

THE ROLE OF NETWORKING FOR NUCLEAR EDUCATION

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Abstract: Nuclear knowledge is the basis for almost all nuclear activities, and education and training are the most fundamental means to transfer knowledge from one generation to the next. Understanding means and trends in knowledge transfer through education and training thus deserves a closer examination.

In the past years, a number of trends and questions in nuclear knowledge, education and training have emerged. With declining student enrolment numbers and a general stagnation of the use of nuclear power in some of the IAEA's Member States, the issue of a slow erosion of the knowledge base and the possibility of losing knowledge has become increasingly important, in particular if seen against the background of a possible renaissance of nuclear power in the future. In other Member States, an expansion of nuclear power is expected, with a corresponding need for human resources. As a result, in many Member States education and training of the next generation and succession planning have become key issues. Several actions are being taken in the nuclear education and training sector, ranging from governmental programs to industry recruitment efforts, but most importantly a trend to increased networking and sharing of resources and facilities has become apparent.

This paper starts with a working definition of "nuclear knowledge" and a review of the history of nuclear knowledge, its accumulation over past decades and trends in its dissemination – either favouring networking and sharing knowledge, e.g. for sustainable development, or restricting such sharing, e.g. in the case of commercially used knowledge. It then examines the present trend to and motivation for increased networking of nuclear education and training as a part of transfer of that knowledge from one generation to the next. After a brief overview about the theory of networking, it can be said that networking can contribute to efficiency, sharing of resources, the effectiveness of programs, the timeliness of responses, to quality control, and to stabilisation and flexibility in the nuclear human resource sector. After an analysis of different types and characteristics of networks, the paper presents selected networks in nuclear education and training as examples, including the IAEA initiative *Asian Network for Education in Nuclear Technology* (ANENT).

It can be concluded that networking already is a key element in shaping the nuclear educational sector, both on national and regional levels, and that networking nuclear education and training can be expected to become even more important in the future.

1. SHARING NUCLEAR KNOWLEDGE

1.1 Nuclear Knowledge

Nuclear knowledge is the basis for almost all nuclear activities. Nuclear knowledge comprises technical information in the form of scientific research, engineering analysis, design documentation, operational data, maintenance records, regulatory reviews and other documents and data. And it includes knowledge embodied in people – e.g., scientists, engineers and technicians. Ensuring the continued availability of essential reservoirs of both technical information and qualified people is hence vital for the nuclear sector, for its productiveness, for its capability of innovation and for its sustainability in the medium and long-term.

1.2 Working definition of nuclear knowledge

Today nuclear knowledge resides in governments, academia, and industry, i.e. encompassing administrative bodies, companies, research and educational institutions, individuals and

retirees. The entire inventory of nuclear knowledge today exists in different forms and formats, ranging from recorded and/or stored nuclear information on different media to tacit knowledge¹ in nuclear professionals' minds. A universally valid definition for knowledge has not yet been agreed upon and the same is true of an accepted definition within the Agency.

Based on the insight gained in Agency meetings, the IAEA uses, *as a working definition, that "knowledge" can range from technical information laid down on paper or electronically to knowledge embodied in people and in their capabilities and skills. Knowledge extends beyond "information" in that knowledge also includes the value added, that is, expertise required to turn raw (nuclear) information into an understanding of (nuclear) issues or, in other words, to give the information a meaning. "Nuclear knowledge" is specifically knowledge about or relevant to nuclear related activities.*

1.3 History of Sharing Nuclear Knowledge

Nuclear knowledge has been accumulated over several decades and was generated by a great variety of institutions, ranging from military institutions to academia and civil R&D centres. Parts of the nuclear knowledge the world possessed today are "public" in a way, other parts remain property of particular institutions, both of military or of commercial nature.

In the early days of nuclear development, nuclear knowledge tended to be kept confidential, in particular when developed in a military context. With the peaceful use of atomic energy becoming more and more important, not only in economic terms, but also as a driving force for further development and R&D, more knowledge was shared on an international level to foster cooperation and development. At the same time, the commercial use of nuclear technology resulted in other types of knowledge being kept by the owners as "commercial confidential"; it was shared with others mostly only in the framework of commercial arrangements.

Two key factors thus dominate the sharing or non-sharing of nuclear knowledge: a military and commercial purpose favour not to share knowledge; the objective of sustainable development works in the contrary direction. Most recently, and also influenced by the IAEA's work, sharing knowledge and networking of institutions has received particular attention in the nuclear community, and networks are appearing to structure that process.

2. THE ROLE OF THE IAEA IN SHARING NUCLEAR KNOWLEDGE

The IAEA was created in 1957 in response to the deep fears and expectations resulting from the discovery of nuclear energy. The Agency's genesis was US President Eisenhower's "Atoms for Peace" address to the General Assembly of the United Nations on 8 December 1953. These ideas helped to shape the IAEA Statute, which 81 nations unanimously approved in October 1956. The Statute outlines the three pillars of the Agency's work - nuclear verification and security, safety and technology transfer. The latter pillar, technology transfer, is the institutionalized expression of an intention to cooperate and to share knowledge for peaceful purposes.

The statute of the Agency states in Article III A, paragraphs 3 and 4

"The Agency is authorized to [...]

3. to foster the exchange of scientific and technical information on the peaceful uses of atomic energy,

4. to encourage the exchange of training of scientists and experts in the field of peaceful uses of atomic energy,

¹ "Tacit knowledge" is knowledge that is not laid down in any way, e.g. as documents, but sits in peoples' minds, possibly not even conscious to people who have it.

From its inception, the Agency has always been a knowledge-based organization requested to serve and promote the cause of peaceful use of nuclear science and technology, and activities related to sharing nuclear knowledge have been and are an integral part of the Agency's work: building databases and intranets, assembling nuclear scientific and technical information, establishing and enhancing library services, sharing best practices, installing groupware, conducting training programmes, fostering collaboration, creating virtual organizations and networks – all of these activities contribute to sharing knowledge as part of the Agency's mandate.

Looking at the history of the IAEA, two important dates in the context of sharing knowledge can be highlighted: In 1961 the IAEA opened its Laboratory in Seibersdorf, Austria, creating a channel for cooperative global nuclear research. In 1969, the International Nuclear Information System (INIS) was formally established by the Board of Governors of the IAEA. INIS today is the world's leading information system on the peaceful uses of nuclear science and technology. Operated by the IAEA in collaboration with its Member States and co-operating international organizations, its existence, growth and widespread membership are a demonstration of the will of participating institutions to share knowledge.

The IAEA today is the world's focal point for scientific and technical cooperation in the nuclear field and works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. The work contributes to fighting poverty, sickness, and pollution of the earth's environment, and to other global "Millennium Goals" for a safer and better future. Where they hold comparative advantages, nuclear science and technology have become preferred solutions - and sometimes the only solutions - to many problems hindering development in poorer countries.

3 THE IMPORTANCE OF NUCLEAR EDUCATION AND TRAINING

3.1 Challenges - globally

Education and training are the most fundamental means to transfer knowledge from one generation to the next. In the past years, a number of trends and questions in nuclear knowledge, education and training have emerged. With declining student enrolment numbers and a general stagnation of the use of nuclear power in some of the IAEA's Member States, the issue of a slow erosion of the knowledge base and the possibility of losing knowledge has become increasingly important, in particular if seen against the background of a possible renaissance of nuclear power in the future. In other Member States, an expansion of nuclear power is expected, with a corresponding need for human resources.

3.2 Nuclear education and training – considerations in IAEA Member States

As a result of this situation, many of the Agency's Member States consider education and training of the next generation to be of key importance, while the individual reasons for that importance may well be different.

- Operation of existing facilities: In some Member States with a highly developed nuclear infrastructure, the need to educate human resources for the *operation of existing facilities* with high safety standards while facing declining student enrolment numbers is dominating.
- Capacity building: In other Member States, in particular in developing countries with intentions to introduce nuclear power, education and training is a high priority as part of national development and for *capacity building*, driven by the need to develop new nuclear human resources.
- Future innovation: In some Member States with significant on-going R&D activities, human resource development is considered key for *future innovations*.

In addition, in almost all-developing Member States nuclear technology at present plays its most important role for nuclear applications (health and medicine, agriculture, industrial

applications), and those Member States wish to strengthen nuclear human resources as part of sustainable national development.

Increased co-operation and networking and intensified sharing of nuclear knowledge, both for nuclear power and for other nuclear applications could help to overcome obstacles to the sustainable use of nuclear technology and could further stimulate progress. Further development and innovation might become possible through increased co-operation, networking and sharing of knowledge.

4. NETWORKING

4.1 Types of networks

In theory, one can distinguish different types of networks, according to the following three points (other distinctions are also possible):

- The “objects” that are being linked or connected can be either “dead” information repositories, e.g. networks of databases or computers, or “living” institutions and people, e.g. networks like university alumni societies.
- Networks can be “institutionalized” (“formal”) or “informal” in character. An example for a formalized or institutionalized network would be the European Union with its established institutions, whereas an informal network could be a group of colleagues meeting regularly after work for informal discussions.
- Networks can be “active” (“productive”) or “passive”. An active network would be established to “produce results”, e.g. an IAEA Coordinated Research Project, whereas a passive network can exist as a framework, but without any in-built activities.

Most relevant for networking nuclear education and training are networks of *institutions*, either formal or informal of character, that are *active* in a sense that a clear orientation to achieve results, i.e. graduates or human resources in general, dominates.

4.2 Benefits from networking

As a general finding, it has been emphasized in the past that a vital factor for the functioning of networks are the willingness of participants to share their knowledge, frequently the existence of an inter- and multidisciplinary approach to facilitate the understanding between different participants from different social cultures, and a certain focus on soft skills such as tolerance, openness and mutual respect. These factors, being difficult to guarantee from the outset for newly founded networks, are nonetheless frequently among the first issues that need to be addressed when shaping a new network.

Networks can improve the efficiency of work carried out jointly, e.g. through sharing of resources, but also the effectiveness of programmes, in that result is available to a larger group. The timeliness of projects can be increased by the stabilisation effect of larger groups and the flexibility arising from having partners; the same considerations apply for quality control issues.

5. NETWORKING EDUCATION AND TRAINING

For the purpose of this paper, “education and training” ranges from higher education at universities, leading to Bachelor, Master or doctorate degrees, to training courses of various duration to on-the-job training in particular in commercial companies. Knowledge can, and is being, transferred also on an “indirect” path from one generation to the next, when it is first stored or archived by one generation and then acquired from there by the next, i.e. without any direct interaction. While this is often the only viable mechanism, it is a widespread conviction that knowledge can best be transferred through a direct and personal interaction, i.e. through education and training in the above sense.

Education and training to date is mostly conducted by specialized institutions, either universities, training centres or specialized departments within organizations. The universal character of nuclear knowledge, in particular of scientific and technical knowledge,

immediately suggests that education and training in the nuclear field could look similar in different parts of the world, in different institutions and organizations.

As a result, and also influenced by economic considerations as well as an overall objective of international cooperation, education and training is increasingly networked. Partnership agreements are being established, with a driving force from two sides:

- from the education and training side, e.g. universities, as part of their general teaching agenda; and
- from the nuclear side, e.g. nuclear R&D and nuclear training centres, as part of cooperation in the nuclear field.

The overall number of existing networks in the nuclear sector, in the light of the different types of networks outlined above, is very large, possibly several thousands. Only a minor fraction of those is institutionalized, i.e. "formal", and only a fraction of those concerns education and training. Some of these networks are being described in the following chapter.

6 NETWORKS IN NUCLEAR EDUCATION AND TRAINING

On the national level, a number of university networks has been established recently, e.g. the *University Network of Excellence in Nuclear Engineering* (UNENE) in Canada or the *Belgian Nuclear Engineering Network* (BNEN) in Belgium. Networking is also an element in many governmental programs in the nuclear sector, so for example in some of the Department of Energy's university programs in the US. Also in the US, the *Nuclear Engineering Departments Heads Organization* (NEDHO) is a network of academic entities active in nuclear education. In Germany, the *German Alliance for Competence in Nuclear Technology* also addressed nuclear education and training and networking and sharing in that area.

Below, three examples for networking education and training on a regional and international level are described in more detail:

6.1 The *Asian Network for Education in Nuclear Technology*

The Asian Network for Education in Nuclear Technology (ANENT) was established in 2004 under the aegis of the IAEA to promote, manage and preserve nuclear knowledge and to ensure the continued availability of talented and qualified human resources in the nuclear field in the Asian region. The First Coordinating Committee meeting in February 2004 in Kuala Lumpur, Malaysia, marked the official formation of ANENT. Membership of ANENT is open to universities, research centers, government agencies and other institutions involved in nuclear education and training.

As of April 2004, ANENT's membership comprised 17 participating institutions and 3 collaborating institutions. ANENT operates based on the principle of cooperation for the mutual benefit of its members. A pragmatic and stepwise approach will be adopted in implementing ANENT activities. At the 1st Coordination Committee meeting, five activities were identified for implementation during the first phase beginning in 2004 and ending with the full operation of ANENT at the beginning of 2006. For each activity, an Action Plan was agreed upon and is being implemented at present, each lead by one lead institution. The activities are:

Activity	Lead Institution and Country
Exchange of information and materials for education and training	Korea Atomic Energy Research Institute (KAERI), Republic of Korea
Exchange of students, teachers and researchers	Malaysian Institute For Nuclear Technology Research (MINT) Malaysia
Distance learning	Philippine Nuclear Research Institute (PNRI), The Philippines
Establishment of reference curricula and	Hanoi University of Technology (HUT),

facilitating credit transfer and mutual Vietnam
recognition of degrees
Liaise with other networks and Atomic Energy Authority, Sri Lanka
organizations.

6.2 *The World Nuclear University*

The World Nuclear University (WNU) is a global partnership of educational, commercial and inter-governmental institutions, dedicated to preparing the nuclear professions for an expanding role throughout the 21st century. Its mission is to strengthen nuclear education and training worldwide, thereby to build the foundations of professional excellence in all aspects of peaceful nuclear technology, and to enhance the appeal of nuclear studies to the young generation.

It was founded at a ceremony held in London in September 2003. The Founding Supporters are key multinational organisations: the World Nuclear Association (WNA) and the World Association of Nuclear Operators (WANO) in the private sector and the International Atomic Energy Agency (IAEA) and Nuclear Energy Agency of the OECD (OECD-NEA) in the public sector.

The WNU states about itself that it is distinct from a traditional university: the WNU will not engage in classroom teaching of standard academic courses or degrees. Rather, the WNU will be a vehicle for co-operation among nuclear educators and other nuclear experts, in order to improve the content and delivery of education and training at institutions which already provide such instruction.

6.3 *The European Nuclear Education Network*

Within the 5th framework program the European Commission supported the European Nuclear Education Network (ENEN). The ENEN contract started on Jan 1, 2002 and lasts for 24 months. Based upon a year-long extensive exchange of views between the partners of ENEN, consisting of a representative cross section of nuclear academic institutions and research laboratories of the EU-25, a coherent and practicable concept for a European Master of Science in Nuclear Engineering has emerged. The concept is compatible with the Bologna philosophy of higher education for academic education in Europe. Pursuing the sustainability of the concept, the ENEN partners organized themselves in a non-profit-making association, the ENEN Association, marking the step from a network of institutions to establishing and formalizing the network as a new institution by itself.

Within the 6th framework program, the Commission services favourably evaluated a follow-up project to ENEN, NEPTUNO. The objectives of the NEPTUNO co-ordination action are to establish a fair dialogue and a strong interaction between the academic and the industrial world and to bring all nuclear education and training activities under a common strategy of the ENEN type.

6.4 *Conclusions*

It can be concluded that networking already is a key element in shaping the nuclear educational sector, both on national and regional levels, and that networking nuclear education and training can be expected to become even more important in the future.

REFERENCES

- [1] ON THE HISTORY OF THE IAEA: <http://www.iaea.org/About/history.html>