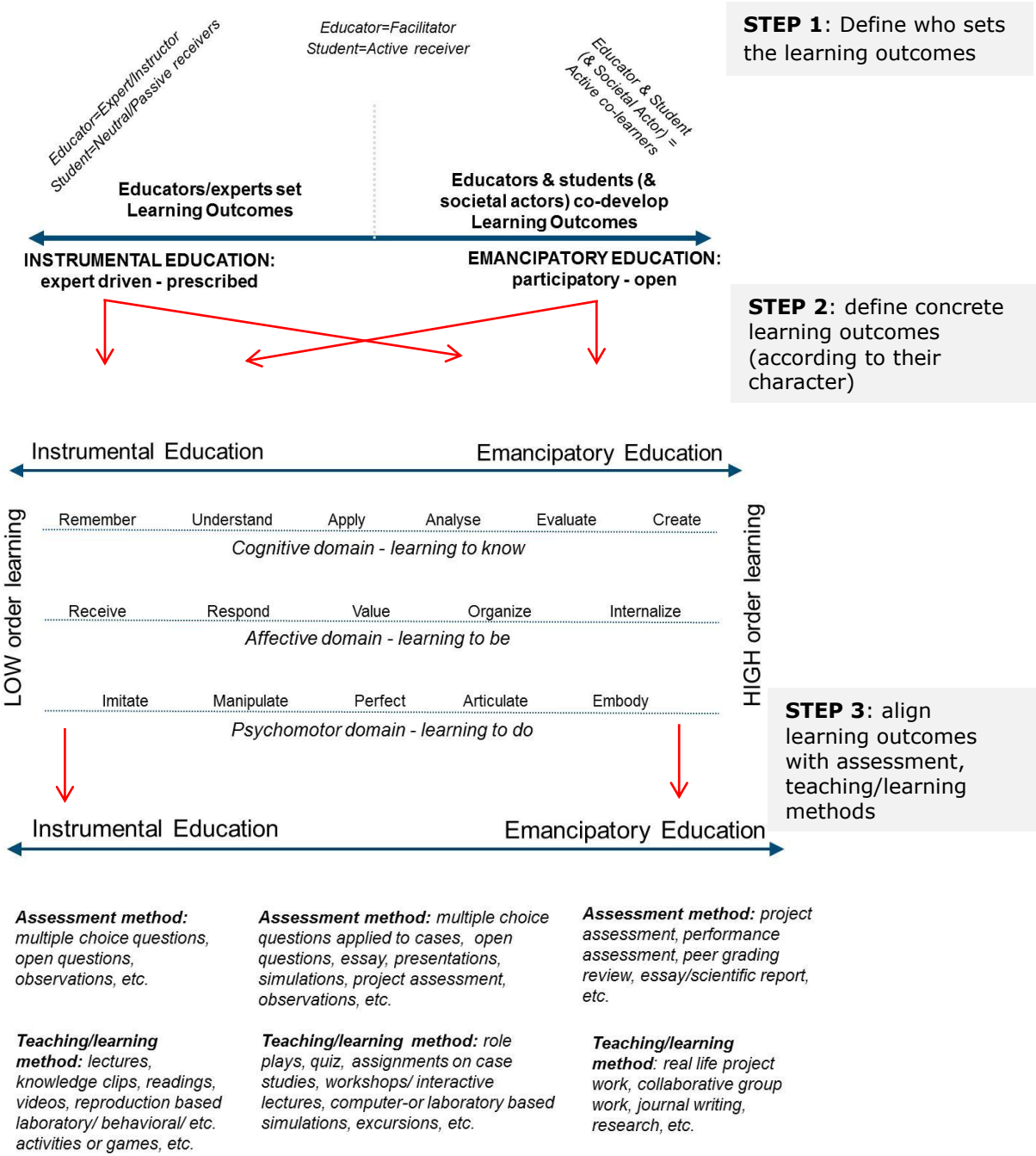
Figure 6: Examples of aligned learning outcomes, assessment, teaching and learning methods



Reflective questions for educators

- ✓ What assessment methods are you considering for assessing learning outcomes? Are those assessment methods aligned to the learning outcomes?
- ✓ How could you deal with the assessment of learning outcomes that may be valuable but may also be challenging to assess or grade?
- ✓ What teaching and learning methods are you considering for achieving learning outcomes? Are those methods aligned to the learning outcomes and assessment?

Figure 7: Summary of key steps for articulating learning outcomes and defining aligned assessment, teaching and learning methods



Appendix

Appendix 1: The RRI keys (*elaborated from EC, 2015*)

1. Governance

RRI is characterised by collaborative efforts of a variety of stakeholders who each have a particular interest in this process. Governance from such a network perspective is the manner to govern RRI dynamic and interactive processes. This key is also seen as an umbrella dimension for the following RRI keys.

2. Public engagement

Public engagement focuses on encouraging and empowering citizens to participate to RRI, and stimulating dialogues among researchers, innovators, citizens and other stakeholders in order to foster mutual learning and collaborative decision-making.

3. Gender equality

Gender equality focuses on equal participation of men and women in research and innovation activities and the inclusion and integration of gender perspectives in RRI content development.

4. Science education

This key is related to the Public engagement key in that it aims to 'boost the interest' in science among children and young people, to contribute to a science-literate society and to better equip future researchers and other societal actors with the necessary knowledge and tools to fully participate and take responsibility in the research and innovation process.

5. Open access/open science

Open access/open science focuses on transparency and accessibility of research and innovation practices and outputs in the attempt to boost innovation, to increase collaboration among actors and the use of scientific findings by society. Open access is not an end in itself, but a means towards RRI.

6. Ethics

Ethics focuses on including shared values, fundamental rights and ethical standards within research and innovation efforts in order to increase societal relevance and acceptability of research and innovation outcomes.

7. Sustainability

The other seven keys explained here are contributing in one way or another to aspects of sustainability, but these keys are not triggering the question to what extent the RRI practice contribute to sustainability? Sustainability focuses on achieving smart, sustainable and inclusive development and includes five target areas: employment, research and development, climate and energy, social inclusion and poverty reduction.

8. Social justice/inclusion

Social justice/inclusion focuses on creating conditions upon which actors have equal rights, equal opportunities and equal access from either participation in research and/or access to benefits arising from it.

Appendix 2: Considerations about purposes of European higher education through RRI lenses

Purposes of European higher education

The four main purposes of higher education are: (Bologna Working Group on Qualifications Frameworks, 2005, pp.24-25):

1. Preparation for the labour market

Preparation for the labour market is the dimension that has over the past generation been most dominant in public discourse on education. Employers have complained that the current education systems of many European countries provide students with insufficient preparation for the labour market.

2. Preparation for life as active citizens in a democratic society

While democratic institutions and laws are indispensable to democratic societies, they can only function in societies marked by a democratic culture that is tolerant and accepts diversity and open debate. Democracy ultimately depends on the active participation of educated citizens. Education at all levels thus plays a key role in developing democratic culture. In addition to transferable (transversal) skills, the active participation of citizens requires a broad education in a variety of fields as well as the nurture of democratic attitudes and values and the ability to think critically.

3. Personal development

This aspect of higher education has not been explicitly addressed so far in the policy texts of the Bologna Process. While personal development may have been a more explicit goal of education and higher education in earlier generations, it is still an underlying assumption of education in Europe. The assumption may appear to have been challenged through the development of mass education, but it should nevertheless be made explicit that whilst preparation for the labour market is an important purpose of education, the aim of personal development has far from disappeared.

4. The development and maintenance of a broad, advanced knowledge base

For society as a whole, it is important to have access to advanced knowledge in a broad range of disciplines. At the most advanced levels of knowledge, this relates to research and research training. It is, however, not limited to research, as advanced knowledge and the transmission of such knowledge play important roles in a wide range of areas and at levels below that of research. Thus, whilst knowledge of advanced skills and methods of, for example welding, as well as the ability to develop them further, may not be characterised as 'research', these skills and their transmission are likely to be of considerable importance to a modern, technologically advanced society.

Some considerations about European higher education purposes through RRI lenses

RRI can contribute to this process by fostering students problem solving, research and innovation capacities, related to addressing societal challenges in a responsible way.

RRI can contribute to this process by preparing students to be inclusive, to develop social values, a sense of care and stewardship, and to be active citizens.

RRI can contribute to this process by encouraging reflexivity about personal attitudes, assumptions and commitments and by fostering experimentation with new ways of doing and being.

RRI can contribute to this process by bridging science and society and by equipping students to develop the capacities for advancing knowledge and innovation in society

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