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The European Nuclear Experimental Educational Platform – ENEEP: Overview and Demonstration Activities

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ABSTRACT

The European Nuclear Experimental Educational Platform – ENEEP is currently being established by five European educational and research organizations in the framework of a Horizon 2020 project, initiated in 2019. The ENEEP partner institutions are the Jožef Stefan Institute (JSI, Slovenia), the Slovak University of Technology in Bratislava (STU, Slovak Republic), the Czech Technical University in Prague (CTU, Czech Republic), Technische Universität Wien (TU Wien, Austria) and the Budapest University of Technology and Economics (BME, Hungary). ENEEP is intended as an open educational platform, offering experimental hands-on education activities at the ENEEP partner facilities, which are in need in order to maintain high education standards in the nuclear field.

ENEEP is being developed on the basis of a comprehensive set of experiments performed at the ENEEP partner facilities, comprising the basics in reactor physics and nuclear engineering curricula, as well as more specific experiments focusing on particular aspects – investigated phenomena, types and working principles of detectors, etc. Novel education activities will be introduced and implemented in ENEEP, following scientific development in nuclear science and technology and nuclear instrumentation detectors stemming from research activities. ENEEP education activities will be offered in different formats (group and individual) and are targeted at university students at all educational levels and young professionals in the nuclear field.

This paper provides an overview of the ENEEP platform, focusing in particular on a series of demonstration courses, which was successfully carried out at the ENEEP partner facilities in early 2022, attended by university students from the EU and other eligible countries.

1 INTRODUCTION

Education activities in nuclear science and engineering are mainly based on theoretical lectures and exercises supplemented by modelling of real or simplified reactor systems by various computational codes. Nowadays, computer modelling is slowly replacing real experiments and, at most European universities, teaching of nuclear engineering is supplemented by the performance of only few basic experiments in radiation laboratories. This fact is very natural, as computer modelling is inexpensive compared to real experiments and it can be easily implemented into academic curricula without the need for complex laboratories requiring high operation costs and human resources. This trend is understandable, however, it should be considered that without real experimental education activities and without hands-on experience, the future nuclear engineers will suffer from a significant handicap in their professional careers. Experimental and hands-on experience is necessary to obtain high quality and complete nuclear education.

In nuclear education, research reactors are the most appropriate experimental facilities to achieve these goals. Critical and subcritical assemblies and training reactors are most suitable, as they are specifically designed for education and training. Research reactors in general are suitable for education activities at all academic levels, not only in nuclear engineering, but also in various non-nuclear engineering studies, such as power engineering, electrical engineering, natural sciences, medical sciences, physical sciences, etc. Experimental education at research reactors can significantly increase the quality of theoretical academic education and extend practical hands-on experience of students at real nuclear installations. In addition to research reactors, specific nuclear laboratories can be used to carry out experimental education and hands-on activities. In addition, it is also very valuable to have access to nuclear power plants, fuel cycle or decommissioning facilities where students can acquire experience with real nuclear installations, and obtain a full overview of their complexity. Nowadays, for several reasons it is difficult to enable access to research reactors for students and their lecturers in order to provide them with a possibility of dedicated reactor physics experiments or hand-on reactor technology experience.

The mission of the ENEEP project [1-4] is to establish a platform at the European level which will fulfil the needs of European users. ENEEP – the European Nuclear Experimental Educational Platform (www.eneep.org) – will contribute to significantly enhance the experimental education and hands-on activities in nuclear curricula, particularly in the fields of reactor physics, nuclear safety, radiation detection, radiation protection, spent nuclear fuel and radioactive waste management. The ENEEP platform will offer access opportunities to nuclear experimental facilities for university students at all academic levels (bachelors, masters and doctoral), professors, lecturers, experts in nuclear education, etc. It will allow specific nuclear training of professionals, particularly young professionals and post-docs at the beginning of their professional career, staff from governmental and non-commercially oriented companies, such as regulatory bodies, governmental organizations dealing with various aspects of peaceful use of nuclear energy, research institutions, etc. ENEEP is currently being established as an open platform for any European university, European research institute or nuclear training organization that is actively involved in experimental nuclear education, training and competence building. The ENEEP founding members are: the Jožef Stefan Institute (JSI, Slovenia), the Slovak University of Technology in Bratislava (STU, Slovak Republic), the Czech Technical University in Prague (CTU, Czech Republic), Technische Universität Wien (TU Wien, Austria) and the Budapest University of Technology and Economics (BME, Hungary) - institutions which are heavily involved in experimental nuclear education, training and competence building. Four institutions operate research reactors and the fifth one operates specific laboratories for nuclear education and training.

2 THE ENEEP PLATFORM

The ENEEP platform is based on experimental education activities, which are being performed at the ENEEP partner institutions for several decades, in the context of university educational programs, training of professional staff, and internationally, in the framework of different cooperations and initiatives. The activities are aimed at demonstrating fundamental experiments in reactor physics, e.g. the critical experiment, the measurement of control rod worth, etc., fundamental phenomena governing the behaviour of a nuclear reactor, e.g. the temperature and void reactivity feedback effects, as well as the measurement of physical quantities of interest in reactor physics and engineering and radiological protection, e.g. the measurement of the neutron/gamma flux distribution in a reactor core, neutron activation, etc. A full list of the education activities is available on the ENEEP website (https://www.eneep.org/experiments/). The ENEEP education activities are highly relevant for nuclear curricula in that they enable a hands-on demonstration of the physical phenomena, which are at the heart of design and operation of nuclear power plants, thus significantly improving the understanding and retention of knowledge.

3 DEMONSTRATION COURSES

As part of Work Package 5 of the ENEEP project, focusing on the demonstration of the ENEEP platform, two group education activities (GA) and two individual education activities (IA) were carried out in early 2022 for a select group of participants from the EU and other eligible countries. The demonstration courses were titled:

- GA-1 Safe and Secure Operation of Nuclear Installations, STU, Bratislava & CTU, Prague
- GA-2 Experimental Reactor Physics, JSI, Ljubljana
- IA-1 Experimental Study of the TRIGA fuel characteristics, TU Wien, Vienna
- IA-2 Experiments on the Training Reactor, BME, Budapest.

The organization of the courses was announced through the project web page, social media, e.g. Linkedin (https://www.linkedin.com/groups/13834594/) and Facebook (https://www.facebook.com/ENEEP-108437037552996) as well as through targeted emails to both institutions and individuals. The evaluation of applications and the selection of participants proceeded according to the ENEEP application procedure, elaborated previously in the ENEEP project. The subsections below report some more specific information about each demonstration course.

3.1 GA-1 Course - Safe and Secure Operation of Nuclear Installations (STU, CTU)

26 valid applications were received for the GA-1 course, comprising 12 countries worldwide. The applications were evaluated in according to the ENEEP application procedure, developed in the framework of the ENEEP project. Based on the evaluation results, 10 applicants were selected for participation. According to the risk analysis performed in relation to the organization of group demonstration activities, 3 additional applicants, were retained in a waiting list. The representation of the countries of the course participants is shown in Fig. 1.

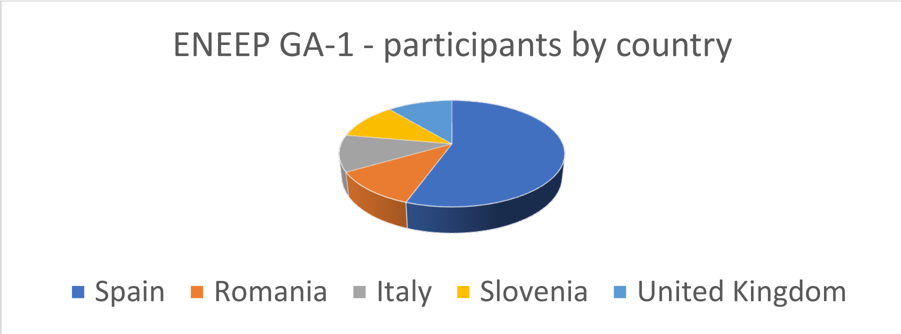

Figure 1. Breakdown of the GA-1 participants by country (9 participants in total).

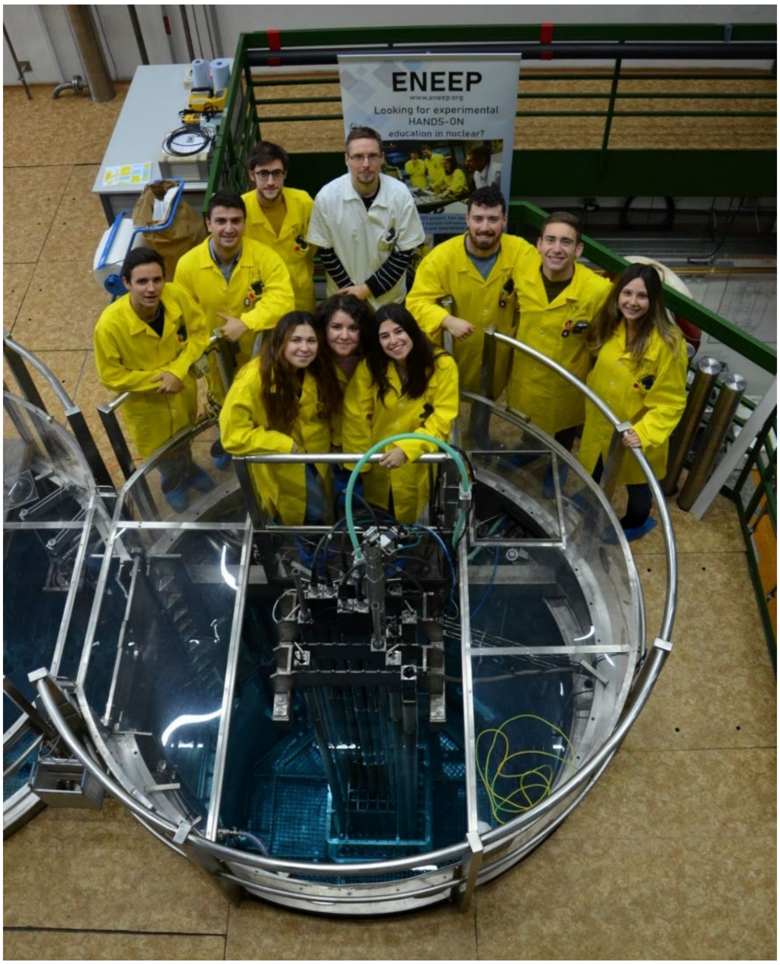

Figure 2. GA-1 participants at the VR-1 reactor at CTU

The course started at STU in Bratislava where both theoretical lectures as well as laboratory exercises (Fig. 5) were held. In the latter, students were divided into two groups to enable a more personalized and individual approach. the participants moved to CTU in Prague where the GA-1 course continued. The course content was targeted at experimental hand-on activities at the VR-1 reactor. During the GA-1 course, the knowledge and skills acquired by the participants were tested. All of the GA-1 course participants completed it successfully. Because of the serious pandemic situation in both countries with a peaking wave of the Omicron variant of COVID-19, appropriate safety measures were taken and no one was affected. From this point of view, the accomplishment of the GA-1 course can be assessed as excellent.

3.2 GA-2 Course - Experimental Reactor Physics (JSI)

For the GA-2 course, 28 valid applications were received comprising 9 countries worldwide. 10 applicants qualified for participation in the GA-1 course. all qualified applicants actively participated in person. The participants to GA-2 were from 6 countries, the gender repartition was 4 females, 6 males. Fig. 3 displays the participants' distribution by country.

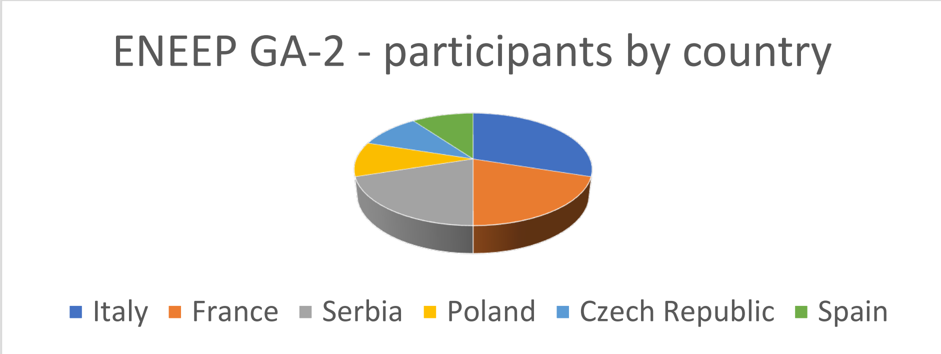

Figure 3. Breakdown of the GA-2 participants by country (10 participants in total).

The course was carried out at JSI according to the originally planned program. Emphasis was put upon experimental hand-on activities that were carried out at the TRIGA Mark II research reactor (Fig. 4). As in the GA-1 course, appropriate COVID-19 safety measures were respected and no one involved in the course was affected.

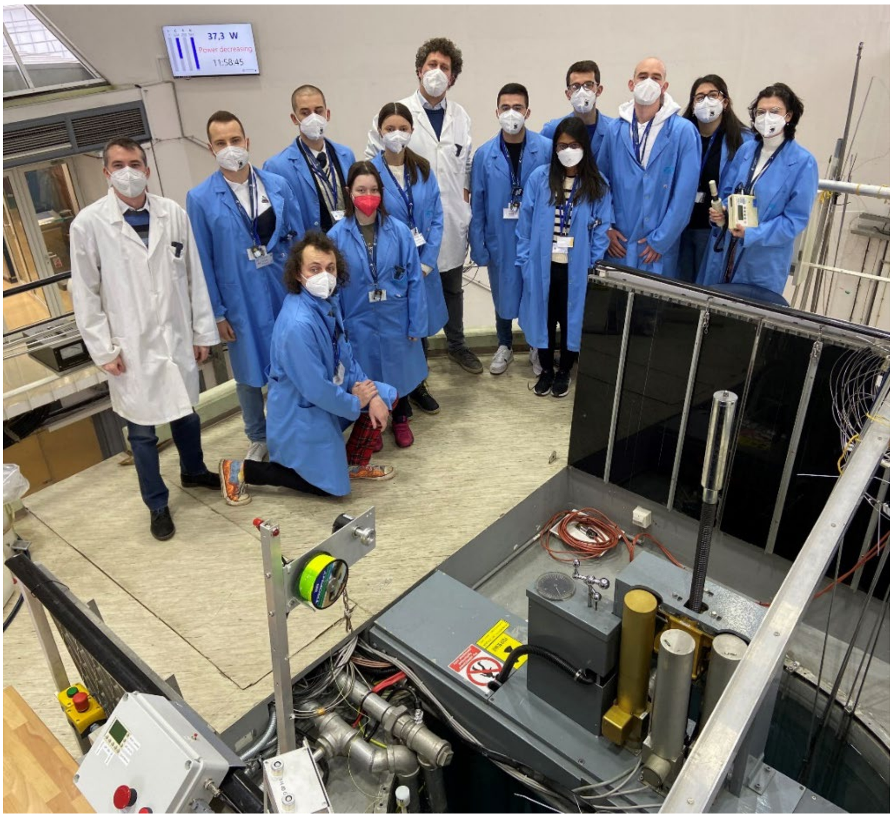

Figure 4. GA-2 participants at the JSI TRIGA reactor

3.3 IA-1 Course - Experimental Study of the TRIGA fuel characteristics (TU Wien)

For the IA-1 course, 10 valid applications were received from 7 countries worldwide, resulting in the selection of one participant from the United Kingdom (PhD student). The program of the IA-1 course consisted of theoretical discussions that were complemented by experiments at the research reactor:

The participant has shown a high level of expertise and has successfully completed the course. After the IA-1 course, the participant was asked to submit an assessment form related to the organization aspects of the course as well as to its content. This will be used in amelioration of the organization of the future ENEEP courses.

3.4 IA-2 Course - Experiments on the Training Reactor (BME)

For the IA-2 course, 7 valid applications were received from 6 countries, based on which one participant from Poland was selected (PhD student). The content of the course was prepared in order to serve the studies of PhD students. Originally the program of the IA-2 course consisted of theoretical discussions, complemented by experiments at the Training Reactor. The program was discussed with the selected PhD student participant before the start of the course in order to offer her course content that suits her studies (safety analyses for NPPs) in the best possible way.

In spite of the very careful maintenance and testing of the BME Training Reactor prior to the course, the organizers of the course were faced with a problem of the reactor in the morning of the first day of the course, due to which the reactor could not be started. Therefore, the original measurement programme was modified at several points, replacing some measurements with evaluations of earlier recorded measurement data. The organizers contacted the Budapest Research Reactor (BRR), which offered its kind and immediate help, so the PhD student was taken to BRR for one day for certain experiments. After discussion with the JSI, the participant was also offered the option to join the GA-2 course in Ljubljana, which took place a week later, which was however not carried out.

Despite the problems with the Training Reactor, the organizers believe that the modified course content conveyed to the Participant reached most of the original goals of the course. This is well reflected by the very good overall feedback of the participant. The participant showed a good level of expertise and successfully completed the course.

4 DEMONSTRATION COURSE EVALUATION

In total, 71 applications for participation in the ENEEP demonstration activities were received from 15 countries worldwide. The high number of countries from which the applications were submitted is very positive. Almost 14 % of the applications were submitted from non-European countries including overseas (Bolivia, Philippine), Middle East (Bangladesh, Iran) and Africa (Tanzania). This indicates that the promotional campaign was very successful and has reached regions far beyond Europe. As far as the gender ratio is concerned, we consider the number of female applicants, amounting to 35 %, as excellent, highly above the average in the nuclear field. According to the IAEA data from February 2019, women make up only 22.4 % of the workforce in the nuclear sector which covers also nuclear-related fields other than energetics [5]. The acceptance ratios for the GA-1 and GA-2 courses were 50 % and 46 % respectively, the ratios for the IA-1 and IA-2 courses were 30 % and 29 %.

4.1 Course evaluation by the participants

The evaluation of the courses from the participants' perspective was performed on the basis of questionnaires, distributed after the course activities. Several aspects of the course organization and performance were evaluated. Namely, an opinion of the participants about the following items was asked for:

- General content of the course
- Meeting the objectives of the course
- Applicability of the acquired knowledge
- Organization and logistics
- Quality of lectures

Specific questions were asked related to the above categories, with answers formulated descriptively (e.g. "Disappointing" / "Average" / "Good" / "Excellent") or numerically (values ranging from 1 to 4). In total, 78 % of the participants responded to the questionnaire. Average scores for the individual areas ranged between 80 % up to 100 % (where 100 % represented an excellent grade). Overall results of the evaluation of both group demonstration courses are shown in Table 1.

Table 1. Results of the evaluation of the demonstration courses by their participants

Items of the evaluation	GA-1	GA-2	IA-1 & IA-2
General content of the course	93.8 %	96.3 %	87.5 %
Meeting the objectives of the course	89.9 %	95.8 %	100 %
Applicability of the acquired knowledge	92.9 %	91.7 %	83.3 %
Organization and logistics	92.9 %	93.5 %	80.0 %
Quality of lectures	95.2 %	87.5 %	100 %
Overall rating	93.0 %	93.2 %	88.9 %

At the JSI, along with the assessment of the whole course, an evaluation was performed of the individual lectures involved in the course and experimental exercises. The evaluation results was also highly positively evaluated (97.5 %) with only few suggestions for minor improvements (2.5 %) and no unsatisfactory rating. In addition to the above-mentioned evaluation in written form, the participants were also asked to express their opinion in short interviews, which are available on the ENEEP Youtube channel (https://www.youtube.com/watch?v=WFfDcttzN6U&t=57s).

Participants of the group demonstration courses have expressed their full satisfaction with the courses and evaluated them as excellent. Still, some critical remarks were raised namely as far as organization and logistics are concerned. They have stem primarily from the fact that the participants had to move between two countries during the course.

5 CONCLUSION

ENEEP is an educational platform being created to enhance and promote experimental education and hands-on activities in nuclear curricula. In the framework of the ENEEP project, the capabilities of the platform were demonstrated with a series of group and individual education activities. Organization of group demonstration courses within ENEEP project was aimed at proving the educational and training (E&T) capabilities offered by ENEEP institutions to students, post-docs and young professionals. Two group and two individual demonstration courses were successfully carried by all five ENEEP project partner institutions, out despite complicated pandemic situation. They were excellently concluded featuring appreciable satisfaction from all participants. The course organization and performance has, at the same time, highlighted the importance of networking among the ENEEP partners and have shown to potential participants the way how to get access to the ENEEP experimental nuclear facilities. The underlying goal was to verify the feasibility of organizational procedures applied to E&T courses for targeted groups of participants. These case studies should also unveiled areas of possible improvement, to be taken into account in the future activities of the ENEEP platform.

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