European Commission

Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI)

Analytical report on the dimension of science literacy and scientific education

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Sub-task 2.5 analytical report, Deliverable D2.2

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Executive Summary

This report is one out of a series of six reports, each targeting a separate dimension of Responsible Research and Innovation (RRI). It specifically focuses on the dimension of 'Science literacy and scientific education' (SLSE).

A brief literature review illustrates the two major shifts the field of science literacy and science education has experienced over the last three decades: First, a change from the deficit model to the dialogue model and then, more recently, a second shift to the participation model, which emphasises the co-production of knowledge. Embracing the arguments of the social construction of science, science education and communication, the team suggests a "thick" notion of science literacy. Such a conceptual move is further warranted by the fact that MoRRI extends to the monitoring of responsible research and innovation i.e. the careful application and diffusion of scientific knowledge. Both processes attribute active roles to actors outside the science and technology community.

For the purpose of this project we define science literacy as the ability of citizens to read about, comprehend and express opinions about science, as well as the ability to contribute to "doing science". By building on this idea, the focus of our understanding of science literacy is put on the idea of developing capacities for science and innovation. Science literacy can be generated through three main mechanisms:

- Science education aims at educating (especially young) citizens about scientific facts (textbook knowledge), the norms of science and the way science is 'done' as well as at conveying a positive 'image' of sciences. However, it also provides the opportunity to reflect and question science and the 'truths' it produces critically.
- Science communication activities aim at educating citizens of all ages about science as well as at generating awareness of science-related issues and a positive image of/attitude towards science.
- Co-production of knowledge is characterised by a co-creation of knowledge through cooperation of scientific experts and non-experts.

Including the co-production of knowledge in the dimension of SLSE alters the way we think about the public and its role in science and innovation, from a mere receiver and customer to an active agent of change. Citizens co-produce scientific data, possibly help in their interpretation and analysis and frame research questions.

The results of the review of existing empirical knowledge of science literacy and science education can be summarized as follows:

- In general, the data availability for the SLSE dimension is mixed. While the availability of quantitative and qualitative data for the science education part of the SLSE dimension is good, there is considerably less data for science communication and co-production of knowledge types of activities.
- Bearing in mind the difference in data availability across the three sub-categories it can be said that significant quantitative and qualitative data for the SLSE dimension exists. The main sources here are – with regard to science education – the international comparative competence tests, such as PISA or TIMSS – and for science education and science communication the Eurobarometer surveys.
- Concerning data availability for the different analytical levels of the logic chart, the situation is, again, mixed. While for science education data is available for inputs, outputs and outcomes, for science communication and co-production of knowledge the data availability concerning outputs and outcomes smaller. However, it can be

expected that input data for these two dimensions can be generated relatively easily.

- Finally, most of the data available for the SLSE dimension is aggregated on a national level. Generally, this national data is available for a comparably large range of countries, especially concerning the science education topic. For all three sub-categories only very limited data is available on a sub-national level, such as institutions or individuals.

The report suggests nine indicators for the dimension of science literacy and science education:

1. Interest in in science and technology (based on Eurobarometer data)
2. Informedness about science and technology (based on Eurobarometer data)
3. Textbook knowledge about science and technology (based on Eurobarometer data)
4. Competence of the general population with regard to numeracy (based on PIACC data)
5. Share of STEM graduates in relation to all graduates (based on OECD data)
6. Science competence of primary school pupils (based on TIMSS data)
7. Science competence of secondary school pupils (based on PISA data)
8. Science communication culture (based on data from the project MASIS)
9. Importance of science communication as an evaluation criterion (based on data from the project MASIS)

While these indicators have been refined and spelled out in greater detail in this report, they will be discussed and elaborated in the subsequent tasks of the MoRRI project.

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1. Introduction – analytical and empirical aspects of Responsible Research and Innovation

This report is one out of a series of six reports, each targeting a separate dimension of Responsible Research and Innovation (RRI). The six dimensions include 'Citizen engagement and participation of societal actors in research and innovation', 'science literacy and scientific education', gender equality', 'open access to scientific knowledge, research results, and data', 'research and innovation governance' and research and innovation ethics'. The six reports collectively form the main output of Task 2 of the 'Monitoring the Evolution and Benefits of Responsible Research and Innovation' (MoRRI) project, and they are informed by the results of the literature review on RRI and its conceptual components which was performed as Task 1 of the project.

The six reports emerging from Task 2 specifically address analytical and empirical issues relating to each of the RRI dimensions. Each report aims to:

- Provide an operational understanding of the RRI dimension it targets
- Present existing empirical information about the RRI dimension
- Assess data availability and specify analytical levels and degrees of aggregation of available material

The reports will provide a platform for subsequent definition of metrics and indicators for the RRI dimensions in Task 3. The report at hand specifically focuses on the dimension of 'Science literacy and scientific education' (SLSE).

It is structured in accordance with the main aims of Task 2 and also provides an outlet for the results of Task 1. In chapter 2, results from the literature review are presented. These provide a background for the following chapters. Chapter 3 is concerned with the development of an operational understanding of SLSE. The objective is to provide a functional vocabulary of SLSE by clarifying important analytical components and definitions of SLSE. This chapter includes a specification of the relationship and a delineation of the SLSE dimension and the other five dimensions of RRI. Chapter 4 accounts for existing empirical information on SLSE. It is based on a review of selected studies funded by the European Commission, along with review of evidence from other empirically oriented studies, which are considered particularly relevant for the SLSE dimension.

In chapter 5, the availability of existing data on SLSE is assessed. Following the scheme outlined in the MoRRI proposal, this chapter specifically considers the availability of data on SLSE relating first to its characteristics in terms of the intervention logic model, i.e. data describing the context, input, output, and outcome of SLSE. More specifically, context relates to the environment and overall situation in a country; input to the activities carried out, measures taken, structures created or resources provided to address what is done in order to address issues of RRI and whether it is done in a systematic manner; outputs to the immediate or direct results of activities and outcomes relate to the achievements (MoRRI Proposal 2014:64). Second, availability of data are described according to the level of aggregation of these data, distinguishing data that describe the global level, the national level, the regional level, the institutional level, the programme/project level and the individual level.

Reflecting the findings in chapter 5, chapter 6 considers issues relating to data gaps and assesses the overall need for primary data collection to fill these gaps. Finally chapter 7 provides early thoughts on the development of indicators and metrics for SLSE, which will be the objective of Task 3.

2. Results of the literature review on SLSE

This chapter presents a list of the core literature on SLSE, as well as a synthesis of the literature review on this dimension. The literature review was performed in Task 1 of the MoRRI project. The synthesis summarizes the main conceptual elements of the targeted dimension and forms the background for the subsequent chapter about the 'functional vocabulary' for the dimension.

2.1 Review of core literature relating to SLSE

The objectives of the literature review (Task 1) is to:

- Review of the state of knowledge regarding the SLSE component of RRI,
- Define the policy context of RRI in Europe and elsewhere,
- Give a comparative assessment of RRI dimensions, weighing-up advantages, disadvantages and available options,
- Conduct a preliminary assessment of the availability of empirical evidence on the dimensions,
- Finalise the definitions and properties of the RRI key dimensions, and to
- Finalise the definition and properties of additional factors that may be relevant for the monitoring tasks.

The literature review for SLSE followed the same procedure with the other themes of Task 2. In order to meet these objectives and provide useful input to the thematically and methodologically strongly related aims of Task 2 and other ensuing project tasks, the approach to the literature review was designed in close cooperation with the dimension and task leaders. In a first step, the five dimension leaders were asked – based on their long-standing experience in their respective fields – to select 10 to 15 key publications in each RRI-dimension for detailed review. Second, a review template was designed in order a) to ensure a systematic analysis of the selected literature and b) to cover all relevant aspects and information required in Tasks 1 and 2. Before it was rolled out to the individual reviewers, the template was subject to a pretest.

For SLSE, the following key publications were selected and reviewed:

Allum, N. (2009). Science Literacy. In S. Priest (Ed.), *Encyclopedia of Science and Technology Communication*. Sage Publications. Retrieved from http://privatewww.essex.ac.uk/~nallum/ScienceLiteracyEncyclopediaofScienceandTechnologyCommunication.pdf

Bauer, M. W. (2008). Survey research on public understanding of science. In M. Bucchi & B. Trench (Eds.), *Handbook of Public Communication of Science and Technology* (pp. 111–130). Routledge.

Bauer, M. W., Allum, N., & Miller, S. (2007). What can we learn from 25 years of PUS survey research?: liberating and expanding the agenda. *Public Understanding of Science*, *16*, 79–95. Retrieved from http://eprints.lse.ac.uk/4750/

Bucchi, M. (2008). Of deficits, deviations and dialogues. In M. Bucchi & B. Trench (Eds.), *Handbook of Public Communication of Science and Technology* (pp. 57–76). Routledge.

Callon, M. (1999). The role of lay people in the production and dissemination of scientific knowledge. *Science, Technology & Society*, *4*, 81–94.

Castellani, T. (2014). Public Engagement. In *The Contribution of Science and Society (FP6) and Science in Society (FP7) to a Responsible Research and Innovation. A Review*.

Dewey, J. (1934). The Supreme Intellectual Obligation. *Science Education*, *18*, 1–4.

European Commission. (2009). *Preparing Europe for a New Renaissance - A Strategic View of European Research Area - First Report of the European Research Area Board*.

House of Lords Select Committee on Science and Technology. (2000). *Science and Society; Third Report of the Session 1999-2000*. London.

Mejlgaard, N. (2007). *Scientific Citizenship - Conceptualisation, Contextualisation & Measurement*. *Gegenworte*. Århus : Dansk Center for Forskningsanalyse.

Miller, J. D. (1983). Scientific Literacy : A Conceptual and Empirical Review. *Deadalus*, *112*(2), 29–48.

Miller, J. D. (1998). Public Understanding of Science The measurement of civic scientific literacy The measurement of civic scientific literacy.

Miller, J. D. (2010). The Conceptualization and Measurement of Civic Scientific Literacy for the Twenty-First Century. In J. Meinwald & J. G. Hildebrand (Eds.), *Science and the Educated American: A Core Component of Liberal Education* (p. Chapter 12). American Academy of Arts and Sciences, Cambridge, MA.

Raichvarg, D., & Jaques, J. (1991). *Savants et Ignorants. Une Historire de la Vulgarisation des Sciences*. Paris: Seuil.

Technopolis Group, & Fraunhofer ISI. (2012). Interim evaluation & assessment of future options for Science in Society Actions Executive Summary.

The Cornell Lab of Ornithology. (2015). Defining Citizen Science. Retrieved March 3, 2015, from http://www.birds.cornell.edu/citscitoolkit/about/definition

The Royal Society. (1985). *The Public Understanding of Science*. Retrieved from https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/1985/10700.pdf

Thomas, G., & Durant, J. (1987). Why Should we Promote the Public Understanding of Science ? *Scientific Literacy Papers*, *1*, 1–14.

Valente, A. (2014). Science Education - What Science to Study and Why. In *The Contribution of Science and Society (FP6) and Science in Society (FP7) to a Responsible Research and Innovation. A Review*.

The guidelines for the review process and the findings of the individual reviews are documented in the Appendix to this report.

2.2 Synthesis of literature review on science literacy and scientific education

The following section provides a review of the literature on science literacy and science education proceeding along the lines of the historical development of the field.

Science literacy and scientific education have been topics of academic and public discussions for a long time and continues to do so, especially in the light of the challenges of modern societies. Given its long history the field is, on one hand, well researched. On the other hand, substantial questions still remain to be answered. A brief review of the historical development will illustrate how over the past five decades, the field of science literacy and science education has experienced at least two major shifts, leading to the current co-existence of three paradigms: the deficit model, the dialogue model and the participation model (or co-production of knowledge).[1]

The topic of science literacy and closely related with it the concept of science communication has a long history dating back to the 18th century. The growing public interest, especially of women, in science and scientific discoveries resulted in the publication of popular science books, such as *Newtonianism for Ladies* or *L' Astronomie des Dames,* numerous articles in newspapers, as well as science exhibitions and fairs (Raichvarg & Jaques, 1991 cited in Bucchi, 2008). However, the subject of science literacy only became a topic of systematic study in the 1930s when John Dewey argued that

"the responsibility of science cannot be fulfilled by methods that are chiefly concerned with self-perpetuation of specialized science to the neglect of influencing the much larger number to adopt into the very make-up of their minds those attitudes of openmindedness, intellectual integrity, observation and interest in testing their opinions and beliefs, that are characteristics of the scientific attitude." (Dewey, 1934)

Dewey suggested that citizens should have the capacities to apply scientific thinking to other areas of life such as social issues, politics and civic affairs (Allum, 2009). Following his idea, a discussion about the formal definition and the measurement of the "scientific attitude" started among science educators that lasted until the end of World War II. In the post-war period the focus changed to the standardised testing of the comprehension of basic scientific constructs and terms (Miller, 1983). In the following decades, so-called textbook questions were highly popular to test citizens' knowledge about scientific facts.[2] These tests yielded unsatisfactory results with regard to the science literacy of the general public (see for instance Bauer, 2008; Miller, 1983, 1998). Especially in the USA the results in combination with the "space race" and the Sputnik shock of 1957 gave rise to the notion that a citizenry that was "literate and well disposed towards science was […] essential in order to provide the human capital and favourable public sentiment needed to facilitate staying ahead of the Soviets" (Allum, 2009).

1 We regard four drivers as particularly important for these shifts towards a more inclusive SLSE approach: societal developments in the last two decades such as the opposition towards genetically modified organisms or the debate about nanotechnology led to a growing awareness of the importance of the inclusion of citizens. Moreover, grand societal challenges such as climate change can only be tackled with the contribution and involvement of citizens. Also, in the last decade, society at large has been discovered as a source of innovation. This is for instance mirrored in the concept of open-innovation. Finally, the shift is supported by the fact that information and communication technologies facilitate new ways of involving citizens in different forms of research and innovation.

2 Examples of such textbook questions include questions like „The centre of the earth is very hot" (yes/no) or „Radioactive milk can be made safe by boiling it" (yes/no).

The general idea underlying the whole debate at this time was that science is "too complicated" for the general public to understand, i.e. that there exists a knowledge deficit in the public.

This idea of a knowledge deficit was challenged from 1985 onwards when the British Royal Society published an internationally influential report on the public understanding of science (The Royal Society, 1985).[3] The report argued that the deficit of the public was deriving less from knowledge but rather from attitudes. It was claimed that the public's attitude towards science and technology is not sufficiently positive and that dangers existed that citizens would become negative or even espouse anti-science attitudes (Bauer, Allum, & Miller, 2007). In order to recover the deficits, activities in this period focussed on changing attitudes and marketing the image of science. They included well-known and popular measures such as "open days" in laboratories, science festivals or training courses for journalists (Bucchi, 2008).

In the late 1990s and early 2000s another shift occurred in the notions about the basis, function and form of SLSE. In this period public concerns over certain science and technology issues (e.g. genetically modified organisms or GMO) have been persistent despite efforts to educate and inform citizens. Moreover, a growing demand of citizens to be involved in such (controversial) issues and large scale surveys and other research implying "negative public responses in respect of science associated with government or industry, and in respect of science not obviously directed towards a clearly beneficial purpose such as human health" led to the declaration of a "crisis of public confidence" and the detection of a "new mood for dialogue" (Bauer et al., 2007; Bucchi, 2008; House of Lords Select Committee on Science and Technology, 2000). This diagnosis puts the deficit not with the public but with the scientific institutions and experts. Significant policy implications derive from this shift.

This conceptual change resulted in the call for a shift from public awareness of science or science literacy to citizen engagement and dialogue. It also altered the priorities: the education of the scientifically "illiterate" public receded more into the background, while the need and right of the public to participate in the discussion has been put to the forefront. It was maintained that "lay people have knowledge and competencies which enhance and complete those of scientists and specialists" (Bucchi, 2008; Callon, 1999).

Finally, it has been argued that the deficit-models share the common idea that lay people are considered to have little or no competence for and share in the production of scientific knowledge (Callon, 1999). Departing from this assumption an alternative model stresses the co-production of knowledge by experts and non-experts. According to this model, "non-experts and their local knowledge can be conceived as neither an obstacle to be overcome by virtue or appropriate education initiatives (as in the deficit model) nor an additional element that simply enriches professionals' expertise (as in the critical-dialogue model) but rather as essential for the production of knowledge itself" (Bucchi, 2008). In this model expert and lay knowledge are not produced independently but knowledge results from joint processes of expert and non-expert interaction. Examples of this type of knowledge production are discussed under the headings open innovation, user-driven innovation or open science involving non-experts or more specifically in the context of this project citizen science projects.

Bucchi (2008) argues that it is implausible to assume that a single model of science literacy and expert-public interaction is able to account for all of reality. Instead, the

3 This report outlined that the base for public understanding of science is the teaching in schools. It also highlights other central actors such as the mass media, the scientific community, museums and libraries as well as the industry.

models described above should not be considered mutually exclusive but rather as complementing each other and may also depend on the stage the science or technology is in as well as the (potential for) controversies it entails. For instance, topics with a low degree of public mobilisation and with relatively low public resonance do not require dialogue or co-generation of knowledge. This also implies that the deficit model(s) and the respective communication strategies will not necessarily disappear but instead they may become the default or the starting point for expert-public interaction.

The rationale for science literacy and science education has been laid out by Thomas and Durant in 1987. They name a list of benefits of a (benign) public understanding of science, which will also prove useful for later stages of this project, eg task 6.

- Benefits for science itself. They are manifested in both, new recruits into the scientific community, as well as the idea that public support for sciences depends on at least a minimal level of public awareness of scientific research.
- Benefits for national economies. This argument highlights that in modern economies competitiveness and economic growth depend upon the sale of innovative goods and services based on research and development.
- Benefits for national power. The idea that an increased public understanding of science benefits not only the economy but also more generally national power and influence is an argument rooted in the thinking of the Cold War. It has been argued that scientific literacy was also important to maintain a country's (in this case the US') position of intellectual and ideological leadership.
- Benefits for individuals. More knowledgeable citizens are able to make better informed day-to-day decisions, for instance on diet, health-care or personal safety. Also, the full range of job opportunities and technical advanced at their workplace is open to them.
- Benefits for policy making. Science and technology issues play a central role in modern day policy decision making, their results are of great importance to the design and issues in public and private life and people are expected to form an opinion concerning science and technology issues (Allum, 2009). Allum argued that this reason is the principal normative justification for why science literacy is important for citizens. He continues that ill-informed citizens make bad decisions – in the sense that they cannot connect their own best interests to the appropriate science policy choices. Thus, citizens have the right to be informed about science and technology developments and they have the right (if not the obligation) to influence the science policy-making process. This is closely related to what other authors call the participative argument (eg Miller, 2010; Valente, 2014). This argument states that science literacy helps citizens act as knowledgeable citizens who are able to take part in decision-making processes related to their own personal and social sphere. In order to be able to fulfil this duty, information on and understanding of science are central. This reflects for example in the ERA's strategic goals by 2030. One of them is "a more educated citizenry is trained in science and technology issues to be able to participate in policy debate" (European Commission, 2009).[4]

4 Thomas and Durant name three more benefits that are described for completeness sake:

An increased public understanding of science can benefit the intellectual culture in the sense that science is a major achievement of our culture and there are benefits for people to develop an educated and cultivated mind by in being able to understand and appreciate science (see also Valente,2008). Similarly, the aesthetic benefit suggests that "science is the distinctive creative activity of the modern mind" (Thomas & Durant, 1987). Ethical or moral arguments for promoting scientific literacy entails that the transfer of norms or

3. Functional vocabulary of SLSE – definitions and terminology

Building on the results of the literature review, the purpose of this chapter is to develop at a functional vocabulary of the SLSE dimension. We wish to underline that the name of the dimension – 'Science literacy and science education' – is without prejudice to the relationship between the constituent concepts. While the name of the dimension might imply a mutual exclusive relationship between the two terms we will suggest a complementary link between the two. The functional vocabulary will be the basis for the subsequent exploration of empirical studies and data. This chapter will also consider the relationship between the SLSE dimension and other relevant RRI dimensions examined in the MoRRI project.

Considering the long-lasting discussion on science literacy and science education, it is not surprising that there is no common, unequivocal definition of what SLSE encompasses. Moreover, the paradigmatic changes that the field witnessed over the past decades, imply that the meaning of the terms, as well as the related activities, practices and routines have also evolved. In the following, we explain, how we understand the central SLSE concepts, in particular science literacy, science education, science communication, and the co-production of knowledge. Our notions of these terms partly deviates from the traditional understanding, emphasising the fact that our scientific knowledge can be considered as a social construct, rooted in the societies and contexts in which they are developed.

In the past, science literacy has been commonly understood as the presence of a certain level of understanding of scientific terms and constructs, which was "sufficient to read a daily newspaper or magazine and to understand the essence of competing arguments on a given dispute or controversy" (Miller, 1998). This concept of science literacy according to Miller (1983) includes four elements:

- Knowledge of basic textbook facts of science,
- Understanding of scientific methods such as experimental design,
- Appreciation of the positive outcomes of science and technology for science, and
- Rejection of superstitious beliefs such as astrology or numerology.

This notion of science literacy implies a specific understanding and definition of knowledge, science and technology, the public, and the problem that is to be addressed. In simplifying terms one could say that this concept of science literacy sees the challenge in transmitting textbook knowledge one-way from scientists to 'illiterate' citizens. Scientific textbook knowledge is true, i.e. consensual and not questionable (among some/most scientists), and refers to a reality that can be described in an objective way. Truth is found by pointing to the correspondence of a scientific statement with the reality "out there". This scientific knowledge merely needs to be conveyed to citizens, akin to filling up empty vessels.

For the purpose of this project we wish to "thicken" this rather thin positivist notion of science literacy by emphasising the socially constructed nature of science, technology, education and communication for two reasons. First, the discourse about science education and communication heavily relies on constructivist notions of knowledge and language. Second, such as thick understanding of the dimension of science literacy

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values of science into the wider culture would "signal a major advance of human civilization" (Thomas & Durant, 1987).

and science education is also warranted by the requirement that the project is to monitor responsible research and *innovation*. Speaking of "innovation" shifts the focus from the "production" of new scientific knowledge to its application and dissemination. While one could still argue that the first aspect is merely concerned with scientists, their laboratories and activities, the latter two processes involve companies, investors, consumers and citizens. They shape, contribute to and can foster or hinder the application of scientific knowledge and feedback into the "production" phase of science and technology. In other words, the inclusion of innovation in the monitoring requires to take into account social/behavioural aspects of science and technology and the active roles that actors outside science play in it.

Our thick concept of science literacy builds on Allum (2009) who states that generally, science literacy is concerned with the ability of citizens to read about, comprehend and express opinion about science (Allum, 2009; House of Lords Select Committee on Science and Technology, 2000).[5] We would add, that science literacy also involves the ability to contribute to "doing science". By building on this idea, the focus of our understanding of science literacy is put on the idea of developing capacities for science and innovation.

The relevant capacities are already described at least in part in Miller (1983). He argues that there are three criteria to be fulfilled for science literacy:

- Understanding of the norms of science or having a scientific attitude. The scientific attitude is characterised by "a willingness to change his opinion on the basis of new evidence; … by the search for the whole truth without prejudice; … (by having) a concept of cause and effect relations; .. (by making) a habit of basing judgement on fact; and … (by having) the ability to distinguish between fact and theory" (Dewey, 1934).
- Knowledge of major scientific constructs and terms, i.e. what today would be called "textbook knowledge".
- Awareness of the impact of science and technology on society and the policy choices.

A more recent understanding of science literacy by the OECD complements this definition by adding the competence to acquire and apply new scientific knowledge and by including the willingness of citizens to be actively involved in "science-related issues".[6] While the latter aspect is addressed under the term "Public engagement" in a separate report of this project, it is concerned with science literacy in our sense, in as much as it addresses the *capacities* to engage in science-related issues. As outlined further below, we consider science literacy to be a condition for public engagement.

Finally, we suggest including the ability of citizens to contribute to science itself in the definition of the SLSE dimension. Citizens can contribute to science and innovation e.g., by participating in the framing of research and innovation, as well as carrying out specific tasks.

The thick concept of scientific literacy comes with its own implied notions about knowledge, science, technology and innovation, about the public, and the problem that is to be addressed. The challenge at hand is not merely one of transferring knowledge from experts to laypeople, but rather one of raising and shaping citizens as well as the context in order to provide them with the capacities and abilities to read, to comprehend and to take active part in science and innovation. Extending SLSE to

5 The term is sometimes used synonymously with public understanding of science, which relates to the understanding of scientific matters by non-experts.

innovation, the thick notion of science literacy assumes that knowledge is co-created, applied and diffused in the interaction between scientists and non-scientists. The public is implied to be a partner in science, technology and innovation and not an ‘empty vessel’ to be filled.

For the purpose of this project we distinguish three aspects of SLSE, which are based on the main mechanisms through which the SLSE abilities are built: science education, science communication and the co-production of knowledge.

Science education: Science education aims at educating (especially young) citizens about scientific facts (textbook knowledge), the norms of science and the way science is ‘done’ as well as at conveying a positive ‘image’ of sciences. However, it also provides the opportunity to reflect and question science and the ‘truths’ it produces critically. It takes place in institutions in early childhood education and care, the school system, higher education, vocational education and training as well as in lifelong-learning. Science education is the basis for science literacy.

Science communication: Science communication activities aim at educating citizens of all ages about science as well as at generating awareness of science-related issues and a positive image of/attitude towards science. These activities can take direct forms, for instance through open days, museums or science centres, or be more indirect with mediators between the scientists and the public, eg via science journalists and their products such as TV programmes or media articles etc.[7] Generally, a large number of different institutions is involved in science communication. Science communication produces linkages between science and society by creating or enabling transmission of knowledge about science and technology. This transmission can be both one-way for instance in pure information formats as well as two-way eg in dialogue-oriented formats.

Co-production of knowledge is a relatively new aspect of science literacy. It is characterised by a co-creation of knowledge through cooperation of scientific experts and non-experts. One well-known example for the co-production of knowledge is Citizen Science. It has been defined as “research collaborations between scientists and volunteers, particularly (…) to expand opportunities for scientific data collection and to provide access to scientific information for community members” (The Cornell Lab of Ornithology, 2015). In addition, there are other ways of co-production, for instance discussed under terms such as open-innovation, crowd science, or user-driven innovation.

To summarise, science literacy as it is defined in the context of the MoRRI project is generated through activities, which aim at providing citizens with a deeper understanding of science, to shape their attitudes towards science and to develop their abilities to contribute to science and science-related policy making. Including the co-production of knowledge in the dimension of SLSE alters the way we think about the public and its role in science and innovation, from a mere receiver and customer to an active agent of change. Citizens co-produce scientific data, possibly help in their interpretation and analysis and frame research questions. It acknowledges the idea that different kinds of knowledge can be brought together to produce an impact. We are aware of the fact that the three aspects are not equally developed across Europe. While all EU countries provide science education, a smaller number of them actively pursue comprehensive science communication and only a handful engage in the co-production of knowledge.

7 One activity that is often mentioned in the context of science communication are public relations activities of research institutions. For this project however, we explicitly exclude this type of activities for our definition of science communication.

The three aspects of the SLSE dimension are thought to contribute to the development of a scientifically literate citizen. Drawing on the concept of internal and external efficacy from citizen studies we hold that a scientifically literate person would have a sense of his/her capacity to take part in the debates about science. He/she would feel knowledgeable and as equipped to have something to offer in those debates (internal efficacy); at the same time he/she would have sense that society and decision-makers will actually listen and respond to the contributions of a scientifically literate person (external efficacy) (Mejlgaard, 2007).

Science literacy is a horizontal concept, which is considered to be a precondition for the effective involvement of the public in research and innovation and for public engagement in science policy (dimension 1). Science literacy contributes to the building capacities, the generation and fostering of a science culture in society or more generally the creation of a reservoir of (human) resources. While science literacy generally enables citizens to contribute to decision making, this is clearly to be distinguished from them actually taking part in decision making on a policy level for instance by defining the context in which science is performed. The mechanisms for actual participation or engagement in decision making are described in the dimension 'public engagement' (dimension 1).

This shows clearly that the dimensions public engagement and science literacy and science education are closely related. Firstly, just like for science literacy it can be assumed that science education is also a prerequisite for public engagement. Secondly, science communication activities often closely resemble or have similar aims as public engagement activities, especially of the 'public communication' type. These types of activities implement educational objectives through mechanisms supporting the transmission of knowledge from scientists to representatives of the public (for further details see the PE dimension report). Finally, our definition of the two dimensions share a "thick" idea about the role of the public in science and the interaction of citizens with scientists.

Similarly, the dimensions of gender equality and SLSE are closely related. Research shows that there is a considerable gender gap when it comes to interest in science, self-assessment in terms of scientific competences, career choices and consequently the presence of women in science-related occupations. These issues will be addressed under the dimension of gender equality. While there is an increasing body of knowledge about gender specific science education and communication, the SLSE dimension will not examine education, communication and co-production of knowledge along gender lines.

4. Review of existing empirical knowledge of SLSE

The following chapter, which constitutes the bulk of the report, examines empirical studies in the area of SLSE. It presents the results of Sub-task 2.2 and Sub-task 2.3, which review the state of knowledge regarding the RRI dimensions, including empirical knowledge emerging from studies funded by the European Commission (EC).

The chapter is divided into two parts. First, a selection of EC studies with particularly rich empirical information on SLSE is reviewed. Second, a selection of other studies that equally hold rich information on SLSE is presented schematically. The aim of the review of EC studies is to 1) specify the questions concerning SLSE, to which the studies provide (partial) answers, 2) tentatively identify the indicators that may be harvested from the reviewed studies, 3) assess whether the information contained in the studies relate to the context, input, output, or outcome of SLSE following the intervention logic model, 4) specify the analytical level of the information, distinguishing between global, national, and sub-national (regional, institutional, programme/project and individual) levels, and 5) specify whether the studies provide quantitative or qualitative data. For the extensive list of other relevant empirical studies, the aim is to summarize the sources of information, the analytical level at which information is presented, and the key focus of the studies, in order to pave the road to subsequent qualified selection of existing indicators of SLSE in Task 3 of the MoRRI project.

These specifications of the studies holding empirical information about SLSE will be used as the background for assessing the overall availability of empirical information on SLSE in the succeeding chapter.

4.1 Commission studies and projects in the area of SLSE

The review of EU projects and studies in the area of SLSE allows to draw three main conclusions:

- There is a large number of projects on science education and science communication activities. So far, only a very small number of projects concerning co-production of knowledge have been identified within FP6 or FP7.
- Within the science education and science communication projects, implementation and/or dissemination/training projects are most prominent.
- For the area of science literacy only very few projects can be identified that are concerned with measurement of effects and which provide data to be used for the purposes of subsequent tasks of this project.

Generally, science literacy and more specifically science education has played an important role in FP6 and 7. For instance within the Science in Society theme in FP7 science education related activities amounted to 33% of the overall budget (Technopolis Group & Fraunhofer ISI, 2012).

Regarding the development of the topics within the FPs a change in the focus can be observed over time. In FP6 the cultural, utility and career arguments of science education were in the focus. This emphasis resulted in projects aimed at teachers, science professionals and educational specialists to increase the attractiveness and relevance of science at schools. Moreover, the special role of teachers and their education was acknowledged. In FP6, also a number of science communication projects (often with a close relation to education) could be identified, for instance science weeks and events. Several science communication projects were related to the role of the media in science communication or implementation of activities eg with museums and science centres.

In FP7, continued emphasis was put on science education. However, the topics of inquiry based learning (IBL) and inquiry based science education (IBSE) received increased attention. They were perceived to be paradigmatic models for teaching and learning, as well as a way to overcome inequalities in education. Moreover, the topic of the relationship between research institutions, the media and the public were addressed more extensively in FP7. FP7 continued to support implementation activities in projects with museums, science centres etc (Castellani, 2014; Valente, 2014).

For the purpose of this report, 7 projects, which have explored the dimension of SLSE, were reviewed.[8] They were selected based on considerations of usefulness in terms of identifying empirical data and developing indicators for the analysis in subsequent work packages. These projects are listed in the table below.

Table 1: Commission studies for review

Proposal Call	Project Acronym	Project Title	Project Start Date	Project End Date	Sources
FP7-SCIENCE-IN-SOCIETY-2010-1	SECURE	Science Education CUrriculum REsearch	01-11-2010	31-10-2013	www.secure-project.eu Report: Balancing the need between training for future scientists and broader societal needs. http://www.artefact.be/secure/EN.pdf
FP7-SCIENCE-IN-SOCIETY-2011-1	CREATIVELITTLESCIENT	Creative Little Scientists: Enabling Creativity through Science and Mathematics in Preschool and First Years of Primary Education	01-10-2011	31-03-2014	http://www.creative-little-scientists.eu/ Report: http://www.creative-little-scientists.eu/sites/default/files/Creativity_in_Science_and_Mathematics_Education.pdf
FP7-SCIENCE-IN-SOCIETY-2013-1	ARC OF INQUIRY	Arc of Inquiry: Inquiry Awards for Youth over Europe	01-03-2014	28-02-2018	http://www.arkofinquiry.eu/homepage Project in Progress
FP7-SCIENCE-IN-SOCIE	AVSA	Audio-visual science audiences (avsa). A comparative study	01-04-2008	31-03-2010	http://cordis.europa.eu/project/rcn/89923_de.html Report (periodic): http://cordis.europa.eu/documents/documentlibrary/118298181EN6.pdf

8 The projects were selected from a comprehensive list of FP6 and FP7 funded studies in the area of SLSE. For further details see Castellani, 2014; Valente, 2014. Moreover, we also selected studies that are not finished yet, as they can still provide interesting insights concerning possible indicators and data sources, as well as possibly interim project results that could become relevant.

Proposal Call	Project Acronym	Project Title	Project Start Date	Project End Date	Sources
FP7-SCIENCE-IN-SOCIETY-2009-1	PRIMAS	Promoting inquiry in mathematics and science education across Europe	01-01-2010	31-12-2013	http://www.primas-project.eu Reports: PRIMAS final publication: http://www.primas-project.eu/servlet/supportBinaryFiles?referenceId=18&supportId=1247 PRIMAS final policy report: http://www.primas-project.eu/servlet/supportBinaryFiles?referenceId=23&supportId=1247

Each of the projects will be reviewed in greater detail.

CREATIVELITTLESCIENT – Creative Little Scientists: Enabling Creativity through Science and Mathematics in Preschool and First Years of Primary Education

The project CREATIVELITTLESCIENT's objective was to develop a map of policies and practices in science and mathematics education for children aged 3-8 years and their potential to foster creativity and inquiry based learning and teaching. It also produced recommendations regarding how creativity in early science and mathematics could look like.9 The study deployed quantitative approaches in the mapping and comparison of policies and practices and surveyed more than 800 teachers. In addition, qualitative approaches such as case studies and online focus group discussions were used to investigate classroom practices and curriculum design processes respectively.

For the purpose of the present study, the project could inform the design of the indicators by highlighting the importance of science education in early childhood and by providing insights into the use of creativity and inquiry based learning in early childhood education and care.

Table 2: Examples of science literacy and scientific education indicators retrieved from CREATIVELITTLESCIENT

Guiding question	Indicator potential	Analytical level (intervention logic model)	Analytical level (aggregation)	Data classification and methods
To what extent does the MS include IBL and creativity in the policy making for early childhood education and care?	Measures taken and activities carried out	Input	National	Baseline study (survey including 815 teachers in 605 schools in 9 countries)

9 The comparative study took place in nine participating countries: Belgium, Finland, France, Germany, Greece, Malta, Portugal, Romania and the UK.

Guiding question	Indicator potential	Analytical level (intervention logic model)	Analytical level (aggregation)	Data classification and methods
To what extent do IBL and creativity play a role in the practice of early childhood education and care in a particular MS?	Measures taken and activities carried out	Input	National	Baseline study (survey including 815 teachers in 605 schools in 9 countries)

Arc of Inquiry - Arc of Inquiry: Inquiry Awards for Youth over Europe

The Arc of Inquiry project (2014-2018) is run by a consortium of partners from twelve countries.[10] It aims at raising youth awareness to RRI. To this end young Europeans (7-18 years old) are invited to participate in a variety of engagement activities. The activities aim to improve the inquiring skills of the youth, to increase their awareness and understanding of conducting 'real' science and to prepare them to take part in different roles in the European research and innovation process.

The project includes a number of activities:

- Development of a framework for identifying inquiry activities that promote pupils' awareness of RRI;
- Collection of existing inquiry activities and environments from various national and international projects;
- Provision of the activities available across Europe through the Arc of Inquiry platform in order to bring together inquiry activities, learners, and supporters (teachers, science and teacher education students, and staff of universities and science centres);
- Training of at least 1,100 teachers to support pupils' inquiry activities in a manner that attracts pupils' interest and motivation towards RRI;
- Implementation of the inquiry activities on a large-scale across a European school network. During the project at least 23,000 students are expected to take part in the project.

Moreover, the Arc or Inquiry Platform will be made available to the public. The platform will bring together pupils and 'supporters' such as teachers and researchers. It will contribute to connecting formal learning settings and curricula to the activity of science centres, museums, as well as universities. In this way different generations of scientists can meet each other, helping to build a society skilled in RRI and related scientific communication.

The project can help to build an understanding of the kind of inquiry based learning activities that help to promote awareness of RRI issues. Its output can also be used to formulate indicators with regard to inquiry activities.

10 Estonia, Greece, Cyprus, Finland, the Netherlands, Italy, Germany, Austria, France, Turkey, Hungary and Belgium.

Table 3: Examples of science literacy and scientific education indicators retrieved from ARC OF INQUIRY

Guiding question	Indicator potential	Analytical level (intervention logic model)	Analytical level (aggregation)	Data classification and methods
What is the current status of inquiry activities?	• Number and types of activities carried out in Europe/each country • Possibly: Number and types of activities carried out by type of institution	Input	European National Institutional	Quantitative data (numbers of projects in different contexts)

SECURE - Science Education CUrriculum REsearch

The project SECURE aimed at improving MST (Math, Science and Technology) curricula and their delivery in Europe by providing relevant and rigorous research data about MST curricula and their delivery in schools. To this aim the project team focussed on MST curricula in three ways: the intention of curricula makers and authorities, the implementation by teachers and the experience by learners.

In the study several methods were applied:

- A curriculum screening instrument
- Survey and interviews of students of different ages (8-, 11-, 13-year olds)
- Survey and interviews of teachers

The study was conduced in ten countries: Austria, Belgium, Cyprus, Germany, Italy, the Netherlands, Poland, Slovenia, Sweden, United Kingdom. Overall around 150 school units, 600 classes, around 900 teachers and around 12,000 learners were involved.[11] For the purpose of this project, the information about MST curricula, implementation and experience could provide valuable insights into the entire 'chain of educational value production'. Moreover, an analysis of the Secure results could be used for the creation an indicator of the gender dimension.

Table 4: Examples of science literacy and scientific education indicators retrieved from SECURE

Guiding question	Indicator potential	Analytical level (intervention logic model)	Analytical level (aggregation)	Data classification and methods
To what extent do MST curricula reflect a concern with RRI issues?	• Is it a separate item (chapter, section) in the curriculum?	Input	National (regional)	Qualitative data Desk research

11 The final report is currently not available online.

Guiding question	Indicator potential	Analytical level (intervention logic model)	Analytical level (aggregation)	Data classification and methods
Do science curricula cater for gender issues in science?	• Is it a separate item (chapter, section) in the curriculum?	Input	National (regional)	Qualitative data Desk research
To what extent does MST teaching practice reflect a concern with RRI issues?	• Responses by teachers surveyed, interviewed	Input	National (regional)	Qualitative data Desk research
To what extent does the experience of pupils taught in MST reflect a concern with RRI issues?	• Responses by pupils surveyed	Output	National (regional)	Qualitative data Desk research

Avsa – Audio visual science audiences

The project Avsa aimed at describing which types of science and the amount of science that is communicated through radio and TV in a comparative study.

The project analysed the determinants, which influence the provision of science programmes in radio and TV. Moreover, it linked science programmes with their use by recipients as well as with judgements of the European public concerning the offers in science programmes. The study was conducted for Austria, Germany, Finland, Sweden, Greece, Bulgaria, Great Britain, Ireland, Estonia, Romania, France and Spain.

In the context of this project avsa could inform indicator development with regard to science communication activities in the media.

Table 5: Examples of science literacy and scientific education indicators retrieved from avsa

Guiding question	Indicator potential	Analytical level (intervention logic model)	Analytical level (aggregation)	Data classification and methods
What type of science is being communicated in the media?	• Communication of science as real subject matter • Communication using science to explain everyday phenomena • Communication of science problematizing scientific findings	Context	National	Qualitative Desk research
In what way is science being communicated in the media?	• Perception of science communicated	Context	National	Qualitative Desk research
How much is science being communicated in the media?	• Amount of science communicated	Input	National	Qualitative desk research

PRIMAS – Promoting inquiry in mathematics and science education across Europe

The project PRIMAS (2010-2013) aimed to support inquiry based learning in science education (and mathematics), thereby effecting the implementation of IBSE approaches throughout Europe. To meet these objectives a range of initiatives and support measures were developed and implemented, which included the following:

- Support and professional development for teachers and teacher trainers,
- Selected materials for professional development and direct classroom use,
- Actions for introducing and promoting teachers' uptake of IBL,
- Methods for working with out-of-school parties (e.g. local authorities, parents etc.),
- Methods for disseminating activities and information to multiple layers of society,
- Contextual analyses on IBL implementation, aimed at gaining political support, evaluation and feedback on the project's own validity and effectiveness (primas-project.eu).

PRIMAS put a particular focus on the policy level. Based on the observation that IBL practices were only to a limited degree implemented in the countries of the project partners[12], the project aimed to feed into the policy-making process at national and international levels. To this end, the project explored and analysed 'policies and education policy contexts relevant to the dissemination of inquiry-based pedagogies' through a common country framework.

Finally, PRIMAS evaluated its own activities and the impact inquiry-based learning had in day-to-day teaching. The evaluation is based on surveys among 1.200 teachers in and among approx. 25.000 students.

Considering the purpose at hand, PRIMAS could inform the design of indicators regarding the role of science and IBL in national curricula, as well as the use of IBL in the classroom. Furthermore, the specific inclusion of various stakeholders such as policymakers, school leaders, teachers and parents to support and sustain the wider application of inquiry based learning at a grassroots level provide a distinct project example of the intersection of the public engagement and science education dimension.

Table 6: Examples of science literacy and scientific education indicators retrieved from PRIMAS

Guiding question	Indicator	Analytical level (intervention logic model)	Analytical level (aggregation)	Data classification and methods
Which roles do science and IBL play in national curricula?	• Relative importance of science to reading -> priority of science in curricula (y/n)	Input	Institutional Individual (across Europe)	Desk research

12 The project partners were located in Cyprus, Germany, the Netherlands, United Kingdom, Spain, Slovakia, Hungary, Malta, Denmark, Romania, Norway and Switzerland.

4.2 Other empirical studies on the dimension of SLSE

In addition to the EC funded studies reviewed above, a number of other reports offer relevant empirical information on SLSE issues in the research and innovation context. Given the large amount of work in this area, we focus our suggestions on those studies that shaped the field, that provide data sources and as well as address the most recent developments in the field.

In Table 7, 17 studies are presented. For each entry, the analytical level in terms of aggregation is specified, and a brief note on the key focus of the study is provided.

Table 7: Main empirical studies on the dimension of science literacy and scientific education - for review

Source	Type of source	Analytical level (aggregation)	Key focus
Allum, N. (2009). Science Literacy. In S. Priest (Ed.), Encyclopedia of Science and Technology Communication. Sage Publications. Retrieved from http://privatewww.essex.ac.uk/~nallum/ScienceLiteracyEncyclopediaofScienceandTechnologyCommunication.pdf	Book section	Global	General introduction, data sources
Bauer, M. W. (2008). Survey research on public understanding of science. In M. Bucchi & B. Trench (Eds.), Handbook of Public Communication of Science and Technology (pp. 111–130). Routledge.	Book section	Global	Overview on survey studies on public understanding of science since 1970
Bauer, M.W. et al (2011). The Culture of Science – How the Public Relates to Science Across the Globe . Routledge.	Book	Global	Overview on survey studies of public understanding of science
BIS - Department for Business Innovation and Skills. (n.d.). International comparision of public dialogue on science and technology. Retrieved from http://www.wilsonielsen.com/wp-content/uploads/2011/05/International-Comparison-of-Public-Dialogue.pdf	Report	National	Comparison of public dialogue on science and technology
Bucchi, M., & Trench, B. (2008). Handbook of public communication of science and technology. Science And Technology. Routledge	Book	Global	General introduction
European Commission, Eurobarometer studies (see report on Public Engagement)	Report/Data	Europe	Data on public understanding of science, incl science edcuation
Eurydice network. (2011). Science Education in Europe: National Policies, Practices and Research. Retrieved from http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/133en.pdf	Report	Europe	Overview of policies, practices and research
Eurydice network (2011). Mathematics Education in Europe: common challenges and national policies (p. 180). Retrieved from http://www.fisme.science.uu.nl/intern/publicaties/2011_eurydice_mathematics_education.pdf	Report	Europe	Overview of policies
Gommerman, L., & Monroe, M. C. (2012). Lessons Learned from Evaluations of Citizen Science Retrieved from http://edis.ifas.ufl.edu/pdffiles/FR/FR35900.pdf	Report	United States	Evaluation results
Henriksen, E. K., Dillon, J., & Ryder, J. (Eds.). Understanding student participation and choice in science and technology education. Dordrecht:	Book	Europe	Reasons for student participation in S&T education

Source	Type of source	Analytical level (aggregation)	Key focus
Springer. (IRIS Project)			
ISC, Trends in International Mathematics and Science Study (TIMSS), Data	Report/Data	Global	International comparative student assessment
Mejlgaard, N., Bloch, C., Dedn, L., Ravn, T., & Nielsen, M. W. (2012). Monitoring Policy and Research Activities on Science in Society in Europe (MASIS) Final synthesis report.	Report	Europe	Data on research efforts in RRI, policies and communication activities
Miller, J. D. (1983). Scientific Literacy : A Conceptual and Empirical Review. Deadalus, 112(2), 29–48.	Scientific article	Global	Basic reference including theoretical concepts and measurement
Miller, J. D. (1998). Public Understanding of Science The measurement of civic scientific literacy The measurement of civic scientific literacy. doi:10.1088/0963-6625/7/3/001	Scientific article	Global	Basic reference including theoretical concepts and measurement
Miller, J. D. (2010). The Conceptualization and Measurement of Civic Scientific Literacy for the Twenty-First Century. In J. Meinwald & J. G. Hildebrand (Eds.), Science and the Educated American: A Core Component of Liberal Education (p. Chapter 12). American Academy of Arts and Sciences, Cambridge, MA	Book section	Global	Basic reference including theoretical concepts and measurement
OECD, Programme for International Student Assessment (PISA), Data	Report/Data	Global	International comparative student assessment
OECD, Programme for the International Assessment of Adult Competencies (PIAAC)	Report/Data	Global	International comparative adult assessment
OECD, Teaching and Learning International Survey (TALIS), Data	Report/Data	Global	International teacher survey
Sjøberg, S., & Schreiner, C. (2010). The ROSE project An overview and key findings. Retrieved from http://roseproject.no/network/countries/norway/eng/nor-Sjoberg-Schreiner-overview-2010.pdf	Report	Global	Attitudes towards science
Wiggins, A., & Crowston, K. (2015). Surveying the citizen science landscape. First Monday, 20(1-5).	Journal Article	Global	Classification

The Eurobarometer Studies are an especially valuable source for data on citizens' scientific literacy. Since 1977 the European Commission conducts public opinion surveys on a wide range of issues, the so-called Eurobarometers, including aspects such as interest in science, attitude towards science or knowledge concerning science. Overall, five large-scale surveys on science, technology, and the public have been carried through in 1989, 1992, 2001, 2005, and 2010. In addition, two barometers specifically addressing the emerging notion of RRI were implemented in 2013 and 2014.

Table 8: Relevant Eurobarometers on public understanding of science

Year	EB wave and name of module
1989	Eurobarometer 31: Europeans, Science and Technology
1991	Eurobarometer 35.1: Opinions of Europeans on biotechnology in 1991

Year	EB wave and name of module
1992	Eurobarometer 38.1: Europeans, Science and Technology
1999	Eurobarometer 52.1: Europeans and modern biotechnology
2001	Eurobarometer 55.2: Europeans, Science and Technology
2002	Eurobarometer 58.0: Europeans and biotechnology in 2002
2005	Eurobarometer 63.1: Europeans, Science and Technology
2010	Eurobarometer 73.1: Science and Technology 2010
2013	Eurobarometer 79.2: RRI, Science and Technology
2014	Eurobarometer 81.5: Public perceptions of science, research and innovation

The Eurobarometer series is an interesting source of empirical evidence for several reasons. First, the Eurobarometers provide time-series data of attitudes towards and interest in science. Despite overall item discontinuity, a number of core items have been safeguarded, including issues such as interest in science, efficacy in matters of science, and knowledge of science (the latter up until 2005). Second, the barometers stretch across a growing number of countries (reflecting the expansion of the EU) resulting in 30+ countries covered in the latest waves.[13] Third, unlike the majority of studies providing empirical information about SLSE, Eurobarometers provide data at the level of the individual, which may also, due to representative sampling, be aggregated to the national and European level. Finally, Eurobarometer data may be relevant at different levels of the intervention logic model. Some items relate to SLSE input, while others may be considered indicators of output or outcome.

The specific items in the surveys are relevant towards both the SLSE and the public engagement dimensions of RRI. There are several items in the Eurobarometers which are especially relevant for the SLSE dimension. These are the indicators on citizens interest in science and technology, the indicator on their feeling of well-informedness as well as questions assessing citizens' "textbook knowledge" of science.

A brief overall analysis of these studies reveals that they can be of use for this project in two ways: on the one hand, they represent another source for the construction of indicators. There are a number of studies providing a general overview of the developments in science education and science communication. They can help inform the development of indicators in a more conceptual and less in a practical or empirical way.

On the other hand, the studies provide empirical data for the monitoring. The most important cross-country studies in this context are PISA, PIACC, TIMSS and results from Eurobarometer surveys. Although the available data might be limited – eg in the sense that it does not cover all countries for which the monitoring system is finally developed or all sub-categories of SLSE – it nevertheless forms the basis for the monitoring and reduces the need for the primary data collection.

As the discussion in the following chapter will show, the data availability differs considerably between the three sub-categories of the SLSE dimension. While there is considerable data available for science education, this is less the case for science communication and co-production of knowledge.

13 Eurobarometer studies include data for non-EU countries such as Norway, Switzerland, Macedonia, Serbia, Montenegro, Albania or Turkey.

5. Assessment of data availability on SLSE

Based on the review and presentation of empirical studies on SLSE above, this chapter provides an overall assessment of SLSE data that is available for the purpose of indicator development. The chapter discusses the issue of data availability in terms of 1) the extent to which the empirical studies provide relevant information across the categories of SLSE, which were identified in the functional vocabulary, i.e. the extent to which the guiding questions that the studies address satisfactorily capture the contents of SLSE as defined in operational terms, 2) the balance and availability of quantitative and qualitative data respectively, 3) the extent to which available information address the four analytical levels specified in the intervention logic model, and 4) the availability of data at different levels of aggregation.

In the following we will review the availability of data on SLSE with regard to all three mechanisms of SLSE. We will discuss the availability of data for different categories of education, for the different indicator types, for various levels of aggregation and according to the type of data. We will show that, while data availability is generally good, most existing data refers to science education rather than in science communication or the co-production of scientific knowledge, in particular citizen science.

5.1 Data availability across SLSE categories

In general the data availability for the SLSE dimension is mixed. While the availability of quantitative and qualitative data for the science education part of the SLSE dimension is good, there exists considerable less data for science communication and co-production of knowledge types of activities. One reason for the wider availability of data on science education compared to the other two sub-categories might be that phenomena of the former are easier to measure and are considered to be economically much more relevant, as well as the fact that the latter is a more recent addition to the notion of science literacy.

There exists considerable data for the sub-category of science education. The data available is mainly based on large-scale surveys in a number of countries. This includes for instance competence tests such as PISA, PIACC or TIMSS as well as results from Eurobarometer surveys or information on attitudes towards science from the ROSE project. Given the detailed information available from international comparative competence tests, the situation concerning quantitative data is good.

- Concerning science communication data on inputs, outputs and outcomes is available only for a handful of countries. Several of the projects supported by the European Commission provide insightful qualitative data on the issues of science communication. However, in most cases the data is not available for all Member States but only a selection of countries. Quantitative data on science communication is available through the Eurobarometer surveys.
- Similarly, for the co-production of knowledge there is little data available that would allow to describe and compare the situation across different countries. The main reason being the fact that co-production of scientific knowledge is still relatively new activity. Hence, hardly any studies have been concluded on this subject.

In sum, while the availability of data for the dimension SLSE differs significantly across the three sub-categories, the existing material can be expected to provide a first basis for the building a monitoring system of RRI. As mentioned in the report on public engagement, it is of central importance to take the overlaps and intersections between the dimensions of public engagement and SLSE, as well as between gender equality and SLSE into account.

5.2 Availability of quantitative and qualitative data on SLSE

Bearing in mind the difference in data availability across the three sub-categories it can be said that significant quantitative and qualitative data for the SLSE dimension exists. The main sources here are – with regard to science education – the international comparative competence tests, such as PISA or TIMSS – and the Eurobarometer.

In addition to the existing quantitative data, several of the projects supported by the European Commission provide very insightful qualitative data on the issues of science education and communication. However, in most cases the data is not available for all Member States but only a selection. The qualitative data is mostly based on methods such as desk research, interviews, focus groups, and case studies. Some of the reviewed studies used mixed methodologies, combining, survey, interviews and/or focus groups.

As also mentioned in the discussion of public engagement the results of studies based on qualitative methodologies are particularly important when opening up a complex and multifaceted issue. For the purpose of monitoring, benchmarking and comparisons across several countries or institutions it will be necessary to transpose qualitative material into 'quantitative' indicators and measures. As mentioned in the report on PE, one way to do this is to code and classify the qualitative data in order to generate quantitative indicators.

5.3 Availability of data across analytical levels included in the intervention logic model

Following the MoRRI proposal, indicators will be considered for different levels or phases of the 'logic model' of SLSE interventions. These levels refer to

- The 'Context', i.e. the overall environment for SLSE and character of society with regard to issues of science literacy and science education,
- 'Input', i.e. the SLSE activities that are carried out, measures taken, structures created or resources provided
- 'Outputs', i.e. the immediate or direct results of such activities, and the
- 'Outcomes' i.e. the mid- and long-term achievements and consequences of SLSE activities.

The empirical information retrieved from the studies presented concerns mainly context data. With regard to other analytical levels, the situation differs significantly across the three sub-categories (see table 5.1).

- For science education data can be found and related to all four analytical levels. This is mainly due to the presence of international comparative competence tests.
- For science communication the data situation is rather mixed: Some information on inputs and outputs is available and accessible. However, data on outcomes of science communication is according to our research rather rare.
- As mentioned before, data availability for co-production of knowledge is rather rare. While it can be expected that data on inputs can be retrieved through desk research, information regarding outputs and outcomes will need to be generated through primary data collection.

Table 9: Data availability across analytical levels

Sub-category	Context	Input	Output	Outcome
Science education	Available	Available	Available	Available
Science communication	Available	Not available (generation easy)	Partly available	Not available
Co-production of knowledge	Available	Not available (generation easy)	Not available	Not available

The existence of context data is well in line with a general interest among SLSE practitioners and researchers, namely in 'how things can be done' rather than how well they have been performed and what impact they have had. Consequently, there is a number of studies examining the implementation of different formats of SLSE activities.

In addition, a considerable share of projects addressed the 'context' level of SLSE, pointing in particular to the historical development of science education and communication and the ways in which these subjects can be related to science policy in general. For the continued work in MoRRI, it is useful to explore further the extent to which these projects might be used for the development of 'impact/benefit'-indicators (activities related to Tasks 6-8).

5.4 Availability of data at different levels of aggregation

Empirical data on SLSE can refer to different levels of aggregation. For the purpose of this project a distinction was made between data at the global, national, regional, institutional, and individual levels was made. It is important to stress that these labels are not meant to capture the scope or coverage of available data, but rather the analytical level at which the available data is oriented. 'Global', thus, does not imply that we have access to data from all countries across the globe, but rather that the available data can inform the team about SLSE issues at the cross-national level, often overall trends, focus points or developments within the field. Likewise, 'national' implies that the information relates to SLSE national policies or procedures, but it does not indicate the actual number of countries that are covered in the study.

Most of the data available for the SLSE dimension is aggregated on a national level. Generally, this national data is available for a comparably large range of countries, especially concerning the science education topic. For all three sub-categories only very limited data is available on a sub-national level, such as institutions or individuals.

- Although science education data is often generated on the level of individuals, eg test results, it is publicly available only in an aggregated form, i.e. at national level.
- For science communication data is available at national level but not at the remaining levels of aggregation.
- Similarly, for co-production of knowledge existing data is very limited. Thus, any aggregated data would need to be generated on lower levels of aggregation, eg on the level of institutions or individual projects.

6. Data selection for RRI monitoring – reflections of current data gaps and required data collection on SLSE

The purpose of this chapter is to assess data gaps and provide reflections on the need for primary data collection in order to fill data gaps, based on the contents and results of the previous chapter as well as on the list of promising indicators constructed in chapter 7. The summary table 6.1.1 below, capturing the contents of chapter 7, serves as a basis for assessing the potential to develop new indicators based on existing empirical material.

As described in the previous chapter the data situation in the SLSE dimension can be summarized as follows:

- In general the data availability for the SLSE dimension is mixed. While the availability of quantitative and qualitative data for the science education part of the SLSE dimension is good, there exists considerable less data for science communication and co-production of knowledge types of activities.

- Bearing in mind the difference in data availability across the three sub-categories it can be said that significant quantitative and qualitative data for the SLSE dimension exists. The main sources here are – with regard to science education – the international comparative competence tests, such as PISA or TIMSS – and the Eurobarometer.

- Concerning data availability for the different analytical levels of the logic chart, the situation is again mixed. While for science education data is available for inputs, outputs and outcomes, for science communication and co-production of knowledge the data availability concerning outputs and outcomes smaller. However, it can be expected that input data for these two dimensions can be generated relatively easily.

- Finally, most of the data available for the SLSE dimension is aggregated on a national level. Generally, this national data is available for a comparably large range of countries, especially concerning the science education topic. For all three sub-categories only very limited data is available on a sub-national level, such as institutions or individuals.

Based on this summary review the following table presents the current data gaps and required data collection.

Table 10: Summary table capturing the contents of chapter 7

INDICATOR	ANALYTICAL MODEL (Logic model) CONTEXT (1) INPUT (2) OUTPUT (3) OUTCOME (4)	ANALYTICAL LEVEL (aggregation) GLOBAL (1) NATIONAL (2) REGIONAL (3) INSTITUTIONAL (4) PROGRAMME/ PROJECT (5) INDIVIDUAL (6)	UNIT OF ANALYSIS COUNTRIES (1) INSTITUTIONS (2) INDIVIDUALS (3) PUBLICATIONS (4) OTHER (PLEASE SPECIFY) (5)		TIME SERIES Y (1) N (2)	YEAR OF DATA, MOST RECENT
Interest, informedness and textbook knowledge about science and technology	3	6 2	6	Around 125 country observations (5 obs, 32 countries) Around 150.000 individual responses (5 obs. 30.000 people)	1	2013
Competence of general population with regard to numeracy	4	2	1	19 (19 countries 1 obs – 2013)	1	2013
Share of STEM graduates	3	2	1	Around 400 (30 countries, 15 years, some missing values)	1	2012
Science competence in of primary school pupils	4	2	1	Around 150 (25 countries, 6 obs)	1	2011
Science competence in subject matters of secondary school pupils	4	2	1	Around 175 (35 countries, 5 obs)	1	2012
Science Communication Culture	1	2	1	37 (37 countries, 1 obs)	2	2011
Importance of science communication as an evaluation criterion	1	2	1	36 (36 countries, 1 obs)	2	2011

This table indicates that most data gaps are in the area of science communication and even more in the area of co-production of knowledge.

Considering the components of the logic model, a distinction needs to be made between the three sub-categories: while for science education output and outcome indicators are available, for the other two dimensions no internationally comparable output or outcome indicators exist at this point. However, the data for generating input indicators should be relatively easily available for all three SLSE aspects.

Concerning the analytical level the table above shows that if data is available, it mostly concerns the national level. Generally there is little information relating to the national level, be it institutional, individual or on a programme level.

7. Early thoughts on SLSE indicators

This chapter provides a space for compiling promising indicators based on existing empirical information identified throughout the report. The intention is to prepare for the ground for Task 3, in which the selection of existing indicators and the development of new ones will take place.

The development of indicators for the measurement of scientific literacy began even before WWII, when school children were evaluated at school. With the Sputnik shock and the subsequent focus on scientific literacy, the first survey of scientific literacy focussing on textbook knowledge was conducted in 1957 in the United States (Allum, 2009). Based on the hypothesis that more knowledge of scientific facts leads to a more favourable attitude towards science, the attitudes towards science were increasingly a topic for survey studies in the following years.[14]

Concerning the development of indicators there are a number of requirements to be taken into account. The indicators developed need to be useful over a period of years and be able to capture the changes in the structure and composition of science literacy sensitively. Time-series indicators are not be revised too often or without consciously designed interlinkages in order to separate real change from measurement changes over time (Miller, 2010). Other criteria indicators might need to fulfil include relevance, robustness, cost-efficiency. These issues will be examined at a later stage of the project.

Table 11: Potential indicator for SLSE, no. 1

Information Item	SLSE1
Name of indicator	Interest in science and technology
Brief description	The indicator taps into citizen interests in science and technology. Interest in science and technology is among the most common aims for SLSE activities, and can be considered an output indicator. The measure presented here is survey-based and the survey item reads: 'How interested are you in developments in science and technology'.
Analytical level (logic model)	Output
Analytical level (aggregation)	Individual level data, can be aggregated
Qual / Quant	Quantitative
Source of data	Eurobarometers, most recently Special EB 401
Date	2013
Time-series	2013, 2010, 2005, 2001, 1989 (slightly different wordings and attributes across EB waves)
Measurement level	Ordinal
Unit of analysis	Individual European citizens

14 Today, there is an academic debate about whether this hypothesis holds in the first place (see also Bauer et al., 2007).

Information Item	SLSE1
Coverage	Across Europe, around 32 countries, 30.000 respondents
Attributes	• Very interested • Fairly interested • Not very interested • Not at all interested • Don't know

Table 12: Potential indicator for SLSE, no. 2

Information Item	SLSE2
Name of indicator	Informedness about science and technology
Brief description	The indicator taps into the degree to which citizen feel well-informed about science and technology. Feeling well-informed about science and technology can be considered a proxy for individual (internal) efficacy in matters of science and technology, i.e. believing to have competence in matters of science and technology. The measure presented here is survey-based and the survey item reads: 'How informed do you feel about developments in science and technology'.
Analytical level (logic model)	Output
Analytical level (aggregation)	Individual level data, can be aggregated
Qual / Quant	Quantitative
Source of data	Eurobarometers, most recently Special EB 401
Date	2013
Time-series	2013, 2010, 2005, 2001, 1989 (slightly different wordings and attributes across EB waves)
Measurement level	Ordinal
Unit of analysis	Individual European citizens
Coverage	Across Europe, around 32 countries, 30.000 respondents
Attributes	• Very well informed • Fairly well informed • Not very well informed • Not at all informed • Don't know

Table 13: Potential indicator for SLSE, no. 3

Information Item	SLSE3
Name of indicator	Textbook knowledge about science and technology
Brief description	Through four Eurobarometer waves, a battery of questions measuring 'text book knowledge' of science has been employed. 8 core items have been maintained in all four waves. The items, 13 in total, tap into the basic, traditional, notion of science literacy. The items are presented as a knowledge quiz, and have been applied in

Information Item	SLSE3
	different combinations as composite measures of text book knowledge of science. Instead of presenting the 13 items separately, they are presented together below.

	EB 1989	EB 1992	EB 2001	EB 2005-1
1. The centre of the earth is very hot	+	+	+	+
2. The oxygen we breath comes from plants	+	+	+	+
3. Radioactive milk can be made safe by boiling it	+	+	+	+
4. Electrons are smaller than atoms	+	+	+	+
5. The earliest humans lived at the same time as the dinosaurs	+	+	+	+
6. Antibiotics kill viruses as well as bacteria	+	+	+	+
7. Lasers work by focusing sound waves	+	+	+	+
8. All radioactivity is man-made	+	+	+	+
9a. The continents are moving slowly about on the surface of the earth	+			
9b. The continents on which we live have been moving for millions of years and will continue to move in the future		+	+	+
10a. It is the father's gene which decides whether the baby is a boy or a girl	+	+		
10b. It is the father's genes that decide whether the baby is a boy or a girl			+	
10c. It is the mother's genes that decide whether the baby is a boy or a girl				+
11. Human beings, as we know them today, developed from earlier species of animals		+	+	+
12a. Does the earth go around the sun or does the sun go around the earth*		+		
12b. The Sun goes around the Earth			+	+
13a. How long does it take for the earth to go around the sun**		+		
13b. It takes 1 month for the Earth to go around the Sun			+	+

Items 1-11, 12b, and 13b:
'Here is a quick quiz. For each thing I say, tell me if it is true or false. If you don't know, say so, and we will skip to the next'.
Response categories: 1) True; 2) False; 3) DK.
Item 12a:
'Does the earth go around the sun or does the sun go around the earth?'
Response categories: 1) The earth goes around the sun; 2) The sun goes around the earth; 3) DK.
Item 13a:
'How long does it take for the earth to go around the sun?'
Response categories: 1) One day; 2) One month; 3) One year; 4) Other answers; 5) DK

Analytical level (logic model)	Output
Analytical level (aggregation)	Individual level data, can be aggregated
Qual / Quant	Quantitative
Source of data	Eurobarometers, most recently EB 63.1
Date	2005
Time-series	2005, 2001, 1992, 1989 (see above for differences in item wording across EB waves)
Measurement level	Interval, when used as composite indexes
Unit of analysis	Individual European citizens
Coverage	Across Europe, around 32 countries, 30.000 respondents
Attributes	• False • True Scores attributed to correct answers

Table 14: Potential indicator for SLSE, no. 4

Information Item	SLSE4
Name of indicator	Competence of general population with regard to numeracy
Brief description	Indicator capturing the competence of the general population with regard problem solving in technology-rich environments.
Analytical level (logic model)	Outcome
Analytical level (aggregation)	Country-level
Qual / Quant	Quantitative
Source of data	OECD Programme for the International Assessment of Adult Competencies (PIAAC)
Date	Primary data from 2013
Time-series	No
Measurement level	Ordinal
Unit of analysis	Countries
Coverage	19 European countries
Attributes	• Average numeracy score: • Low numeracy (below level 1 and level 1) • Medium-low numeracy (level 2) • Medium high numeracy (level 3) • High numeracy (level 4 and level 5)

Table 15: Data presentation, SLSE4

Medium-low numeracy	Medium-high numeracy
Austria	Finland
Estonia	Flanders-Belgium
Germany	Netherlands
Cyprus	Sweden
United Kingdom	Norway
Poland	Denmark
Ireland	Slovak Republic
France	Czech Republic
Italy	
Spain	

Table 16: Potential indicator for SLSE, no. 5

Information Item	SLSE5
Name of indicator	Share of STEM graduates
Brief description	The indicator presents the share of graduates in STEM in relation to all graduates in a country
Analytical level (logic model)	Output
Analytical level (aggregation)	Country-level
Qual / Quant	Quantitative
Source of data	OECD Education Statistics (Graduates by field of education)
Date	Primary data since 1998
Time-series	yes
Measurement level	Interval
Unit of analysis	Country-level
Coverage	OECD countries
Attributes	High share of STEM graduates Low share of STEM graduates

Table 17: Data presentation for 2012, SLSE5

High share of STEM graduates	Low share of STEM graduates
Austria	Belgium
Czech Republic	Finland
Denmark	Hungary
Germany	Iceland
Greece	Italy
Ireland	Netherlands
Luxembourg	Norway
Spain	Poland
Sweden	Slovak Republic
Switzerland	
Turkey	
United Kingdom	

Table 18: Potential indicator for SLSE, no. 6

Information Item	**SLSE6**
Name of indicator	Science competence in subject matters and cognitive domains of primary school pupils
Brief description	Indicator describing science competence of primary school pupils in science subjects (life science, physical science, earth science)
Analytical level (logic model)	Outcome
Analytical level (aggregation)	Country-level
Qual / Quant	Quantitative
Source of data	TIMSS study
Date	1995, 1999, 2003, 2007, 2011, (2015 available 2016)
Time-series	yes
Measurement level	Interval
Unit of analysis	Countries
Coverage	25 European countries covered
Attributes	Overall average score over the science subjects

Table 19: Data presentation, SLSE6

Country	**Average score**
Finland	570
Czech Republic	536
Hungary	534
Sweden	533
Slovak Republic	532
Austria	532
Netherlands	531
England	529
Denmark	528
Germany	528
Italy	524
Portugal	522
Slovenia	520
Northern Ireland	517
Ireland	516
Croatia	516
Serbia	516
Lithuania	515
Belgium (Flemish)	509

Country	Average score
Romania	505
Spain	505
Poland	505
Norway	494
Malta	446

Table 20: Potential indicator for SLSE, no. 7

Information Item	SLSE7
Name of indicator	Science competence in subject matters of secondary school pupils
Brief description	Indicator describing science competence of secondary school pupils in science subjects (biology, chemistry, physics and earth science)
Analytical level (logic model)	Outcome
Analytical level (aggregation)	Country level
Qual / Quant	Quantitative
Source of data	PISA
Date	2000,2003, 2006, 2009, 2012 (PISA)
Time-series	Yes
Measurement level	Interval
Unit of analysis	Countries
Coverage	35 European countries
Attributes	Mean PISA score for science

Table 21: Data presentation, SLSE7

Country	Average score	Country	Average score
Finland	545	Czech Republic	508
Estonia	541	Austria	506
Poland	526	Belgium	505
Liechtenstein	525	Latvia	502
Germany	524	France	499
Netherlands	522	Denmark	498
Ireland	522	Spain	496
England	529	Lithuania	496
Denmark	528	Norway	495
Germany	528	Hungary	494

Italy	524	Italy	494
Portugal	522	Croatia	491
Slovenia	520	Luxembourg	491
Northern Ireland	517	Portugal	489
Ireland	516	Sweden	485
Croatia	516	Iceland	478
Serbia	516	Slovak Republic	471
Lithuania	515	Israel	470
Belgium (Flemish)	509	Greece	467
Romania	505	Turkey	463
Spain	505	Bulgaria	446
Poland	505	Serbia, Republic of	445
Norway	494	Romania	439
Malta	446	Cyprus	438
Switzerland	515	Montenegro, Republic of	410
Slovenia	514	Albania	397
United Kingdom	514		

Table 22: Potential indicator for SLSE, no.8

Information Item	SLSE8
Name of indicator	Science communication culture
Brief description	Indicator summarizing overall national science communication culture. Builds on six parameters that collectively form a framework for describing the science communication culture of a specific country. These include the degree of institutionalization (e.g. the presence of popular science magazines, regularity of science section in newspapers, dedicated science communication in television etc.), political attention to the field, the scale and diversity of actor involvement, traditions for popularization within academia, public interest in science and technology, and finally the training and organizational characteristics of science journalism in the country.
Analytical level (logic model)	Context-related
Analytical level (aggregation)	Country level
Qual / Quant	Quantitative (derived from qualitative primary data)
Source of data	Indicator presented in Mejlgaard et al 2012; primary data developed in the MASIS project
Date	Primary data from 2011
Time-series	No
Measurement level	Ordinal
Unit of analysis	Countries
Coverage	37 European countries included
Attributes	• Fragile science communication culture • Developing science communication culture • Consolidated science communication culture

Table 23: Data presentation, SLSE8

Consolidated	Developing	Fragile
Belgium	Austria	Albania
Denmark	Cyprus	Bulgaria
Finland	Estonia	Croatia
France	Greece	Czech Republic
Germany	Hungary	Israel
Italy	Iceland	Lithuania
Lichtenstein	Ireland	Macedonia
Norway	Latvia	
Portugal	Luxembourg	
Spain	Montenegro	
Sweden	Poland	
The Netherlands	Romania	
United Kingdom	Serbia	
	Slovakia	
	Slovenia	
	Switzerland	
	Turkey	

Table 24: Potential indicator for SLSE, no. 9

Information Item	SLSE9
Name of indicator	Importance of science communication as an evaluation criterion
Brief description	Indicator informing about the degree to which activities related to science communication and dissemination are evaluation criteria for project assessment.
Analytical level (logic model)	Context related
Analytical level (aggregation)	Country level
Qual / Quant	Quantitative (derived from qualitative data)
Source of data	MASIS country reports
Date	2011
Time-series	No
Measurement level	Nominal
Unit of analysis	Countries
Coverage	36 European countries (+ Turkey)
Attributes	Presence of science communication as evaluation criterion Absence of science communication as evaluation criterion

Table 25: Data presentation, SLSE9

Presence of the criterion	Absence of the criterion
Austria	Albania
Czech Republic	Belgium
Germany	Bulgaria
Estonia	Croatia
Spain	Cyprus
Macedonia	Denmark
Hungary	Finland
Luxembourg	France
Latvia	Greece
Portugal	Iceland
Slovakia	Ireland
Turkey	Israel
	Italy
	Liechtenstein
	Lithuania
	Montenegro
	Netherlands
	Norway
	Poland
	Romania
	Serbia
	Slovenia
	Spain
	Sweden
	Switzerland
	Turkey
	UK

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Appendix – literature review

Review guidelines

MoRRI

Final version / 17.11.2014 (rl)

Task 1: Literature review | Review template

Background and objectives

The purpose of this template is to provide each member of the review team with a common framework and reference point to conduct the literature review and, one the reviews are conducted, to facilitate a systematic and structured analysis of the literature.

According to the TOR, the main objective of this first task in the MoRRI project is to

- Review of the state of knowledge regarding RRI
- Define the policy context of RRI in Europe and elsewhere
- Give a comparative assessment of RRI dimensions, weighing-up advantages, disadvantages and available options
- Conduct a preliminary assessment of the availability of empirical evidence on the dimensions
- Finalise the definitions and properties of the RRI key dimensions
- Finalise the definition and properties of additional factors that may be relevant for the monitoring tasks.

How to use this document

- Due to the standardized nature of this template, you may feel that the content of the literature cannot be adequately represented. In these cases, please use the comment spaces provided for most questions.
- The literature review takes into account a selection of relevant publications in the 5 key dimensions of RRI (as defined by the EC: citizen engagement, science literacy, gender equality, open access, governance and ethics) and a selection of key publications dealing explicitly with RRI. Some of the questions in this template only relate to the 5 key dimensions, others only to the explicit RRI literature. Please make sure to fill in the template accordingly.
- Try to briefly summarise the relevant statements of the review document in your own words, perhaps using bullet points; please always refer to the page number of the document.
- If a question in the template does not apply to the publication at hand, please leave the entry blank.
- Important definitions or other central statements may be copied into the template; please always make reference to the page number of the review document
- Given the diversity of literature covered in this review, it is difficult to provide guidance on how extensive each review should be. For a "normal" journal article we expect the filled-in template to count roughly about 8-10 pages.

If you have any questions, please get in touch:
Ralf Lindner, ph.: +49 (0) 721 / 6809-292
ralf.lindner@isi.fraunhofer.de

Review reports

<table>
<tr><td colspan="3">Basic information</td><td colspan="3">Document no.:
(citavi #)</td><td colspan="3">000</td></tr>
<tr><td>Reviewer's name</td><td colspan="8">Philine Warnke</td></tr>
<tr><td>1. Bibliographical information (author/s, year, title, editor/s, journal/book, volume, publisher, place of publication, pages, DOI)</td><td colspan="8">Allum, Nick, 2009, Science Literacy IN Priest, 2009 Encyclopedia of Science and Technology Communication, Sage Pub
(available at http://privatewww.essex.ac.uk/~nallum/ScienceLiteracyEncyclopediaofScienceandTechnologyCommunication.pdf)</td></tr>
<tr><td>2. Abstract (copy and paste)</td><td colspan="8">The article provides an overview on different and partly conflicting notions and assessments of Science Literacy. It provides evidence that there is no linear relationship between the degree of science knowledge in the public, its attitudes towards science and the science related judgments and decisions. This implies that improving science education will not necessarily change the ability for decision making on science related matters.</td></tr>
<tr><td rowspan="3">3. Main focus (key dimensions according to MoRRI)

Comment on 3:</td><td>RRI / RI</td><td>☐</td><td>Citizen participation</td><td>☐</td><td>Science literacy</td><td>☒</td><td colspan="2">Gender equality</td></tr>
<tr><td>Open access</td><td>☐</td><td>R&I governance and ethics</td><td>☒</td><td>Other</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="8">The relationship between SL and aility of good governance is discussed</td></tr>
<tr><td rowspan="2">4. Main perspective (multiple entries possible)</td><td>Theoretical, conceptual</td><td>☒</td><td>Methodological</td><td>☐</td><td>Policy oriented</td><td>☒</td><td colspan="2">Evaluative</td></tr>
<tr><td>Other</td><td>☐</td><td colspan="6">Comment on 4:</td></tr>
<tr><td rowspan="3">5. Type of document

Comment on 5:</td><td>Scientific article</td><td>☐</td><td>Book chapter</td><td>☐</td><td>Book</td><td>☐</td><td colspan="2">Report</td></tr>
<tr><td>Project deliverable</td><td>☐</td><td>Policy/ strategy document</td><td>☐</td><td>Other</td><td>☒</td><td colspan="2">Encyclopedia Article</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td rowspan="2">6. System level (if applicable)

Comment on 6:</td><td>Global</td><td>☒</td><td>European</td><td>☐</td><td>National</td><td>☐</td><td colspan="2">Sub-national</td></tr>
<tr><td colspan="8"></td></tr>
</table>

Basic information		**Document no.:** (citavi #)	**000**
7.1 Country focus (if applicable, please specify)	General conceptual considerations but explicitly mentions US and Europe		
7.2 Country/ies of origin indicated by institutional affiliation of editor(s)/ author(s) (if applicable, please specify)	UK	Comments on 7:	

Data and indicator availability				
8.1 Data, indicators, measurements	Document contains data	☐	If yes, please specify (including page numbers in document)	
Comment on 8.1				
8.2 Reference made to data, indicators measurements in other sources	Document refers to relevant sources	☒	If yes, please list source(s): (URLs, data banks, reports, statistics, etc.)	SL Surveys: NSF, National Science Board, Eurobarometer (2005), Jon Miller
Comment on 8.2:				
Guiding questions for review *- please add page numbers where appropriate -*				

<table>
<tr><td colspan="2">11. Claims regarding the key dimension (Science Literacy)
(benefits, costs, disadvantages, trade-offs)</td></tr>
<tr><td>11.1 What claims are being made?</td><td>1. With respect to SL there are four different interest groups with partly conflicting interests: 1. Science education community concerned with reforming science education, 2. Social scientists, Opinion researchers 3. Sociologists of science (want to understand the relation between knowledge and attitudes towards science issues 4. Science Communicators (including “angles” that enable two way communication between science and public eg public understanding of science actors)
2. The relationship between knowledge about science and attitudes towards science is not as linear as previously assumed:
a. More knowledge does not automatically mean more positive attitudes towards science
b. More knowledge about science does not necessarily allow better orientation in science related policy questions
c. Conclusion: Increasing knowledge of science is not so crucial for the quality of democratic decision making as formerly expected .</td></tr>
<tr><td>11.2 Which arguments are used to support the claim(s)?</td><td>2. The claim is based on empirical findings (no linear correlation between the factors). Possible explanations that are mentioned are (p4):
• Low information rationality: Rather than building their attitudes and decisions on knowledge people take shortcuts like believing a trustworthy experts.
• Perceptual predispositions (religion, political and social values) override the information when it comes to judgments
• Online updating hypothesis: People get the knowledge when they need it and then forget it so despite low SL decisions may be grounded</td></tr>
<tr><td>11.3 What evidence is presented to support the claims?
(e.g., data, indicators, research results, case studies, anecdotal evidence)</td><td>• Social science literature with different claims (eg Wynne is critical towards the established notion of SL as improving citizens decisions)
• the empirical surveys mentioned above</td></tr>
<tr><td>11.4 According to the author(s), which type of evidence/data is missing to better support the claim? (e.g. data gaps, limitations with regard to analytical levels, lack of indicator specifications etc.)</td><td></td></tr>
<tr><td>Comments on 11.</td><td></td></tr>
<tr><td colspan="2">12. Key dimensions of RRI
(For literature dealing with one or more of the 5 key dimensions.)</td></tr>
<tr><td>12.1 How is the key dimension defined?
(terminology applied, central</td><td>“the understanding of scientific matters by non-experts” (p1)</td></tr>
</table>

features/characteristics)	The three dimensions of Jon Miller (understanding of scientific methods, key concepts, societal impacts) are mentioned
12.2 Does the document reach beyond one single dimension / are more than one of the key dimensions discussed? If yes, what is the proposed relationship between different dimensions (complementary, contradictory…)?	no
12.3 To which concepts, theories, approaches, schools of thought, communities (scientific or practice) in the area of research and innovation does the literature relate or make reference to? (e.g., STS, constructive TA, anticipatory governance, foresight, deliberative democracy, …)	Indirectly to STS (Wynne)
Comments on 12.	
13. Are other important "dimensions" / aspects of RRI discussed, presented which are so far not covered by MoRRI?	No
14. Anything else deemed relevant?	No
15. General comments and remarks	No
16. Relevant sources cited (Please list references to other sources cited in the literature which seem to be highly relevant for MoRRI and/or represent important contributions in the field)	Brian Wynne

Basic information								**Document no.:** (citavi #)	**#966**
Reviewer's name	Philine Warnke								
1. Bibliographical information (author/s, year, title, editor/s, journal/book, volume, publisher, place of publication, pages, DOI)	Bauer, Allum, Miller What can we learn from 25 Years of PUS survey research? Liberating and expanding the agenda. Public Understanding of Science 16 2007, 79-95								
2. Abstract (copy and paste)	This paper reviews key issues of public understanding of science (PUS) research over the last quarter of a century. We show how the discussion has moved in relation to large-scale surveys of public perceptions by tracing developments through three paradigms: *science literacy*, *public understanding of science* and *science and society*. Naming matters here like elsewhere as a marker of "tribal identity." Each paradigm frames the problem differently, poses characteristic questions, offers preferred solutions, and displays a rhetoric of "progress" over the previous one. We argue that the polemic over the "deficit concept" voiced a valid critique of a common sense concept among experts, but confused the issue with methodological protocol. PUS research has been hampered by this "essentialist" association between the survey research protocol and the public deficit model. We argue that this fallacious link should be severed to liberate and to expand the research agenda in four directions: contextualizing survey research, searching for cultural indicators, integrating datasets and doing longitudinal analysis, and including other data streams. Under different presumptions, assumed and granted, we anticipate a fertile period for survey research on public understanding of science.								
3. Main focus (key dimensions according to MoRRI)	RRI / RI	☐	Citizen participation	☐	Science literacy	☒	Gender equality	☐	
	Open access	☐	R&I governance and ethics	☐	Other	☐			
Comment on 3:									
4. Main perspective (multiple entries possible)	Theoretical, conceptual	☐	Methodological	☐	Policy oriented	☐	Evaluative	☐	
	Other	☐	Comment on 4:						
5. Type of document	Scientific article	☐	Book chapter	☐	Book	☐	Report	☐	
	Project deliverable	☐	Policy/ strategy document	☐	Other	☐			

Comment on 5:								
6. System level (if applicable)	Global	☐	European	☐	Nationa l	☐	Sub-national	☐
Comment on 6:								
7.1 Country focus (if applicable, please specify)								
7.2 Country/i es of origin indicated by institution al affiliation of editor(s)/ author(s) (if applicable, please specify)				Comments on 7:				

Data and indicator availability				
8.1 Data, indicators, measurements	Document contains data	☐	If yes, please specify (including page numbers in document)	
Comment on 8.1				
8.2 Reference made to data, indicators measurements in other sources	Document refers to relevant sources	☐	If yes, please list source(s): (URLs, data banks, reports, statistics, etc.)	
Comment on 8.2:				

Guiding questions for review

- please add page numbers where appropriate -

11. Claims regarding the effects of the key dimension (benefits, costs, disadvantages, trade-offs)	
11.1 What claims are being made?	1. When studying the relationship between science and the public knowledge interest is not tied to one specific method protocol. Contrary to the discussion to date there is no automatic association like: quantitative approach=affirmative/public deficit model, qualitative approach=critical/expert deficit model. 2. Science Literacy and Science Attitudes are not correlated in a linear manner rather it is in itself a variable that depends on the culture. There is eg a clear distinction in the correlation for industrialized and post-industrial countries (two cultures model) (p89). 3. Science literacy and attitudes should be incorporated into the accounting of the national science base (p88) 4. Existing survey databases need to be integrated and continuous time series should be generated for longitudinal modeling. Together this will allow for dynamic modeling of PUS (p89). 5. The range of data used to monitor public understanding of science should be broadened. To get more meaningful results comparative collections of science reportage in mass media is required (p90). 6. An enriched analysis of PUS might contribute to a wider dynamic theory of social representations and knowledge (p90).
11.2 Which arguments are used to support the claim(s)?	1,3,4,5 The conclusions are based on a historical review of the debate around SL. Three different phases are revealed each with its own deficit diagnosis. It is argued that now is the time to move towards dynamic modeling of PUS. The “two cultures model” is presented as an example of the kind of results that could be achieved. 2 Is based on empirical cross-sectoral analysis of existing longitudinal. survey data.
11.3 What evidence is presented to support the claims? (e.g., data, indicators, research results, case studies, anecdotal evidence)	The surveys that were use are US biennial survey, UK, France, EU and ISSP (p89)
11.4 According to the author(s), which type of evidence/data is missing to better support the claim? (e.g. data gaps, limitations with regard to analytical levels, lack of indicator specifications etc.)	• Continuous time-series (p89) • Global integration of databases (p89) • Persistent and comparative collection of qualitative data such as media coverage (p99) • An inventory of the international PUC movement is urgently needed (88).
Comments on 11.	
12. Key dimensions of RRI (For literature dealing with one or more of the 5 key dimensions.)	
12.1 How is the key dimension defined?	The authors do not explicitly give their own definitions but present the different definitions that were used in the last decades. They propose to interpret PUC indicators as measures of performance of the

(terminology applied, central features/characteristics)	mediators ("angels") on the one hand and indicators of a cultural climate on the other, they maintain however the two elements "literacy" (ie knowledge about science) and attitudes towards science (p88).
12.2 Does the document reach beyond one single dimension / are more than one of the key dimensions discussed? If yes, what is the proposed relationship between different dimensions (complementary, contradictory…)?	no
12.3 To which concepts, theories, approaches, schools of thought, communities (scientific or practice) in the area of research and innovation does the literature relate or make reference to? (e.g., STS, constructive TA, anticipatory governance, foresight, deliberative democracy, …)	Political science. It is suggested that PUS research is less sophisticated than political science discourse on other knowledge realms because of the high interdisciplinary nature of the field. (87)
Comments on 12.	
13. Are other important "dimensions" / aspects of RRI discussed, presented which are so far not covered by MoRRI?	no
14. Anything else deemed relevant?	no
15. General comments and remarks	
16. Relevant sources cited (Please list references to other sources cited in the literature which seem to be highly relevant for MoRRI and/or represent important contributions in the field)	

Basic information		**Document no.:** (citavi #)	**#1037**
Reviewer's name	Philine Warnke		
1. Bibliographical information (author/s, year, title, editor/s, journal/book, volume, publisher, place of publication, pages, DOI)	Miller, J. D. 1983. Scientific Literacy: A Conceptual and Empirical Review, Daedalus, 112:2, 29-48		

2. Abstract (copy and paste)

The paper introduces a notion of SL as composed of three dimensions:

- Understanding scientific methods and norms
- Knowledge of major basic scientific constructs (e.g. cell, atom, gravity)
- Awareness of the impact of science and technology on society (civic science literature p.32 top)

Based on a 1979 NSF survey assessing SL in these three dimensions it is concluded that the majority of the American adult population is scientifically illiterate. This situation is deemed dangerous for democracy as an increasing number of science related issues is expected to enter the policy agenda.

3. Main focus (key dimensions according to MoRRI)	RRI / RI	☐	Citizen participation	☐	Science literacy	☒	Gender equality	☐
	Open access	☐	R&I governance and ethics	☐	Other	☐		
Comment on 3:								
4. Main perspective (multiple entries possible)	Theoretical, conceptual	☒	Methodological	☐	Policy oriented	☒	Evaluative	☐
	Other	☐	Comment on 4:					
5. Type of document	Scientific article	☒	Book chapter	☐	Book	☐	Report	☐
	Project deliverable	☐	Policy/ strategy document	☐	Other	☐		
Comment on 5:								
6. System level (if applicable)	Global	☐	European	☐	National (US)	☒	Sub-national	☐
Comment on 6:								

7.1 Country focus (if applicable, please specify)	US	
7.2 Country/ies of origin indicated by institutional affiliation of editor(s)/ author(s) (if applicable, please specify)	US	Comments on 7:

Data and indicator availability				
8.1 Data, indicators, measurements	Document contains data	☒	If yes, please specify (including page numbers in document)	1979 NSF Survey pages 39-42
Comment on 8.1				
8.2 Reference made to data, indicators measurements in other sources	Document refers to relevant sources	☐	If yes, please list source(s): (URLs, data banks, reports, statistics, etc.)	Historical sources from 1930es: NAEP surveys
Comment on 8.2:				

Guiding questions for review

- please add page numbers where appropriate -

11. Claims regarding the effects of the key dimension (benefits, costs, disadvantages, trade-offs)	
11.1 What claims are being made?	1. Next to the two established dimensions (understanding of methods and content of science) a third dimension of SL needs to be introduced: civic science literacy (p40) 2. The overwhelming majority of the American adult population is scientifically illiterate p41 3. Policy is becoming more specialized and more complex (p43) 4. The lack of SL is dangerous to democracy 5. Key measures to enhance SL are a. Start at elementary and secondary schools b. Concentrate on the "attentive public" ie people interested in science 6. Communication of science only works if there is a basic understanding in the audience.
11.2 Which arguments are used to support the claim(s)?	1. Reasons: (p40) • Science becomes increasingly dependent on upon public support • Public regulation reaches deeper into the conduct of science • The number of S&T relevant issues on the policy agenda is increasing 4. Lack of SL is dangerous because the increasing number of S&T related issues on the policy agenda cannot be adequately tackled if

	both the attentive and inattentive public lack basic understanding. Translators such as science journalists become very powerful.
11.3 What evidence is presented to support the claims? (e.g., data, indicators, research results, case studies, anecdotal evidence)	Evidence for claim 2 stems from an empirical survey (1979 NSF survey) p.37-41
11.4 According to the author(s), which type of evidence/data is missing to better support the claim? (e.g. data gaps, limitations with regard to analytical levels, lack of indicator specifications etc.)	Comprehensive consensual definition of SL is lacking p.36
Comments on 11.	
12. Key dimensions of RRI (For literature dealing with one or more of the 5 key dimensions.)	
12.1 How is the key dimension defined? (terminology applied, central features/characteristics)	P31.: SL comprises three aspects: • Understanding scientific methods and norms • Knowledge of major basic scientific constructs (eg cell, atom, gravity) • Awareness of the impact of science and technology on society (civic science literature p.32 top)
12.2 Does the document reach beyond one single dimension / are more than one of the key dimensions discussed? If yes, what is the proposed relationship between different dimensions (complementary, contradictory…)?	no
12.3 To which concepts, theories, approaches, schools of thought, communities (scientific or practice) in the area of research and innovation does the literature relate or make reference to? (e.g., STS, constructive TA, anticipatory governance, foresight, deliberative democracy, …)	Pragmatism (John Dewey), Theory of democracy (Almond)
Comments on 12.	
13. Are other important “dimensions” / aspects of RRI	

discussed, presented which are so far not covered by MoRRI?	no
14. Anything else deemed relevant?	no
15. General comments and remarks	The data is outdated but the concepts may still hold
16. Relevant sources cited (Please list references to other sources cited in the literature which seem to be highly relevant for MoRRI and/or represent important contributions in the field)	Gabriel Almond?

Basic information								**Document no.:** (citavi #)	**#1038**
Reviewer's name	Philine Warnke								
1. Bibliographical information (author/s, year, title, editor/s, journal/book, volume, publisher, place of publication, pages, DOI)	Miller, J. D. 1998. The Measurement of Civic Scientific Literacy. Public Understanding of Science, 7:1-21.								
2. Abstract (copy and paste)	Building on two decades of national surveys in the United States and two Eurobarometer studies, the history, rationale, and structure of a measure of civic scientific literacy are described. Estimates of the proportion of adults who are very well informed or moderately well informed on the index of civic scientific literacy appear in the literature more frequently, and this paper provides the first comprehensive description and analysis of the civic scientific literacy measure. It is hoped that this analysis and discussion will encourage the inclusion and replication of the measure in a wider range of studies of the public understanding of and attitudes toward science and technology.								
3. Main focus (key dimensions according to MoRRI)	RRI / RI	☐	Citizen participation	☐	Science literacy	☒	Gender equality	☐	
	Open access	☐	R&I governance and ethics	☐	Other	☐			
Comment on 3:									
4. Main perspective (multiple entries possible)	Theoretical, conceptual	☐	Methodological	☒	Policy oriented	☐	Evaluative	☐	
	Other	☐	Comment on 4:						
5. Type of document	Scientific article	☒	Book chapter	☐	Book	☐	Report	☐	
	Project deliverable	☐	Policy/ strategy document	☐	Other	☐			

Comment on 5:								
6. System level (if applicable)	Global	☐	European	☐	National	☐	Sub-national	☐
Comment on 6:								
7.1 Country focus (if applicable, please specify)	Focus on Europe and US, other countries are mentioned							
7.2 Country/ies of origin indicated by institutional affiliation of editor(s)/ author(s) (if applicable, please specify)	US				Comments on 7:			

Data and indicator availability				
8.1 Data, indicators, measurements	Document contains data	☒	If yes, please specify (including page numbers in document)	US National Survey 1995 Eurobarometer 1992
Comment on 8.1				
8.2 Reference made to data, indicators measurements in other sources	Document refers to relevant sources	☐	If yes, please list source(s): (URLs, data banks, reports, statistics, etc.)	
Comment on 8.2:				
Guiding questions for review *- please add page numbers where appropriate -*				

11. Claims regarding the effects of the key dimension (benefits, costs, disadvantages, trade-offs)	
11.1 What claims are being made?	1. The number of science related issues on the policy agenda will dramatically increase. In order for citizens to participate in these debates they need to understand basic scientific concepts and methods. (civic scientific literacy) p218/19 2. In order to accurately measure csl with a single indicator based on both these dimensions, more sophisticated survey items and computer based statistical methods are required (IRT Item Response Theory). The article presents such a set for measure of csl in adult population. In particular, instead of asking citizens to assess their knowledge themselves direct substantive enquiries with open ended questions should be used. (p207)
11.2 Which arguments are used to support the claim(s)?	2. The new approach will deliver greater precision and durability. This is needed as classical items and measures are prone to misinterpretation. (p207)

11.3 What evidence is presented to support the claims? (e.g., data, indicators, research results, case studies, anecdotal evidence)	3. Detailed comparative data of US and 12 European countries is presented. (p209 ff.)
11.4 According to the author(s), which type of evidence/data is missing to better support the claim? (e.g. data gaps, limitations with regard to analytical levels, lack of indicator specifications etc.)	• Apply IRT to other survey data sets on other substantive areas (p219) • Explore the optimal number of total items and the number of linkage items for IRT comparisons (p219) • Explore various combinations of open ended and closed-ended measures in obtaining cost-effective cross-national measures of adult understanding of science and technology (p219) • Studies need to focus on the role of scientific literacy in the decision of citizens to participate in a particular dispute (p220) • Panes studies are required to study the stability of csl and how it might change during controversies(p220) • The same individuals should be studied periodically over some time span (p220)
Comments on 11.	
12. Key dimensions of RRI (For literature dealing with one or more of the 5 key dimensions.)	
12.1 How is the key dimension defined? (terminology applied, central features/characteristics)	Civic Scientific Literacy is based on two dimensions: understanding of scientific constructs and understanding of scientific methods (theory testing by experiments)
12.2 Does the document reach beyond one single dimension / are more than one of the key dimensions discussed? If yes, what is the proposed relationship between different dimensions (complementary, contradictory…)?	Indirectly on RTI governance (csl is seen as precondition for adequate governance)
12.3 To which concepts, theories, approaches, schools of thought, communities (scientific or practice) in the area of research and innovation does the literature relate or make reference to? (e.g., STS, constructive TA, anticipatory governance, foresight, deliberative democracy, …)	IRT Item Response Theory
Comments on 12.	

13. Are other important “dimensions” / aspects of RRI discussed, presented which are so far not covered by MoRRI?	
14. Anything else deemed relevant?	Miller briefly refers to criticism of the CSL concept (deficit model) but brushes it aside. There is clearly a need to position the MORRI approach before embarking into measuring as there are conflicting notions of the benefit of SL.
15. General comments and remarks	
16. Relevant sources cited (Please list references to other sources cited in the literature which seem to be highly relevant for MoRRI and/or represent important contributions in the field)	

Basic information								
					Document no.: (citavi #)		**000**	
Reviewer's name	Philine Warnke							
1. Bibliographical information (author/s, year, title, editor/s, journal/book, volume, publisher, place of publication, pages, DOI)	Miller, Jon D, 2010 , The Conceptualization and Measurement of Civic Scientific Literacy for the Twenty-First Century IN Science and the Educated American: A Core Component of Liberal Education (available at https://www.amacad.org/content/publications/pubContent.aspx?d=1118)							
2. Abstract (copy and paste)	The chapter reviews the last 3 decades of SL measurement, presents the survey methodology currently used in US, EU27 and 6 other countries as well as key findings. It is argued that CSL should focus on understanding of basic science concepts rather than on detailed knowledge and that survey items should be continuously adapted to reflect the dynamic development of S&T.							
3. Main focus (key dimensions according to MoRRI)	RRI / RI	☐	Citizen participation	☐	Science literacy	☒	Gender equality	☐
	Open access	☐	R&I governance and ethics	☐	Other	☐		
Comment on 3:								
4. Main perspective (multiple entries possible)	Theoretical, conceptual	☒	Methodological	☒	Policy oriented	☐	Evaluative	☐
	Other	☐	Comment on 4:					
5. Type of document	Scientific article	☐	Book chapter	☒	Book	☐	Report	☐
	Project deliverable	☐	Policy/ strategy document	☐	Other	☐		
Comment on 5:								
6. System level (if applicable)	Global	☐	European	☐	National	☐	Sub-national	☐
Comment on 6:								
7.1 Country focus (if applicable, please	US (Survey has been extended to several countries)							

specify)		
7.2 Country/ies of origin indicated by institutional affiliation of editor(s)/ author(s) (if applicable, please specify)	US	Comments on 7:

Data and indicator availability				
8.1 Data, indicators, measurements	Document contains data	☒	If yes, please specify (including page numbers in document)	NSF Science and Engineering Indicators 1988-1999, Science News Studies 2004-2008 p246-249
Comment on 8.1				
8.2 Reference made to data, indicators measurements in other sources	Document refers to relevant sources	☐	If yes, please list source(s): (URLs, data banks, reports, statistics, etc.)	See above
Comment on 8.2:				
Guiding questions for review *- please add page numbers where appropriate -*				

11. Claims regarding the effects of the key dimension (benefits, costs, disadvantages, trade-offs)	
11.1 What claims are being made?	1. The health of the American democracy in the 21st century will depend on the development of a large number of scientifically literate citizens (p241) 2. American secondary schools do a poor job in providing SL 3. Only 28% of American adults have sufficient understanding of basic scientific ideas to be able to read the NYT science section. 4. The level of public confusion is greatest in life sciences (p 245) 5. An individual's level of CSL can be thought of as the results of a combination of several factors (path model): (number of college science courses, formal education attainment, religious views (negative correlation), media use, gender, age) (p249,250) 6. SL should not focus on learning the details of current science but on basic concepts 7. Science touches ever more personal realms, therefore conflicts with religion and other beliefs will grow.
11.2 Which arguments are used to support the claim(s)?	1. Political science 2. Evidence from 30 years of testing, OECD (Pisa Study) p.242 3.4 Surveys in US EU27 and 6 other countries see above 5 US Surveys 6 Science is always changing therefore citizens will need to grasp ever new issues so there is no point for csl in assessing the detailed kg of today's concept p 252 7 increasing influence of religion on SL, emergence of genetics
11.3 What evidence is presented to support the claims? (e.g., data, indicators, research results, case studies, anecdotal evidence)	Surveys see above
11.4 According to the author(s), which type of evidence/data is missing to better support the claim? (e.g. data gaps, limitations with regard to analytical levels, lack of indicator specifications etc.)	• Indicators need to grow to reflect the changing nature of S&T p 252
Comments on 11.	
12. Key dimensions of RRI (For literature dealing with one or more of the 5 key dimensions.)	
12.1 How is the key dimension defined? (terminology applied, central features/characteristics)	SL comprises consumer sl (ability of informed consumer choices), cultural sl (knowledge of the role of science in society) civic scientific literacy csl: the level of understanding of scientific and technological constructs needed to function as citizens in a modern industrial society including the level of understanding necessary to follow and make sense of public-policy issues involving S&T.

12.2 Does the document reach beyond one single dimension / are more than one of the key dimensions discussed? If yes, what is the proposed relationship between different dimensions (complementary, contradictory…)?	Indirect relationship with governance of RTI, csl is seen as precondition for good governance
12.3 To which concepts, theories, approaches, schools of thought, communities (scientific or practice) in the area of research and innovation does the literature relate or make reference to? (e.g., STS, constructive TA, anticipatory governance, foresight, deliberative democracy, …)	Political science
Comments on 12.	
13. Are other important “dimensions” / aspects of RRI discussed, presented which are so far not covered by MoRRI?	no
14. Anything else deemed relevant?	no
15. General comments and remarks	This is a specific approach to SL. Need to include other views (STS).
16. Relevant sources cited (Please list references to other sources cited in the literature which seem to be highly relevant for MoRRI and/or represent important contributions in the field)	

<table>
<tr><td colspan="7">Basic information</td><td>Document no.:
(citavi #)</td><td>#1078</td></tr>
<tr><td>Reviewer's name</td><td colspan="8">Philine Warnke</td></tr>
<tr><td colspan="2">1. Bibliographical information
(author/s, year, title, editor/s, journal/book, volume, publisher, place of publication, pages, DOI)</td><td colspan="7">Taskinen et al, 2013, Adolescents' motivation to select an academic science-related career: the role of school factors, individual interest, and science self-concept. Educational Research and Evaluation, 2013
Vol. 19, No. 8, 717 -733,
http://dx.doi.org/10. l 080/13803611.2013.853620</td></tr>
<tr><td>2. Abstract
(copy and paste)</td><td colspan="8">Many researchers consider a lacking interest in science and the students' belief that science is too demanding as major reasons why young people do not strive for science-related careers. In this article, we first delineated a theoretical framework to investigate the importance of interest, self-concept, and school factors regarding students' career preferences. Then, we tested the expected effects on a sample of German 9th-grade students (N = 7,813). We focused on two school factors: the amount of (additional) science activities and the real-life applications in science classes. The multi-level analysis showed that school factors were highly relevant for the students' interest in science and science self-concept. In turn, interest in science and science self-concept affect the students' interest in science-related careers. We conclude that focusing on the link between individual and school characteristics is important for the understanding of students' interest in science-related careers.</td></tr>
<tr><td rowspan="3">3. Main focus
(key dimensions according to MoRRI)

Comment on 3:</td><td>RRI / RI</td><td>☐</td><td>Citizen participation</td><td>☐</td><td>Science literacy</td><td>☒</td><td>Gender equality</td><td>☒</td></tr>
<tr><td>Open access</td><td>☐</td><td>R&I governance and ethics</td><td>☐</td><td>Other</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="8">Focus is on aspiration to science careers rather than science literacy</td></tr>
<tr><td rowspan="2">4. Main perspective
(multiple entries possible)</td><td>Theoretical, conceptual</td><td>☐</td><td>Methodological</td><td>☐</td><td>Policy oriented</td><td>☐</td><td>Evaluative</td><td>☒</td></tr>
<tr><td>Other</td><td>☐</td><td colspan="6">Comment on 4:
theory based
Empirical study</td></tr>
<tr><td rowspan="3">5. Type of document

Comment on 5:</td><td>Scientific article</td><td>☒</td><td>Book chapter</td><td>☐</td><td>Book</td><td>☐</td><td>Report</td><td>☐</td></tr>
<tr><td>Project deliverable</td><td>☐</td><td>Policy/ strategy document</td><td>☐</td><td>Other</td><td>☐</td><td colspan="2"></td></tr>
<tr><td colspan="8"></td></tr>
<tr><td rowspan="2">6. System level (if applicable)

Comment</td><td>Global</td><td>☐</td><td>European</td><td>☐</td><td>National</td><td>☒</td><td>Sub-national</td><td>☐</td></tr>
<tr><td colspan="8"></td></tr>
</table>

on 6:		
7.1 Country focus (if applicable, please specify)	Germany	
7.2 Country/ies of origin indicated by institutional affiliation of editor(s)/ author(s) (if applicable, please specify)	Germany	Comments on 7:

Data and indicator availability				
8.1 Data, indicators, measurements	Document contains data	☒	If yes, please specify (including page numbers in document)	Statistical analysis of findings from PISA 2006 p.725
Comment on 8.1				
8.2 Reference made to data, indicators measurements in other sources	Document refers to relevant sources	☒	If yes, please list source(s): (URLs, data banks, reports, statistics, etc.)	PISA 2006 (OECD)
Comment on 8.2:				
Guiding questions for review *- please add page numbers where appropriate -*				

11. Claims regarding the effects of the key dimension (benefits, costs, disadvantages, trade-offs)	
11.1 What claims are being made?	1. Modern societies suffer from a shortage of well trained highly competent employees in science related fields p717 2. On the individual level interest and self conception are the most important factors determining students motivation to study science p724 3. Belonging to a class with higher level of interest in science is strongly correlated with a positive attitude towards science in the class p724 4. Fostering interest in science is a key inroad to motivating more students to study science in particular for girls p727 5. Teaching methods suitable to foster interest in science 727: • A wide range of activities in science classes (eg science clubs, class trips to labs) • Focus on real life applications • More exposure to science 6. Particular effort needed to raise girls interest in science p728
11.2 Which arguments are used to support the claim(s)?	1. OECD 2. – 6. Analysis of PISA 2006
11.3 What evidence is presented to support the claims? (e.g., data, indicators, research results, case studies, anecdotal evidence)	1. none 2. – 6. Analysis of PISA 2006
11.4 According to the author(s), which type of evidence/data is missing to better support the claim? (e.g. data gaps, limitations with regard to analytical levels, lack of indicator specifications etc.)	• Multi-level analysis of career choice data is still rare p717 • Lack of research in methods to kindle interest in science p727 • Need for more studies taking into account contextual effects in large populations p729 including other important socialisers (than school) such as parents p 730
Comments on 11.	
12. Key dimensions of RRI (For literature dealing with one or more of the 5 key dimensions.)	
12.1 How is the key dimension defined? (terminology applied, central features/characteristics)	Number of students striving for science carriers p717
12.2 Does the document reach beyond one single dimension / are more than one of the key dimensions discussed? If yes, what is the proposed relationship between different dimensions (complementary, contradictory…)?	Gender dimension is also affected
12.3 To which concepts, theories, approaches, schools of thought, communities (scientific	Educational research, motivational theory, career choice theories, learning research, psychology

or practice) in the area of research and innovation does the literature relate or make reference to? (e.g., STS, constructive TA, anticipatory governance, foresight, deliberative democracy, ...)	
Comments on 12.	
13. Are other important “dimensions” / aspects of RRI discussed, presented which are so far not covered by MoRRI?	
14. Anything else deemed relevant?	
15. General comments and remarks	Need to explain how number of students aspiring to science carriers relates to Scientific literacy and RRI.
16. Relevant sources cited (Please list references to other sources cited in the literature which seem to be highly relevant for MoRRI and/or represent important contributions in the field)	

MoRRI – Literature review

Basic information								**Document no.:** (citavi #)	**#964**
Reviewer's name	Nils Heyen								
1. Bibliographical information (author/s, year, title, editor/s, journal/book, volume, publisher, place of publication, pages, DOI)	Eurydice (2011): Science Education in Europe: National Policies, Practices and Research. Brussels: EACEA. doi:10.2797/7170								
2. Abstract (copy and paste)	From the conclusions (p. 125): This study has examined organisational features of science teaching across Europe and it has mapped the policies and strategies put in place to improve teaching and promote science learning in schools. In particular, it has looked at the support available to teachers to help them change students' attitudes to science and raise levels of interest in this key subject. The study also incorporates reviews of recent research literature on science education, the main findings from international surveys (PISA and TIMSS) as well as the results of a Eurydice pilot survey of initial teacher education programmes (SITEP).								
3. Main focus (key dimensions according to MoRRI)	RRI / RI	☐	Citizen participation	☐	Science literacy	X☐	Gender equality	☐	
	Open access	☐	R&I governance and ethics	☐	Other	☐			
Comment on 3:	Without refering to or using the term RRI								
4. Main perspective (multiple entries possible)	Theoretical, conceptual	☐	Methodological	X☐	Policy oriented	X☐	Evaluative	☐	
	Other	☐	Comment on 4:	Study provides overview on how science education is organized in Europe, including a mapping of corresponding policies					
5. Type of document	Scientific article	☐	Book chapter	☐	Book	☐	Report	X☐	
	Project deliverable	☐	Policy/ strategy document	☐	Other	☐			
Comment on 5:									
6. System level (if applicable)	Global	☐	European	X☐	National	☐	Sub-national	☐	
Comment on 6:									
7.1 Country focus (if applicable, please specify)									
7.2 Country/ies of origin indicated by institutional affiliation of editor(s)/ author(s) (if applicable, please specify)				Comments on 7:					

Data and indicator availability				
8.1 Data, indicators, measurements	Document contains data	X☐	If yes, please specify (including page numbers in document)	• Comparative analysis based on responses to a questionnaire developed by the Eurydice Unit within the EACEA. The report has been checked by all Eurydice National Units participating in the study. (p. 8) • SITEP (Survey on Initial Teacher Education Programmes in Mathematics and Science): pilot field survey conducted by EACEA/Eurydice, which has been sent to 2500 initial teacher education programmes in order to collect information on existing practices in the initial education of science and mathematics teachers across Europe (cf. pp. 112ff.)
Comment on 8.1				
8.2 Reference made to data, indicators measurements in other sources	Document refers to relevant sources	X☐	If yes, please list source(s): (URLs, data banks, reports, statistics, etc.)	• TIMSS (Trends in International Mathematics and Science Study); cf. pp. 13ff. and, most recently, Olson et al. 2008 • PISA (Programme for International Student Assessment); cf. pp. 13ff. and, most recently, OECD 2009 • ROSE (Relevance of Science Education); cf. pp. 22f. and Sjøberg/Schreiner 2010
Comment on 8.2:				

Guiding questions for review *- please add page numbers where appropriate -*	
9. How is RRI characterized? (For literature dealing explicitly with responsible (research) and innovation. If the publication deals with one of the 5 key dimensions, please proceed to 11.)	
9.1 Which definition of RRI is being used? (author's definition or reference to other source)	
9.2 Which aspects of RRI receive special emphasis? (e.g., certain normative goals, procedural approaches, reference to one or more of the 5 key dimensions, ...)	

9.2 Which arguments are presented in support or rejection/criticism of RRI?	

9.3 To which concepts, theories, approaches, schools of thought, communities (scientific or practice) in the area of research and innovation does the literature relate or make reference to? (e.g., STS, constructive TA, anticipatory governance, foresight, deliberative democracy, ...)	
Comments on 9.	
10. Policy context of RRI (For literature dealing explicitly with responsible (research) and innovation. If the publication deals with one of the 5 key dimensions, please proceed to 11.)	
10.1 Which RRI-related developments (international, EU, national, sub-national) are mentioned, how are they characterized and what are they aiming at (strategies, funding initiatives, regulation etc.)?	
10.2 Which approaches, instruments are discussed to facilitate the uptake of RRI?	
10.3 Which problems, barriers, potential drawbacks for RRI are brining discussed, how could they be addressed?	
Comments on 10.	
11. Claims regarding the effects of RRI and / or the key dimension (benefits, costs, disadvantages, trade-offs)	
11.1 What claims are being made?	• Foreword by Commissioner Vassiliou: "A basic understanding of science is considered a necessary skill for every European citizen." (p. 3) • The international student achievement surveys provide a wealth of information on science achievement but they largely focus on individual and school factors; they do not systematically gather data on education systems (PISA) or analyse such data (TIMSS)

	with a view to assessing its impact on student science achievement. (p. 24) • Few European countries have developed a broad strategic framework to raise the profile of science in education and wider society. However, a wide range of initiatives have been implemented in many countries. The impact of these various activities is nevertheless difficult to measure. (p. 9 and chapter 2) • Very few countries have initiatives which focus on encouraging girls to choose science careers. (p. 9 and chapter 2) • In all European countries, science education begins as one general integrated subject. By the end of lower secondary education, however, science teaching is usually split into the separate subjects of biology, chemistry and physics. (p. 9 and chapter 3) • However, in six countries, integrated science teaching exists alongside the separate subject approach. In some countries, schools are free to decide for themselves how to teach science. (p. 86) • Most European countries recommend that science should be taught in context. Usually this involves teaching science in relation to contemporary societal issues. Environmental concerns and the application of scientific achievements to daily life are recommended for inclusion in science lessons in almost all European countries. (p. 9 and chapter 3) • In order to increase motivation and interest in science, it is essential that the curriculum emphasises connections with students' personal experiences (p. 126) • There is no specific support policy for low achievers in science subjects. (p. 10 and chapter 3) • In half of the European countries and/or regions examined, pupils' and students' knowledge and skills in science are assessed through standardised procedures. (p. 10 and chapter 4) • Traditional written/oral examinations and assessment of students' performance in class as well as their project work are the most frequently recommended methods. (p. 127) • As past evaluations of science promotion strategies have shown, strengthening teacher competences is a particularly important concern. (p. 10 and chapter 5) • Dealing with diversity, i.e. teaching a diverse range of students, taking into account different interests of boys and girls, and avoiding gender stereotypes when interacting with students, is less often addressed in generalist teacher education programmes than in programmes that prepare mathematics/science teachers. (p. 123 and 129)
11.2 Which arguments are used to support the claim(s)?	
11.3 What evidence is presented to support the claims? (e.g., data, indicators, research results, case studies, anecdotal evidence)	• Cf. 8.1 • Research has clearly established that home background is very important for school achievement (Breen & Jonsson, 2005). TIMSS reports a strong relationship between pupils' science achievement and student background, measured by the amount of books at home or speaking the language of the test at home (Martin, Mullis and Foy, 2008). (p. 21) • Gender differences in average science performance are rather small compared with other basic skills assessed by international

	surveys (i.e. reading and mathematics) (EACEA/Eurydice, 2010). (p. 21) • International student achievement studies demonstrate a clear link between enjoyment of learning science and science achievement. ... TIMSS results seem to suggest that attitudes towards science differ between grades and different science subjects. (p. 22) • ROSE views positive attitudes towards science and technology as important learning goals in themselves. The ROSE results show that attitudes to science and technology among young people were mainly positive, but students were more sceptical towards school science. (p. 22)
11.4 According to the author(s), which type of evidence/data is missing to better support the claim? (e.g. data gaps, limitations with regard to analytical levels, lack of indicator specifications etc.)	
Comments on 11.	In general, the study attempts to provide a mapping of the policies and strategies in place across Europe to improve and foster science teaching and learning in education systems today. (p. 7)
12. Key dimensions of RRI (For literature dealing with one or more of the 5 key dimensions.)	
12.1 How is the key dimension defined? (terminology applied, central features/characteristics)	• As a term, “scientific literacy” hardly plays a role in the report. • However, a definition provided by PISA is given: “The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.” (p. 14; cf. OECD 2003, p. 133). • Another definition noted is: “being comfortable and competent with broad scientific ideas, with the nature and limitations of science and with the processes of science, and having the capacity to use these ideas in making decisions as an informed and concerned citizen” (p. 68; cf. Harlen 2009, p. 34).
12.2 Does the document reach beyond one single dimension / are more than one of the key dimensions discussed? If yes, what is the proposed relationship between different dimensions (complementary, contradictory…)?	• Gender equality does play a role throughout the document, especially in chapter 2 and 5, implying that girls need additional fostering in order to encourage them to choose science fields/careers.
12.3 To which concepts, theories, approaches, schools of thought, communities (scientific or practice) in the area of research and innovation does the literature relate or make reference to? (e.g., STS, constructive TA,	None, but an empirical result of the comparative analysis is: “The reasons commonly expressed as the driving force for developing strategies to improve science education are, in most cases, a: • declining interest in science studies and related professions; • rising demand for qualified researchers and technicians; • concern that there may be a decline in innovation and, consequently, economic competitiveness.” (p. 26)

anticipatory governance, foresight, deliberative democracy, …)	
Comments on 12.	In general, the study attempts to provide a mapping of the policies and strategies in place across Europe to improve and foster science teaching and learning in education systems today. (p. 7)
13. Are other important "dimensions" / aspects of RRI discussed, presented which are so far not covered by MoRRI?	
14. Anything else deemed relevant?	
15. General comments and remarks	Good overview on how science education is organized in European school systems.
16. Relevant sources cited (Please list references to other sources cited in the literature which seem to be highly relevant for MoRRI and/or represent important contributions in the field)	• Olson, J.F., Martin, M.O. & Mullis, I.V.S. eds., 2008. TIMSS 2007 Technical Report. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College. • OECD, 2009. PISA 2009 Assessment Framework - Key Competencies in Reading, Mathematics and Science. Paris: OECD Publishing. • Sjøberg, S., Schreiner, C., 2010. The ROSE project: an overview and key findings. [pdf] Available at: http://roseproject.no./network/countries/norway/eng/nor-Sjoberg-Schreiner-overview-2010.pdf [Accessed 20 September 2010]. • OECD, 2003. The PISA 2003 assessment framework: reading, reading, science and problem solving knowledge and skills. Paris: OECD Publishing. • Breen, R., Jonsson J.O., 2005. Inequality of Opportunity in Comparative Perspective: Recent Research on Educational attainment and Social Mobility. Annual Review of Sociology, 31, pp. 223-43. • Martin, M.O. et al., 2008. TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College. • EACEA/Eurydice, 2010. Gender Differences in Educational Outcomes: Study on the Measures Taken and the Current Situation in Europe. Brussels: EACEA/Eurydice • Harlen, W., 2009. Teaching and learning science for a better future. The Presidential Address 2009 delivered to the Association for Science Education Annual Conference. School Science review, 333, pp. 33-41. • Brickman, P., Gormally, C., Armstrong, N., & Hallar, B., 2009. Effects of Inquiry-based Learning on Students' Science Literacy Skills and Confidence. International Journal for the Scholarship of Teaching and Learning, 3(2), pp. 1-22. • Holbrook, J., Rannikmae, M., 2007. The Nature of Science Education for Enhancing Scientific Literacy. International Journal of Science Education, 29(11), pp. 1347-1362.

MoRRI – Literature review

Basic information						**Document no.:** (citavi #)		**#967**
Reviewer's name	Nils Heyen							
1. Bibliographical information (author/s, year, title, editor/s, journal/book, volume, publisher, place of publication, pages, DOI)	Gräber, Wolfgang (2002): „Scientific Literacy" - Naturwissenschaftliche Bildung in der Diskussion. In: Döbrich, Peter (Hrsg.): Qualitätsentwicklung im naturwissenschaftlichen Unterricht. Fachtagung am 15. Dezember 1999. Frankfurt am Main: GFPF/DIPF, S. 1-28.							
2. Abstract (copy and paste)	n.a.							
3. Main focus (key dimensions according to MoRRI)	RRI / RI	☐	Citizen participation	☐	Science literacy	X☐	Gender equality	☐
	Open access	☐	R&I governance and ethics	☐	Other	☐		
Comment on 3:	Without refering to or using the term RRI							
4. Main perspective (multiple entries possible)	Theoretical, conceptual	X☐	Methodological	X☐	Policy oriented	☐	Evaluative	☐
	Other	☐	Comment on 4:	Focus on school education in natural sciences				
5. Type of document	Scientific article	☐	Book chapter	X☐	Book	☐	Report	☐
	Project deliverable	☐	Policy/ strategy document	☐	Other	☐		
Comment on 5:	Report on conference session							
6. System level (if applicable)	Global	X☐	European	☐	National	X☐	Sub-national	☐
Comment on 6:	International and German context							
7.1 Country focus (if applicable, please specify)	Germany							
7.2 Country/ies of origin indicated by institutional affiliation of editor(s)/ author(s) (if applicable, please specify)	Germany				Comments on 7:			

Data and indicator availability				
8.1 Data, indicators, measurements	Document contains data	☐	If yes, please specify (including page numbers in document)	
Comment on 8.1	No original data			
8.2 Reference made to data, indicators measurements in other sources	Document refers to relevant sources	x☐	If yes, please list source(s): (URLs, data banks, reports, statistics, etc.)	• Miller (1997), p. 6 and 26
Comment on 8.2:	Hardly any reference to data			

Guiding questions for review *- please add page numbers where appropriate -*	
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9.1 Which definition of RRI is being used? (author's definition or reference to other source)	
9.2 Which aspects of RRI receive special emphasis? (e.g., certain normative goals, procedural approaches, reference to one or more of the 5 key dimensions, …).	
9.2 Which arguments are presented in support or rejection/criticism of RRI?	
9.3 To which concepts, theories, approaches, schools of thought, communities (scientific or practice) in the area of research	

and innovation does the literature relate or make reference to? (e.g., STS, constructive TA, anticipatory governance, foresight, deliberative democracy, ...)	
Comments on 9.	
10. Policy context of RRI (For literature dealing explicitly with responsible (research) and innovation. If the publication deals with one of the 5 key dimensions, please proceed to 11.)	
10.1 Which RRI-related developments (international, EU, national, sub-national) are mentioned, how are they characterized and what are they aiming at (strategies, funding initiatives, regulation etc.)?	
10.2 Which approaches, instruments are discussed to facilitate the uptake of RRI?	
10.3 Which problems, barriers, potential drawbacks for RRI are brining discussed, how could they be addressed?	
Comments on 10.	
11. Claims regarding the effects of RRI and / or the key dimension (benefits, costs, disadvantages, trade-offs)	
11.1 What claims are being made?	• Scientific literacy (should) goes beyond fact and content knowledge, it rather includes the relationship between science and society (p. 4), an understanding of the processes of science (p. 13) and diverse competencies/skills at the interface of knowledge, values and action/everyday life (p. 14)
11.2 Which arguments are used to support the claim(s)?	• Current situation in schools is unsatisfactory: a) knowledge and skills are not learned as intended, b) initial interests get lost through school education, c) knowledge is hardly applicable in everyday life (p. 6)
11.3 What evidence is presented to support the claims? (e.g., data, indicators, research results, case studies, anecdotal evidence)	• Miller (1997), p. 6 and 26

11.4 According to the author(s), which type of evidence/data is missing to better support the claim? (e.g. data gaps, limitations with regard to analytical levels, lack of indicator specifications etc.)	none
Comments on 11.	The claim is presented as not being contested, the problem rather lies in how to implement this in the concrete design of school lessons
12. Key dimensions of RRI (For literature dealing with one or more of the 5 key dimensions.)	
12.1 How is the key dimension defined? (terminology applied, central features/characteristics)	• Scientific Literacy means general education with regard to natural sciences (p. 3) • „Scientific Literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity." (p. 13; OECD, 1999) • Scientific Literacy is the interface of diverse competencies/skills relating to knowledge, values and action/everyday life (p. 14)
12.2 Does the document reach beyond one single dimension / are more than one of the key dimensions discussed? If yes, what is the proposed relationship between different dimensions (complementary, contradictory…)?	• Focus is solely on scientific literacy
12.3 To which concepts, theories, approaches, schools of thought, communities (scientific or practice) in the area of research and innovation does the literature relate or make reference to? (e.g., STS, constructive TA, anticipatory governance, foresight, deliberative democracy, …)	• Science-Technology-Society (STS) (p. 4f.) • Pedagogy (throughout the text)
Comments on 12.	
13. Are other important "dimensions" / aspects of RRI discussed, presented which are so far not covered by MoRRI?	

14. Anything else deemed relevant?	• Importance of self-determined learning is stressed (p. 20f.)
15. General comments and remarks	• Paper also covers some historical roots of (the term) scientific literacy (e.g., p. 8)
16. Relevant sources cited (Please list references to other sources cited in the literature which seem to be highly relevant for MoRRI and/or represent important contributions in the field)	• Miller, J. (1997). Civic Scientific Literacy in the United States: A Development Analysis from Middle-school through Adulthood. In Gräber, W. & Bolte, C. (Eds.), Scientific Literacy (S. 121-142). Kiel: IPN. • OECD (1999). Measuring student knowledge and skills (No. 50619 1999). Paris: OECD. • Sjoberg, S. (1997). Scientific Literacy and School Science – Arguments and Second Thoughts. In Sjeberg, S. & Kallerud, E. (Eds.), Science, Technology and Citizenship (Vol. 7/97, S. 9-28). Oslo: Norsk institutt for studier av forskning og utdanning. • Shamos, M. (1995). The myth of scientific literacy. New Brunswick: Rutgers University Press.