Networking for Safeguards Education

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Abstract

For nuclear technology, which involves many disciplines of science and engineering, knowledge is one of the most important resources and needs to be managed carefully. Knowledge management consists of generating, disseminating, preserving and applying expert information from different sources in an organised way. The International Nuclear Safety Advisory Group to the IAEA Director General emphasized in Note No.4 of 2001 the importance of maintaining capabilities for nuclear research and education [1]. In the European Union, nuclear engineering education at twenty-two European universities was reinforced in 2003 with the European Nuclear Education Network (ENEN) association. The academic curriculum for this Master in Nuclear Engineering does not typically include the safeguards and non-proliferation aspects of nuclear systems (fuel cycle and reactors). A newly trained nuclear engineer, although during the work possibly exposed to relevant international agreements and regulations in the area of nuclear safeguards and non-proliferation (incl. the import/export of nuclear material and/or dual use goods…) thus generally has very little knowledge of the relevant treaties, their implementation, and their control.
Under the umbrella of ESARDA, a first training session on nuclear safeguards and non-proliferation was developed in 2004, which in the last 3 years has been further elaborated, resulting in a full week programme held in March 2007. The very valuable contribution and "ownership" of the various ESARDA working groups to the training course modules makes it a unique European initiative, led by the ESARDA Training and Knowledge Management Working Group. This course offers more than purely academic information, because it includes the various expertises of different actors in the nuclear field and is accompanied by exercises and laboratory visits. Not only the lecturers are representing the different European operators, inspectors, researchers, but also all ESARDA Working Groups are involved in the review of the lecture notes. The latter is used to establish a course syllabus as reference material for the full academic recognition of this course.
To deal with international nuclear security concerns many relevant initiatives have been launched in recent years. Also in the US and Russia, specific training and education programmes in nuclear safeguards and non-proliferation are built up and/or running including elements of nuclear security. The referred ESARDA training course also covers the links to these initiatives, through collaboration with the International Atomic Energy Agency and US labs and will be extended further to include Russian contributions.

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1. Historical background

A declining knowledge and expertise in the nuclear field were reported e.g. by the OECD (2000) [2]. In 2002, a report of the Secretary-General of the United Nations [3] underlined that "there has never been a greater need for education in the areas of disarmament and non-proliferation" and that "Additional disarmament and non-proliferation related educational efforts are needed at all academic levels, for which support by the UN and its Member States is crucial". This report suggested 34 recommendations, of which implementation is only gradually proceeding.

In Europe a internationally recognized Master[2] of Science in Nuclear Engineering is offered at 22 European universities under the auspices of the European Nuclear Education Network Association. This education of nuclear engineers is appreciated mainly by the reactor industry, because it focuses on the labour market in the reactor design and operation. In this programme the subject of nuclear safeguards and non-proliferation is not addressed as a compulsory academic course. Few universities, such as Uppsala, Hamburg, and Florence are now starting to offer specialized courses and programmes in nuclear safeguards and non proliferation.

In Russia various Master degree programmes[3] dealing with the Fuel cycle and Nuclear Material Accountancy and Control are offered by the Moscow Engineering Physics Institute (Mephi State University) and the Tomsk Polytechnic University. " In the US nuclear material management and control is quite often embedded in the Faculties of Political Sciences and/or International Relations. To our knowledge a full fledged master degree which combines the scientific/technical with the political/legal aspects of nuclear safeguards and non proliferation is rare.

The European Safeguards Research and Development Association (ESARDA) has therefore built-up a short integrated programme, as explained below in detail. It is also addressing the problem of knowledge retention in the nuclear safeguards field [4]. The nuclear safeguards has been evolving over a relatively long period, learning from historical events and experts of different disciplines. In particular it needs a multinational collaboration and therefore international approach.

2. European Networks promoting Nuclear Education

The Joint Research Centre is connected on the one hand to European Nuclear Education Network (ENEN) by some personnel teaching some ENEN courses, and on the other to European Safeguards Research and Development Association (ESARDA) by its chairmanship of some Working Groups and its secretary role to the ESARDA. In the following a description is given of ENEN and the ESARDA WG TKM, because they are of direct benefit for "networking for safeguards education".

2.1. Results of the ENEN Association

The European Commission replied to the dwindling teaching capacity in nuclear science and technology by financing the set-up of European Nuclear Higher Education in a sustainable manner. The temporary European Nuclear Engineering Network, established through the EC 5th

[2] It is common practice to follow this programme as a Master after Master.
[3] Examples of such masters at Mephi are "Systems of Physical Protection of Nuclear Materials and installations", and "Automation of Power Physical Installations".

Framework programme project ENEN, was given a permanent character by the foundation of the ENEN Association, pursuing a pedagogic and scientific aim. [5]

Nowadays it includes twenty-two universities and thirteen other partners from nuclear industry, regulators and research centers from eighteen different EU Member States and every year successful students are granted a Master degree in Nuclear Engineering. The activities of the ENEN Association are organized in five committees: the Teaching and Academic Affairs Committee, the Advanced Courses and Research Committee, the Training and Industrial Projects Committee, the Quality Assurance Committee, and the Knowledge Management Committee. The ENEN envisages to provide a common qualification in nuclear engineering, with a mutual recognition and with a facilitated mobility of teachers and students. [6]

Barely fours years after being founded, the ENEN has completed a variety of tasks and delivered appreciated products to the European Higher Education by harmonizing nuclear education. The students with a ENEN diploma are highly valorized in the reactor industry. Nowadays the ENEN Association intends to expand its activities with professional training programmes.

2.2. Results of the ESARDA Working Group on Training & Knowledge Management

Since 2004 ESARDA started to introduce a compact course on Nuclear Safeguards and Non-Proliferation, which was since then yearly organized in March as reported in [7, 8]. In the meantime the programme of the course under the umbrella of ESARDA, as given in 2007 from Monday 5 March till Friday the 9th addresses:

- "what is safeguarded" (definition of nuclear material subject to safeguards),
- "where is such nuclear material found" (nuclear fuel cycle),
- "with which legal protective means" (the international and regional treaties, institutions and organisations),
- "how to control the nuclear material inventory and to audit an accountancy" (the methodology of verification, statistics for accountancy & control),
- "practical implementation of control measures" (how inspections are performed, and which tools the inspector has),
- "what additional information offers" (importance of the collection of open source data, illustrated with some case studies, and with import/export data control)

in a 80% core part with standard set of lectures, given by representatives from regulatory bodies (IAEA, IRSN, DG-TREN), industry (AREVA, BNG), and research (Stockholm University, Hamburg University, JRC-ITU, and JRC-IPSC) (cfr. Table 1). The remaining part is completed with topical lectures addressed by invited lecturers, such as from PNNL and IAEA in 2007 addressing physical protection, illicit trafficking, the Iraq case study, exercises, including satellite imagery interpretation etc. With this structure of a stable core part and a variable set of invited lectures, the course should remain sustainable and up-to-date. A course syllabus, as reference material for the full academic recognition, is under development.

Institution	# lect.	Institution	# lect.
IAEA	4	AREVA (FR)	2
DG-TREN	1	BNG (GB)	1
Stockholm Uni. (SE)	1	JRC-IPSC	5
Hamburg Uni. (DE)	1	JRC-ITU	1
IRSN (FR)	1	PNNL (US)	1

Table 1: Lecturers of the 2007 ESARDA course

The ESARDA 2007 course was followed by sixty students with eighteen different nationalities (cfr. Table 2) and eight have included the course in their academic curriculum and have it evaluated for the current academic year. The ENEN has recognized this 2007 ESARDA course academically for 3 points in the European Credit Transfer System.

As academic evaluation of the course those eight students of five different universities wrote an essay, paper and poster. The evaluation of the essays varied from E (Adequate) to B (Excellent).

Institution	# stud.	Institution	# stud.
IAEA (UN)	1O	King's Col. (GB)	6E
CTBTO (UN)	1E	London Econ. (GB)	1L
IRSN (FR)	2E	STUK (FI)	2E
Hamburg/Freiburg Uni. (DE)	8E	SKI (SV)	1L
Nuc. Saf. Auth (SK)	1E	ENEA (IT)	1E
Tzochev NRA (BU)	1E	Poli Torino (IT)	7E
Budapest Uni (BU)	1O	TU Vienna (AU)	2E
Thrakom. (GR)	1L	Omsk/Tomsk Uni (RF)	2L, 2E
Uni Ghent (BE)	2L, 3E	Torrejon SC (EU)	2O
IISS UK (GB)	1L	JRC IPSC/ITU (EC)	12E

Table 2: 60 students of 18 nationalities at the 2007 ESARDA course with different background (L=Law, Political Sciences, Int. Relations and Economics and History, E=Engineering, Physics and Chemistry, O=Others or unknown)

Four best essays with posters were selected for display at the ESARDA Symposium (Aix-en-Provence, 22-24 May 2007):

1. Vienna University of Technology: Ultra-low-level measurements of argon, krypton and radioxenon for treaty verification purposes
2. Tomsk Polytechnic University: Control of nuclear material hold-up in process lines and equipment at isotope-separation facilities
3. Graz University of Technology: Methods for the detection of undeclared plutonium production facilities
4. University Ghent: Advantages and disadvantages of fusion-fission based hybrid reactors

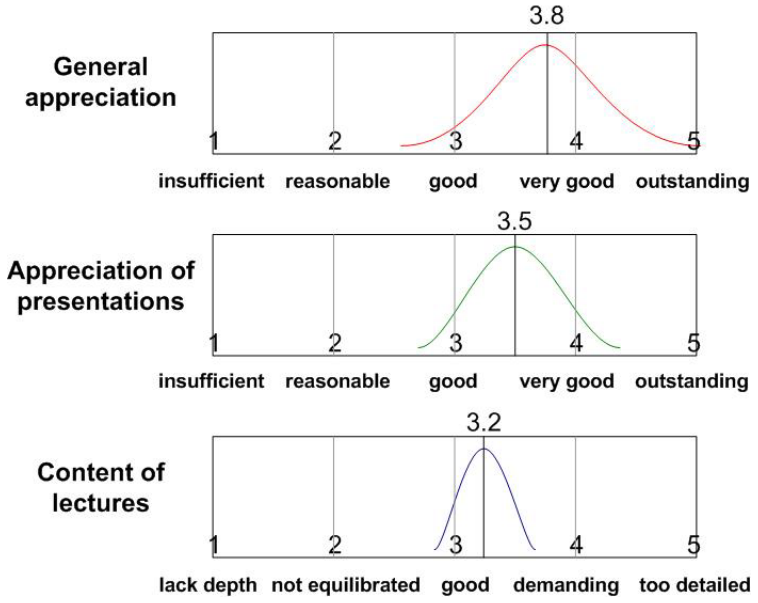

Fig. 1: Appreciation of the ESARDA Course (Ispra, March 2007)

The course feedback allowed to perform only a limited statistical analysis but the remarks of the students were very valuable to draw few lessons. In particular the specific examples or applications addressed in or after the lectures, and the practical visits to the 5 labs, (one per day) were appreciated very much.

The students could mark the general appreciation of the course from 1 “insufficient” to 5 “outstanding”. The outcome of the appreciations is presented in Fig. 1. A mean value of 3.8 was scored with standard deviation of 0.7. This means that the overall opinion is near 4 “very good”. This is a clear indication that the course is on the right track and responds appropriately to what students are looking for, nevertheless their varying background. Therefore the course will be repeated on a yearly basis in the same way.

Major comments and suggestions of the students indicated the wish for further practical applications, and more time dedicated to the class-room exercise. The exercise, presented by IAEA, asked the students to take the role of a safeguards inspector. The description of a fictitious state bordering a nuclear weapon state, “Salinas” was provided, that has a nuclear power plant, a research reactor, and a fuel fabrication plant, and that signed recently NPT and concluded a comprehensive safeguards agreement with the IAEA. A few more info’s were provided under the description of the case. The job of each group of students consisted of designing a safeguards approach, keeping in mind technical capabilities of the country, minimal disruption to the operator and the cost of inspections. The outcome was discussed between the different groups and the IAEA lecturer in a dedicated afternoon session. In the next course of March 2008, we envisage a two-phase approach, with a feedback to the students after a first rough design and a splitting up of the more specific tasks between the different student groups.

3. Integrated Knowledge Management as Perspective

3.1. Management of nuclear safeguards knowledge by and within ESARDA

The ESARDA Nuclear Safeguards and Non-Proliferation course is offering more than a standard academic course, because the course contains contributions of different experts in the field. The lecturers are selected by the ESARDA WG TKM such that there is a representation from the different ESARDA members: including European nuclear industry, EURATOM and IAEA inspectorate, European researchers.

The syllabus is under development with the lecture note contributions form the authors and the review and completion of all ESARDA Working Groups. The label “ESARDA approved” to the syllabus ensures that it covers an overview verified by the recognized experts and presented under a European view shared by the different ESARDA actors. The syllabus will be published as a Special ESARDA Bulletin. With the course schedule, the syllabus and evaluation scheme a standard recognition at ENEN level can be asked on a long-term basis.

The ESARDA WG TKM is accomplishing with the course and syllabus a first task of information gathering and dissemination. This knowledge gathering and structuring needs to be continued as support to a future integrated knowledge management. The latter underlines the second part of the WG’s name “Training and *Knowledge Management*” with the role of knowledge retention, including collection, structuring, dissemination and assessing the application.

3.2. Extension towards training and nuclear security

In recent years, nuclear and other radioactive material and associated facilities and transports have been identified as requiring higher levels of control, and nuclear threat scenarios have become more dangerous and more complex. At the same time, energy security concerns and fears of climate change are making nuclear power more attractive. In this context, States have to be prepared to acquire the necessary knowledge and skills to fulfill adequately their obligations stemming from adherence to the international instruments related to nuclear security. Several binding and non-binding international instruments such as the *Convention on the Physical Protection of Nuclear Material,* the *Convention on the Suppression of Acts of Nuclear Terrorism, UNSC Resolution 1540* or the *Code of Conduct on the Safety and Security of Radioactive*

Sources, require, inter alia, States to establish appropriate systems to prevent, detect and respond to unauthorized acts involving nuclear and other radioactive material. In order to meet these requirements, an increased attention to education and training in this field is crucial.

In the light of the identified need for better international cooperation and interaction in nuclear security education and training, the IAEA convened at the end of April 2007 a consultants meeting to explore the possibility of better coordination in this field. This was in follow-up of a recommendation of the International Seminar on Education & Training in Non-Proliferation, Security Culture & Accounting for and Control of Nuclear Material, organized by CNS in Moscow, in November 2006.

This international coordinating mechanism will address key issues such as coordination of nuclear security educational and training activities at international level in an effort to avoid overlaps, to ensure the effective use of resources and to identify gaps in the existing programs.

As a first step it was suggested conducting training needs analysis in order to identify the target audience and their required competency profile. This target audience ranges from the decision makers, politicians, diplomats, managers, CEO as well as technicians, border guards to the worker in the field, experts (lawyers, engineers, …) or in the control loop (regulatory body, safety authorities,…). They may be starting a career or be already in senior positions, they may work in the nuclear area as specialists, or through cross cutting activities.

The second step would be to consider training as a tool for career management. Training can be a career development tool as well as a component in knowledge management. Training could also assist technical staff to obtain a broader knowledge outside or their normal duties. Short training courses (e.g. two-day' sessions) could also become mandatory for senior management with nuclear responsibilities, such as nuclear crisis management.

The third step would be to assess the effectiveness of training courses in States. Setting up a relevant feedback mechanism, gathering information from the "field" (e.g. events related to illicit trafficking, communication difficulties between National Authorities and Operators, lessons learned from Safeguards related events). Analysis of this data will lead to better understanding of States' training needs related to nuclear security issues.

Through enhanced co-operation between different international organizations, better use will be made of dwindling teaching capacity, scientific equipment and research infrastructure to ensure the efficient utilization of limited resources.

4. Conclusions

The ESARDA course is a contribution in setting up through a network the necessary tools meeting the increasing education needs in the nuclear safeguards and non-proliferation area and beyond:

- Self sufficient, it provides operating engineers, national SG authorities representatives, young professionals or qualified managers with the necessary knowledge of the relevant international agreements and regulations in the area of nuclear safeguards and non-proliferation and of the tools to monitor those.
- Recognized as an optional academic course in the European Master Degree curriculum for nuclear engineering, it is fully included in the European educational system, as initial education or in the framework of continuing training.
- Self-sustainable, it is setup with a core part, lectured by a pool of lecturers representing ESARDA members and kept up-to-date with specific topics given by invitees, allowing collaborations with the IAEA, US national laboratories and Russian institutions. By

enabling a pan-European and even world-wide participation of students and young professionals an international view on today's non-proliferation regime is given.
- Gathering lecturers from concerned international, national or private organisations, it represents a real focal point where experiences can be shared
- Fed by the ESARDA Training and Knowledge Management Working Group in collaboration with the other Working Groups, its up-dating is granted, and it makes possible capturing the knowledge in Safeguards from various horizons, including building in a return of experience
- Its information gathering, structuring and validation process can constitute a contribution towards future more comprehensive knowledge management initiatives.

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