Internationalization of nuclear education and training with the use of nuclear infrastructure and simulation tools

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Abstract. Internationalization the training programmes with inclusion of web-based training modules and students’ mobility access to the research facilities within the international initiative is a proposed mechanism to bring nuclear education to the new level in terms of attractiveness and quality. The paper discusses proposed nuclear-educating forums which could be international training courses, which are the complex of training modules containing practical exercises and theoretical training in both online format and traditional face-to-face sessions. Among foreign countries demonstrating interest in Russian reactor facilities, there is a demand for training courses on the use of software to justify the safety and technical parameters of nuclear power plants based on different design: from classic VVER to advanced SMR technologies. At the Rosatom Tech, the new format of regional courses are held on an annual basis within the framework of the technical cooperation project of Rosatom State Corporation and the IAEA on infrastructure development and safety assessment of VVER-type pressurized water reactors with the active use of Russian computational tools.

1. Introduction
The interest in nuclear industry from the young specialists thinking about their future careers is not as high as ten-fifteen years ago and there are many of reasons for that – nuclear accident, vague plans for nuclear future in leading countries with a large number of NPPs and sometimes even negative image of nuclear overall [1]. A recent study shows that few millennials see nuclear as a top emissions-free energy source, or as part of our future energy sources [2].

In order to increase the attractiveness of the nuclear field globally, it is necessary to educate a broad audience of people, to communicate clearly with the general public about the advantages of nuclear power has and to position nuclear as a backbone option for sustainable development.

The approach proposed within this work is a further expansion of international cooperation in terms of research, education, and training through joint involvement of the capabilities of educational, research and industrial organizations involving in the process students and young researchers from all over the world [3].

Among new-comer countries that show interest in nuclear technologies, there is a demand for training courses on the use of software to justify the safety and technical parameters pre-selected nuclear technologies. Russia State Atomic Energy Corporation ROSATOM is a world leader in a nuclear industry at an international level implementing projects in 50 countries. The construction of Nuclear Power Plants abroad is a clear indicator showing that the Corporation one of the leaders in the world in
this field. By the end of 2018 portfolio of NPP construction projects is made up of 36 power units to be constructed all around the world.

Furthermore, ROSATOM proposes a new project different from NPP – Centre of Nuclear Science and Technology (CNST) and this is a good offer for countries which want to take an intermediate step and bring economic to the new level.

Both products are the integrated offers including the wide range of works and services which begin from the stage of creating of the infrastructure in the newcomer country meeting the IAEA requirements. And of course, these entire activities will be finished when the nuclear facility will have been decommissioned.

2. International nuclear education and training

Training of NPP and CNST personnel is one of the key stages since it starts long before construction of the facility [4]. As an example, foreign partners showing interest in Russian reactor installations are also interested in training courses using Russian software, which is used to justify the safety and technical parameters of NPPs under construction. Usually such software has some specific features due to long history of development for the Russian designs of nuclear reactors, which can be covered by

The paper discusses a new approach to the internationalization of nuclear research education and training based on the experience of Rosatom Technical Academy in conducting training courses and bringing together key stakeholders from education, science, and industry.

Competences related to the safety assessment of nuclear facilities is key for making knowledgeable decisions in the design, licensing, and operation of nuclear power plants.

The core of nuclear-educating forums could be international training courses, which are the complex of training modules containing practical exercises and theoretical training, e-learning and interactive sessions conducted all over the world and have a duration from 36 up to 504 academic hours of training overall. Modular training program for professional training, continuing education, and retraining on the safety assessment of NPP conducted in English and different formats: eLearning modules including simulation tool practice and face to face training.

The main tool for that is a new kind of international course with the mobility of young researches and students around the world and also with the use of domestic simulation tools and research infrastructure. As an example, the course could be composed of 8 modules of theoretical and practical training with overall duration – 504 hours (14 weeks) [5]:

- Training module «Introduction to practical aspects of reactor technologies»;
- Training module on regulatory base issues;
- Training module on preliminary safety analysis report (Including PSA);
- Course on review of simulation codes: neutronic and thermal hydraulics;
- Practical session on the analytical simulator of NPP;
- Fellowships with the use of Russian and international simulation codes for safety assessment;
- Training module on the economics of nuclear power industry;
- Practical fellowship at a universities’ research facility dedicated to accident analysis.

The target audience for such a course are students, young specialists, and personnel of national organizations (regulator, NEPIO, TSO, etc).

A comprehensive training like the one suggested above inevitably involves an impact from nuclear companies representing different sides of the industry, science, and education.

3. Training course using cloud technologies

There are different formats, in which training could be conducted, so each module could be conducted as a workshop including scientific visits, regional training courses, fellowship programmes, international schools. Rosatom Tech has experience providing the services in the following formats and combinations of them, including bringing together experts from the different sides of the industry. The biggest challenge in organizing this kind of training is to attract counterpart from the industry side, for whom training is not a top priority activity. The best practice case for such activity at Rosatom Tech is
regional courses which are held on an annual basis within the framework of the technical cooperation project of Rosatom State Corporation and the IAEA on infrastructure development and safety assessment of pressurized water reactors with the active use of Russian computational tools [6].

For example, the regional training course of the IAEA, dedicated to the special issues of safety analysis of VVER / PWR reactors, was held from October 25 to November 2 at two sites: Rosatom Technical Academy in Obninsk, Kaluga region, and NITI Institute at Sosnovy Bor, Leningrad region. This course was organized within the framework of the technical cooperation project of ROSATOM and the IAEA RER/9/144: “Capacity building for infrastructure development and safety assessment of water-cooled power reactors with improved safety characteristics”, with a significant part of the course devoted to the one-dimensional thermal-hydraulic code of the improved evaluation KORSAR.

Russian Federation was represented by six experts from four organizations, as developers of computer codes used in the safety assessment and Rosatom Tech. A representative of the IAEA participated in the course as an international expert.

Ten specialists from six countries: Armenia, Belarus, Bulgaria, Hungary, and Slovakia participated in the training course as trainees. The experts delivered their lectures and presentation on new design principles in international safety standards, safety assessment procedures using improved evaluation codes, calculation codes and their numerical models, verification results, examination and certification of improved evaluation codes, etc. Besides, a significant part of the program included practical exercises using the codes MCU and KORSAR, which were particularly noted by the students of the program as a very useful activity. The event was the first stage in the implementation of the concept of an interactive training course for the development of the Russian nuclear technology market, within the framework of which a set of training tasks was developed for conducting practical sessions for students.

The practical part of the course included both basic demonstration tasks, which allow to visually show the work of codes - modeling harmonic oscillations with increasing levels in one of two communicating vessels, and the task of verifying the code on known experimental data. In the course of laboratory work, not only methods of solving problems using domestic software codes were demonstrated, but also the main approaches used by developers in conducting calculations to justify safety. Participants praised the practical session on the code application.

4. Web-based laboratory workshop
An important part of the course is a laboratory workshop, created to develop basic skills for calculating the basic processes occurring in reactor installations, to justify their safety using Russian software systems. To demonstrate the level of development of Russian design codes in support of nuclear technologies the Rosatom Tech has developed a new interactive course for training foreign specialists. An important part of the course is a laboratory workshop, developed to develop basic skills for calculating the basic processes occurring in reactor installations, to justify their safety using Russian software systems. An interactive course at the Technical Academy of Rosatom is being introduced into a web portal that combines lectures, test assignments, and a practical test. Access to the portal is open and free to all registered users.

The web-portal to be used as an entry point and an invitation to attend a full-time course. Correspondence use of the course will give an overview of the technology and prepare the listener for a face-to-face meeting, and full-time training, in turn, will speed up the testing process, simplify the use of software in a practical case, demonstrate the full range of uses of Russian calculation codes.

The next step in implementing interactive web-training module for the training was taken in February 2020 during the training course in Indonesia, STTN [7], where the cloud platform was used by students to access the remote desktop with preinstalled KORSAR code. This solved the potential issues: universal workstation environment among students (eliminates the software configuration steps) and restriction of software distribution. At the same time, students could work using their personal computers and having direct access to the input and output files.
The course results demonstrated a high satisfaction of students by the training provided, including web-based practical exercises. The next step would be to propose such a mechanism in the form of a digital laboratory for worldwide use.

Designing an interactive training course concept with the use of the KORSAR code is the introduction of its demo version into the web-based platform of the Technical Academy is a new step toward the modern training approach using state-of-art simulation tools.

The presented online course, unlike the well-known educational online platforms, will include highly specialized courses on nuclear power and domestic technologies, read by leading experts of Rosatom, as well as use special Russian codes for practical sessions.

The proposed online course includes highly specialized courses on nuclear power and domestic technologies, read by leading experts of the nuclear industry, as well as use special simulation codes for practical sessions.

The motivation for developing such a big program composed of face-to-face training sessions and integrated online courses is a training of highly educated personnel with very specific knowledge, skills, and competences which will be still required regardless of the development of nuclear power sector around the world, since new builds, development of innovative and advanced reactors, long-term operations, shut-down, decommissioning, waste management and radiation protection – all these sectors have a lack of qualified staff already or will face this lack in near term future.

Such training including development of training materials and content for online training facilitates international cooperation between universities, industry and research institutes and will help to:

- maintain international cooperation between industry, universities, and institutes to ensure high quality of education following international standards, keeping the level of teaching and preserving knowledge in the field of research, education, and training in the field of nuclear science and technology;
- build joint educational programs to prepare a community of highly educated and experienced experts in the field of nuclear science and technology;
- provide an opportunity to exchange existing curricula, programs and handbooks for students, graduate students, and trainers;
- joint development of new curricula, programs, and handbooks;
- joint participation in international projects related to the development of nuclear research, education, and training, including implementation of advanced simulation tools;
- improve the image of nuclear power as one of the key tools to fight climate change in the world;
- perform joint research to support enhancement and justification of modern pressurized water reactors safety features, as well as the development of fourth-generation reactor technologies, including commercial fast reactors to create a two-component nuclear power industry.

So internationalization the training programmes with inclusion of web-based training modules and students’ mobility access to the research facilities within the international initiative is a proposed mechanism to bring nuclear education to the new level in terms of attractiveness and quality.

The adaptation of the training module on software use into interactive web-course at the Technical Academy of Rosatom is underway. A web portal that combines lectures, test assignments, and a practical test is being developed as a standalone product. Passing the course provides an overview of the technology and prepares the student for a face-to-face meeting, and full-time training, in turn, will speed up the testing process, simplify the use of software in a practical case, demonstrate the full range of simulation codes applications.

To increase the attractiveness of the nuclear field globally it is necessary to educate a broad audience of people, to communicate clearly with the general public about nuclear power. The core of nuclear-educating forums could be international training courses, which are the complex of training modules containing practical exercises and theoretical training in both online format and traditional face-to-face sessions.
5. Conclusion
In order to increase the attractiveness of the nuclear field globally, it is necessary to educate a broad audience of people, to communicate clearly with general public about the nuclear power. The core of nuclear-educating forums could be international training courses, which are the complex of training modules containing practical exercises using simulation tools and theoretical training provided by experts from all over the world.

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