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NUCLEAR EDUCATION, TRAINING AND QUALIFICATION OF PERSONNEL WITHIN THE UNITED KINGDOM NAVAL NUCLEAR PROPULSION PROGRAMME

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ABSTRACT

This paper outlines the nuclear reactor technology education and training given by the Nuclear Department to uniformed personnel destined to become nuclear submarine naval reactor plant operators and to civilian support personnel within the wider Naval Nuclear Propulsion Programme. It describes the Nuclear Department's military and civilian student customer base and its teaching disciplines and facilities. The paper also details the marine engineering officer and technician training pipelines as well as some of the education and training provided to civilian support staff.

1. Introduction

This paper outlines some key aspects of the shore based nuclear reactor technology education and training given to uniformed and civilian personnel destined to take up posts within the Naval Nuclear Propulsion Programme (NNPP) by the Nuclear Department (ND), Defence College of Management and Technology (DCMT)[1] in conjunction the Systems Engineering Group (SEG)[2], HMS Sultan. A mix of shore based education and training followed by specialised functional and on-job training form the backbone of the NNPP military training pipelines, conducted in accordance with the Defence Systems Approach to Training since the beginning of the nuclear submarine programme. This Paper also covers the ND customer base, purposes, resources and range of teaching disciplines as well as outlining generic reactor plant operator training. It also details the nuclear submarine engineering technician and engineering officer education and training pipelines as well as some of the courses given to various grades of civilians, that contribute to personnel being suitable qualified and experienced to take up posts within the NNPP.

2. Military customer base

A very important part of the ND military customer base is naval officers who undertake the 25-week Nuclear Reactor Course (NRC), attracting a Post Graduate Diploma in Nuclear Reactor Technology. The newly promoted naval officers are designated as Assistant Marine Engineering Officers (AMEOs) destined to become nuclear submarine reactor plant supervisors following the NRC, a number of additional specialised courses and a lengthy period of on-job training at sea. Another important part of the military customer base is the further education of experienced

[1] ND, DCMT is part of the UK Defence Academy and is lodger unit at HMS Sultan
[2] SEG is part of the Defence College of Electro Mechanical Engineering (DCEME)

AMEOs returning from sea appointments, who undertake the Nuclear Advanced Course (NAC), a one-year Master of Science degree course in Nuclear Technology and Safety Management, alongside selected NNPP civilians, both of whom being designed for design and procurement type jobs following graduation. ND also provides a very significant amount of nuclear reactor technology education to the various systems engineering training courses run by SEG for nuclear submarine marine engineering ratings and non-commissioned officers; in turn, SEG provides systems engineering related training to the majority of the ND educational courses. Furthermore, ND provides a 12-week course in nuclear reactor technology to all nuclear submarine executive officers and weapon engineering officers, thus is unique in having a vital roll to play in the education and training of all naval officers and marine engineering ratings destined for nuclear submarine service.

3. Civilian customer base

The prime ND civilian customer base consists of MoD civilians who work within the NNPP at various levels of experience and competence. While ND has a varied course portfolio that matches civilian customer requirements, the basic course for civilian personnel destined to support the NNPP at ‘Awareness’ level is the 2-week nuclear introductory course; the 8-week Nuclear Warships Support Course is designed for the more experienced senior ‘Practitioner’ level personnel; and the various postgraduate level courses delivered by ND, including the NRC and NAC previously outlined, are tailored for the more technically advanced personnel operating at the so called ‘Expert’ level within the NNPP. An equally important part of the civilian customer base is non-MoD civilians who primarily work for the MoD’s Defence Industrial Partners, employed on nuclear submarine development and design, build and test, dockyard maintenance, safety authorities and safety justification issues and decommissioning related activities. In addition, ND provides nuclear accident countermeasures courses to the UK emergency services that form part of the national and local nuclear accident response organisations.

4. ND purposes, staff and facilities

The prime purposes of ND are the provision of nuclear education and training in support of the NNPP, training in Radiation Protection for all three armed services, research, consultancy, advice and support to the NNPP and provision of nuclear training and consultancy services to civil nuclear sector. The total ND complement is 40 posts, of which 30 are involved in academic delivery and 10 in support and administration. While the majority of the academic deliverers are MoD personnel[3] there are 2 non-MoD civilian Senior Lecturers work within ND but are employed by a commercial company called ‘Flagship’, who also provide the majority of the support staff functions. In addition to the usual classroom and syndicate rooms ND has access to extensive nuclear, radiological and chemical laboratories, a bespoke nuclear library, scanning electron microscope, irradiation facilities (X-ray, gamma and neutron), maintainer training aids, basic principles simulator that consolidates education and a range of class specific nuclear submarine high fidelity simulators that consolidate training.

5. Nuclear training profile and teaching disciplines

ND and SEG have a portfolio of 45 different courses ranging from one day to one year and form introductory to MSc level. 30 courses are academic based and 15 are

[3] 1 Professor, 4 Principal Lecturers, 13 Senior Lecturers, 3 Higher Scientific Officers, 1 Scientific Officer and 6 Royal Navy personnel

systems engineering based, covering military students ranging from junior naval rating to admiral rank, with civilians ranging from semi-skilled to managing director level. While ND delivers most of its traditional NNPP related courses in-house an increasing percentage of bespoke courses are delivered peripatetically. ND has a significant range of teaching disciplines ranging from ‘enabling’ subjects, ‘core’ academic subjects and ‘specialist’ subjects, with most of the specialist areas supported by research activities. The academic enabling subjects are mathematics, statistics, computing, atomic and nuclear physics and general engineering. The core academic subjects are reactor physics, radiation protection, reactor engineering, reactor safety, thermal hydraulics, nuclear safety, nuclear materials and nuclear chemistry. Specialist subjects and academic staff research areas include computational reactor physics, criticality, radiation shielding, structural integrity, computational fluid dynamics, thermal hydraulics, risk assessment, nuclear safety management, environmental impact assessment, radiation emergency planning and response and nuclear decommissioning.

6. Operator training

Marine engineering officers and ratings destined to become naval reactor plant supervisors, panel operators and machinery space watch keepers, undergo a similar generic operator training regimes, but at differing educational levels commensurate with their level of responsibility on the reactor plant. The shore side elements of this training regime commences with academic courses, mostly delivered by ND, through systems engineering, operational and simulator training, delivered by SEG. This is followed by a period of on-job training at sea culminating in a plant based operational board before personnel are considered suitably qualified to operate the naval reactor plant, at the various levels of responsibility.

7. Marine engineering technicians

Following a marine based electro-mechanical apprenticeship, junior technicians within the NNPP undertake the 10-week Nuclear Propulsion Systems Course (NPSC). Following qualification in the more junior (Category C) watch keeping positions and a substantive period at sea these technicians will return for the Nuclear Propulsion Operators Course (NPOC). The 14-week NPOC is a prerequisite qualification course for further qualification as reactor panel operator, designated a Category B watch keeper. Following qualification and a further substantive period at sea in this more responsible watch keeping position, senior technicians return for the 18-week Nuclear Propulsion Supervisors Course (NPSC)[4], a prerequisite for the so called Category A plant supervisory watch keeping position. The overall training pipeline from Category C to Category A watch keeper, including necessary shore training courses, sea and shore maintenance workshop employment takes many years to complete[5].

8. Marine engineering officers

Marine engineering officers are either recruited directly from university or have been promoted from the Chief Petty Officer or Warrant Officer ranks. In both cases these officers undertake a Systems Engineering Management Course (SEMC), which is somewhat reduced in length for officers promoted from the ranks, who will already be

[4] The academic element of the NPSC is 18%, the NPOC is 35% and the NPSupC is 50%

[5] During this period, selected marine engineering ratings will normally progress up through the ranks through selection for promotion to Petty Officer, Chief Petty Officer and Warrant Officer.

very experienced in nuclear submarine systems engineering matters. In addition all graduate officers have to undertake a 7-week Officers Nuclear Operators Course (ONOC) Phase 1, followed by ~ 23 of initial sea training in a nuclear submarine, as part of their 2-year SEMC, which enables them to qualify in all subordinate watch keeping positions and obtain the required level of knowledge of nuclear submarine engineering systems. Regardless of background, all marine engineering officers are required to be educated to postgraduate level by ND on the Nuclear Reactor Course (NRC).

9. Nuclear Reactor Course

The NRC is part of the recently introduced phased and streamlined postgraduate level educational programme called the Nuclear Engineering Educational Programme (NEEP), specifically designed to meet the future nuclear engineering educational needs of NNPP marine engineering officers. The NRC provides students with a detailed understanding of the core principles of nuclear technology, including classroom delivery in reactor physics, reactor engineering, radiological protection, reactor safety, materials, chemistry, reactor dynamics, accident studies, nuclear safety management and regulation and related disciplines associated with the naval reactor plant and a study project in a technical area of particular professional interest. While the NRC is an educational prerequisite for naval reactor plant supervisors, its aims are to educate officers and their civilian (officer equivalent) counterparts from the Naval Reactor Test Establishment at Dounreay in nuclear reactor technology and nuclear propulsion engineering so that, with further training, they can take up senior operational posts and subsequent wider posts in support of the NNPP. Following the NRC, graduate officer students undertake an 11-week Officers Nuclear Operators Course (ONOC) Phase 2, before proceeding to sea for further on-job training to qualify as reactor plant supervising officer, entitled the Engineer Officer of the Watch.

10. Nuclear Advanced Course

Following two or three years at sea, selected marine engineering officers will return for the Nuclear Advanced Course (NAC), as previously outlined. While the NAC/MSc is normally conducted full time over one academic year, it is modularised and is delivered in 3 Phases, with Phase 1 attracting a postgraduate certificate, Phase 2 a postgraduate diploma and Phase 3 an MSc degree, with returning officers having the option of attending Phases 2 and 3 only. The NAC also caters for inexperienced but academically qualified NNPP civilians, through an enabling up front 2-week introductory course.

11. Civilian personnel

In addition to the postgraduate level qualifications that a number of civilians gain form attendance on the NRC and NAC, the vast majority of the MoD's NNPP civilians undertake a series of short courses specifically designed to meet the level of responsibility commensurate with the relevant support post or position, normally in nuclear submarine design, procurement, safety organisations and dockyards. There are three levels of responsibility for civilian posts within the NNPP all designated as 'Nuclear Suitably Qualified and Experienced Persons' (NSQEP). The three NSQEP levels are 'Awareness', 'Practitioner' and 'Expert'.

12. Awareness level NSQEP

The basic level of NSQEP is the Awareness level, where personnel are fully aware of the safety management procedures and safety culture that exist within their organisations and are thoroughly conversant with its Nuclear Accident Response Organisation (NARO). Typical qualification and experience requirements are the ND delivered 2-week Nuclear Introductory Course and the 1-week Nuclear Accident Procedures Course followed by at least 6 months experience in post. Once so qualified, the individual retains NSQEP awareness level qualification indefinitely.

13 Practitioner level NSQEP

The next level up is the Practitioner level NSQEP, who has the ability to draft and critically review safety management procedures, participate in the safety clearance process and NARO operations, sit on safety committees and authorisation groups and participate in licensing/authorisation and internal/external audits. The typical qualification and experience requirements are ND delivered shorts courses, such as the 6-week Nuclear Systems Designers Course (which qualifies for a postgraduate certificate if accompanied by a project) or the 8-week Nuclear Warship Support Course and the 1-week Nuclear Site Safety Justification Course, combined with at least 18 months experience in post at awareness level. Individuals will lose their Practitioner status after 4 years employment outside the NNPP and subsequently have to re-qualify by time/experience.

14 Expert level NSQEP

The highest level of NSQEP is the Expert level, which normally requires post graduate nuclear qualifications and chartered engineer status (or equivalent). While they need to be educated to Practitioner level at minimum, most would have undertaken the ND delivered NAC/MSc or NRC/PgD or the ND Nuclear Radiological Protection Course (PgD in Radiation Protection). Individuals must have least 5 years experience in Practitioner level posts and Expert level status is lost after 3 years outside the relevant experience field. They will also have national and international peer recognition in their respective fields

NUCLEAR EDUCATION IN ARGENTINA: PAST, PRESENT AND FUTURE

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ABSTRACT

The aim of this presentation is to describe nuclear education and training in Argentina, particularly in the National Atomic Energy Commission (CNEA). It started with the beginning of nuclear activities in the early fifties, and is based on formal education at three academic institutes, and "on the job" learning via a fellowship programme. The evolution of CNEA educational system is described, including its projection to other countries. Current expansion of the programme to face the relaunching of a national nuclear plan and the main problems affecting it are also analyzed.

1. Introduction

Nuclear energy's history in Argentina is marked by some important achievements, including early introduction of nuclear power generation, self-sufficiency in the fuel cycle, development of medical applications and exportation of nuclear technology. Fulfillment of these goals has always been based on a long-standing active policy of human resources development
For more than 50 years the Argentinean Atomic Energy Commission (CNEA) has been deeply involved in nuclear education and training, offering academic studies and "training on the job" opportunities to young technicians and graduate students [1].
The aim of this presentation is to describe the development, current situation and prospectives of this long lasting effort, and to share our experiences and lessons learned.

2. A quick review on the argentinean nuclear sector

The Argentinean Atomic Energy Commission (Comisión Nacional de Energía Atómica – CNEA) was created in 1950. Since the onset of these activities the country maintained a policy of technological autonomy search in the peaceful uses of nuclear energy.
From the very beginning the decision of introducing nuclear energy generation for the country was taken, and further steps were guided by the idea of using nuclear activities as a catalyst for general industrial development. All the technological decisions were merged into the idea of continuous and broad development of knowledge and human resources capacities.
Research reactors and nuclear power plants development and construction became driving forces. The first research reactor built in the country began operation in 1958, and 9 years later a production reactor of local design and construction started supplying most of the radioisotopes used in the country for medical, industrial and agricultural applications.
The first nuclear power plant feasibility studies were done locally in 1965. Priority was given to participation of local industry, and resulted in qualitative jump in general industrial procedures, introducing Quality Assurance concepts.
The first NPP was connected to the grid in 1974, and the second one ten years later.

After three decades of sustained growth, and in accordance with a trend that started in industrialized countries, in the mid 1980´s nuclear activities began to decline in Argentina, due, in this case, to a combination of financial and political reasons. Major projects were delayed due to lack of funding and political support, and in the case of the third NPP, finally stopped.

Recently, the whole world became conscious about the consequences of global warming on climate changes, as well as about the risks associated with the dependence of energy mainly on fossil fuels. Nuclear energy became a quite clear option worldwide, and Argentina was not an exception to that trend.

The argentinean government has recognized the importance of including the nuclear option in the energetic matrix for the country, and has given extra support to the nuclear sector. In 2006 announced a new policy in the nuclear field, including completion of the third NPP, life extension of the second one, and feasibility studies for a fourth NPP.

3. Reinforcing nuclear knowledge assets

In this context of high demand of qualified workforce, the main concerns regarding nuclear human resources are, as in many other countries, loss of critical knowledge peril, need to identify key experts and present-future knowledge gaps, capture of knowledge from leaving professionals, and share and transfer of relevant knowledge.

The need of a strategy to face the problem is an internationally well known issue that affects the nuclear community. It has been analyzed in many publications [2-5] and conferences (e.g. [6]).

A concentrated effort on human assets development is under way, including doubling the number of students and fellowships devoted to nuclear engineering, nuclear reactors and radiochemistry, and increasing the number of fellowships for a “training on the job” programme, assigning priorities to critical knowledge maintenance and transfer.

Taking into account problems such as lower enrollment in technical studies, hard competition with growing private industries job offers, and international demand of graduates in nuclear areas, it is not an easy task.

4. Historical evolution of Nuclear Education in Argentina

From the very beginning of the Argentinean nuclear development, the availability of competent human resources was considered a necessity and a top priority. In the fifties most distinguished chemists, physicists and technologists of the country were recruited for reactor physics, radiochemistry, metallurgy and radioisotope applications. Early courses were afterwards consolidated with the creation of academic institutes in association with national universities.

Even though disciplines such as Engineering (mainly civil) and Chemistry were rather strong in the country in the fifties, other areas relevant for nuclear activities either had little development in the universities, as Physics, or none at all, as Metallurgy.

The programme started in the early fifties with courses and schools on reactor physics, metallurgy, radioisotope applications and nuclear physics.

A major milestone was the creation in 1955 of the Physics Institute (nowadays Balseiro Institute, named after its creator and first Director), in a joint venture between CNEA and the National University of Cuyo. Located in Bariloche, in the South-West of the country, it exemplifies the interweavement between development and education in nuclear activities. It share laboratories with an important CNEA Atomic Center and its faculty consists of active technologists and researchers. Its full-time students are supported by CNEA fellowships.

Simultaneously, and in close contact with the Bariloche Physics Institute, a series of lectures by leading foreign experts at CNEA set in 1955 the foundations of the formation in Metallurgy. A formal framework for this activity was established in 1962, when the first of a series of ten annual Panamerican Courses on Metallurgy, sponsored by the Organization of American States (OAS), took place at Buenos Aires. As it was planed, Pan-American Courses of metallurgy were moved afterwards to Mexico. Nevertheless, CNEA remained active in the field through annual courses, seminars and colloquia attended by hundreds of Argentinean and foreign professionals.

In the mid 1970´s, with one NPP already operating and a second one under construction, the need for Nuclear Engineers began to be felt. A study was made of nuclear engineering careers in Europe and the US, and a School of Nuclear Engineering was created in 1977, attached to the Balseiro Institute. Laboratories and a Research Reactor, RA-6, were built to support the experimental work.

In 1993, education in materials science attained full university status when the Sabato Institute was founded, as a joint venture between CNEA and the National University of San Martín. The formula of full-time students, fellowships, and technologists / researchers as teachers first implemented in the Physics Institute, was also applied. This Institute offers undergraduate and graduate studies in Materials Science and Technology, leading to Engineer, Master and PhD degrees.

Formation in Radiochemistry began in a similar way - with the establishment of some research groups and the first courses on the subject in 1952 -, and rapidly gained momentum.

Human resources development in this field continued by means of courses and alliances with different universities, until the recent creation, jointly with the National University of San Martín, of the Dan Beninson Institute of Nuclear Technology. As well as formation in radiochemistry and nuclear applications, it offers graduate studies in nuclear reactors.

Regarding health applications, CNEA has promoted the activities since the late fifties, with courses on dosimetry and in radioisotope applications that have been attended by hundreds of professionals, mainly physicians.

Close collaboration in the area of nuclear medicine was established between CNEA and several universities and health institutions. Two Nuclear Medicine Centers devoted to research, teaching and health services, were created.

5. Present capabilities in Nuclear Education

The conception of CNEA´s programme for human resources development, sustained continuously through the years, has been to form professionals with a strong scientific and technological background, and not just specialists for the nuclear techniques of the day.

Based in the understanding of the rapidly evolving field of nuclear technology, to form creative workers with problem-solving skills, backed by their solid formation, able to keep up with this high rate of changes, was and still is the target.

At present, CNEA human assets development is based on two main branches:

- **Education in its three Institutes**

Today they offer graduate and postgraduate studies in nuclear engineering, materials science and engineering, physics, radiochemistry, nuclear medicine and nuclear applications. Through the years, almost 1000 young have completed their graduate studies, and around 700 have obtained Master and PhD degrees. Besides, thousands from Argentina and other countries have taken short courses on different related topics. These CNEA's “nuclear education capacities” were recently recognized by IAEA, proposing Balseiro Institute to be a unique regional reference center for nuclear education in Latin-America.

- **Training on the job programme**

Learning by doing under the direction of senior staff members has proven to be a confident source of trained personnel and a convenient way of transferring both explicit and implicit knowledge to the new generations. Quoting a former CNEA president “experience is something that can not be bought or borrowed”

So, as an important instrument for human resources development, since the early sixties CNEA has also maintained a “training on the job” fellowships programme.
Fellowships are offered to technicians and undergraduate, doctoral and post-doctoral students in working areas selected taking into account the relevance of the subject to the main projects, and the availability of adequate direction and facilities. The need of knowledge transfer from experts retiring in the near future is also considered.
Fellows are being trained in CNEA laboratories, under supervision of staff members, mainly in: nuclear energy in its main areas, spent fuel management, radioactive wastes, environment; nuclear applications of radiations and radioisotopes, uranium prospecting, alternative energy sources, as well as some basic physics, chemistry and biology.
Some of the fellows continue afterwards their career in CNEA and its related companies of the nuclear sector, and others become engaged by the national industry or other research, development and innovation national or international institutions.
Around 200 young technicians and professionals are yearly participating in this programme, for periods between 2 to 5 years.

6. Brief description of CNEA academic institutes

Balseiro Institute, located at CNEA Bariloche Atomic Centre in the South West of the country, was created in 1955. It offers graduate and post-graduate studies in Nuclear Engineering, Mechanical Engineering, Physics, Technological Applications of Nuclear Energy and Medical Physics.
Almost 300 students have graduated in Nuclear Engineering and around 50 have got their PhD. Around 900 physicists have graduated, and more than 300 have got a PhD. Also close to 100 professionals have completed post-graduate studies in Medical Physics, and a similar number in Technological Applications of Nuclear Energy.
Its main infrastructure includes advanced laboratories for engineering and physics, library, research reactor for training, and particle accelerators.

Sabato Institute, located at CNEA´s Constituyentes Atomic Centre, close to Buenos Aires city, was created in 1993. It offers graduate and post-graduate studies in Materials Engineering, Materials Science and Technology, and Non Destructive Testing.
More than 60 Materials Engineers have graduated, while more than 130 have obtained Master and PhD degrees in Materials Science and Technology. Around 20 professionals have completed post-graduate studies in Non Destructive Testing.
Its main infrastructure includes advanced laboratories for materials science, physics and non destructive testing, library, research reactor, and tandem heavy ion accelerator.

Beninson Institute, located at CNEA Ezeiza Atomic Centre, close to Buenos Aires city, was created in 2006 to provide full academic status to a long lasting educational activity.
It offers graduate and post-graduate studies in Nuclear Medicine, Radiochemistry and Nuclear Applications, Nuclear Reactors and the Fuel Cycle. It also hosts post-graduate courses in Methodology and Application of Radio nuclides, Dosimetry for Radiotherapy and Physics for Radiotherapy.
From this Institute and previous Ezeiza´s educational activities, which lasted for more than three decades, more than 2000 professionals have completed specific topical courses.
Its main infrastructure includes advanced laboratories for radiochemistry, nuclear applications, nuclear materials, radiological protection, library, hot cells, radioisotope production reactor and its associated plant, and irradiation facilities.

7. International projection

Since its very beginning, CNEA´s efforts in education have been opened to nationals from other countries, mainly from the Latin American region.

About 60 foreign students have graduated from CNEA Institutes, while hundreds have assisted to topical courses, seminars and training on the job stays, using CNEA's financial support, or aided by bilateral agreements or by International Agencies as IAEA, the OAS or United Nations via UNDP. As an example, in the period 1999-2006 the country has received more than 280 foreign fellows and scientific visitors under IAEA Technical Cooperation programmes, almost 130 of them in CNEA working groups . Also training of foreign staff related to exports of nuclear technology as research reactors, radioisotopes production plants, fuel fabrication plants, etc., has been accomplished at CNEA laboratories.

8. Final remarks

Argentinean CNEA´s fifty years of experience have confirmed the validity of its basic educational principles: to provide a solid basic formation, complemented with important problem-solving skills, developed in an actively working environment, sharing everyday experience with professionals involved in real nuclear projects.

More than forty years of "learning by doing" at CNEA laboratories have resulted not only a valuable method for training and selecting professionals and technicians for the Institution while transferring implicit knowledge to the new generations, but has also provided creative manpower with problem-solving skills to national universities, R&D institutions and industry.

At present, Argentina has significant means to provide the qualified personnel necessary for the growth of nuclear activities in the country, with capacities and equipment that can be offered to international projects on nuclear education. Based on its 50-year experience on international cooperation in this field, CNEA is willing to contribute to the worldwide effort in developing human resources for the nuclear future.

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INSTN: CEA'S INSTITUTION DEVOTED TO NUCLEAR EDUCATION AND TRAINING

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ABSTRACT

Originally designed to train mainly engineers and researchers already involved in their professions at EDF in the nuclear industry, the INSTN has now set up a broad range of further education in leading-hedge technological disciplines (nuclear engineering, health science, nanoscience, material science) relying on the skills available at the CEA and in other organizations and industries such as, for the nuclear power sector, EDF and AREVA. Overall, its main activities cover high level education programs in partnership with universities and engineering schools, professional training for CEA as well as nuclear operators and coordination of doctoral and post-doctoral educational programs. Currently, the INSTN ambition is to reach a European and international dimension by strengthening and developing already existing transnational cooperation with universities and enterprises from the European Union as well as third countries in the frame of the European Community programs.

Introduction

The Institut National des Sciences et Techniques Nucléaires (INSTN) is an advanced education institution devoted to post-graduate education and professional training in nuclear science and technology. Created within the French Atomic Energy Commission ("Commissariat à l'Energie Atomique", CEA) in 1956, it is placed under the joint supervision of the Ministry of National Education and the Ministry of Industry.

INSTN provides students with high scientific qualifications, professionals and engineers with specialised education in all disciplines related to nuclear energy applications. Academic courses and professional training sessions are designed to put students in direct contact with specialists of each discipline providing up-to-date knowledge and know-how. To this end, INSTN has an in-house academic and administrative staff of around 115, plus the backing of some 1,200 collaborators from French and foreign Universities, research organizations (CEA, CNRS, INSERM …), hospitals, industry (EDF, AREVA…).

The institute has its own experimental facilities: an experimental reactor, ISIS (700 kW), a 2 MV Van de Graaff accelerator, new generation PWR simulators (SIREP for normal operation and SIPACT for accidental situations), scanning and transmission electron microscopes fitted with an energy dispersive X-ray analyser, simulation work sites for radiation protection, and several laboratories (nuclear physics, metallurgy, radiochemistry, biology...) where students acquire experience every year. In addition, its location facilitates the access of students to the extensive facilities of CEA laboratories.
The main mission of the INSTN is to contribute to dissemination of the CEA's expertise through specialised courses and continuous education, not only on a national scale, but across Europe and worldwide.
This mission is focused on nuclear science and technology, and one of its main features is a Nuclear Engineering diploma. Bolstered by the CEA's efforts to build partnerships with universities and engineering schools, INSTN has developed links with other higher education institutions, leading to the organisation of more than twenty-five jointly-sponsored Masters graduate diplomas. There are also courses covering disciplines in the health sector: nuclear medicine, radiopharmacy, and training for hospital physicists.

Continuous education constitutes another important INSTN activity. Short-term training programs (lasting a few days to a few weeks), mainly in French language, are designed for professional engineers, researchers or qualified technicians.
In 2007, INSTN hosted about 7500 specialists for some 2900 days of training in various fields: nuclear power plants, materials, nuclear fuel cycle, environment, health physics, security, safety, radiobiology, molecular imaging, radiochemistry, etc.. The actual complete panel of training offered by INSTN covers more then 200 different topics.

INSTN coordinates various PhD programs within the CEA which hosts approximately 1100 young scientists preparing doctoral theses in its laboratories. Research topics include all CEA areas of expertise: fundamental research in physical sciences or life sciences, research and technology for industry, R&D for nuclear energy, protection and nuclear safety. A special attention is given to the theses quality improvement. In particular, a careful preparation of subjects and, as far as PhD candidates are concerned, a rigorous selection, annual activity reports enabling a better follow-up of their research, a series of specific training completing their background are implemented.

Concerning doctoral studies INSTN offers 9 advanced courses in nuclear engineering taught in English (one module per week) to be held in Saclay, France, in September and October 2008. These doctoral-level courses address both PhD students and post-docs in nuclear research. Further information can be obtained on INSTN's website.

The following chapters will focus on INSTN's education and trainings activities in the fields of nuclear engineering and radiation protection.

Education in the field of Nuclear Engineering at INSTN

The "Nuclear Engineering degree" in France is delivered by the INSTN, also called "Génie Atomique" course. It represents a "specialized" course (Master after the masters degree in nuclear engineering) designed for engineers who can thereby acquire a broad view of sciences and techniques implemented in the nuclear energy sector based on a specific high level fundamental courses in disciplines such as reactor physics, thermal hydraulics and nuclear materials.
The "Génie Atomique" course is organized by INSTN in Saclay and Cadarache research centres for the "civilian" students and in Cherbourg for the future officers and staff of nuclear submarines and aircrafts carrier at the EAMEA military school. The curriculum, which is defined by the INSTN's professors last one calendar year and takes place in two phases:
- a first phase, from September till end of March, is devoted to the study (course, exercise and laboratory sessions) of "purely" nuclear related topics such as: nuclear physics, neutronics, applied thermal hydraulics, nuclear materials, nuclear mechanical design criteria, nuclear instrumentation, radiation protection and safety, reactor operation and control (PWR), nuclear fuel cycle, decommissioning and nuclear reactor systems. This phase totalizing more than 550 hours includes practical projects using the "major" neutronics, thermal hydraulics, mechanical and radiation protection computer codes as well as laboratory sessions on training reactors, PWR simulators and nuclear instrumentation tools.
- A second phase, from April till early September, consisting of an internship period for the students hosted by industry, universities and research centres in France and abroad. Since specialization in nuclear engineering is a multidisciplinary training, projects conducted by the students during this period provide them the opportunity to apply the systemic view acquired during the first phase to a concrete industrial situation. A Master thesis report is established and a defence is organized and evaluated by a selected jury.

This educational scheme is unique in France in terms of the number and volume of the courses and the installation involved in the training. Since its inauguration in 1956, INSTN has graduated more than 4500 students (cf. Figure 1) active today in all the major organizations (mainly EDF, AREVA and CEA) of the French nuclear industry and research centres.

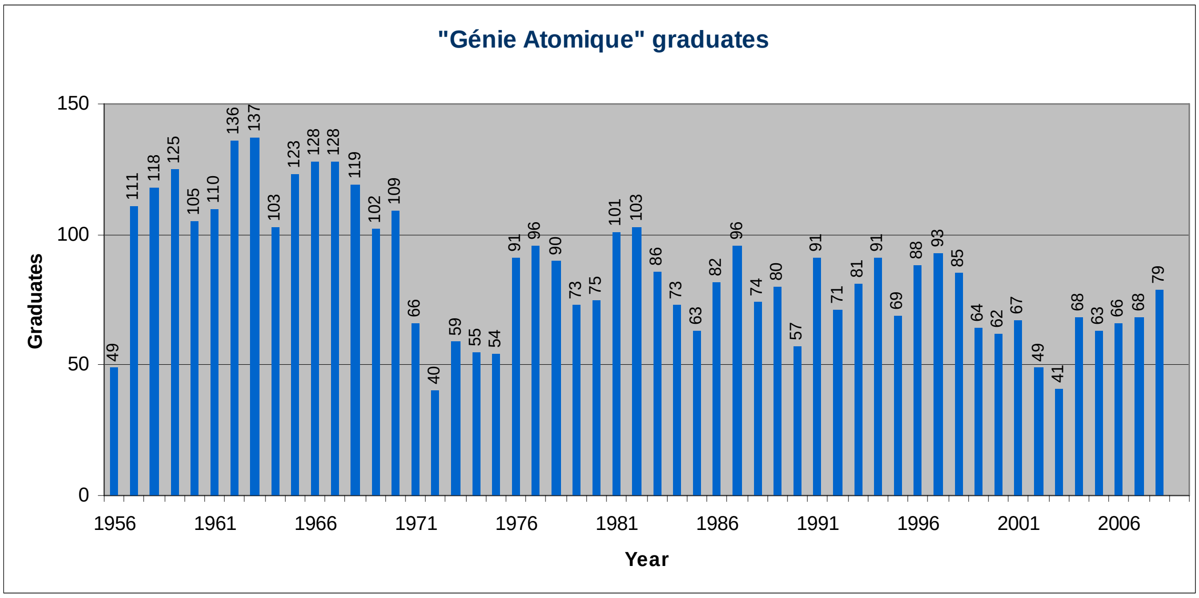

Fig.1 "Génie atomique" students registered from 1956 to 2008

Since 2003, the course is organized according to a modular structure to facilitate the mobility of French and European students taking advantage of established schemes of mutual recognition and harmonisation of best practices established under the different European Framework Programmes Coordination Actions (FP5 & 6), the ENEN and the NEPTUNO projects. The different modules are presented Figure 2 and exams are scheduled at the end of each module.

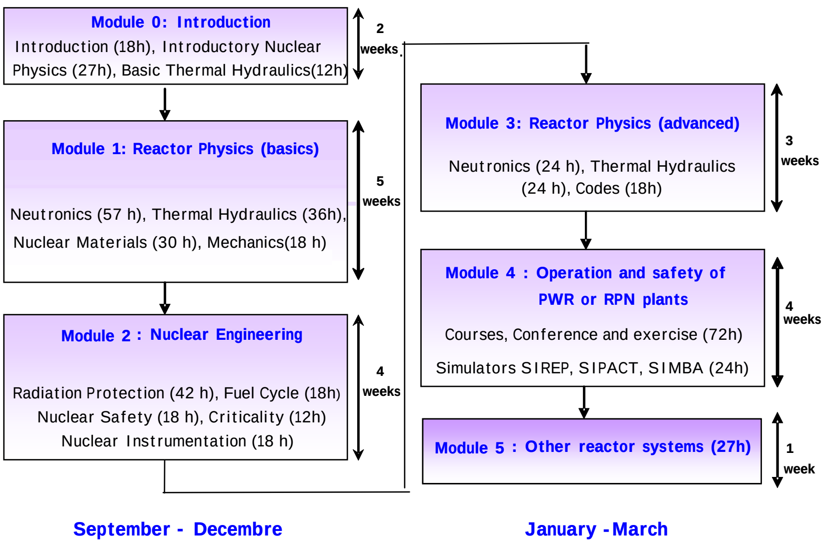

Fig.2 "Génie atomique" training modules

This modular structure of the curriculum offers young professionals the possibility of having an easier access to training on the subject of their choice. Furthermore, a comprehensive knowledge in nuclear engineering can be acquired by following the different modules over several years.

During the last period, industry representatives have clearly expressed their increasing need to engage high level engineers, educated in the field of nuclear engineering to face the new challenges of what is now called the "Nuclear Renaissance". INSTN together with University Paris Sud 11 developed a new masters degree in nuclear engineering opened to students from France and abroad. The objective of this speciality is to provide in-depth training in the field of nuclear reactor physics for the purpose of using existing tools, developing and installing third-generation reactors, and designing and developing the future systems still known as 'integrated systems'. The following courses (Table 1) will be taught in English.

	Course	Number of Hours	ECTS
UE1	Introductory to Nuclear Engineering and to Nuclear Physics	55	5
UE2	Neutron Physics – Part I	50	5
UE3	Neutron Physics – Part II	40	4
UE4	Heat Transfer – Nuclear reactor thermal hydraulics	70	7
UE5	Nuclear Materials	50	5
UE6	Use of codes, mini-projects	30	4
UE7	Pressurised water reactors – Nuclear reactors systems	50	5
UE8	Nuclear fuel cycles, Safety & Criticality, Radiation Protection	50	5
	Total	~ 400	40
Internship		5 months	20

Table 1. Courses that will be taught in the frame of the Master in Nuclear Engineering

Radiation Protection education and training

At the national level, INSTN plays a pivotal role in all the level of radiation protection education from high school graduate to engineer level. The choice of different training levels results from the analysis of the needs expressed by professionals and industrial operators. Four categories of personnel need to be trained in Radiation Protection: i) the staff capable of performing routine actions in the field of radiation protection, ii) technicians for the performance of radiation protection measurements and a check of their effectiveness, iii) advanced technicians participating in the definition of radiation protection measures and capable of managing action teams, iv) engineers developing the design, risk prevention and control of installations and monitoring of the exposed personnel in normal or accidental situations. Accordingly, four types of courses has been developed by INSTN (cf. Figure 3), each corresponding to a category of personnel: i) first level of general training in radiation protection (PNR, eight weeks), ii) the Technician Diploma in Radiation Protection (BT, four months + one months of practical work), iii) the Advanced technician Diploma (BTS, six months + two month of practical work) and iv) the Master in Radiation Protection (six month + six months of practical work). Those highly specialized theoretical and practical courses, which are recognized by professionals and operators, are open to students but also to employees willing to improve their professional qualification in the Radiation Protection field. The Master degree is approved by the French Ministry of Education and will reach a European dimension by September 2008 (cf. European and international education at the INSTN).

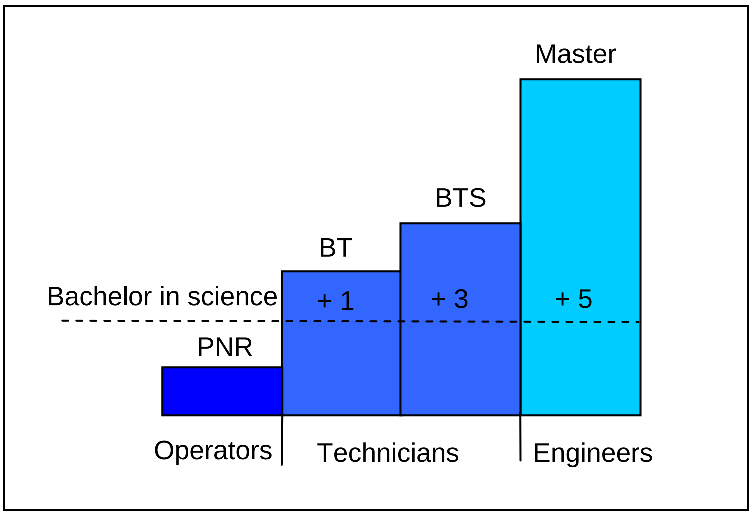

Fig.3 Initial training of professionals in radiation protection

In addition to those courses designed to prepare for a degree, INSTN offers also a wide variety of training sessions for users of radiation sources and exposed personnel. Some of those courses follow regulatory requirements (competent person, transport of radioactive material) or specific requirements of the operators, such as the CEFRI courses. CEFRI (stands for the French Committee for Certification of Companies for Training and follow-up of personnel working under Ionizing Radiation) is the only certification agency in France for outside companies that employ workers in ionizing environments. Its purpose is to check the proper application of French regulations governing radiation protection in a quality system. It grants a four years certification to the companies, temp agency and training institutions. Training is a major requirement of CEFRI, which sets the programs and duration of each course and stipulate the procedures for a school site as well as the teachers training requirements. Several INSTN trainers has the CEFRI certification which enables them to give lectures and manage CEFRI accredited courses. In 2007, 181 courses on “Risks prevention” accredited by CEFRI has been held for almost two thousand operators from EDF, CEA, AREVA and other companies.

European and International educational at the INSTN

The strategy of INSTN at the European and International level complies with the CEA directives. Cooperation at the European level is one of the priorities of the CEA that is involved in over 180 projects under the 6th European Framework Programme and coordinates 34 of them. INSTN has been involved in these actions by participating to the European Nuclear Engineering Network (ENEN) under FP5 and coordinating the Nuclear European Platform of Training and University Organisation Network (NEPTUNO) under FP6. INSTN plays also a key role in the management of up to 25 theoretical and practical trainings in the molecular imaging field in the frame of the Networks of Excellence European Molecular Imaging Laboratories (EMIL, www.emilnet.org) coordinated by the CEA and Diagnostic Molecular Imaging (DiMI, www.dimi.eu) coordinated by the MPI in Cologne. More recently INSTN has been involved in several ERASMUS curriculum development programs such as the European Masters in Radiation Protection (EMRP) and Molecular Imaging (EMMI, presented as P1.62) which is coordinated by INSTN. Jointly developed by the CEA/INSTN and the Universities of Paris-Sud 11, Antwerp (UA), Crete and Torino, EMMI will welcome in September 2008 its first students in France, Italy and Belgium. This high level program is promoted and financially supported by the European Commission. Its ambition is to ensure a high level teaching program in the emerging field of molecular imaging from which will graduate scientists destined to work in research as well as in the Industrial field.

The Institute has been awarded the extended European University Charter 2007-2013 and, as stated in its Erasmus Policy Statement (EPS), it intends to strengthen and extend the undertaken actions by:

- implementing European master and doctorate curricula as well as intensive programmes in the fields of nuclear engineering, nanoscience, health technologies, material sciences, mathematics and applications in which the CEA is a major player,
- increasing the number of multilateral cooperation with higher education institutions and enterprises,
- promoting the mobility of students and teaching staff to favour scientific exchanges, cooperation and dissemination of best practice.

Traditionally, INSTN also organises courses exclusively intended for specialists from foreign countries under the auspices of the International Atomic Energy Agency (IAEA).

Conclusion

INSTN is one of the major players in France in education and training on nuclear engineering and radiation protection fields. In addition, it implements high level educational programs in partnership with universities and engineering schools as well as professional training in the new fields explored by the CEA’s research team. With a wealth of experience in international collaboration for many years, INSTN is highly committed to the development of the European higher educational area in nuclear sciences and technologies.

CAPACITY BUILDING INITIATIVES FOR THE NUCLEAR SECTOR IN SOUTH AFRICA

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ABSTRACT

South Africa is facing a serious challenge of meeting current and future energy demand. In order to address this challenge head-on, the government has promulgated a number of nuclear-related policies and programmes that particularly look at capacity building, research and development The biggest challenge is to provide a critical mass of human capital to address a nuclear expansion programme that will see an addition of about 20 000 MW of nuclear power by 2025. One notable programme to address this challenge is the South African Nuclear Human Asset and Research Programme (SANHARP), whose aim is to facilitate a broad-based national programme that will deliver on capacity building and research and development initiatives for and in partnership with the nuclear sector. Although focusing on the upper part of the skills pyramid, SANHARP seeks to play a further role in initiating and facilitating the alignment and co-ordination of funding programmes.

1. Introduction

South Africa's electricity utility, Eskom, intends to build an additional 40 000 MW of energy by 2025. Of this, 20 000 MW will be from nuclear sources, composed of new conventional nuclear power plants and the pebble-bed modular reactor, when the technology has been successfully demonstrated. This nuclear expansion programme will be kick-started with *Nuclear 1* – the supply of about 3 800 MW from PWR technology to be operational by 2016. This will then be followed by a fleet quadruple that of Nuclear 1 by 2020 to 2025. The skills requirements for the expansion programme for Eskom alone are illustrated in Table 1.

	Nuclear 1	Fleet (X4)	Localisation
1. Power Stations	1000	3200	3200
1.1 Engineering	100	300	2500
1.2 Programmes	100	400	600
1.3 Other	100	200	400
2. Nuclear Programmes	300	900	3500
Total (Eskom)	1300	4100	6700

Source: TSAPRO, 2008

Table 1 Eskom's skills requirements by 2020

2, Discussion

There are currently a number of educational courses provided at institution and industry levels aimed at the nuclear sector in South Africa. These have been in place to support the already existing nuclear infrastructure.

2.1 Education and Training Programme

2.1.1 Nuclear Education (Institution level)

Courses that are currently on offer and being planned are shown in Table 2.

Institute	Course	Stage of Development
Nelson Mandela Metropolitan University (NMMU)	Bsc Reactor Physics and/or Radiation Protection	Under Discussion
	Diploma: Radiation Protection	Under Discussion
Northwest University - Faculty of Engineering (Postgraduate School of Nuclear Science & Engineering)	Masters & Doctorate: Nuclear Engineering	Currently Offered
	Postgraduate Diploma: Nuclear Engineering	Applied to provide
	Masters: Nuclear Project Management	Currently Offered
Northwest university - Center for Applied Radiation Science & Technology	Bachelors (Hons) & Masters: Applied Radiation Science & Technology	Currently Offered
Stellensbosch University	Bachelors (Hons): Radiation & Health Physics	Currently Offered
	Bachelors (Hons) Nuclear Physics	Currently Offered
University of Cape Town	Nuclear Power Engineering and Nuclear Power Sources: 4th year Electrical Engineering Module	Currently Offered
University of the Witwatersrand	Postgraduate Diploma: Radiation Protection	Currently Offered
	Postgraduate Diploma: Physics, engineering and Safety of Nuclear Power Reactors	Currently Offered

Table 2 Nuclear education courses provided at various South African Institutes

2.1.2 Industry Training

Table 3 shows education and training programmes provided by industry.

Arecsa Human Capital	Joint venture between South African Nuclear Industry (headed by Necsa) and Areva
IAEA fellowships	
AFRA workshops and training courses	
Bilateral arrangements between SA nuclear organisations and overseas institutions	Training and staff exchanges
In-house training	e.g. at Koeberg Nuclear Power Station and Necsa

Table 3 Training provided in industry

2.2 Funding Programme

In support of the South African government's vision for expanding nuclear energy in the South African electricity mix, the Department of Science and Technology (DST) undertook to establish a coordinated programme to advance skills and innovation frontiers along the value chain of the Pebble Bed Modular Reactor (PBMR), ranging from basic and applied research in all applicable science and engineering disciplines, to manufacturing and distinctive aspects of waste management. The PBMR Human Capital Research and Innovation Frontier Programme (PHRIFP) was established out of a consensus of key stakeholders in nuclear energy. In February 2005, PBMR (Pty) Ltd was awarded a one-year contract to initiate the implementation of the Programme.

Since the initiation of the Programme, the South African government has reiterated its commitment to nuclear energy as a significant ingredient of the future electricity mix. It is envisaged that the expansion of nuclear power will in the short to medium term come from conventional nuclear power technologies such as Pressurized Water Reactors.

Skills to support the future nuclear energy industry would need to be broadened to support the entirety of the government's strategy for the industry, that is, the technologies that will be employed in the near to medium term and longer term technologies, such as the PBMR.

The PMBR, being only one of a number of nuclear technologies, and given a number of applications of nuclear technology (beyond energy), a decision was taken to expand the scope of PHRIFP to address the skills needs of the entire nuclear industry. To this end, PHRIFP was renamed the South African Nuclear Asset and Research Programme (SANHARP) and the secretariat moved from the PMBR (Pty) Ltd in Centurion to the South African Nuclear Energy Corporation (NECSA) in Pretoria West.

The vision of SANHARP is to facilitate a broad-based national programme that will deliver on capacity building and research and development initiatives for and in partnership with the nuclear sector in South Africa.

The mission of SANHARP is initiate, facilitate and support education, learning, knowledge transfer and research programmes that would provide solutions to the current and future human as well as intellectual capital requirements of the SA nuclear sector.

SANHARP has the following objectives:

1. To strategically position the development of human and intellectual capital for the SA nuclear sector on the local and international platform.
2. To promote teaching, research and innovation capacity in South African secondary and tertiary institutions in strategic areas of science, engineering and technology for the nuclear sector.
3. To facilitate nuclear skills development through skills transfer programs, collaboration and co-operation as part of technology acquisition from local and international institutions.
4. To develop a critical research and skills base to support the SA nuclear sector.
5. To promote and ensure comprehensive public awareness and understanding of nuclear related issues.

Aimed at achieving the above objectives, SANHARP is running the following projects:

1. The Bursaries Scheme which offers full sponsorships to students in selected areas of science and engineering from undergraduate level to postgraduate level. There are currently more than 160 bursary holders in the scheme and the number is expected to reach 500 in the next 5 year.
2. The Schools Outreach Project seeks to ensure a pipeline of learners with a strong foundation in mathematics and science to take up undergraduate bursaries which are offered by the Programme. The project currently offers bursaries (scholarships) to students from grade 10 to grade 12 in 32 so-called Dinaledi Schools (Science- and Mathematics-themed schools)
3. The Nuclear Hub Website dedicate to provide awareness of nuclear industry and serve as a hub for different stakeholder users

4. The Research Chairs (who's management is under the NRF's South African Research Chairs Initiative, SARCHi) seeks to create chairs in defined research themes pertinent to nuclear technology
5. Communities of Practice aimed at supporting stakeholder-groups and associations in the nuclear industry

Figure 1 shows funding of education programmes along the skills pyramid. Although there are funding programmes, these are rather sporadic and properly streamlined and co-ordinated. There are now attempts co-ordinate programmes through the education and training sub-committee of the newly-formed *Nuclear Industry Association of South Africa (NIASA)*, an association representing the nuclear industry.

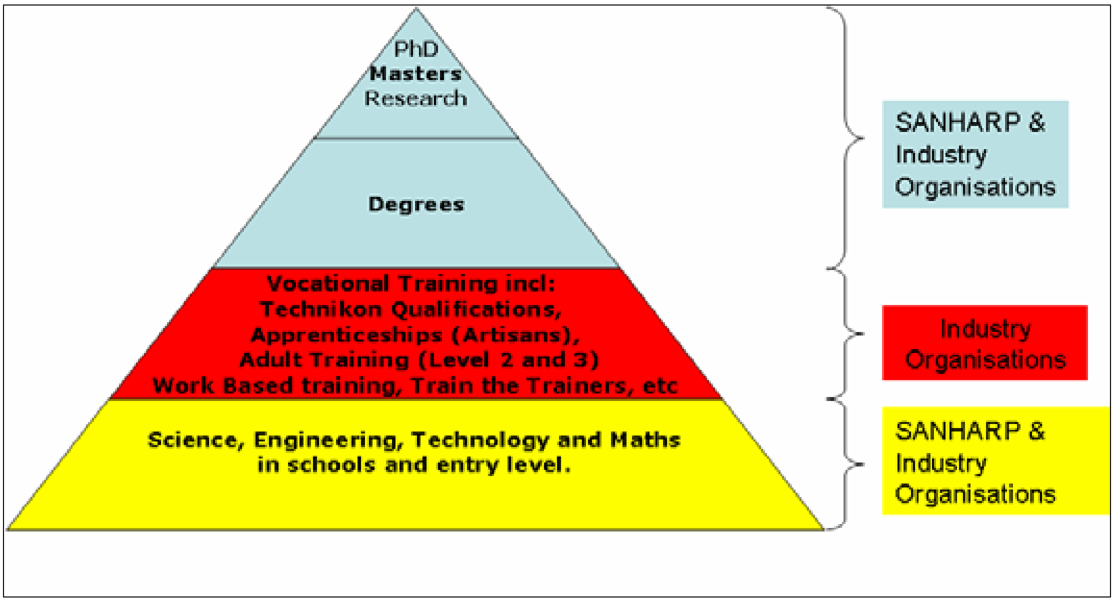

Figure 1 Funding programmes for nuclear education and training along the skills pyramid

Conclusion

South Africa has a challenge to develop a critical mass of skills required by the nuclear expansion programme that will see 20 000 MW of power from nuclear sources by 2025. Although government has responded to this challenge by establishing SANHARP which will address the high-end skills within the skills pyramid, there is a need to address all required skills in a co-ordinated fashion. To this end the NIASA education sub-committee will attempt to create a framework that will be holistic in addressing skills requirement for the South Africa nuclear expansion programme.

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THE USE OF MOBILE LEARNING TECHNOLOGY IN THE NUCLEAR SCIENCE AND ENGINEERING PROGRAMS AT THE UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY

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ABSTRACT

The Ontario Province of Canada is dependent on nuclear power for 50% of its electricity production. There is increasing demand for graduates of nuclear engineering and science programs to provide the expert human resources needed to operate, maintain and extend the life of the current units, and to deign, construct and operate new units. Reflecting the extensive use of computers in the nuclear industry, the specialist nuclear education programs should also make strong use of computers to enhance the learning process. The only nuclear engineering undergraduate degree program in Canada is offered at the University of Ontario Institute of Technology (UOIT), where every student is issued with a standard configuration laptop computer. Through a coordinated, comprehensive and ubiquitous use of digital technologies, UOIT has built a unique technology-enhanced learning environment, wherein the use of laptop computers, learning management systems, powerful course-specific software programs and comprehensive online interactions define the educational experience for all students.

1. Introduction

Nuclear generated electricity was first produced in Canada in 1962, from the Nuclear Power Demonstration (NPD) unit, the first CANDU (CANada Deuterium Uranium) power plant. From that small beginning grew an industry that conducts world-class research, development, design, construction, commissioning, operation and maintenance of nuclear power plants, as well as research reactors and several related technologies. The Province of Ontario, with a population of 13 million, has been the centre of Canada's nuclear industry, in particular approximately 50% of the electricity used in Ontario is generated from CANDU nuclear units. Two other provinces each operate 700 MW CANDU units.

The current fleet of Canada's nuclear plants ranges in age from 15 to 37 years, with a substantial amount of life-extension work having already been carried out on the older units, and similar projects being planned for the remaining ones. The continuing increase in demand for electricity as the population grows and its standard of living increases, and despite strong conservation efforts and the transfer of significant manufacturing capacity abroad, the Government of Ontario has requested proposals for new nuclear generation. In addition to meeting increased demand, the new units are required to enable the closing of the remaining coal fired generation, so as to meet environmental targets to reduce green-house gas as well as particulate emissions.

2. Human resources development for Canada's nuclear industry

Corresponding to the aging of the nuclear power plants is the demographics of the workforce. About half of the engineers and scientists in the nuclear industry are reaching retirement age in the next five years. A similar situation exists in several other high technology industries in Canada, and world-wide in the nuclear technology sector.

During the design and construction of the early units, particularly in the 1970s and early 1980s, a combination of university science and engineering programs and industry-specific training produced the required skilled personnel. As the design activities decreased in the late 1980s and the construction of new units in Ontario essentially stopped by mid 1990, universities no longer had the number of students required to keep offering nuclear-specific courses and degree programs. At the start of the new millennium the industry recognized the lack of specialized graduates being produced by universities, and decided to establish the University Network of Excellence in Nuclear Engineering (UNENE) to address this problem (1). The specific mandates of UNENE are to fund research chairs at the seven member universities located in Ontario, to fund additional nuclear-specific research at any Canadian university, and to offer a course-based Master of Nuclear Engineering program. Unique features of the latter are the offering of courses on weekends, and the option to take any course at any of the participating universities.

The appointment of professors with specialist knowledge in the nuclear field has enhanced the offering of undergraduate courses, and has provided new consulting services to industry. The increased profile of nuclear research at the universities, and the public's awareness of employment opportunities in the nuclear sector have also raised student interest in these courses. However, the majority of university graduates hired into the nuclear industry gain their nuclear-specific knowledge after becoming employed in the industry, typically via company or other specialized training courses.

Apart from universities, community colleges are graduating technicians and technologists, and are supporting apprentice programs that produce the trades people who are in even greater demand than scientists and engineers. With a few exceptions these graduates have received little if any nuclear-specific education, and will require the specialist training after joining a particular company.

Industry training remains a critically important part of ensuring that the required specialist knowledge and skills are given to the men and women working in the nuclear sector. Training that requires such specialized equipment as full-scope replica simulators, systems and components unique to a given unit, tasks to be performed within the plant, are best conducted by the particular company that is responsible for the operation and maintenance of the equipment.

3. UOIT's nuclear degree programs

A somewhat unique combination of events led to the establishment of nuclear degree programs at the University of Ontario Institute of Technology (2). These events included the aspects of plant aging and demographics described above, the location of 12 CANDU units within a 25 km radius of UOIT, the decision by the operator of these units (Ontario Power Generation) to move their nuclear head office staff from downtown Toronto to within the above mentioned 25 km radius of UOIT, and the recognition that the combination of demographics, plant life extension and new build projects will require an unprecedented number of nuclear science and engineering graduates.

The first intake of students into the undergraduate nuclear programs took place in September 2003, with 110 students selected from over 400 applicants. The first graduates of these programs joined the work force in 2007, and initial feedback indicates that the nuclear-specific education they received has resulted in enabling them to become more productive sooner than graduates of the more typical science and engineering programs.

The master of Nuclear Engineering program, both research and course based has recently received approval, and will have its first students in the 2008-09 academic year.

While classroom lectures remain an essential part of the education provided at UOIT, the use of computers to enhance learning has been a key aspect of the success of the programs and our graduates. The CANDU reactors, by their unique characteristics, required the use of computer monitoring as early as the 1960s, and the use of computers was extended to control and safety systems with each subsequent power plant. As well, Canada was an early developer of full-scope nuclear plant replica training simulators, with the first such training tool for the Pickering A units becoming operational in 1976. The unique synergy of the use of computers in the CANDU reactors and operator training programs made the extensive use of computers in UOIT's nuclear degree programs a logical outcome.

4. The use of mobile learning technology at UOIT

UOIT's goal from the outset was to be both a research-intensive and a student-centric institution. An important additional mission of the university was to investigate how strategies for college-university transition could be facilitated through co-location and the application of information and communication technologies (ICT) to facilitate movement of students from one level of education to the other. The university administrators envisioned the incorporation of ICT throughout all aspects of the institution. They believed that the use of computer technology to enhance learning would support high achieving students who would be fully prepared for the emerging high-tech world of work. Consequently, the university was designed as a fully "laptop" university, the second in Canada, and the first in Ontario. Planning included building both an online infrastructure and a purpose-built physical infrastructure, to facilitate learning both on and off campus, from any location and at any time in lecture halls, research laboratories, the library, and in public areas such as study halls, cafeterias and on-campus restaurants. The combination of ubiquitous Internet access and the provision of standards-based laptop hardware has allowed UOIT to establish a teaching and learning environment that addresses total student access to learning technologies, creating common access to a unique web-centric learning environment.

The "web-centric" learning environment at UOIT can be defined as the strategic integration of information and communication technologies into all aspects of the teaching and learning processes. Through coordinated, comprehensive and ubiquitous use of digital technologies, UOIT has built a unique technology-enhanced learning environment, wherein the use of laptop computers, learning management systems (LMS), powerful course-specific software programs and comprehensive online interaction defines the educational experience for all students.

A "web-centric" learning environment is best described as the coordinated implementation of institutional services and learning infrastructures to support network-based teaching and learning. The adoption of digital technologies within higher education institutions requires investment in both hardware and software, and in the necessary support systems to provide a learning environment where students experience both a "high-touch and a high-tech" educational experience, and where faculty are supported in their use of both new network technologies and new pedagogical approaches to instruction (3, 4).

Four support components and/or services systems form the core of the web-centric environment at UOIT: Learning Infrastructure, Online Educational Services, the Mobile Learning Program, and Research Support. Each component provides a foundational element for the strategic use of information and communication technology at UOIT. Rather than merely applying ICT to enable distance learning or distributed education, UOIT has developed a unique learning model, whereby digital technologies enhance face-to-face (F2F) education through the application of digital technologies to enhance student engagement, both online and in F2F classroom settings, in a coordinated strategy. To that end, all learning spaces are equipped with instructional technology that supports the blending of online and classroom-based interaction. All learning spaces are equipped with smart podiums to facilitate F2F instruction using laptop computers, data projectors, DVD players, and Internet access.

Laptop programs are most often valued for their provisioning of hardware and campus connectivity. However, the value of the laptop component of the web-centric learning environment is not only the distribution of 4500 IBM ThinkPad laptop computers, but also making available the necessary course-specific software for learning. All laptop computers are “imaged” with course and/or program specific software that students require for specific courses or programs. Software is preloaded each summer when all student laptop computers are returned to the university for refurbishing and re-imaging. Making software available centrally to students results in standardized software tools for students and financial benefits for procurement and institutional support. In addition, standard software packages assist faculty in designing courses and specific activities using pre-selected course software. For example, students in the Faculty of Energy Systems and Nuclear Science have access to nuclear plant simulation programs on their laptop computers.

The adoption of ICT and its effect upon pedagogy continues to challenge institutions with the question of how best to address paradigm shifts in both teaching and learning. Research indicates that students and faculty experience frustration with the introduction of new technology without also having the appropriate support structures in place (5). To successfully merge traditional F2F lectures with the development of an online learning community, UOIT recognized that it is imperative to develop strategic support systems that can provide a seamless environment whereby students and faculty could receive assistance when required. By empowering both faculty and students with “right-fit” technologies, the institutional focus was to enhance students’ education/experiences. The UOIT institutional support centers are depicted in Figure 1.

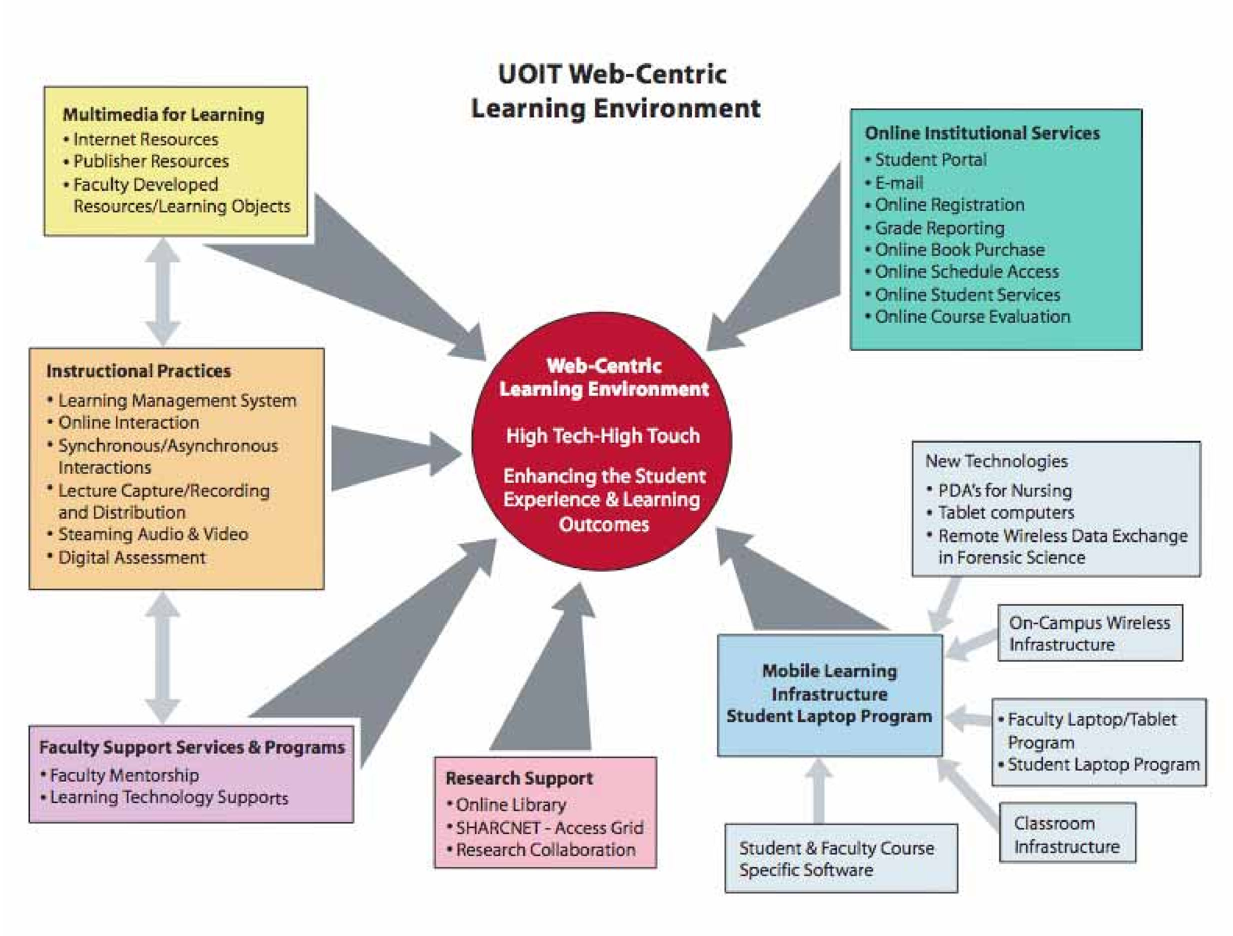

Fig 1: Web-centric learning environment

Finally, the potential impact on other postsecondary institutions emanating from UOIT's pioneering development of a web-centric learning environment may be substantial. While many institutions are expanding their use of information and communication technologies on campus and encouraging the adoption of mobile computing devices by students, the scale and scope of the current integrated technology-enhanced learning environment positions UOIT as a leader in the field of campus-based "web-centric" learning. The scope of the technology provision at UOIT and the scale of the implementation and use of "network" technologies are providing important theoretical and practical insights into best practices regarding technology adoption by universities.

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