A transdisciplinary approach to education and training in radiological protection

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Abstract
This introductory text aims at developing an argumentation for an approach to education and training in radiological protection that is broader than the 'classical' acquiring of factual knowledge related to physics and regulation. As for most other areas where applications of a technology are connected to a certain risk, the complexity of applications of radioactivity and nuclear technology has generally technical as well as social dimensions.
As well the nuclear worker, the medical doctor as the policy maker could face situations requiring action where, apparently, the available factual knowledge does not lead unambiguously to a way forward that is 'justified enough' in relation to the potential risk. And if the solution *would* be justified for him/her, it could be that others involved have different opinions. Having this in mind, it is clear that education and training in radiological protection - seen as a continuous learning process - should elaborate on as well the socio-technical complexity of 'risk assessment' as on the conditions and methodologies to 'find a way out'.
Rather than dwelling on methodologies for the organisation of this 'broader' education and training, this introduction will analyse elements of complex problem solving and make a link to ethical aspects in order to found the argumentation for this broader approach. It will conclude with highlighting some key ideas related to complex problem solving that emerged from socio-political science and with some examples of the application of these ideas as developed by the Belgian Nuclear Research Centre SCK•CEN.

1. Complexity and the ethical sense

1.1 The real world

As for many other occupations, the learning environment for anyone dealing with radiological protection includes the 'the real world'. While theoretical and practical courses lead to 'factual and methodological knowledge' on the one hand and 'practical knowledge' on the other hand, it is clear that this gathering of information is not always sufficient to be able to act 'responsible' in a real (working) environment. Many times, one is faced with complex situations that not only emerge as technical problems and/or scientific uncertainties, but also (and mostly primarily) as a result of social interaction of the involved people who, in addition, may have different perceptions on the character of the problem as such.

Clearly, 'responsible acting', facing the uncertainty and ambiguity of this kind of situations, is acting

- for which there exists no factual logic or procedures 'in the books';
- that you cannot train in the laboratory;
- for which you cannot always rely on similar (comparable) cases from the past.

Therefore, in addition to the ability to acquire and apply scientific or procedural knowledge, practical expertise in radiological protection should be completed with gaining insight in the complexity of the situation as such.

1.2 Complexity

In the (theoretical) frame of this article, we should only consider complex situations

- that can be 'influenced' by personal acting or 'intervening' (this is: we don't consider the complexity of weather forecasts), and, in addition,
- that, beyond their 'structural complexity', concern activities with a certain risk for the person(s) involved (this is: we don't consider the complexity of solving word puzzles)

The reader may understand that the 'criteria' described above apply to activities that bring along a radiological risk and thus require 'radiological protection' (this includes also protection against (enhanced) naturally occurring radioactive materials such as Radon).

Complexity as such can be described by way of its double character. First of all, the *phenomenon or activity* can have a complex character, in the sense that it doesn't show a clear cause - effect relation with regard to risk (e.g. the climate change process, low level radiation). Secondly, additional complexity may come with the search for possible 'solutions' for the problem due to different views of the involved 'stakeholders' (complexity related to governance).

In the first sense, complexity can generally be described as a combination of
- unpredictability of outcome of processes due to lack of scientific understanding of the process, and
- unpredictability due to the multiplicity of interacting processes as such (these processes can either be 'technical' or 'social').

Governance complexity in its turn can be described by four elements:
- interconnection — there is no single problem, but a related web of problems
- incompatibility — different points of view are possible, inspired by different scientific disciplines (economy, sociology, …).
- multidimensionality — in space (local, global); in time (intra-generational, intergenerational)
- pluralism of values — lack of generally accepted standards and values to support development

1.3 When are ethical aspects relevant ?
Ethical aspects become relevant when a 'judgement' is needed in face of complexity when there is risk involved or, in other words, when a judgement related to (the justification of) a certain 'action' is needed, in a context of uncertainty with regard to a certain risk toward 'others'.

Basically, ethics is about norms and values, with norms describing 'what should (not) be', and values expressing 'aspects of life that are considered to be important'. While this way of reasoning can be applied to the behaviour of one person as such, in general, ethics enter the case when *action towards* one or more people or *interaction between* two or more people is concerned. Thinking in ethical terms for myself is maybe not relevant when I jump from a bridge, but it might be relevant towards my relatives. In the same sense, ethics become relevant for issues such as euthanasia and radiation risk for the foetus, but also with regard to the siting of a waste disposal near a community. In certain situations, also the ALARA principle for occupational protection can have ethical characteristics. More general, ethics play a role in complex problems that concern 'the distribution of the goods and the bads among people' and/or 'the protection of the weak or helpless'.

1.4 Developing an 'applied ethical sense'
Gaining insight in complex problems as characterised above is in fact gaining insight in the 'norms and values' involved. As these values 'by definition' also include the values of the other people involved, this 'learning' implies the willingness (and the ability) to 'broaden the perspective' and to put the issues in context, and this in a two-step approach:

inside	starting with the 'self'
→	awareness of own knowledge
→	recognise incompleteness and relativity of own knowledge
→	awareness of - and insight in - own values
outside	looking towards the situation, the others / in context / in perspective (curiosity / 'the beginner's mind')
→	awareness of (other's) knowledge
→	recognise incompleteness and relativity of knowledge as such
→	awareness of - and insight in - values / context / perspective

One could describe this process as ‘developing an ethical sense’. Obviously, an ethical sense is merely an individual thing and should as such not be ‘shaped’ or ‘uniformed’ from the outside. Neither should it be seen as a ‘final and single end state’ that can (or cannot) be reached by everybody. It is known that philosophies of ethics, ‘free will’ and responsibility don’t have the ambition to develop general applicable solutions to ethical (complex) problems, but rather aim at investigating ‘possible behaviour’ that could lead to better mutual understanding (and subsequently to a kind of ‘consensus solution’ for the problem at stake).
In this respect, an ethical sense can be considered as a *critical sense*. This sense should not be restricted to a critical stance towards ‘the observed outside’, but should initially be based on the *willingness to question* own knowledge and views and the *willingness to learn* by opening up the mind for the knowledge and views of others. This attitude is of course no guarantee for a final solution that would have the support of all involved people, but it is certainly a primary condition. In extension, one could thus add the *willingness to seek* win-win ‘solutions’ by joint problem solving (instead of maximisation of own benefit) as a third step.

2. Basic learning and governance concepts related to complexity

The science of complex problem solving facing uncertainty and risk has led to a number of ideas and concepts that cannot be described in detail in the frame of this introductory text. In general, these ideas and concepts have developed in the frame of research that studies the way technology has an impact on our society (and vice versa). The applications of radioactivity and their impact on society is just but one example.

The three aspects of ‘willingness’ that were identified as key aspects of an ‘ethical sense’ (or critical sense) in the previous paragraph can also be seen as the core ideas behind three main concepts that became known in socio-political sciences. In addition to a description of ‘personal behaviour’, these aspects of ‘willingness’ form also the basis for applications in the research/learning environment and the governance environment:

Second mode science (willingness to question own knowledge and views)
In ‘second mode science’, the monopoly of science on ‘truth’ is challenged. “Second mode science, precautionary science, post-normal science share the insight that scientific knowledge is, in essence, a social construct, and therefore the attention is directed towards the context(s) of application of scientific knowledge, rather than to its ‘truth’ in an absolute sense.” [Beck (1992), Risk Society]

Transdisciplinarity (willingness to learn from the knowledge and views of others)
Thanks to the recognition of the intrinsic social dimensions of the complexity of ‘impacts of technology on society’, well-known disciplines such as ‘technology assessment’ and ‘risk assessment’ gradually start to move away from a pure exact sciences - approach to a more ‘transdisciplinary approach’ by way of including other disciplines such as philosophy and sociology.

In this sense, transdisciplinarity can be seen as an *attitude* in the research/learning environment or in the governance environment: problem solving oriented thinking and acting across disciplines, taking into account that own (disciplinary) knowledge is always relative. In extension, transdisciplinarity also incorporates so-called ‘indigenous knowledge’ (knowledge brought into the group by ‘non experts’ or (local) stakeholders).

Through transdisciplinary learning, the involved practitioners or researchers should f.i. become able to
- interpret and learn from historical lessons
- state and accept uncertainties instead of trying to exclude them
- better understand social mechanisms, also in the working environment
- broaden the risk scope to ‘multifactorial concerns’ in complex (hazardous) situations

“*Transdisciplinarity as a new approach to research and problem solving : the core idea is that researchers, practitioners and stakeholders must cooperate in order to address the complete challenges of society.*” [ETHZ Transdisciplinarity conference, 2000]
“[…] *the transdisciplinary attitude, one which implies putting into practice transcultural, transreligious, transpolitical and transnational visions.* […]” [www.unesco.org]

Participatory Technology Assessment (pTA) (willingness to learn from the knowledge and views of others / willingness to seek win-win 'solutions')

Participatory Technology Assessment can be described as a process aimed at a systematic investigation of the uncertainties surrounding a certain technological development (regarding as well the 'factual' level as the 'value' level), through an inclusion of a broader range of 'stakeholders' in the assessment process (learning/research environment). In most cases, pTA 'exercises' are organised in the frame of a local or national policy. The result of pTA tools such as focus groups, round tables and consensus conferences can eventually be translated into policy measures (governance environment).

3. Transdisciplinary research related to radiological protection - SCK•CEN's PISA and isRP projects

The use of nuclear technological applications in society can be considered as a complex problem, covering a number of issues such as

- risk, risk management and risk perception
- transgenerational issues
- legal aspects and liability
- interpretation frameworks and values
- expert culture vs social culture

Based on this assumption and dedicated to seek deeper insight in the complexity of these applications and their consequences, the Belgian Nuclear Research Centre SCK•CEN developed projects that are guided by the above mentioned concepts of second mode science and transdisciplinarity.

3.1 PISA (Programme of Integration of Social Aspects into nuclear research)

PISA was developed as an answer to a (self formulated) 'in-house' need 'to better understand ourselves'. The research, involving human science PhD students, is organised into 5 research tracks:

- Sustainability and nuclear development
- Transgenerational ethics and the disposal of radioactive waste
- Legal aspects and liability
- Risk management
- Experts and ethics

In addition, so-called cross-cutting issues are discussed in reflection groups, involving relevant stakeholders and invited scientists:

- Ethical choices in radiation protection
- Role and culture of the nuclear expert
- Involvement
- Justification and optimisation

More information can be found on www.sckcen.be/pisa

3.2 Cross-over projects of the isRP (international school for Radiological Protection)

In coordination with the academic sector, the research of isRP concentrates on how to integrate this transdisciplinary approach within education and training programmes for professionals as well as students and pupils.

Pupils have a wide attention span and are eager to learn. In our complex society, they should be able to develop an open and critical mind in order to gain more insight in and confidence towards multi-aspect issues, such as the risks and benefits of radioactivity and nuclear technology, and their possible applications in the medical and energy sector. In this sense, isRP interacts with teachers of secondary schools in order to discuss how the standard education programme can integrate a pluralistic approach to complex technical issues, such as the applications of radioactivity. The aim is to identify gaps in the existing curriculum and to find out how to establish links between specific courses and how to organise 'cross-over' sessions in practice.

Towards the general public, isRP works together with Belgian industries' visitor centres as well as with regional and Belgian state-sponsored communication activities on physics and nuclear science. In cooperation with SCK•CEN-PISA (Program of Integration of Social Aspects into Nuclear Research), isRP has build up experience with the theory and practice of participation and involvement in technology assessment. On various occasions, the two groups organise round tables, workshops and focus groups with schools and local communities, and this on topics such as medical applications of radioactivity, (nuclear) energy policy and radioactive waste management.

More information can be found on www.sckcen.be/isrp

4. Conclusion

Due to the typical characteristics of ionising radiation, the radiological risk is a very specific one. Risk assessment has to take into account as well scientific uncertainties related to biological effects as well as different perceptions on the risk and on the usefulness of the specific applications of radioactivity as such. It is not always easy for practitioners with a certain responsibility to grasp al the facets and nuances of this risk and of the social dynamics in face of it. This text arguments for a transdisciplinary approach to education and training in radiological protection by stating that practitioners should in a way become prepared to face complex situations that not only emerge as technical problems and/or scientific uncertainties, but also (and mostly primarily) as a result of social interaction of the involved people who, in addition, may have different perceptions on the character of the problem as such.

Transdisciplinarity is an attitude based on the ability to develop a ‘critical sense’, thus based on the willingness to test own knowledge and views to the knowledge and views of others. This attitude of transdisciplinarity can be acquired through research and in learning processes. By fructifying technical knowledge with ideas from philosophy and sociology, the involved practitioners and stakeholders should be able to gain a better understanding of the complex situation.

E&T should continuously stimulate the development of this critical sense. This sense is an essential ‘tool’ needed to gain more confidence in the own work and credibility towards the outside world.

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