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Since 1999 the ETRAP conferences intend to bring together training providers, academics, policy makers, radiation protection experts, regulators and authorities, and end-users. It offers the opportunity for learning, discussing and networking about the latest findings and developments in education and training in radiation protection.

This 7th edition focuses on the challenges and opportunities of educating and training in a virtual context.

This conference is organized by the Belgian Nuclear Research Centre SCK CEN in cooperation with EUTERP, IRPA and IAEA.

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IMPACT OF COVID-19 ON RADIATION PROTECTION TRAINING: INITIAL PERCEPTIONS

EUTERP FOUNDATION

EUTERP, Petten, The Netherlands

The EUTERP Board hosted an online meeting for EUTERP Associates on the in November 2020. The meeting was well attended with some 25 participants from 20 Associates represented. At this meeting the opportunity was taken to have a discussion session on the <u>initial</u> impact of the prevailing challenges to radiation protection training as a consequence of the COVID19 pandemic. The necessities of mask wearing, social distancing and the constraints on travel, had all made the conventional approach to training delivery problematic and the Board was keen to provide a forum for training providers to share initial experiences.

Each representative provided a brief summary of the perspective from their organization and/or country. It was certainly the case that many training providers were offering their courses as online versions or in some form of virtual environment in order to keep training accessible, but a significant proportion of providers were still offering training in-situ albeit with suitably adapted delivery. The main experiences and observations presented at the meeting were as follows :

(i) Where the detail of required of required training is prescribed in law, or a condition of maintaining a performance standard (for example, an ISO standard) moving to online or virtual modalities may not be an option.

(ii) Some pre-existing challenges in delivery of training within in certain sectors had been observed to have been compounded by the COVID19 situation

(iii) General consensus that the experience has triggered a change in how radiation protection training will be accessed and delivered going forward : the financial implications cannot be ignored, online availability extends accessibility, tools & technology are improving all the time and increased portfolios of delivery options improve resilience.

(iv) Some concerns were expressed over the effectiveness of online training: this is not suitable for all topics or desired learning outcomes

(v) The loss of real time, face-to-face interactions was felt to be a significant detractor in both the effectiveness of the training and the experience of trainers and trainees.

(vi) Translation of a training event to a virtual version of that event requires significant re-working of both the schedule and the training materials

What became very clear during the discussions was that there are many useful and effective tools and resources available to help providers build online or virtual training products. A library detailing the various tools, their specific applications and how to access them would be of value to providers. While the initial impact of COVID19 on the provision of training was made clear during the discussions, how training is provided in the future and, perhaps more importantly, what the impact (if any) on the effectiveness of training and ultimately on radiation protection and safety in practice was less clear; it is too early to tell.

This was an interesting and animated discussion and the Board is grateful to the Associates for their active contribution.

LESSONS LEARNED: THE PAUL SCHERRER INSTITUT'S EDUCATION CENTER'S TRANSITION TO ONLINE LEARNING DURING THE COVID-19 PANDEMIC

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An analysis of course contents, regulatory requirements as well as participant background and availability is used to identify characteristics that make topics well suited for conversion into asynchronous learning modules and blended-learning structures. Also presented are the lessons learned from transitioning to online teaching and learning of radiation safety during the COVID-19 pandemic at the Paul Scherrer Institut's Education Center in Switzerland.

1 Introduction

The COVID-19 pandemic catapulted educators into the world of online teaching and learning. Within days of going into lockdown, courses were stopped mid-way, cancelled or rescheduled, but many were re-designed to be carried out partially or fully online. The idea of bringing more content into the digital age is nothing new, but no one ever thought it would have to be done so quickly or lead to such great successes.

As a self-financed institution that is also one of the only training providers in Switzerland where certain radiation safety courses are taught and students can be certified, cancelling classes was not an option for the Paul Scherrer Institut's Education Center. Especially during the COVID-19 pandemic, the education and certification of professional radiation safety personnel was critical in order not to further de-stabilize an already stressed system (e.g. health sector). Postponing courses was also not feasible because it would lead to a future pile-up in an overloaded schedule. As with many educational facilities, the most reasonable solution was to switch to teaching online. This, however, brought with it many new issues:

- new skills and equipment had to be acquired or developed;
- new terms had to be defined to ensure instructors, students, stakeholders, and regulators were speaking the same language (e.g. e-learning, web-based-training, blended learning, synchronous vs asynchronous, breakout sessions, self-paced learning, etc.);
- regulations and course accreditation documents had to be reviewed to ensure legal requirements could be fulfilled online;
- the logistics of online assessments had to be considered;
- secure, stable, easy to use and technically sufficient online platforms and tools had to be chosen (several customer groups immediately restricted what their employees were allowed to access from work); and
- several course-participant groups were not used to self-paced or self-organized learning formats

Our initial solution was to create modularized content that could be re-used in several courses, but the significant demands on software and format expertise not to mention time, quickly led to heavy reliance on live broadcast platforms such as Zoom and WebEx to transmit more or less traditional lectures.

2 Training Center Overview

The Paul Scherrer Institut (PSI) is Switzerland's largest research laboratory, providing students with exposure to innovative facilities, technologies and expert instructors. The six-member team of the radiation safety training group of the Education Center, along with numerous on and off-site subject matter experts, teaches approximately 70 different radiological safety training courses in the medical field (including veterinary medicine), for nuclear facilities, for emergency organizations such as fire and police departments, as well as for industry, research, and transportation groups. Courses vary in length from half a day to 80 days. Practical training is central to all classes. Students carry out experiments in Switzerland's largest x-ray lab, in class-C laboratories where sealed as well as open sources can be handled, and in an outdoor facility where accident response scenarios are simulated.

The majority of the course content is dictated by Swiss regulations and ensured through accreditation. The training requirements are laid out in the Radiological Protection Ordinance (RPO from 26 April 2017, SR 814.501) and detailed in a radiation safety specific education and training regulation (Verordnung des EDI über die Aus- und Fortbildungen und die erlaubten Tätigkeiten im Strahlenschutz from 26. April 2017, SR814.501.261) as well as in various sector-specific regulations and guidelines. The education and training rule includes tables of permitted activities, competencies, education and continuing training hours and frequency, as well as detailed training contents with corresponding taxonomy levels broken down by occupation. A total of 67 occupations or competencies in four categories are covered. Though such detailed regulations help instructors develop highly targeted training, course content, format, and testing cannot be changed without approval from the supervising authorities. In addition, key clients groups, such as the association of Swiss nuclear power plants, provide input and special requirements that must also be considered.

3 Pandemic Timeline Effect

When the Swiss lockdown was announced in early March 2020, scheduled courses were quickly reviewed and sorted based on whether or not they required permission from the regulating authorities for changes in format, content, length, or examination method, as well as on whether a 100% online training methodology was suitable or a blended format (partially online and partially on-site) was feasible. The regulators extended the certification requirements for certain customer groups, allowing those classes to be cancelled or postponed to 2021. Some allowances were also made to replace hands-on experiments and site-visits with live online demonstrations or videos. Only classes with no hands-on requirements could be switched to 100% online teaching and learning. Splitting theory and practice by postponing practicals was generally deemed unrealistic due to large temporal gaps that could result in the need for significant material review as well as scheduling and space issues later on. Therefore, after the initial lockdown ended on June 8, hands-on work resumed. Although a few additional courses were added to the schedule later in the year, students scheduled to attend in the spring were generally moved into already scheduled summer and fall classes. Unfortunately, this resulted in a few students being moved more than once as the lockdown progressed, and lead to an overall decrease in the total number of open slots available in 2020.

After June 8, students were allowed back on site until the second wave hit in October. During this time, common hygiene measures were implemented and physical distancing was maintained by limiting class sizes and splitting large groups into two rooms and broadcasting lectures using traditional video conferencing equipment. Since October 2020, almost all courses have been conducted in a blended format whereby lectures are held via Zoom or WebEx while non-exempt practical requirements continue to take place on-site[1].

4 Development of Online Content

In March 2020, when Switzerland entered its first pandemic lockdown, the Education Center management put heavy emphasis on the necessity of moving as many courses as possible online and creating learning modules that could easily be used as building blocks in dozens of radiation safety courses.

Creating effective and engaging asynchronous teaching and learning modules in the form of pre-recorded lectures, video demonstrations, and interactive exercises requires time, technical knowledge, a variety of resources (e.g. recording and editing equipment) and skills that go beyond being a subject matter expert in a particular field. However, once created, the material can be re-used from class to class and if designed properly (short modules with no course-specific content) in different courses.

With the help of an in-house e-learning expert, several radiation safety instructors carefully considered their audience and their course content in order to narrow down the topics to be taught online, the format to be used, and the overall structure of their course. Some of the specific questions asked included:

- Should the course be compact and follow the traditional consecutive days format or should it consist of several shorter intervals over a longer period?
- Have students already schedule time off or do they have the flexibility to join at a later point in time or study during non-standard hours?
- Do the students have access to and experience with computers?
- If practicals or group work are an integral part of a course, does everyone need to attend together or are smaller groups or individual efforts just as valuable?

Furthermore, when considering the thematic interdependency of topics (modules) to be covered, consideration was given to whether or not:

- the order of the presented information would affect learning (could students jump around);
- there should be a time limit or time frame within which certain modules have to be completed;
- efficiency can be gained from breaking down modules into the smallest possible concepts so that they can more easily be used in multiple courses;
- questions, feedback, and evaluation phases can be integrated (how); and
- student will remain attentive (what is a good mix of formats).

Clearly, not all topics and not all students can be taught using the same methods, yet most decisions on how to proceed are influenced not only by didactics and methodology, but also by resource allocation and participant availability/flexibility. Ultimately, the topics selected for self-guided learning modules (asynchronous format) had to meet the following three criteria:

1. they had to be suitable from a didactic point of view,
2. the frequency of their potential reuse was heavily weighted, and
3. the effort for implementation had to be reasonable (time, money, and technical knowledge).

[1] The PSI pandemic task force has recognized the importance of radiation safety training in maintaining the overall safety of various Swiss industries and the public and thus allows essential hands-on work to occur.

Day 1		
08:30	Welcome& introductions -Course organization -General instructions	Zoom w/PP
09:30	Fundamentals I	(Documents and exercises in Moodle)
10:30	Repetition	Zoom
11:00	Fundamentals II	Zoom w/PP
12:00	Lunch	
13:00	Measurement techniques	(Documents and exercises in Moodle)
14:15	-Repetition -Practicals demo	Zoom w/PP
15:15	Practical radiation safety	Self-study (Documents and exercises in Moodle)
16:30	-Repetition -Q&A	Zoom
17:00	End	
Day 2		
08:00	-Repetition -Q&A	Zoom
08:30	Radiation biology	Self-study (Documents in Moodle)
10:30	-Repetition -Q&A -Excercises	Zoom
11:00	Regulations	Zoom w/PP
12:00	Lunch	
13:00	-Repetition -Q&A	Zoom
14:00	Self-study	
15:00	Course review	Zoom, Findmind
15:30	Exam	Moodle
16:30	End	

Figure 1. Course schedule for the Education Center's first fully on-line course: "Accredited training for radiation protection experts when handling installations without full and partial protective equipment".

Day 1	Teaching block	Format, Tool	ARIVA Phase
09:00	– Welcome, introduction, course organization – Introductory discussion: what does radiation protection mean to you?	Synchronous: WebEx (face-to-face and guided class discussion).	– Organize/Prepare – Reactivate
10:00-16:00	Self-study phase minimum: – Physics basics – Chart of the nuclides	Asynchronous: self-learning phase (WBTs, videos, PDFs in Moodle)	Information
16:00-17:00	Q&A session, end of the day, feedback	Synchronous: WebEx (teaching talk)	Process, Evaluate
Day 2	**Teaching block**	**Format, Tool**	**ARIVA Phase**
08:00-12:00	Group 1: practical followed by Q&A session, feedback	Synchronous: Bildungszentrum (group work and guided class discussion).	Process, Evaluate
	Group 2: Self-study phase, incl. exercises, at least: – Radiation biology – Legal basics – Radiation protection	Asynchronous: self-learning phase (WBTs, videos, PDFs in Moodle)	Inform, Process
12:00 - 13:00	Lunch		
13:00-17:00	Group 1: Self-study phase, incl. exercises, at least: – Radiation biology – Legal basics – Radiation protection	Asynchronous: self-learning phase (WBTs, videos, PDFs in Moodle)	Inform, Process
	Group 2: practical followed by Q&A session, feedback	Synchronous: Bildungszentrum (group work and guided class discussion).	Process, Evaluate
Day 3	**Teaching block**	**Format, Tool**	**ARIVA Phase**
08:00-10:00	Self-study phase: – Remaining topics and supplementary material	Asynchronous: self-learning phase (WBTs, videos, PDFs in Moodle)	Inform, Process
10:00-12:00	NPP Technology	Synchronous: WebEx (frontal and instructional discussion)	Inform, Process
12:00-13:00	Lunch		
13:00-15:00	Processing radiation biology, dose estimation	Synchronous: WebEx (guided class discussion and frontal).	Process
15:00-16:00	My personal contribution to radiation protection? Q&A session, feedback, conclusion of the course	Synchronous: WebEx (teaching talk)	Activate, Evaluate

Figure 2. Course schedule for a blended format course: "Radiation protection training for engineers".

Student feedback from the first course designed to be taught fully online at the Education Center (Figure 1) was very positive[2], and the format received a Comenius EduMedia Award for online teaching. Some of the asynchronous modules from this first online class have since been re-used in other courses and a library of resources is slowly being built up for incorporation into future classes.

[2] Examples of participant feedback to the question «What did you particularly like about this course?": The content & mix self-study and lecture / WBT, Effective flow, good mix of information for different levels of prior knowledge, and the mix between frontal teaching and self-study.

Unfortunately, the significant demands for software and format expertise, not to mention the very large demand on time, diverted our efforts from creating modularized self-guided learning content to instead making heavy use of synchronous lectures and breakout groups via platforms such as Zoom and WebEx using traditional teaching aids such as Power Point slides and flip charts.

Though much faster and easier to implement, synchronous online teaching and learning has its own positive and negative aspects as summarized in Table 1. However, by again considering format as much as content, live online classes can be very successful. In addition to using standard teaching aids such as Power Point slides, flip charts, and demonstrations, variety can be integrated using more interactive methods such as allowing students to annotate on-screen, making use of online polls, and crating breakout sessions for group work or discussions.

Table 1: Positive and negative aspects of synchronous online lectures.

Positive	**Negative**
Existing lecture notes in PowerPoint can easily be shared	Time must be dedicated to setting ground rules for online interactions and to explain the key functions of the applicable platform and online tools used
Real-time feedback from students is possible via direct audio and chat functions	It can be difficult to "read the room"/students may be shy to engage (students should be encouraged to leave their cameras on and use their real names online)
If the instructor takes time to engage students with questions and group work via breakout session, students will pay attention and feel included	Time must be planned for dealing with technical difficulties (if possible, a second contact person should be available to provide assistance)
Group work is more efficient with collaborative tools	Flip charts, white boards and demonstrations may be hard to see (moveable or multiple cameras are useful)
Groups can be created and separated at the click of a button	Instructors are less free to move around (clip on microphones are useful, marking off a "free movement zone" in order to stay visible on camera and within audio range is useful)
Live steamed site-tours can be better than in-person visits: – Guides are better prepared knowing they will be on camera – Students from multiple classes can attend the same tour (efficiency) – Students can "access" otherwise restricted areas – They are ALARA – No time is wasted walking around campus or dressing out	Students are less likely to take notes and more likely to request electronic or printed handouts to refer back to

5 Conclusions

Creating professional online content constitutes a full-time job with skills, such as technological expertise and visualization, that differ significantly from those of a radiation safety trainer. In 2020/2021, most of the radiation safety courses at the Education Center that were taught online via synchronous and asynchronous methods were prepared in part with the help of a dedicated staff member who specializes in online training. Much was learned through this collaborative process, student and stakeholder feedback, regulatory input, and instructor experience. The main take-aways can be summarized as follows:

- As much consideration must go into deciding what format to use as what information to present.
- The methods for ensuring completion and understanding of the material may need to be adapted.
- Creating asynchronous learning content is very time consuming, but with careful planning, material can be used in multiple courses.
- Keeping students interested and engaged becomes much more crucial when working online.
- The technical knowledge/skills of instructors and students must be carefully considered[3].
- Employers may limit student access to certain online tools or not provide the time and a quiet space to work when training is not offered at a specific time and place.
- Real-time student/teacher contact remains crucial.
- Convincing customers and regulators, that course content can be conveyed well and in a secure manner takes time.

However, regardless of the methods used, similar positive feedback such as gratefulness that training continues to be available and at the same time a wish for and appreciation of a return to in-person learning was broadly reported. In closing, the mantra for anyone choosing to teach online should be: know your audience, put as much thought into format as you do content, integrate live time and do not lose sight of the importance of hands-on learning.

Acknowledgement

Our thanks go to the Education Centers's administrative staff who have been inundated with questions during uncertain times, our external lecturers who have gone outside their comfort zone by adapting to new tools, and our team of radiation safety instructors:

- Barbara Roth
- Peter Häberling
- Ralph Hardegger
- Lars Kämpfer
- Dieter Mohr

[3] Certain target groups are not used to working with computers or having to synthesize information they read or see in videos.

ON-LINE RADIATION PROTECTION TRAINING AT A UNIVERSITY RESEARCH REACTOR

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Radiation protection at research reactors encompasses a much wider scope of training requirements than usually seen at nuclear power plants, accelerators, or other industrial settings. Research reactors can offer a wide range of experimental facilities that can produce an array of isotopes of differing beta and gamma-ray strengths. With the rapid turnover of students and visiting scientists it behoves the university to have on-line training with rotating quizzes to reduce costs while maintaining and documenting an on-going program. The training required of the typical Nuclear Engineering Teaching Lab worker includes Hazard Communication, Laboratory Safety (every three years), Hazardous Waste Management, Radiation Safety (every two years), Portable Fire Extinguisher Basics, Information Security Awareness (yearly), and refresher courses periodically.

1 Introduction

Over the past decades on-line technologies have slowly infiltrated into the pedagogical arena in academia, government, industrial settings, health care institutions, etc. The COVID-19 pandemic has hastened this phenomenon to the point that on-line teaching is now fully integrated into many institutions. Equally important is that high quality videos can be amalgamated into on-line teaching with advanced smart phones that now have excellent video and slow-motion capabilities. The incorporation of vivid still and moving animations enrich on-line teaching. And lastly, random multiple-choice questions can properly quiz the learner. All the above characteristics make on-line teaching a very enticing platform to use on its own or in conjunction with in-person classroom environments. Teaching the principles of radiation protection are equally challenging and on-line training affords unique opportunities to the array of skillsets needed in all the modern nuclear related technologies. Training at university research reactors inherently encompasses a wide variety of undergraduate and graduate students, post-doctoral fellows, research faculty members, staff members and visiting scientists and engineers. Radiation sources include the research reactor that may produce from tens of kW to tens of MW power, subcritical facilities less than 1 kW, neutron sources such as plutonium-beryllium (Pu(Be)) sealed sources, D-D (2 MeV) and D-T (14 MeV) neutron generators. The main goal of this paper is to emphasize the many different types of radiation exposures encountered while utilizing the research reactor and the ancillary facilities and how on-line training is vital to keep up with safety protocols.

2 Nuclear and Radiation Engineering (NRE) Program at the University of Texas at Austin

The NRE program is both nationally and internationally recognized and promotes basic and applied research and training/education in nuclear science and engineering and technology development to support the nation's critical needs in a variety of areas. The mission of NRE is to educate the next generation of leaders in nuclear science and engineering, conduct leading research at the forefront of the international nuclear community, apply nuclear technology for solving multidisciplinary problems, and to provide service to the citizens of Texas, the U.S., and the international community. A key component of the NRE program is to offer undergraduate research opportunities across many topics of nuclear science and engineering in the experimental and computational domains.

3 Nuclear Engineering Teaching Lab

The 1.1 MW TRIGA research reactor is housed at the Nuclear Engineering Teaching Lab (NETL) at the University of Texas at Austin. A variety of teaching and research is undertaken producing isotopes of differing beta and gamma-ray strength for medical, nuclear forensics, industrial research, neutron and prompt gamma activation analysis, and radiochemistry either using the in-core facilities in the rector or neutron beam ports (see Figure 1). Additionally, neutron radiation damage studies are conducted using the reactor or Pu(Be) neutrons. And lastly, a 14 MeV D-T neutron generator and several additional Pu(Be) neutron sources are used for various shielding experiments or NAA experiments. A graph depicting the number of days the reactor has been in usage in the past four years is shown in Figure 2. Such a multi-phased research operation involving radiation from a variety of sources needs to have strict training protocols. These safety procedures are coordinated by the staff certified health physicist including follow up training.

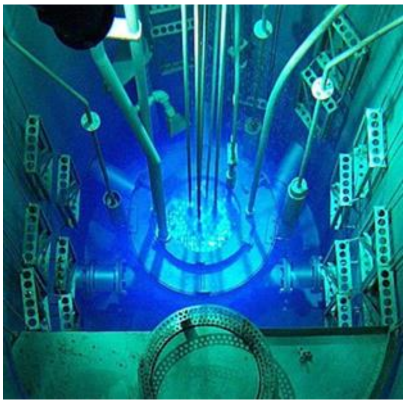

Figure 1. 1.1 MW TRIGA reactor core and beam ports

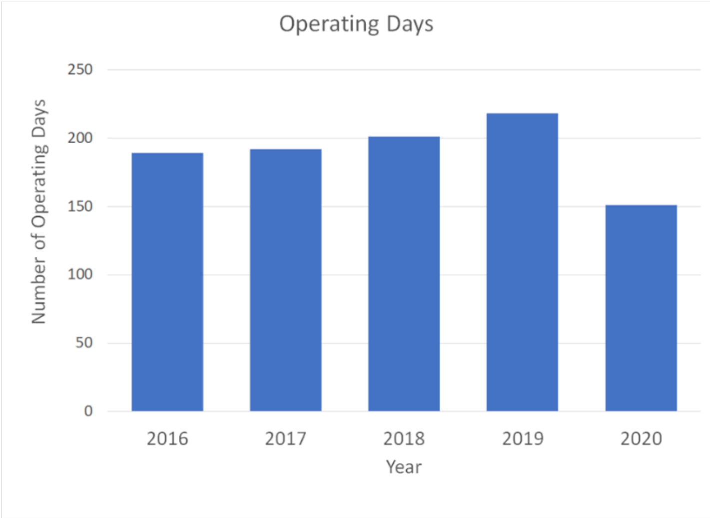

Figure 2. Number of days operated at the 1.1 MW TRIGA reactor during the last five years.

4 Analytical Laboratories

Several laboratories are available to perform research. These include neutron activation analysis (NAA), radiation effects on materials, detector development, gamma-ray spectroscopy, chemistry and sample preparation, radiochemistry, neutron generator room housing the 14 MeV D-T neutron generator, and Pu(Be) sources.. A new hot cell is being planned for construction as a major research effort to produce radiopharmaceuticals and will require additional radiation safety protocols. In each of these facilities there are different radiation practices that are needed to be observed. For instance, in neutron activation analysis (Figure 3) there is a wide variety of radiation dose rates that can come from the many different types of samples that are irradiated. Currently, we have a project to use computational modelling in Python to determine expected radiation exposure in NAA and compare the results to MCNP [1].

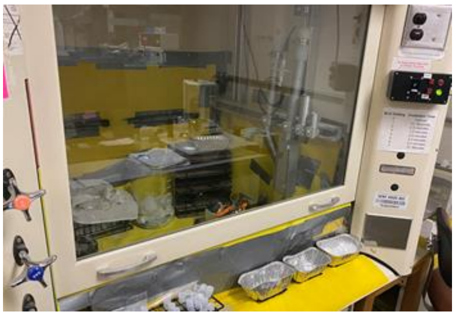

Figure 3. Neutron activation analysis sample handling station

Irradiation of electronic components (Figure 4) also pose potential unexpected radiation dose rates. Pu(Be) sources shown in Figure 5 have been used for neutron detector instrumentation development These experiments have led to an acute awareness of neutron fields not experienced in any other facility. Radiation protection during Prompt Gamma Activation Analysis (PGAA) using one of our neutron beam ports has also led to monitoring of dose rates from samples post irradiation.

Figure 4. Electronic component being prepared for radiation damage studies

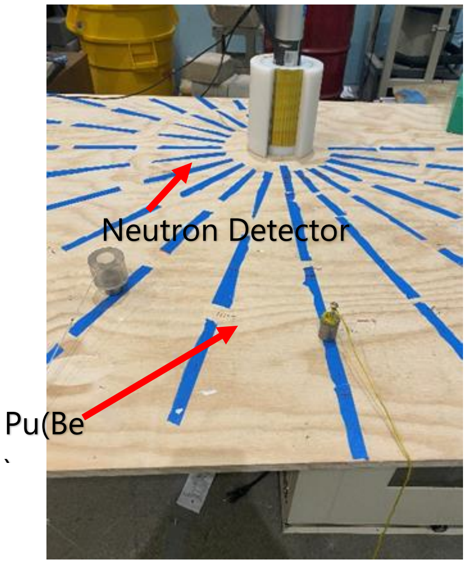

Figure 5. Pu(Be) source and neutron detector

5 Major courses in health physics and nuclear instrumentation

All our undergraduate and graduate students in the NRE program take one or more courses in nuclear instrumentation. These courses include Radiation and Radiation Protection Laboratory, Gamma-Ray Spectroscopy, Neutron Activation Analysis, Nuclear and Radiochemistry, Nuclear Engineering Laboratory, and Nuclear Analysis Techniques.

As a result of COVID-19 and a need to offer instruction to our ever-increasing number of distant learning students we have beta tested the addition of a virtual lab in an introductory course in nuclear forensics in the summer of 2020. The advent of powerful video technology of smart phones has replaced the need for more expensive equipment. Furthermore, video recordings can be made in just a few minutes and then uploaded to a website [2]. A series of videos were made outlining several experiments. Experimental information was collected and then sent to the students who analysed the data. Results for four experiments are shown in Figures 6-9.

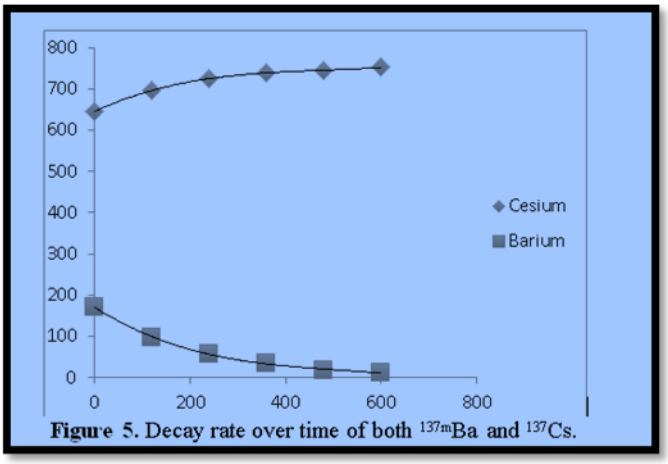

Figure 6. Secular Equilibrium for ^{137}Cs and ^{137}Ba generator

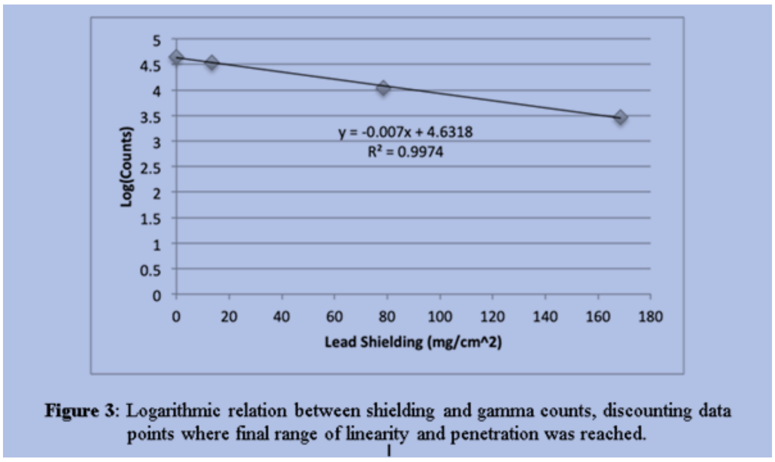

Figure 7. Various thicknesses for lead shielding

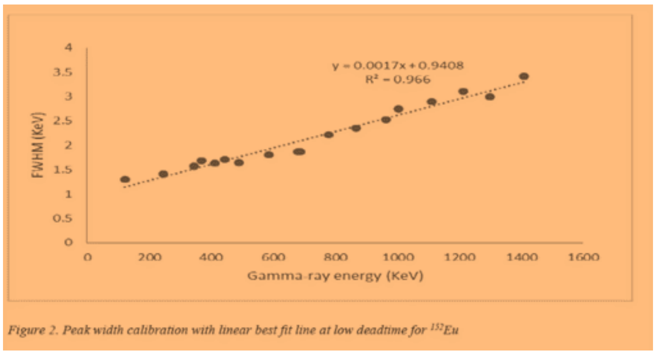

Figure 8. Full Width Half Maximum (FWHM) germanium detector resolution

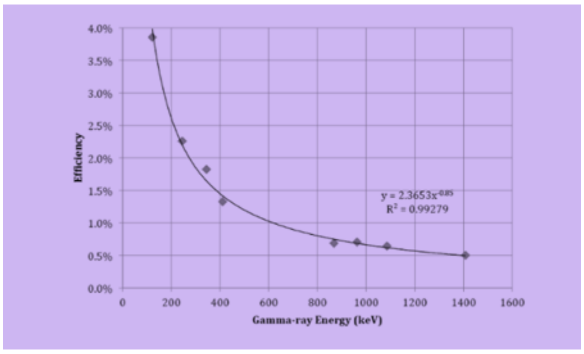

Figure 9. High-purity germanium (HPGe) detector efficiency

Virtual laboratories are planned for the summer of 2021 for the undergraduate/graduate course in radiation protection laboratory which includes, personnel monitoring, radiation statistics, neutron shielding, fission product identification, Geiger-Müeller counting, gamma-ray self-attenuation in soil samples, neutron detection, high activity ^{137}Cs gamma shielding, and background gamma-ray detection with a HPGe.

6 Conclusions

On-line teaching and training in all aspects of radiation protection and nuclear instrumentation is now an integral part of our mission in teaching and research and we see its growth by including more sophisticated video recording and animations.

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EDUCATION AND TRAINING IN RADIATION PROTECTION IN A VIRTUAL SETTING - CHALLENGES AND OPPORTUNITIES BROUGHT BY THE COVID-19 PANDEMIC

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Competency-based learning or competency-based education is our framework for teaching and assessment of learning. The competencies consist of skills, abilities and knowledge, these have been and will be the goals of our education before, during and after the COVID-19 pandemic situation. The biggest challenge was to find a solution for the situation as life could not stop, students had to be educated. Digital education has many inadequacies that makes it incomparable to personal occasions especially for the field of radiation protection. A blended education which proportionally utilizes the conclusions of the pandemic period while providing the students and the instructors with the opportunities of being an active participant of their learning and teaching experience can be considered a feasible long-term solution for future trainings in radiation protection.

1 Introduction

In recent years, we have become accustomed to providing our students with face-to-face trainings with theoretical parts and laboratory work in radiation protection. We have developed competency-based programs detailing knowledge, skills and attitude. During lectures, we actively communicate with students and participants. We monitor their reactions, facilitate their learning, try to constantly explore the shortcomings, answer questions and help them to solve the different tasks in person. Then, overnight, due to the COVID-19 pandemic, our carefully established system collapsed entirely. We were full of plans, arranged programs, but suddenly, they all seemed irrelevant and unaccomplishable.

According to the competency-based method in traditional (face-to-face) education teachers can:

- communicate with students and participants
- monitor their reactions
- facilitate their learning
- try to constantly explore the shortcomings
- answer questions
- help them to solve the different tasks in person
- assess students in a controlled way

students/participants can:

- ask and answer questions
- conduct independent laboratory work
- make calculations technically more easily
- ask for help if necessary

2 Competency-based method in online education

E-learning refers to the use of advanced information and communications technology in the learning process, where advanced technology consists of electronic media [1]. A model for using E-learning in education can be found in Figure 1. compiled by Arkorful and Abaidoo [2]. Online education has several forms: The Definition of Blended Learning: Blended learning is an approach to learning that combines face-to-face and online learning experiences. Ideally, each (both online and off) will complement the other by using its particular strength [3].

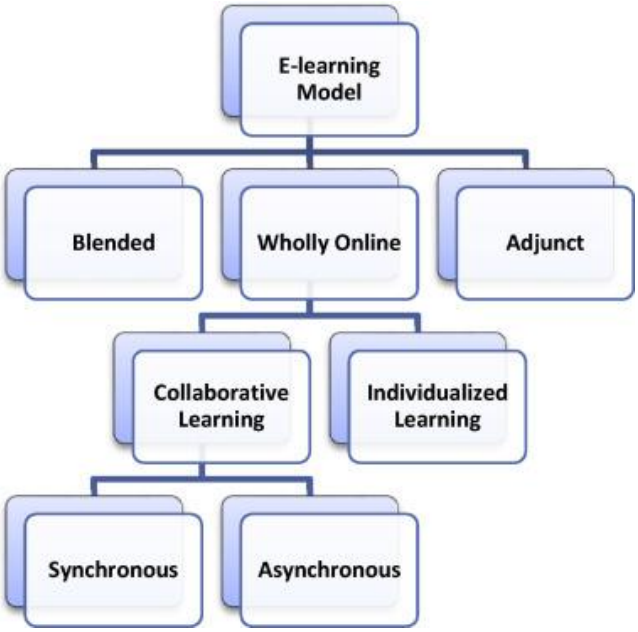

Figure 1. Model for using E-learning in education.
https://doi.org/10.1016/j.heliyon.2019.e02424

We knew that we had to realise a Wholly Online teaching and learning experience, which is mostly collaborative, but also complemented with individualized learning. These units have all teaching resources and undertake all teaching online including [4]:

- All content (either commercial print-based textbooks or commercial texts may be used as supplementary material)
- All communication and interaction with students
- Assignment submission and feedback (examinations are also online)
- Each unit will have at least ONE session of interactive communication (synchronous, asynchronous, or both) between teacher and students online at least weekly or as established at the beginning of the course.

Also, we knew that an online educator has many roles when they operate such a system. For example: assessor, facilitator, technical, social, pedagogical, manager, content expert, psychological etc. [5].

3 The practical implementation

The biggest challenge was to find a way to continue the education of students online, in an effective way, which could be managed both by the teachers and their students. Ideally, it takes a few months to put together an online course - in reality, we usually only had a week or two in every country, even to start several courses.

When we searched the Internet, we found the most well-known online services and surfaces such as Microsoft teams, Google forms, Zoom, WebEx etc. These have already been familiar to us, but we had no relevant experience in using them. We had to learn and practise their use in a very short time, which was sometimes incredibly challenging. Mastering these applications has been essential; however, organising digital learning consisted of many more tasks and challenges. New phrases and concepts had to be learnt, for instance; host, co-host, stream, screen share, mute or un-mute. We had to be able to schedule and start meetings, send invitations and allow participation. We had to know how to record our presentations via Teams or Zoom, and we also prepared mp4 video files using the PowerPoint programme.
In order to use these services and surfaces, we need special equipment. For example: the Internet, a computer, tablet, a smartphone, headset, camera, scanner, and different software. Also, all of us have experienced many difficulties while trying to get these devices. Many shops have been closed due to the pandemic which makes it difficult to get the necessary equipment. In case of webshops, the delivery time can be very long and they might have run out of the right tools. We had a very short time to master the use of the tools. And last but not least, both teachers and students have their financial barriers and limits, while technological devices can be extremely expensive, especially if we want to buy a quality product.
Still, there have been many difficulties of online presentation.

Figure 2. The lecturer has the feeling that she/he is giving a presentation to ghosts.

Finding the ideal file size is very important because the resolution of the presented material has to be of good quality, but the file size should not be very large. If the internet bandwidth is low, the audio and video will not be in sync, the presentation will be incomprehensible; in this case students have to be asked to turn off their cameras. But then, the lecturer has the feeling that she/he is giving a presentation to ghosts which is very strange (Figure 2.).
Also, we have to mention the Reaction time of students which can be very long, so the lecturer has to wait for reactions insecurely for a while, which is a bit uncomfortable as well.

Besides solving the problems of online education, getting the right equipment and overcoming the difficulties, we could take on another challenge: organising online events.
As life could not and should not stop professionally, in spite of the difficulties, we have successfully managed to organise different types of events, such as; competitions, conferences, workshops, and symposiums.

In Figure 3. you can see the differences between the ENEN PhD Events held in 2018 and in 2020. There are many differences, but we could manage to achieve the same goal: to gather together professionally no matter what the circumstances are.

Figure 3. ENEN PhD Events 2018 (left side) and ENEN PhD Events 2020 (right side).

4 The differences between traditional and online education

Talking about the differences, we can obviously recognise several differences between traditional and wholly online education.

First, we can discuss the advantages and disadvantages of traditional learning.
The advantages are:

- There is no need to come up with new solutions, teachers and students can take part in education as usual
- We can have personal contact and direct communication
- Cooperation between students can improve, interpersonal skills can develop
- We can give and get immediate reactions and feedback

The disadvantages can be that:

- We use regular teaching and learning methods, there are no challenges
- It is more expensive (because of the equipment, materials and books)
- There are time and location constraints: it has to have an arranged time and place
- The number of students has to be limited.

Wholly online learning has many advantages, for instance:

- Students and teachers can participate in education from the comfort of their homes
- It gives an opportunity for all participants to learn and develop their IT skills
- Students can become more independent and learn how to self-motivate
- Teachers and students can try new, interesting methods, there are endless possibilities
- It has flexibility (there is no need to arrange a place and time)
- It is more environmentally friendly (no need for paper, waste or travelling)

However, there are the disadvantages, for example:

- Experimental and laboratory work is extremely difficult and time-consuming to realise in online education
- Theoretical lectures are easier to implement in an online learning environment which can lead to teaching more theoretical knowledge and less practical skills

- It is difficult to involve students to actively participate
- There is minimal supervision, there can be a lack of discipline and it is hard to prevent students from cheating during tests
- Students cannot cooperate, they mostly work individually
- There is a dependence on modern technology and Internet connection.

This extraordinary situation has presented us with several opportunities, not only difficulties. Professors and students can attend classes from the comfort of their homes. While sometimes instructors need to prepare even more to their virtual lessons, they can truly improve their competence in modern technology and explore the world of digital teaching with its endless possibilities. Consequently, when the COVID-19 pandemic situation is over, we will still apply these newly-obtained competences and incorporate digital learning into our personal education.

5 Conclusion

If we take into account our experiences and the information we have collected, we can say the following:

- Blended education which proportionally utilizes the conclusions of the pandemic period while providing the students and the instructors with the opportunities of being an active participant of their learning and teaching experience can be considered a feasible long-term solution for future trainings in radiation protection.
- Both digital and traditional education have their own set of benefits and limitations. These are a supplement to each other and both have their own importance [6].

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THE "TRAIN THE FUTURE TRAINERS PROGRAM, A WAY TO INCLUDE SOFT AND TECHNICAL SKILLS IN A BLENDED LEARNING PROGRAM

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During the period 2018-2021, seven universities and the Greek Atomic Agency were involved in a two-year European Erasmus+ partnership, whose topic is "Train the future trainers". This program was developed using an educational approach expanding the target competences, to improve the blended learning process. Generic skills, such as SDGs and soft skills, are of growing importance for future nuclear engineers. Different innovative ways were explored in the present strategic partnership and adopted to define a new approach. The blended learning activities developed have the value of 4 ECTS per year per topic, subdivided into 2 ECTS for pre-training activities and 2 for the training school. Individual students will be encouraged to follow the activities of both years. Three themes were selected. Each activity must contain an important technical part, but also includes soft skills like communication, stakeholder awareness, teaching to students....

1 Introduction

The present and near future market needs of the nuclear sector are enormous for qualified nuclear engineers, technologists, radiation protection officers (RPO) and radiation protection experts (RPE) [1]. For example, within the coming years numerous nuclear reactors will be in shut down phase in Europe and the forecast is that the number will rise continuously.[2] Large decommissioning projects and waste management plans demand an interdisciplinary team of workers to succeed, keeping in mind financial, technological, project management and human aspects. Also other sectors face new demands in professional skills. The management of naturally occurring radioactive materials (NORM) represents an important challenge regarding the large volumes with low specific radioactivity.[3] Moreover, extensive use of radionuclides and ionising radiation in medical sectors involve doses given to a large public.[4]

A transition from profit driven organisation to cost driven organisation implies significant changes in the overall approach to business operation. A lot of current workers must be retrained on the work floor. A transition has also started in view of the adoption of the sustainability development goals (SDGs) [5], a range of objectives agreed upon at the United Nations General Assembly on 25 September 2015.

They aim at stimulating actions over the next 15 years in areas of critical importance for mankind and the planet. IAEA supports these SDGs in many fields as energy, waste management, human health and environmental protection.[6] Our current and future students of nuclear engineering will start their career in this world of transition and will play an important role as radiation protection experts, future trainers, supervisors- and/or advisors for RPO's in all sectors.

At ETRAP 2017 and EUTERP 2019, the attention was especially drawn to the soft skills needed for future radiation protection professionals. Stakeholder awareness, networking, ethics, multi languages, risk communication and communication at large, trainer skills,…are important skills that have to be learned, together with the correct approach and attitude in the context of radiation protection and nuclear sciences. Therefore, blended learning incorporating distance learning together with face-to-face education, on site labs and simulation exercises needs to be developed further. Virtual learning and online collaborative learning will also increase in an unwanted but compelling way due to COVID 19 pandemic.

Albeit the current students are raised in a digital age, and while e-learning is useful, the sharing or transfer of special non-common knowledge cannot be efficiently transferred outside of an interactive 'classroom' environment. Moreover, the development of most soft skills, as well as specialized technical skills, needs interaction and a real "role playing" environment.

Development of an attractive training program where nuclear sciences and technology meet the SDG's for the transition to a better future world by 2030 and beyond, needs to be supported and tuned by different, skilled trainers.

2 The "Train the future trainers" program

Starting from the analysis of the needs on the work market and the capabilities in education and training offered, a group of 8 institutions coming from 7 European countries went on to design a program that combines distance learning and face to face training and integrates soft and technical skills for three selected themes. This program was submitted to the Belgian Erasmus Agency (French speaking part) in the KA2 Erasmus + key program [7] and received a grant for 2 years (from September 2018 to originally August 2020). The grant was extended to 2021 due to COVID 19.

2.1 General organisation

The partnership comprises 8 institutions, all members of the CHERNE network, together with associate members of the work field. 7 Partners are involved in academic teaching linked to Master's in Engineering Sciences:

- Haute Ecole Bruxelles Brabant-ISIB (Brussels, Belgium)
- University of Hasselt (Hasselt, Belgium)
- University of Bologna (Bologna, Italy)
- Czech Technical University (Prague, Czech Republic)
- HS Mannheim (Mannheim, Germany)
- Universitad Politecnica de Valencia (Valencia, Spain)
- Universidade da Beira Interior (Covilhã, Portugal)

The 8th partner is the Greek Atomic Energy Agency who brought its skills in management of digital teaching platform. The associate partners are actively involved in the on-site training schools.

Three themes related to certain radiation applications and radiation protection issues were selected: 'Environmental radioactivity', 'Nuclear reactors and waste management' and 'Radiochemistry and medical dosimetry'. For each theme, a two-year program was developed and organised by at least two partners at two different universities. Individual students were encouraged to follow the activities for both years. Figure 1 illustrates the trajectory of a student through the 2 years of the program.

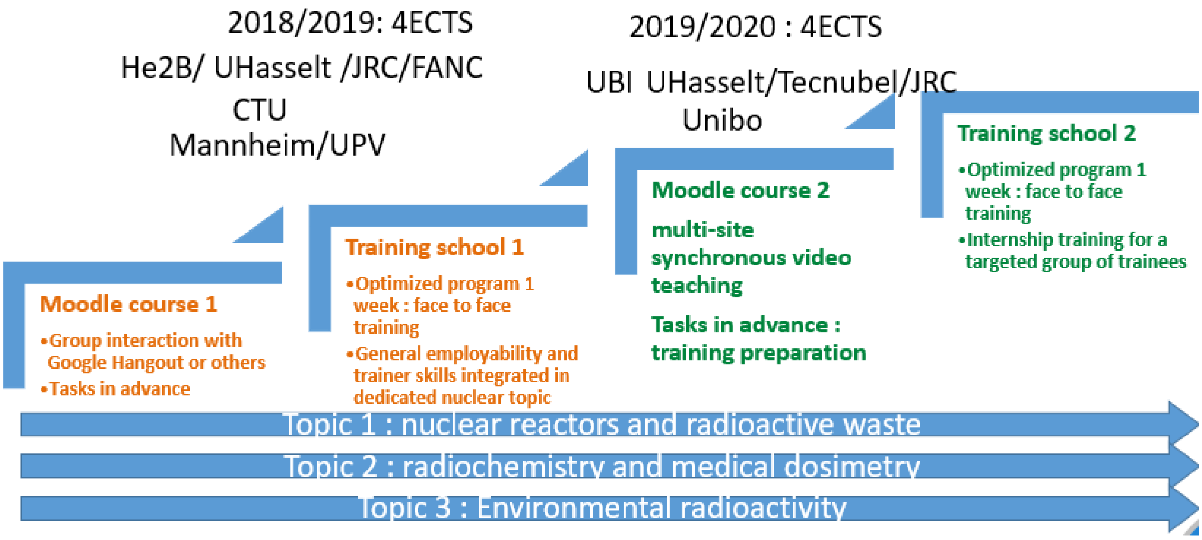

Figure 1. Trajectory of a student during the 2 years of the program.

As shown in figure 1, the yearly program represents 4 ECTS divided in pre-training activities (2ECTS) and a training week (2ECTS). The global program was divided in work packages leading to specific outcomes. The online interaction increased gradually from year 1 to year 2. One full on-line, collaborative learning training school had to be adopted for the last training week foreseen, due to Covid 19 constraints.

2.2 Methodological approach and activities of the first year

As mentioned before, a major interest of the program was the concern about SDG and the importance of knowledge transmission to a large public audience. The first part consisted of an analysis of the way to integrate soft skills and SDG into the courses. A workshop for trainers was organised just after the kick- off meeting (in November 2018) and was developed by specialists together with stakeholders and representatives of the work market. It led to the creation of the specific modules developed for the pre-training phase. A clear description of the activities, of starting and end competences and of evaluation methods was made for all training schools and communicated to all by means of an ECTS fiche. This will assure the sustainability and uniform approach throughout the activities organised by different partners.

The first-year activities were conducted to lay the foundation of the technical knowledge. For that purpose, general course modules were created on the Moodle platform: Basics in Nuclear Physics, Basics in Nuclear Measurements and Radiation protection approach. Students have to succeed in a Multiple-Choice Questionnaire related to these matters in order to enter the following parts of the program.
The pre-training activities to prepare for the real training week were conducted by groups of students, formed mixing students from different home institutions, . They were dedicated to one specific topic in relation with the theme chosen. For example, within the topic of radiochemistry and medical dosimetry, the different groups had to use the SDG Sheet Priorities and identify the most relevant SDGs for different topics related to the production of radionuclides for use in medical applications (reactor or cyclotron) as well as their use in imaging (scintigraphy or positron emission tomography). The students had to analyse (using a broad survey) and discuss their choice of the SDGs and rank the priority. At the training school, this task had to be presented in an innovative and interactive way.
The complete program of the first year can be seen on table 1.

Table 1: Organisation of training school of the first year.

Title	Nuclear reactors and waste management (8-12/4/2019)	Environmental measurements (7-13/3/2019)	Radiochemistry and medical (4-8/3/2019)
Subject	• Reactor training • Site visits (industrial, radioactive waste treatment and management) • Decontamination and waste management • Site monitoring and characterization of contamination • Teamwork, networking, ethics • Multi languages	• Measurement techniques • Field trip and sampling • Analysis of sample in the laboratory • Training skills, • Stakeholder awareness, SDGs, • Multi languages	• Measurement of doses • Calculation of shielding • cyclotron experiments • Risk communication, • software trainer tools (dosimetry), • Trainer skills, • Multi languages
Leader	CTU (Prague)	HE2B-ISIB	Mannheim

3 Activities of the second year

The second year of the partnership was mainly dedicated to communication and trainer skills: communication between peers (i.e., other master's or bachelor students in applied science) as well as with other groups of people Such as high school students, nurses…. During this year, a second set of pre-training and training modules was settled. The training module mainly consisted of real mobility and work in multi-national group to increase international cooperation. Online and onsite workshops and technical visits were organised to help in the preparation of training activities and real training was presented to people in some specific work situation. Mixed groups of students developed a specific training activity already during the pre-training activities by preparing the topic using a standard form to prepare the didactical approach.

3.1 Theme: Nuclear reactor and radioactive wastes

The second-year training school related to the theme 'Nuclear reactor and radioactive wastes' was organised mainly by UHasselt with the help of other partners and associate partners during the last week of November 2019. The schedule is presented in table 2.

Table 2: Schedule of the NIRM2 training school

	Monday	Tuesday	Wednesday	Thursday	Friday
	25th November	**26th November**	**27th November**	**28th November**	**29th November**
Morning	Welcome Introduction Waste management	Technical Visit – Belgoprocess (waste management)	Technical Visit- Euridice and Hades (long term storage)	Preparation of training course material in group	Adjustment of training course material
Afternoon	Preparing training sessions	Technical Visit – Myrrha Workshop on ethics	JRC- interactive lectures and demonstration	Training – Ba 2 University students	Training - High School students
Evening	**Team building activity 'meet and greet @ Hasselt'**			**Invited lecture 'nuclear decommissioning' Social event**	**Farewell drink**

A total of 15 students were divided into four international groups. During the month before the mobility, they received a specific topic in the framework of the waste management and had to propose a training activity. In total 4 training activities were developed (2 on communication and 2 related to practical exercises) The standard form prepared during the pretraining guided them in their didactical approach. It included the identification of the trainees, the definition of the subject, goals and subgoals, discuss the pillars of a good didactical approach, inventory of materials and method needs, and a detailed course scheme. Feedback moments (e-coaching) and real training moments were included in the pre-training and training school.
During the training school, interaction with experts on communication training and technical visits gave the students the opportunity to improve their pre-training task. Important time slots were also incorporated to include the on-site face to face interaction and repetition time in their own group. Social interactions were encouraged so that the trainers within a group would get to know each other well.

The last two days were dedicated to the real trainer activity. After presenting an overall introductory lecture on radioactivity, the real training activities were performed twice in small groups (4-8) of pupils: first to 16 second bachelor's students of UHasselt and secondly, to 33 high school students of 17-18 years. Between the repetitions, an adjustment could be done according to the feedback of the bachelor students and keeping in mind the diversity and larger group of the high school students. A significant improvement and appreciation were observed in the final training.

3.2 Theme: Environmental radioactivity

The second-year course organised in the final round took place in Universidade de Beira Interior (UBI) in Covilha (Portugal) during the first week of March 2020. It was coordinate by UBI, UHasselt and HE2B-ISIB according to the following schedule (table 3)

Table 3: Schedule of the Merade2 training school

	Thursday	**Friday**	**Monday**	**Tuesday**	**Wednesday**
	5th March	**6th March**	**9th March**	**10th March**	**11th March**
Morning	Welcome Introduction Intro lecture Workshop – The Environet and Training Programs	Workshop – Visit LRN (Laboratório de Radioatividade Natural)	Workshop– APA (Agência Portuguesa do Ambiente) Radon Norm Radon Plan Project in Portugal	Preparation of training course material in group	Adjustment of training course material
Afternoon	Preparing training sessions Presentations of students workshop activities	Technical Visit - ICNAS (Instituto Ciências Nucleares Aplicadas à Saúde) in Coimbra	History about the old mines and visit	Training - Master University students	Training - High School students Q&A
Evening	**Welcome meeting**		**Social event**		**Farewell drink**

A total of 17 students (in 4 groups) participated to the pre-training activities linked to the preparation of the final task but only 11 attended the training week due to the beginning of the COVID 19 pandemic. Two groups of students had to prepare a communication task: The first one had to choose 3 relevant SDGs and develop them in relation with environmental radioactivity. The second group was dealing with the impact of nuclear accidents in environment. The two other groups had to prepare a practical session to deal with radon and NORM. One team was invited to illustrate the safety or unsafety of building material and the second one had to enlighten the problem of radon in dwellings. The goal was to train students from UBI and from secondary school on those topics, but the pandemic made it turn in schoolmate training.

3.3 Theme: Radiochemistry and Medical dosimetry

The last training course of the second year was originally scheduled the week of the 15th of March 2020 but due to the rapid development of the COVID 19 pandemic it had to be delayed. After different attempts to organise it in presence, it had to be totally rethought for a completely remote organisation. Nevertheless, 12 students were divided into 3 multinational groups. The goal of this session was to create tools to raise the awareness of medical workers to radiation protection principles in high dose risk situations like production of radiopharmaceuticals using cyclotrons and generators (group 1), radiometabolic therapy (group 2) or imaging techniques using single photon emission or positron emission tomography (group 3).

As the course is organised by UNIBO, a Teams session was created for the course. This interactive platform could be used to share documents but mainly to organise video conference sessions. As there are no more real mobilities, the course was spread on three weeks during March 2021 and courses are scheduled every Thursday and Friday afternoons.

These courses contained lectures and small videos through which the students can virtually follow medical physicists during their daily work. Reference persons working in the hospital of Meldola were defined for each work situation to help students in their personal work. During April 2021, students will have to interact within their group to design a tool for radiation protection awareness. This tool will be presented by the end of April to the other groups as well as to a jury of teacher and medical workers. At the time of closing this document, the training program is under way but not yet completed.

4 Results and sustainability of the program

The global training program can be analysed from different angles.
Regarding the teaching program, the importance of soft skills, mainly communication and innovative training approaches were the major points to train future trainers. The lack in communication capabilities outside the close scientific community appears in many cases as a negative point common to a large majority of technical workers. They are capable to manage technical issues but fail to explain things to people not involved in their field like stakeholder, young students, other workers within their institution… One of the aims of the program was to train our students in that field, to give them tools for clear, transparent and understandable communication whatever the public will be. For most of the students involved in the program, it was their first experience in that exercise.
Inclusion of ethics and sustainable development goals in the work practice is also of foremost importance. These principles aren't really included in lectures for engineering students during their courses. In modern education, holistic approaches should not only be extensively included in the practical sessions and trainings but also in the theoretical and fundamental courses, so students familiarize under many aspects with these principles. Moreover, transnational discussions on these subjects could be very fruitful because they deeply depend on cultural sensibilities, previous experiences or educational principles. The real mobilities allow the students to meet each other as well as experts from the work field (network) and to gain skills and competences by using experimental devices or visiting specific workplaces they don't have in or near their home institution. The remote activities and the use of virtual tools allow to gain knowledge from specialists outside the home country with minimal "waste of time". It also permits interaction between students outside the week of real mobility. The lectures given directly or recorded and uploaded on a teaching platform give more time to experimental and participative work during the training week.

From the students' point of view, it seems obvious that international programs are always of interest mainly if they contain a part of real mobility. 33 students participated to the program of the first year and 38 attempted the second year. Even if we encourage the students to follow the two years program, less than half of the student were involved in the complete cycle. This may depend on the possibilities to validate the ECTS in the academic curriculum of the home institution.

For now, it is quite difficult to evaluate the effect on the employability of our students as some of them aren't graduated yet. Nevertheless, the improvement of language and communication skills represents an important advantage for employability.

The sustainability is an important point for programs developed in the framework of Erasmus+. Some of the activities and OI's developed during the "Train the future trainers" program will be maintained after the end of the grant. The methodological approach can be reused and translated for other courses in the curricula of each partner, even in fields other than radiation protection. The course modules developed during pre-training and training activities will be used in the future. The pre-training activities could be organised each year, preparing the students either for training activities or for the "end of study "internship.

The e-learning platform can be used after a simple registration (without fee). It will also serve as a dynamic data base for the development of new training modules in the future. The training modules can be organised keeping the cost related to participation and mobility as low as possible.

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ADVANCE IN DIGITAL LEARNING AT KTE – A FIELD REPORT

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Employees of KTE need to pass regular trainings in the areas of radiation protection, occupational safety, fire protection, and general plant safety. Since 2017 already, has annual training on a basic level been performed using interactive e-learning modules integrated in a Learning Management System (LMS). Intermediate- and high-level trainings have been performed online since the start of the Corona pandemic. High-level trainings including site inspections were also performed virtually. Control of success and the attachment of signatures can take place online. The supervisory authority confirmed the efficiency of all these new methods applied by KTE.

1 Introduction

1.1 Initial situation

Kerntechnische Entsorgung Karlsruhe GmbH (KTE for short) is in charge of decommissioning closed-down nuclear facilities on the campus of the former Karlsruhe Nuclear Research Centre. The following plants are decommissioned:

- WAK - Karlsruhe Reprocessing Plant
- MZFR – Multi-purpose Research Reactor
- KNK – Compact Sodium-cooled Fast Reactor
- HZ – Hot Cells
- FR2 – Research Reactor 2

KTE is also responsible for the management of nuclear wastes from the Karlsruhe site. The task of EB (Waste Management Department) is the collection and conditioning of waste for a future final repository for low- and medium-level nuclear waste. KTE is a state-owned company.

Every employee of KTE needs to pass annually basic trainings in the areas of

- radiation protection,
- occupational safety,
- fire protection,
- and general plant safety.

Workers with higher responsibilities (supervisors, team leaders) have to pass triennial intermediate and high level trainings in the above mentioned areas. Radiation Protection Experts are trained externally every five years at licensed training centres (figure 1).

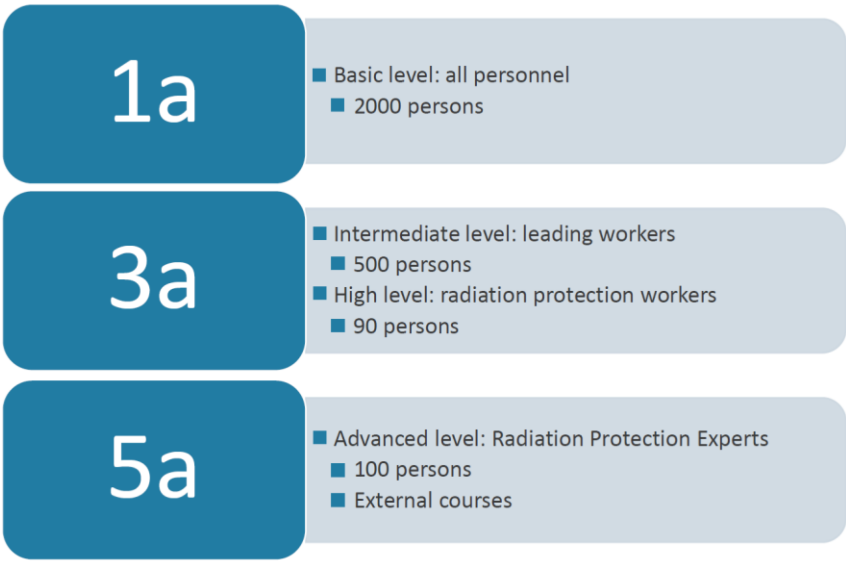

Figure 1. Training at KTE (periods in years, level of training in radiation protection and number concerned personnel.

1.2 Legal background

Trainings are performed in order to comply with KTE-internal rules and standards. KTE-internal rules for training have been harmonised for all plants. Employees of all plants and also staff from comprehensive departments, like maintenance, have the same standards. At KTE, is it called Framework Training Programme (Rahmen-Aus- und -Weiterbildungsprogramm).

This programme is derived from requirements specified in the

- German Radiation Protection Ordinance (Strahlenschutzverordnung, Article 63),
- Guideline to ensure the necessary qualification of personnel working in nuclear power plants (Richtlinie über die Gewährleistung der notwendigen Kenntnisse der beim Betrieb von Kernkraftwerken sonst tätigen Personen [of 30th November 2000, Joint Ministerial Gazette 2001, No. 8, p. 153])
- German Occupational Safety Act (Arbeitsschutzgesetz, Article 12).

For instance, it is outlined in the German Radiation Protection Ordinance that persons working with radioactive substances or inside a controlled area need to be trained before starting work and at least once a year.

2 Digital Advances

2.1 E-learning for basic training

Since 2017 already, annual training on a basic level has been performed using interactive e-learning modules (figure 2). About 2000 participants pass the basic level training every year at KTE.

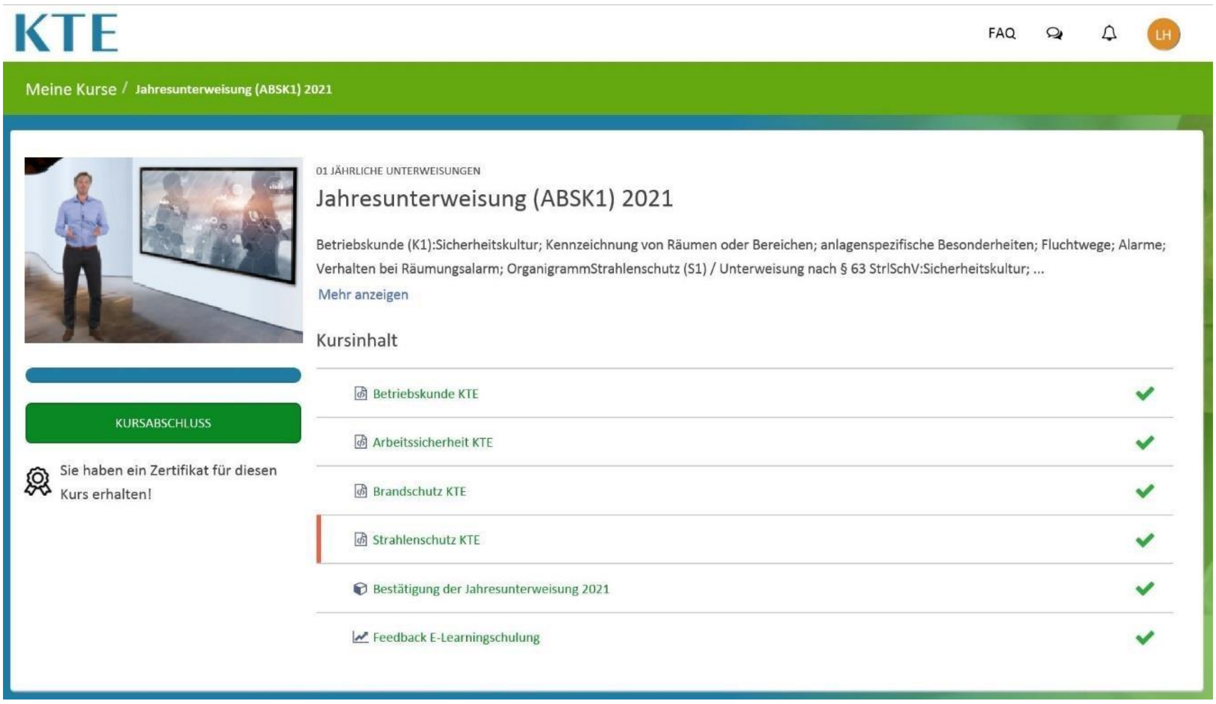

Figure 2. Learning Management System (LMS) view on the annual training.

According to the Radiation Protection Ordinance, radiation protection training is performed orally in an understandable form, but the authority can decide that training is performed by e-learning or by audio-visual media. In this case, it must be ensured that success is controlled and that it is possible to ask questions. E-learning at KTE has been approved by the responsible authority. KTE received the corresponding permit. This decision is reviewed after five years and also covers the requirements for e-learning according to the Radiation Protection Ordinance.

The requirements are implemented as follows. At the beginning of the radiation protection training, information on a contact person is provided, e.g. telephone number and e-mail address. At the end of training, success is controlled. Five questions from a pool of about 20 questions are picked randomly. Four questions need to be answered correctly to pass the test. Also the length of the training is specified. The Guideline for personnel working in nuclear power plants specifies that radiation protection training must have a minimum duration of half an hour. The training was designed accordingly. Of course, training can last longer depending on the individual speed of the trainee.

E-learning modules are integrated in a Learning Management System (LMS). Depending on the function, employees are assigned to trainings. Employees can log in and check their status of training, register for trainings, start e-learning, and download certificates of passed trainings. Supervisors can track the training status of their staff.

2.2 Live online intermediate- and high-level training

Intermediate- and high-level trainings in all four areas, including radiation protection, are mandatory for workers with higher responsibilities. So far, these trainings have been performed in the form of class lectures and repeated every three years. During the first wave of the Corona pandemic, KTE had to stop class lectures. Lecturers of KTE quickly acquired skills of live online training (figure 3). Here, this means that on the date given, trainees and lecturer sit in front of an internet-connected computer with a video conference software.

The trainees listen to the live lecture of the lecturer. Equipment and video conference software have been tested for this purpose. First test lectures took place with a small group of trainees. Officers of the responsible authority then joined the online trainings and confirmed their efficiency, but made some requirements concerning feedback possibilities.

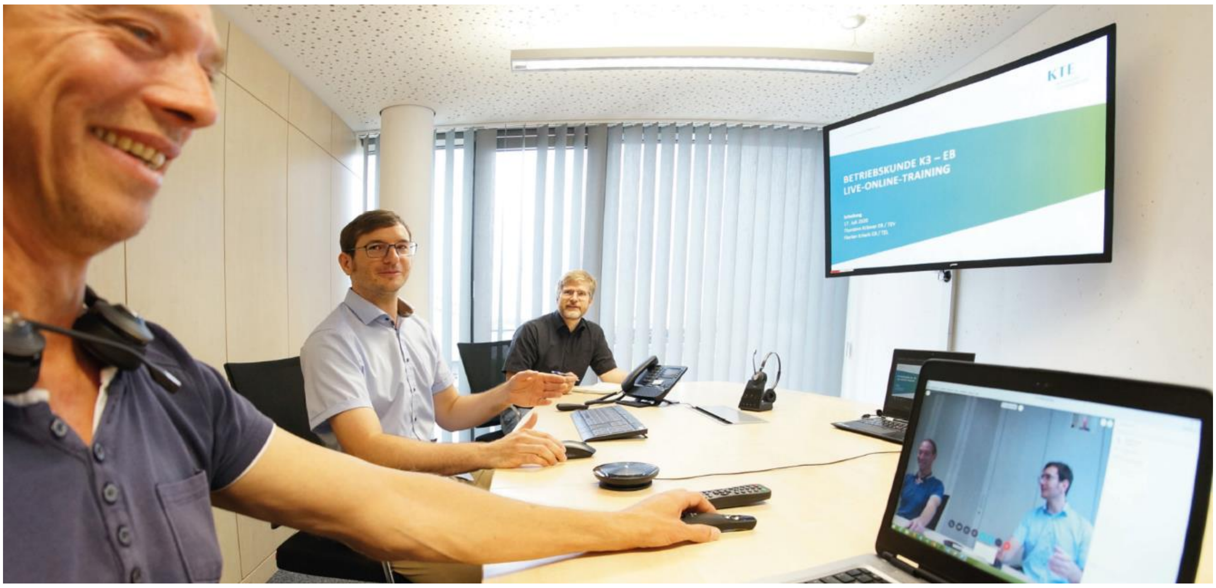

Figure 3. Lecturers in action in their life online training studio.

The officers requested to use webcams to help to communicate better in both ways from lecturer to trainee and from trainee to lecturer. Visual communications include, for example, waving or face expressions which give a feedback to the lecturer. Furthermore, the trainee can be identified and the presence of the trainee is documented. Headsets are recommended to ensure a good audio connection.

The officers demanded to keep record of the success of a live online training. For this purpose, questionnaires in PDF format were electronically distributed and then printed and filled in by trainee after the training. The lecturers evaluate the answers in the questionnaires manually and decide whether they need to talk to the trainee to correct potential mistakes. Four out of five answers must be correct to pass without further consultation.

In the meantime, paper questionnaires have been replaced by electronic questionnaires. The electronic version of the questionnaire was encoded with Articulate 360 (figure 4), which is also used to encode and design e-learning modules. Now, the lecturer just has to confirm the trainee’s participation. The LMS checks, whether the questionnaire was completed correctly for a successful training.

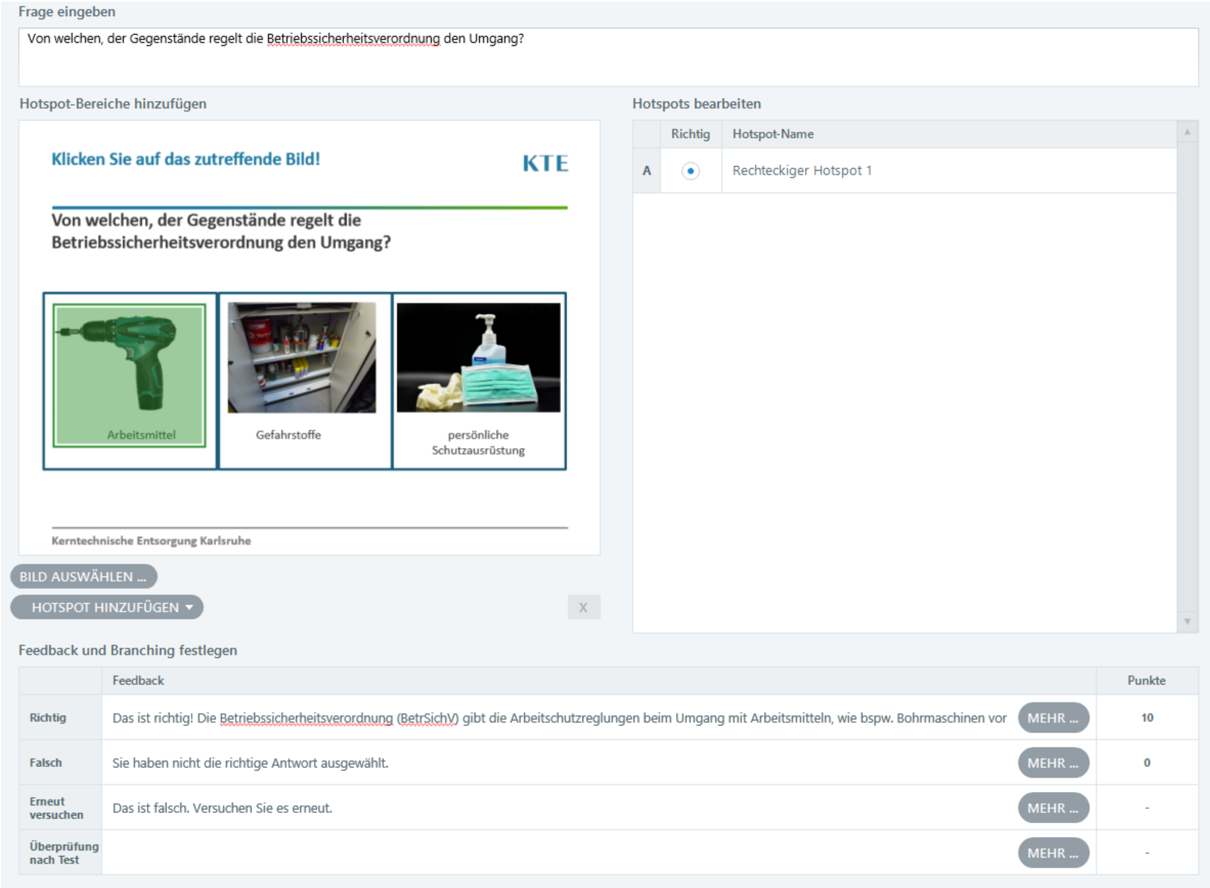

Figure 4. Editing a questionnaire with Articulate 360.

2.3 Virtual site inspections

High-level training in the area of general plant safety includes site inspections. Due to the Corona pandemic, it is difficult to lead a group of trainees through the plant. Social distancing can hardly be observed, especially in loud areas of the plant when the guide gives explanations to the group.

For this reason, lecturers created a kind of slide show which can be presented in an online training to substitute the inspection on site. Slide shows have been developed to guide the trainee from one room to the next on the same path as the real inspection (figure 5). The advantages are as follows: Images can be shown, which cannot be seen on site, for instance process flowcharts or a view into the furnace of an incineration plant. Detailed images can be shown and are clearly visible by all trainees without crowds in front of display windows. The acoustics are better without loud noise of machinery or ventilation systems. Additionally, a virtual inspection saves a lot of time, which is normally spent when entering controlled areas with all radiation protection measures. Disadvantages, especially for new employees, are a worse feeling of orientation inside the building and the lack of training to learn the access procedure of the specific plant. Staff on site cannot be met virtually.

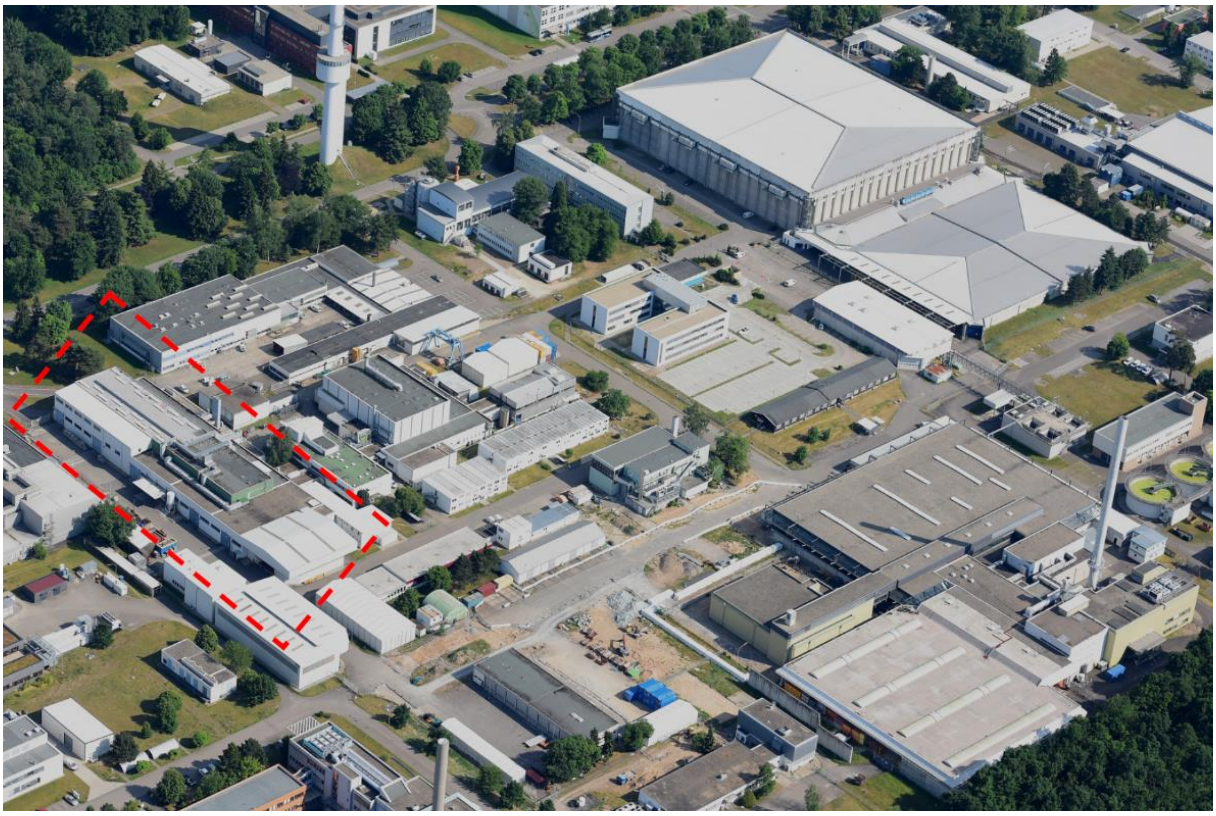

Figure 5. Aerial view of the plant as a start of the slide show substituting the site inspection.

Again, the responsible authority confirmed that this method of virtual site inspection is suited for obtaining an overview of the plant and its safety equipment at least. Disadvantages are compensated by another step of training which is performed on site. New employees will have to be physically present at their workplace for on-site briefing before they start work. This briefing is performed by an experienced supervisor, who explains technical details.

2.4 Authentication

Handwritten signatures traditionally are the most secure proof of a successfully performed training. In times of online banking, handwritten signatures are losing importance. Up until 2020, e-learning-certificates needed to be printed and signed by the trainee and sent to the training department, where they were scanned and documented in a database.

KTE discussed this topic with the responsible authority to facilitate this process for all parties involved. Access to the LMS already is password-protected, but a two-factor authentication procedure was added to the LMS. This procedure is used at the end of the training and allows the trainee to confirm a successful participation without a handwritten signature. As a second factor, a secret code is sent by text message to the registered e-mail address or to a registered phone number. The trainee is asked to enter the code to confirm that she/he understood the training and completed the training all by herself/himself. The responsible authority permitted KTE to use this new method of authentication in written form. It is planned to extend a decision of the authority, which will allow e-learning for the radiation protection training by the new two-factor authentication method.

2.5 Conclusion

Corona pandemic boosted digital learning at KTE. E-learning and live online trainings helped KTE to fulfil its training requirements in 2020. New techniques for digital learning have been approved by the authority.

2.6 Future prospects

For some repetitive trainings, it is planned to develop more e-learning modules, an example being repetitive intermediate radiation protection training. The authority is invited to follow this development at KTE and is asked to confirm the success of the new learning methods.

At the end of the Corona pandemic, it is also planned to strengthen the use of blended learning. This means that basic information, which does not change much, is given in e-learning modules. Current information will be presented in a class lecture. It is also conceivable to combine site inspections with e-learning lectures. This way, the advantages of both methods can be used.

Acknowledgement

The author like to acknowledge all colleagues, who helped to achieve the advance mentioned in this paper, especially the team of TST and all involved lecturers of KTE who made the advance possible.

TRAINING IN RADIATION PROTECTION REQUIRED BY LEGISLATION: APPROACH DURING THE COVID-19 CRISIS AND PRACTICAL IMPLEMENTATION

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According to international and national legislation, various professional profiles require education and training in radiation protection. In Belgium, a new regulatory framework entered into force in early 2020, implementing the latest requirements of the 2013/59/EURATOM EU BSS Directive.

With the healthcare sector being under enormous pressure during this health crisis, various temporary measures were taken by the national regulator for the health professionals.

From a practical point of view, training courses in radiation protection were organised in adapted circumstances to prevent further spreading of the COVID-19 virus.

This article highlights the Belgian pragmatic approach of the regulator with regard to radiation protection education and training during the COVID-19 crisis, as well as the experience of a national training centre organising radiation protection education and training for diverse target audiences.

1 Introduction – overview of E&T requirements in radiation protection in Belgium

The Belgian Royal Decree of 20 July 2001 laying down the general regulations on the protection of the public, the workers and the environment against the hazards of ionizing radiation (ARBIS/RGPRI) [1], contained at that moment the transposition of the European directives in radiation protection. This included the former European directives 96/29/Euratom (basic safety standards) and 97/43/Euratom (patient directive). While at the European level the directive 2013/59/EURATOM "Basic Safety Standards" (BSS) [2] replaced 5 former directives, among which 96/29/Euratom and 97/43/Euratom, in Belgium the opposite approach was taken: only the general requirements and framework were maintained at level of the ARBIS/RGPRI, which underwent a thorough revision, while sector specific requirements were laid down in separate royal decrees.
This is also the case for the medical exposures, veterinary applications and distribution of radioactive products for in vivo or in vitro use in medicine, for which requirements are laid down resp. in the Medical Exposures Decree [3], the Veterinary Exposures Decree [4] and the In vivo-In vitro Decree [5].

The articles 14 (General responsibilities for the education, training and provision of information), 15 (Training of exposed workers and information provided to them), 16 (Information and training of workers potentially exposed to orphan sources), 17 (Prior information and training for emergency workers), 59 (Training and recognition), 79 (Recognition of services and experts), 82 (Radiation protection expert) and 84 (Radiation protection officer) of the BSS are transposed in the ARBIS/RGPRI for the workers, the emergency workers, the radiation protection officer, the radiation protection expert and the occupational physician. The articles 18 (Education, information and training in the field of medical exposure) and 83 (Medical physics expert) of the BSS are transposed into the Medical Exposures Decree for the practitioners and individuals involved in the practical aspects of medical radiological procedures, as well as for the medical physics expert.

Complementary to the regulations on the well-being of workers [6], which define general requirements on information and training about occupational risks, the ARBIS/RGPRI stipulates the obligation of the undertaking to *inform* workers and outside workers who may be exposed to ionizing radiation, including emergency workers, before their entry into service, about the occupational health risks due to ionizing radiation and protection against it. Female workers, including female outside workers, are informed of the risk of ionizing radiation to the embryo and foetus and to the necessity and duty of making an early declaration of pregnancy. They are informed of the risk to the infant when breastfeeding after intake of radionuclides or bodily contamination, and the importance of announcing their intention to breast-feed.
This information is regularly updated, depending on the needs, but at least once a year, and it is made available in writing [1].

In addition to this information, the undertaking has to organize sufficient and adapted *training* for each worker and outside worker specific for their workplace or function, about the use of equipment and substances that emit ionizing radiation.
The training is given when hiring, in the event of a transfer or change of position, when changing or introducing new work equipment, when introducing a new technology and is repeated according to the needs and documented.
In installations where orphan sources are most likely to be found or processed, training is provided by the competent authority, which also provides support to training courses organized by professional federations or companies. To this end, the FANC has developed several tools to inform companies and their workers [1].

Workers and outside workers who are identified in advance to be *involved in radiological emergency intervention*s are informed of the risks that their interventions may entail and the precautions they should take. The information is adapted to the type of intervention and is regularly updated. The information takes into account the different possible emergencies that may arise and the type of intervention. If necessary, it also includes practical exercises.
The information is regularly updated, depending on the needs and at least every three years.
As soon as an emergency occurs, the information is repeated and supplemented with the relevant information according to the circumstances.
Interveners who volunteer again with full knowledge of the facts will also receive instructions when the reference level might be exceeded.
Workers and outside workers who have not been identified in advance to be involved in radiological emergency interventions are adequately informed before their intervention about the risks to their health and about the precautions to be taken in such cases. This information takes into account the existing emergency and the specific intervention conditions [1].

In order to obtain a recognition as *radiation protection expert (RPE)*, the applicant must hold a master degree in engineering sciences, industrial sciences, industrial engineering sciences, physics, chemistry or any other master degree in exact sciences or any other degree that provides its holder with suitable training. Furthermore, the applicant should have a diploma or certificates of training in radiation protection and nuclear safety, covering a truncus communis of at least 12 ECTS in radiation protection, and a number of ECTS for technology and nuclear safety that depends on the domain, from 24 ECTS for assignments in nuclear reactor installations downwards to 50 hours for the medical and industrial applications. A training of 35 hours is required for assignments in the transport of Class 7 dangerous goods characterized as fissile materials or materials presenting a risk of corrosion, and 20 hours for the transport of other class 7 dangerous goods. For assignments in nuclear installations, the application is subject to advice of an external advisory board [1].

Radiation protection officers (RPO) have to follow modular training courses corresponding to the nature of equipment or sources or the types of transports in which they are involved. The minimal duration and contents of the modules are specified in the regulations [7].

Occupational physicians involved in the medical surveillance of professionally exposed persons and outside workers are subject to a training programme of at least 150 hours of theory and at least 45 hours of practice on the subjects specified in the regulations, and an internship of at least 160 hours. For the medical surveillance of workers in nuclear installations, an additional training of 50 hours and an additional internship of at least 750 hours is required. The application for the recognition is subject to advice of an external advisory board [1].

In installations where medical radiological procedures are performed, the undertaking has to ensure that these are only performed by licensed practitioners and their authorized staff such as nurses and radiographers [3].

For *medical practitioners*, personal licenses for the use the medical radiological equipment or radioactive products are granted on the basis of their competence in the field of radiation protection in medical exposures, specific with respect to the nature and conditions of use of the medical radiological equipment or radioactive products they use : licenses can be obtained for the use of x-rays for medical imaging, equipment and sealed radioactive products in radiotherapy, non-sealed radioactive products in radiotherapy or radioactive products in nuclear medicine. A license is limited in time, with a typical validity period of 10 years, and is specific to certain radioactive products and types of medical radiological equipment and to certain application forms of the ionizing radiation.
The competence of practitioners is assessed according to diplomas, certificates and titles and according to proven scientific or professional elements. The regulations specify the number of hours and the topics for each basic education and training, ranging from 15 hours for dentists up to 200 hours for radiotherapy or nuclear medicine.
When the practitioner already holds or has held a license and seeks renewal, his competence will be assessed on the basis of compliance with the applicable continuing education requirements during the validity period of his past license. To this extent, the competent authority evaluates the initiatives for continuing education that are notified, and allocates for each target group the number of hours that will be taken into account for the renewal of their license or recognition [3].

Authorized staff such as nurses and radiographers who have an active role in medical exposure, are not subject to a personal license. A basic training of at least 50 hours regarding the radiation protection of the patient is required, with an additional 10 hours for radiotherapy or nuclear medicine [3].

In order to become a recognition as a *medical physics expert (MPE)* in a specific field of competence (radiology, radiotherapy or nuclear medicine), the applicant must have successfully completed a training in medical radiation physics consisting of either a master's degree of 120 credits or a master after master's degree of 60 credits, dedicated to the topics specified in the regulations.
If the applicant already has or has been recognized and seeks renewal, his competence will be assessed based on compliance with the applicable continuing education requirements during the validity period of this recognition and a report on the activities carried out during this period. A clinical internship of one year per field of competence is required (for a second field of competence 6 months if this second field of competence is radiology or nuclear medicine). The application is subject to advice of an external advisory board [3].

The *medical physics assistant (MPA)* must at least hold a bachelor's degree or a diploma recognized or declared equivalent in Belgium and have successfully completed a training at a level at least corresponding to that of non-university higher education and comprising a minimum of 20 credits spent on the subjects specified in the regulations [3].

Due to technical developments with possible implications for radiation protection, FANC may at any time impose specific complementary training for certain applications [3].

The undertaking is responsible for ensuring that the radiation protection officers, the authorized staff for medical exposures, the medical physics assistants have received the basic education and training and the continuing education in the field of radiation protection appropriate to their professional activities, without prejudice of the regulations on the health care professions, which stipulates the general requirement on their education and training and recognition as health care professional [3].

Pharmacists can obtain a recognition as *radiopharmacist* if they followed a university level study programme in radiopharmacy [5].

Veterinary practitioners have to follow an education and training of at least 40 hours for the use of x-rays and 112 hours for radiotherapeutic or nuclear medicine applications. For the *authorized staff* involved in veterinary practices, 24 hours of training are required, and an additional 8 hours for radiotherapeutic or nuclear medicine applications [4].

Continuous education is required for all categories of actors [1,3,4,5,7].

2 Impact of COVID-19

2.1 For the competent authority

2.1.1 Continuity plan of the competent authority

In March 2020, following the declaration of COVID-19 as a pandemic by WHO, at national level the Ministerial Decree of 13 March 2020 announced the federal phase of coordination and management of the COVID-19 crisis in Belgium. At that moment, the competent authority for nuclear safety and radiation protection, FANC, activated its internal crisis cell and its continuity plan for its activities. The nuclear and radiological sector being considered as an essential sector, also during lockdown the essential activities had to go on in order to continue ensuring safety and security. However in order to limit the spread of the Coronavirus, the activities in the various sectors had to be adjusted.

2.1.2 Measures for the health care services and professionals

Next to this general crisis cell, an additional internal crisis cell dedicated to the health care sector was created and activated, as this sector is highly impacted and under strain during the health crisis. Within this crisis cell “health care sector”, the situation of the pandemic in the medical installations was followed up continuously, by regular contacts with different stakeholders in this field. Decisions were taken based on the actual situation at each moment. The main aim of these measures was to facilitate where needed, in order to relieve some of the pressure on the healthcare staff, within the possibilities of the competent authority.

The coronavirus COVID-19 being an infectious disease that mostly affects the lungs and respiratory tract, it was noted that the capacity of medical radiological equipment, specifically X-ray devices needed for diagnosis and follow-up of the disease, might not be sufficient to meet the increased demand for medical imaging. Therefore, a temporal derogation from the general regulations in ARBIS/RGPRI was needed to allow commissioning of additional medical radiological equipment within the shortest possible time.
It was also noted that undertakings might be faced with a shortage of qualified personnel to assist practitioners with the necessary medical exposures in the context of the diagnosis and follow-up of patients for COVID-19, and that there might be a need to call on staff for assistance during medical exposures other than authorized staff.

For this purpose a safety measure was imposed by a nuclear inspector. This safety measure allows to derogate from the normal procedure, motivated by the exceptional circumstances that require exceptional measures. This made it possible to commission additional medical radiological equipment for conventional planar medical imaging without updating the operating license, provided there has been a favourable acceptance into service by an MPE in radiology and an RPE, and that the formal request to update the operating license is submitted to FANC within a reasonable period of time after the equipment has been taken into use, with a maximum of three months.
If the medical imaging of the thorax, using conventional planar imaging of patients for the diagnosis or treatment of the coronavirus COVID-19 can only be done in rooms with limited access due to the risk of contamination with the coronavirus COVID-19, doctors or nurses who do not meet the E&T requirements for radiographers may act as radiographers within the meaning of the Medical Exposures Decree [3], under the following conditions:

i. These persons have previously received a brief training on the essential elements in taking conventional X-rays from the MPE in radiology and the medical imaging service. The undertaking keeps a register of the persons involved who have received this training;
ii. Where applicable, there is close guidance and supervision of a radiographer during the medical exposure;
iii. The RPE must determine whether these persons should be considered as professionally exposed persons and the need for dosimetric follow-up. If dosimetry is necessary, a personal dosimeter must be worn. If this is not possible, an alternative dosimetric follow-up can be set up, for example by registering the number and type of exposures, so that afterwards a dose estimate can be made.

The safety measure was valid from the 1st of April 2020 until the 30th of June 2020 and was renewed on 23rd of October 2020 for 6 months. Of course, the basic principles of radiation protection continue to apply during the validity period of this safety measure.

FANC monitors compliance with the specific conditions that it may impose in the licenses and recognitions. The renewal of a license for the use of medical radiological equipment by practitioners, or the recognition of medical physics experts or radiopharmacists, is assessed based on compliance with the applicable continuing training requirements during the period covered by this license or recognition.
It had to be noted that practitioners, MPEs and radiopharmacists were at the moment of the crisis unable to meet the requirements with regard to the timely request for the extension of their authorization or recognition and compliance with the requirements for their continuing education as they had to prioritise certain tasks such as fighting the crisis and the acceptance of equipment necessary for this.

Therefore, it was considered appropriate to exempt all practitioners, medical physics experts and radiopharmacists from the obligation of continuing education for the year 2020. Finally, a single automatic extension of six months was granted for the licenses and recognitions that arrived at their end between 13th of March and 31st of August 2020.
These decrees were annexed to the individual licenses or recognitions issued by FANC.

2.1.3 Evaluation of basic and continuous education and training programmes

For basic training and education, provided by universities and colleges, FANC can verify the compliance of training programmes with the criteria set in the regulations [1,3,4,5,7]. However, the exact form of the education and training is not within the competence of FANC. The directives of the authorities competent for education, and the internal directives of the educational institution have to be respected. At the federal and regional level, measures have been taken on the one hand to avoid COVID contamination and on the other hand to allow universities and colleges to organize themselves in a more flexible way in this regard, for example with respect to the format of the education and training, the end of the academic year, the assessment method, etc. In a general way, online courses have been obliged at the federal level for universities and colleges.
Universities and colleges could therefore make the necessary adjustments to their current training programmes taking into account these guidelines and if the provisions of other applicable regulations, such as ARBIS/RGPRI and the Medical Exposures Decree are respected. In particular, these provisions impose a knowledge test but do not specify how this test should be organized in practice. This is the responsibility of the university or college, who has to ensure that the necessary knowledge and skills are acquired, regardless of the way of assessment.

FANC evaluates continuous education initiatives in order to determine to what extent, expressed in number of hours, it can be taken into account for the renewal of a license or recognition, for each target group. The same is done for radiographers, even if there is no individual license, in order to allow compliance check with the education and training requirements.

For all types of education and training, taking into account the federal COVID-19 measures, the competent authority accepts online courses which comply with the regulatory obligations. Participants must be registered and assessment must be performed when required by regulation. This is the case for training of employees, theoretical training for RPOs, academic training for professionals,...

2.1.4 Training initiatives provided by the competent authority

The competent authority provides some training initiatives itself. For these, alternative methods were used as well. The yearly symposium for occupational physicians was organised in the form of a webinar, with use of a voting tool to make it more interactive. The central examination for dentists with a foreign radiation protection certificate, which is organised by all Belgian universities in the premises of FANC, was organised physically, in different shifts, respecting social distancing and hygiene measures. The training for drivers of radioactive transport was organised online and an online tool for examination was used.

2.2 For the training providers

At the initial phase of the COVID-19 pandemic in Belgium (first months of 2020), training providers such as the SCK CEN Academy rearranged their face-to-face training courses in order to respect social distancing and hand hygiene. Practical exercises and technical visits were left out of the programmes or replaced by alternatives where possible (e.g. explanation by photographs).

At the Belgian Nuclear Research Centre (SCK CEN), the SCK CEN Academy worked in close contact with the internal service for prevention and protection at work, as well as the medical service, to determine feasible and effective protection measures to allow further training courses.

As the situation rapidly worsened over the next months, some training courses were postponed or cancelled. Practical training modules were organised in exceptional circumstances (e.g. mandatory trainings to warrant a safe working environment), with great care for prevention of contamination.

Since it became clear in the Spring of 2020 that large improvements were not to be expected in the upcoming months, training courses were postponed on a larger timescale (e.g. towards the upcoming year) and theoretical training courses were organised online by using webinar platforms. Preparations were made to convert some training modules into self-paced e-learning.

During the summer of 2020, preparations were made by many training providers to offer distance learning in a sustainable way, at least for the duration of the measures to restrict the further spreading of COVID-19.

3 Challenges and opportunities

3.1 For the competent authority

Taking into account the limitations set by the COVID-19 measures at the federal and regional level and the need to continue education and training in order to comply with regulations on one hand but on the other hand seeing the need for more qualified staff in certain domains, the competent authority had to adapt its activities and way of working. Derogations from the regulations cannot be taken on an informal basis, therefore safety measures and formal decisions in the form of extensions to existing licenses and recognitions had to be taken, as was detailed above.

While theoretical modules can relatively easily be converted in online learning and alternative forms of assessment can be organized, distance learning is more difficult to implement for practical training. During the COVID-crisis, risk of contamination makes it hard to organize it physically. For medical professions, additional difficulties exists, as medical departments are obviously too busy to organize training, and a higher risk of contamination exists in these environments. Video recordings were therefore allowed as an alternative during the crisis. However these are not ideal. More active simulator-like methods could be investigated.

As distance learning and more flexible ways of learning will also stay after the crisis, the challenge for the competent authority is to take into account this new reality in the requirements set in regulations.

3.2 For the training providers

In the early phase of the outbreak of COVID-19 in Belgium, where face-to-face training was still possible, large uncertainties were introduced on the necessary measures to implement, their effectiveness and duration. This uncertainty fuelled the hesitation of some companies to search or request training in radiation protection from external training providers.

The switch towards distance learning required the training organisers to invest in several resources: software licenses for qualitative online broadcasts and e-learning, hardware such as headsets, camera's and (tablet) computers. Other 'consumable' expenses from regular face-to-face training sessions were of course reduced (printed course material, coffee and lunches).

The administrative support of the training course needed to make a shift from room reservations, assurance of coffee and refreshments, lunches, reformatting and printing of course material towards electronic support in terms of trainee registration, connectivity and follow-up. Depending on the technology used, it posed a challenge to track the online participation of the trainees in order to

Next to common organisational issues, training providers were also urged to develop guidance for trainers and course participants. A lot of trainers were not familiar with online teaching and training, and needed an introduction into the technological tools to use (hardware and software), as well as how to convert training material towards an online format and how to engage the online audience for effective training. At the SCK CEN Academy, a dedicated webpage on the intranet was setup gathering all information about online training. For the training participants, guidance documents were developed to help the participants in the process of registration and access to the online environment (including the course material).

3.3 For the trainers

The application of social distancing and the use of simple PPEs such as face masks, face shields, gloves and disinfectant alcohol gels seemed easy to apply at first, but gave a whole new dimension to the training courses: the inability to read body language from the trainees and the inability to use body language during lecturing and training was disadvantageous to give effective training. The informal networking where background, training expectations and pre-knowledge could be discussed during (coffee) breaks was more difficult during face-to-face training and mostly absent during online training.

The training material had to be redesigned to meet the new COVID-19 setting. This resulted in the adaptation of the setup and (re-)used material for practical training, the creation of instructional videos where live demonstrations were no longer possible, and the reformatting of presentation files to suit the programmes of distant lecturing in a webinar format. Besides a large workload, this sometimes resulted in specific situations where the quality of training was negatively affected, e.g. a delay between the broadcasted presentations, advanced animations and video’s not working,

In terms of practical skills, many trainers needed to familiarize themselves with webinar tools, extra hardware (table microphones, headsets and drawing tablets) and the optimisation of online lecturing environments (background, lightning, noise, stability of the network)

3.4 For the trainees

The application of social distancing and the use of PPEs in face-to-face training resulted also in similar experiences for the trainees: the networking during coffee breaks became difficult, as well as the cooperation between trainees for practical exercises, peer discussions and group assignments.
The participation of distant learning activities required some level of discipline to stay focused on the screen. In terms of resources, it was challenging for some trainees to get access to a personal screen and audio devices to follow the training courses, in combination with a stable network and a quit environment. Access to the digital training course material was ensured by the training provider where needed. A large advantage for both trainers and trainees was the gain in time since physical relocation was not needed.
From the feedback of 148 training course participants of 13 online training courses in radiation protection organised by the SCK CEN Academy from March 2020 to March 2020 it became clear that the majority were satisfied to very satisfied on the webinar software used (MS Teams, Adobe Connect and Bigmarker).

Depending on the type of training (e.g. multi-day training vs short webinar in the framework of continuous professional development), the overall preference of the participants was expressed to a face-to-face format in comparison with online training. Recurring remarks were the need for increased amounts of breaks during online training, as well as the need for more interaction.

4 Future outlook

To ensure a high level of protection for the population, the workers, the patient and the environment, and to optimise and improve the related policy and its practical application, a continuous effort is needed to assure the knowledge, skills and competences of scientists and professionals in radiation protection. Even in challenging times of a worldwide pandemic, the radiological and nuclear sector found a way to ensure an offer for radiation protection training, although mainly limited to mainly theoretical training. The regulatory authority facilitated a practical approach with respect of the requirements of the legislation, and the training providers switched gears to offer adapted programmes to professionals and students where necessary.

For the training providers it became clear that on the long term investments are needed to maintain distant learning. By now (spring 2021), most training providers in radiation protection in Belgium are ready to offer online engagement, but are also longing forward to reinitiate face-to-face training courses with all associated (dis)advantages.

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HOW OUR BRAINS LEARN – TIPS FOR ONLINE TEACHING

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Having more knowledge about how information is being processed and stored in the brain helps us find ways to improve our teaching. Tips that underline this approach are: activate prior knowledge, use a step-by-step structured approach, use examples, combine words and images, and make them think. These tips can be applied for both offline and online teaching.

1 Introduction

In education, unfortunately, many myths persist, such as the existence of 'learning styles', 'left and right brain preference', and the 'learning pyramid'. Thankfully, there is a lot of research about how we actually do learn. In order to teach effectively we need to understand how our brains process information so that participants will really learn what we want them to effectively.

2 Learning and memory

Learning can be described as an enduring change in behavior, or in the capacity to behave in a given fashion, which results from practice or other forms of experience [1]. The elements of this definition that stand out are that learning involves change, and that it results from practice or experience. This implies that learning is an active process in the brain that doesn't happen just automatically or very easily. Specifically, learning involves storing knowledge in our *long-term* memory. But in order to get there, knowledge has to pass through our *working* memory first, and that can be a problem, because working memory is limited. In working memory, we can only store around seven items at the same time, and only for a few seconds. When we present knowledge, despite all of our best intentions, it is very easy to overload our participants' working memory, and hence impede their learning.
Cognitive load theory explains that this can happen by providing too much extraneous information that is not necessary for learning, but that does take up room in working memory, hindering the essential knowledge from passing through [2]. Another way that our working memory can be overloaded is when our expertise makes us unaware that we should break down the content into small chunks. That is, give the participants just enough information to *digest* each one at a time, instead of choking them with too much complex information.

In addition, we know that new knowledge can be stored better by connecting it to already-existing knowledge in our brain. The more connections being made, and the stronger those connections are, the better participants will remember and be able to retrieve the new knowledge, and apply it when needed.

3 Teaching strategies

This understanding of how our brain handles new knowledge helps us identify strategies to enhance the participants' learning process. In the next paragraphs a few of these strategies, which apply equally to in-person and online learning, will be explained.

3.1 Activate prior knowledge

Activating prior knowledge is an important strategy to help participants remember new knowledge better, since the new knowledge can be more easily connected to existing knowledge, making it easier for participants to remember it [3, 4, 5]. There are many ways to do this. The simplest way is to ask the participants what they already know about the subject. Other ways are starting off with an introductory quiz, letting the participants make a mind map about what they already know about the subject, or letting them write down the questions they have regarding the topic.
For online teaching, using tools like Mentimeter or Kahoot can be an excellent way to do this, but also simply just giving participants one minute to write down everything they already know about the topic, can already be an effective way to activate prior knowledge, without having to use additional online tools.

3.2 Offer a step-by-step structured approach

Formulating learning objectives is an excellent way to bring structure to your courses, but also to force yourself to think about what it is that you really want to achieve with the course, and find the adequate teaching method to do that. Literally communicating your learning objectives to the learners is not necessary, however; just offering an overview of the structure will help participants organize the new knowledge, making the transition to long term memory smoother.

In addition, breaking new content into small understandable chunks will make it easier to pass new information through onto long term memory, as explained above that we now understand this from cognitive load theory. Stripping content from unnecessary extraneous and intrinsic load will enhance this process. This could be achieved, e.g., by using a minimal amount of text on (PowerPoint) slides and using a new slide for each concept.

Because the cognitive load can be a bit heavier for participants who are online, offering structure and a step-by-step approach are especially important in that situation. Therefore, in online teaching it is even more essential to break the content into small chunks. Making short videos about complex concepts is a great way to reduce the participants' cognitive load. If needed, participants can pause the video and replay the parts they did not understand. Both with asynchronous learning and synchronous learning it is crucial to give participants the possibility to ask questions. This can be done using forums, chat sessions, Q&A sessions etc. In addition, it is usually harder to gauge the understanding of the participants when teaching online, so it will be helpful, and even more important than during in-person teaching, to check from time to time whether the participants understand what you are teaching.

3.3 Use examples

Examples make it easier for participants to understand content and store it in long term memory. Examples can be analogies, metaphors, visuals, or so-called *worked examples*. Important here is to explain a new topic first, and then give examples. By using examples, participants will have enough working memory capacity left, to build more in-depth understanding. They can focus on underlying principles, and structural characteristics of the concept. In addition, concrete situations and abstract concepts will be connected to each other [6].

As mentioned before, cognitive load can be heavier in online learning, therefore, extra care should be paid to finding examples to illustrate and demonstrate the content.

3.4 Combine words and images

Using words and images in the right combination will give the participants the opportunity to save the content in their brains both as text and as images, which means double profit, since two pathways, instead of one, will lead to the same piece of knowledge [7]. In combining words and images it is important to take into account the 'multimedia principles' that were formulated by Richard Mayer [8]. A few of the most relevant principles, are the 'coherency principle' (limit the amount of text and images to the essential, to avoid distraction) the 'modality principle' (better use speech to explain an image, than written text) and the 'redundancy principle' (avoid spoken and written text at the same time).

With online teaching it is especially important to take the redundancy principle into account. When preparing e-learning modules or videos, either choose speech or written text to accompany images, but not both, since this will impede learning. Furthermore, it is useful to use different sorts of visuals, like graphs, diagrams, photos, and icons to enrich the content. Keep in mind to not use them as merely decoration, in line with the coherency principle.

3.5 Make them think

Learning is an active process. Participants will remember content that they have been actively involved with better when they have to produce knowledge themselves. This is called the *generation effect* [9, 10]. Having them generate answers to questions is a very effective strategy to increase information storage in long-term memory. This retrieval practice is one of the most effective approaches to learn, remember, and apply information [11]. Compared to re-reading or reviewing learning materials, retrieval practice improves learning drastically [12].

There are many ways to implement this activity, like simply having participants answer questions or do assignments. Having them solve cases and present the outcomes to each other is another way to make participants think.

For both online and in-person teaching there are many ways to make participants think. Again, quizzing tools are useful for this. Another very effective way for online teaching is the use of breakout rooms. These breakout rooms are very well suited for discussion and collaboration in smaller groups, contributing to a more active participation, which in turn leads to better understanding and recalling of the content.

4 Conclusion

Taking into account how people learn, and using the strategies above, like 'activating prior knowledge', 'offering a structured step-by-step approach', and 'make them think', among others, helps us become more effective as educators. Applying what we know about how the brain learns, facilitates making participants achieve the change that learning really requires. Taking these strategies into account does not really take that much work, since they are very easy to implement, but results in substantially improved outcomes.

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RADIOMON – ISOTOPES, RADIATION AND NUCLEAR TECHNOLOGIES IN A NEW GAME FOR THE I-GENERATION

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Making pupils enthusiastic to learn more about science, technology, engineering and mathematics (STEM) is a challenge, and the small population of STEM students is often unaware of the scientific and technological aspects related to radioactivity. The underlying goal of this project is to create interest in nuclear technologies and their fundamental science via a videogame that has also the ambition of becoming a teaching tool. The paper introduces the retained idea of an original videogame with well-defined learning objectives, discussing its benefits and challenges. The long term vision is not limited to one videogame but rather a properly developed franchise to open up infinite possibilities of different story lines where all the different facets of nuclear science and technologies could be addressed. This effort requires the cooperation of skilled developers and numerous nuclear stakeholders to reach the desired effect.

1 Introduction

In these last decades, the word "nuclear" has often been connected to negative connotations by the general public in a popular thinking. The use of nuclear technology for warfare purposes has not yet been forgotten, and the many benefits brought by its peaceful use for electricity production are overshadowed by accidents. As an additional factor, nuclear physics and associated technologies are seldom easy to understand; whilst sciences of macroscopical phenomena can often be spectacular, the effects of decay, fission, fusion or other nuclear phenomena are intangible, odourless and not even visible with microscopes. These characteristics demand even more abstract thinking, which can be, without appropriate guidance, a difficult exercise for many students. The already small population of potential STEM pupils and students are often left unaware of this field as they are not broadly introduced to nuclear science and technologies in their secondary school studies and do not have means to visualize the physics. These youngsters would rather turn their attention to either more popular technologies for the same purpose, e.g. wind turbines, which is socially accepted as a good technology to combat climate change, or more sensational, e.g. rocket engineering if they are attracted by exciting challenges.

Nowadays, innovative video materials succeed in visualizing nuclear phenomena and more investment could be allocated for developing these tools into teaching means for complex concepts. Indeed, the target group of these media is intended to be large and in certain cases they succeed in reaching a large population, as for example [1].
Nonetheless, within the large amount of media material available on the social networks, the impact is not enough and cannot be compared to the direct effect that the perspective of a Mars exploration can have on a young mind.

The authors of this paper share a wish to attempt broadening the circle of people that could have an interest in nuclear physics while rendering the topic more popular. The objective is to find a way to reach a large population among those promising young pupils and students that still have to choose their study and career path.

The possibilities to integrate nuclear phenomena into a videogame have been explored. The direct objective is therefore to teach to the younger generations basic nuclear and radiation physics and to let them discover nuclear technologies in the fun environment of a videogame, without stressing the learning possibilities when distributing the product but accurately integrating them and declaring them as such. The primary target group are teenagers, for which videogames are an effective means to reach a large population, but by extension the game can be played by all age categories. The other reason for which videogames are chosen is their potential to visualize phenomena such as radiation decay and elements such as radionuclides in an attractive and accessible way, as they benefit from artistic freedom. At the same time the player learns-by-doing, if the game is designed such that the game's objectives are aligned with the learning objectives. The next chapter discusses what the gaming industry already produced.

2 Discussion on explored options

One of the most popular options to attempt a connection between the subject and the mean is to insert the danger of radiations into a realistic **action game** (i.e. games with one main character in first person carrying out different tasks/quests), which would make an interesting concept allowing to discover technologies and learn radiation protection in a simulated environment. Nonetheless, it remains a limited approach, highlighting the negative effects of radiations, which we do not strive for, and moreover it has already been adopted in the past. The most significative and popular game that has already integrated the danger of radiations is undoubtedly *Fallout*, where the main character would roam in areas that may be highly radioactive, measuring the radiation levels with a Geiger counter and collect a radiation dose (in rads) that affects the skills of the character. To render the concept "playable" though, several features were invented, as the possibility to remove rads by taking medicines, or that people, instead of dying of radiation sickness, would become ghouls, zombie-like creatures that may even glow. Indeed, the whole environment was reflecting a post-nuclear-war apocalypse wasteland.
Besides the simplifications, that are justified for playability reasons, this sort of apocalyptic vision created by *Fallout* is feeding the common negative perception on nuclear, which we intend to counteract.
Therefore, we discarded any inclusion of radiation into post-apocalyptic scenarios.

Some games were specifically created to simulate nuclear reactor functioning or the environment of Chernobyl after the accident, with a concept similar to Fallout. These games remain for niche public and most present the negative connotation too. The desired setup is rather the one of a more casual game, which is accessible for all and especially for those who desire to have some fun without investing too much time in the game.

Theoretically, any action game could host radiations, even **platform games** as Super Mario or **sandbox games** as Minecraft, and indeed choosing a successful franchise would maximize and guarantee the reach. The obstacle found on this path is to contact the major producers of such videogames and, even if we surmounted such obstacle, convincing them of the added value of integrating radiation for the game itself and avoiding another title as "Fallout" (especially in terms of invented facts) are even bigger risks that we cannot face at this stage.

Developing an original game is the best solution to avoid unwished twists of reality. The option of realistic action games becomes though unaffordable, as such games require a big effort in terms of resources (see Figure 1).

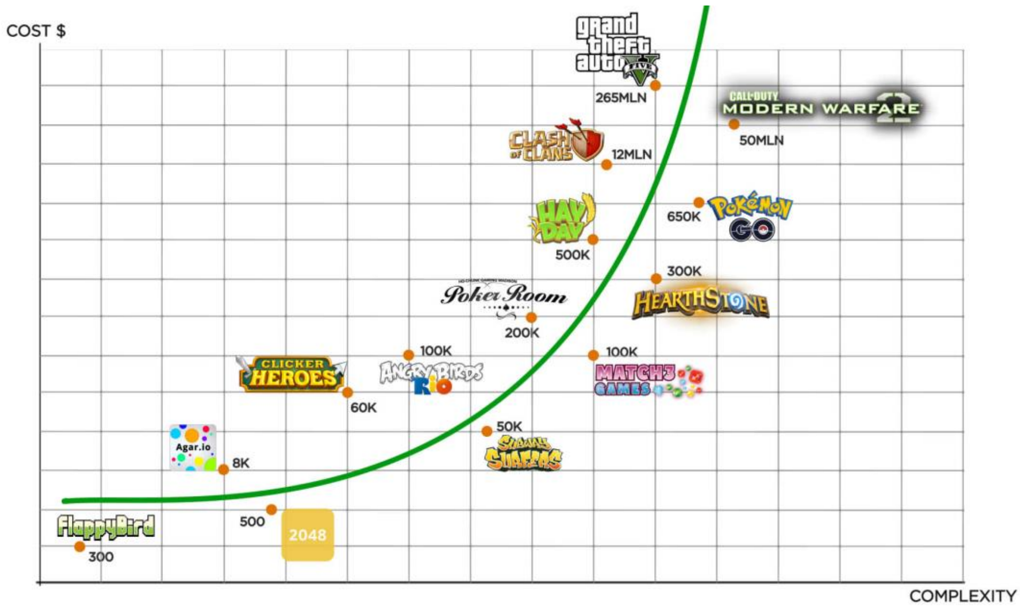

Figure 1. The cost as a function of the development complexity follows an exponential trend [3].

A more abstract and artistic idea consists in the attempt to visualize nuclear phenomena and give a face to radionuclides. As each radionuclide has its own characteristics (atomic number, size, half-life, decay types, energies of emitted particles, cross-sections) one can imagine that each of them represents a separate character, with its own features and personality. This leads to a direct association to a very popular franchise that also produced videogames, i.e. Pokémon.

Pokémon is categorized as a “**monster-collection Role Playing Game**” and it has inspired similar concepts along the years. We argue here that their success is connected to the aspect of collection. At the light of this incredible success, the following question was raised: why inventing imaginary characters when nature offers us the chart of nuclides?

Radiomon is a concept loosely inspired by Pokémon, that will probably become a mix between a monster-collection RPG and a strategy game, as the player will have to choose in advance the best Radiomons from the collection.

Lastly, the choice of the platform on which the game will be developed is driven by the wish of greatest accessibility to a large audience, which nowadays is guaranteed on mobile applications for free download. This is supported by the data retrieved from the gaming industry [2], that indicate an important rise in the mobile gaming section of the market, leading us to focus on a game supported by a mobile app.

3 Retained approach

In Pokémon the characters are evolving thanks to the experience gained in battles: each of them has one or more types of attack, with associated attack points, and to protect itself from the adversary it has defence points and, together with its life points, the resilience to the adversaries’ attacks is determined.
Few of these properties can be associated to Radiomon properties: types of attack are decay types and attack points are decay energies. Their evolution occurs via decay after a specific time or particle capture, which is intrinsically defined by a property called the "cross-section".

These three properties (decay time, decay energy and cross-section) make the concept viable for a time-driven game in which the mastery of the cross-section will allow the player to trigger the best physical effects to win the game. Indeed, it is by activating Radiomons that decay energy is emitted against the target.
With this basic concept, the purpose can be flexible, let it be a fight between two teams of Radiomons or a task of sending the decay energies towards a target as a tumour cell in the allotted time. At this stage, the project is consulting with game developers to determine the best goal for the player.

As the concept should be synonymous of fun, consistently with a casual game, we identify here below the elements that we think will bring joy to the player:

- Collection: there are more than 100 elements and potentially hundreds of radionuclides – the objective to have a full collection of characters can be the main drive for the player.
- Hitting the spot: sending a ball to a goal is the most popular form of entertainment in the world. In this game: the ball is the incoming particle and the goal is the cross-section.
- Fun visuals: all nuclear phenomena being invisible, they can be visualized in an entertaining manner without restrictions associated to reality.
- Storytelling: we are preparing to important discussions with the developer to include a story-telling that may link the game to the discovery of technology and history, through dedicated missions to accomplish or modes of collecting the Radiomons.

In the most basic concept of the game, the player can carry out the following actions: the choice of the Radiomons based on the acquired collection, their activation by "feeding" them a neutron and the use of shielding equipment, which is consistent with the concept of a casual game. Nonetheless, to be more successful in the game, the knowledge of the three properties (decay time, decay energy and cross section) is a must. This has the purpose of stimulating the curiosity of all the players which, in order to win, will gladly try to remember by heart which Radiomon has a higher fission cross-section or most energetic gamma rays, for example.

3.1 Learning objectives

This leads us to list the learning objectives of the basic concept into 3 categories:

- nuclear physics, the properties of the Radiomons.
- radiation protection: as the decay particles are sent, they can be stopped interacting with the environment, which will be used to let the player learn basic concepts of radiation protection in the game.
- chemical compositions: one last important aspect to be addressed by this game is the association of the Radiomons to the reality. The player should not lose contact with the context of the game, lest he/she will start thinking about magics rather than nuclear physics. The collection method within the game will therefore be linking real-life objects, either common or specific technologies, with the Radiomons. E.g., from water one can extract two hydrogens and an oxygen, while inside a nuclear fuel pellet the same oxygen can be found together with uranium.

To assess if the player actually learns the three aspects (nuclear physics, radiation protection and chemical composition), we will use the game prototype together with a "before and after" test.

4 Challenges

The main challenge identified for this project is the market competition: a game has to be a flawless, attractive and engaging product and many other games in the market have these characteristics. The necessary condition is therefore to achieve a high quality gameplay within the final product.

In fact, although the game concept is rather unique, the choice of mobile games in the app store is such that the average player will tend to choose only the most popular options, i.e. high rating and number of downloads. The associated risk of a failure is the loss of investment and a lower-than-expected reach among players.

Among the major goals of the concept there is to visualize the radionuclides in an impactful way: inspiration for this goal is the famous cartoon series "Il était une fois…la vie" from 1987 [4], where the human cells were "humanized" to explain how the human body works. The challenge here is to create meaningful representations of the Radiomons, easily recognizable, and conceptually consistent with their nature: all gases shall have similar look, all metals shall have a shiny appearance, stable nuclides will look dormant while radioactive ones distressed, the cross-section can represent a visual feature of the nuclides, and so on.

Simplification of reality is inevitable in games and this concept is not left untouched. For playability purposes, the following points are necessary simplifications:

- the decay time is a fixed time rather than a half-life,
- decay particles don't scatter in air and travel "forward" undisturbed in a straight line until the target,
- the number of decay and capture modes will be limited and the energy dependence minimized
- sizes and distances are adapted to the dynamics of the game.

For each of these points additional media material, e.g. edutainment videos, should be created to explain the reality and why it has been modified within the game.

Finally, the objective to realize a profitable product which is educative and realistic on one hand while presented as a casual game on the other hand does not have many precedents and it will require a good and balanced effort between conceptualization, development, marketing and dissemination.

5 Roadmap and long term vision

The project has concluded an *exploration phase* where the interest of nuclear organisations was confirmed and possible developers were consulted.
In the current phase, the *definition phase*, the high level concept has been completed and presented for discussion to stakeholders and developers, with the objective to obtain a prototype version to be tested before proceeding into the full development of the product.
During an *acceleration phase* we will therefore determine the basis for the product that will be commercialised at the end of the next phase.
The flexibility of the concept proposed allows a *scaling-up* of the concept, where we could twist or adapt the product into other versions with a more educational purposes or other dedicated tasks. The long term vision is therefore not limited to one videogame but rather a properly developed franchise to open up infinite possibilities of different story lines where all the different facets of nuclear science and technologies could be addressed.

6 Conclusion

Having debated the possible benefits that a game for a broad population would bring to both the society and the nuclear scene, this project is of high interest. The major challenge being found within the market competition, the necessary condition for a success is the high quality of the product. We call for an extended collaboration among the nuclear organisations to share the risks as the benefits will be common for all.

Our original approach relies on the support of experienced game developers and, most importantly, the cooperation of numerous nuclear stakeholders for this effort of creating, branding and spreading a product that would have the ambition of "giving a face" to all the radionuclides and decay particles and give visibility to nuclear technologies to benefit the whole nuclear industry, healthcare and research organisations.

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This project could not be started without the Innovation Lab within Tractebel, nor without the first interest shown by, in chronological order, Foratom, the Belgian Nuclear Forum, the Nuclear Skills Strategy Group (UK), the SCK CEN Academy, Engie Talent development and Gaston Meskens and Adrian Bull for their precious insights, the SFEN-JG together to all the individuals that showed interest in the development of such concept. Last but not least, the European Enterprise Network allowed us to get in contact with more than 30 videogame developers, that may one day develop the first version of the game.

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ONLINE TEACHING OF A BASIC RADIATION PROTECTION COURSE FOR FUTURE ENGINEERS

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Due to the COVID-19 pandemic, teaching at UPM during 2020 has been developed mainly online, including the basic Radiation Protection courses. The main tools used are MS-Teams, with video recording of lectures and using digital tablets to help explaining some topics, and Moodle, as an e-learning platform to organize all the relevant materials. The aim was not to lose contents of the curriculum usually taught and ensuring a correct acquisition of skills by the students. However, undoubtedly, the quality of the student-teacher relationship has been impaired. Practical activities were developed online and with live demonstration sessions in the laboratory. The final assessment of each student was done through a written exam carried out in person. The online teaching was necessary, and some of the tools and methods used could be maintained in future courses as a useful complement to teaching in traditional mode.

1 Introduction

Due to the COVID-19 pandemic, teaching at UPM during 2020 was developed mainly online, including the basic Radiation Protection courses. The aim was not to lose contents of the curriculum usually taught and ensuring a correct acquisition of skills by the students. However, undoubtedly, the quality of the student-teacher relationship has been impaired. Students in general tend to be not very active during online classes and, when groups are large, visual communication is largely lost. The students usually keep their cameras turned off, as well as and their microphones so as not to introduce interference during classes. But this circumstances make it very difficult for the teacher to check if the students are paying due attention during the classes and if they are duly assimilating the information. To mitigate that problem, lectures have been video-recorded, the presentations were made available to download and the teachers have been available for questions either via forum or by email correspondence, and in some cases for more complete personal tutorial sessions by videoconferencing.

Some practical activities were also developed online, but the contact with radiation protection instruments took place through a laboratory visit to the laboratory in small groups, where the instructors made live demonstrations. The assessment of each student was also a mixture of online and traditional methods, by considering the attendance record to online classes, submission of individual personal work (problems) and the performance during the practical activities, evaluated by short questionnaires and written reports, with a final written exam carried out in person.

2 Main tools

Beyond conventional PowerPoint presentations, online teaching has required to use other practical tools that help to get a better organization of the course, and to attract the attention from students. They are summarized below together with their main advantages.

2.1 MS-Teams

Microsoft Teams is a proprietary communication platform developed by Microsoft. During the COVID-19 pandemic, it has gained much interest and the community of users has grown due to its convenient features to facilitate meetings and interaction in a virtual environment. UPM has included it as part of the Microsoft 365 academic licence that faculty staff and students benefit.

It allows teachers to set up specific teams for each class group, and then, within a team, members can set up channels, that can be equivalent to virtual classrooms for each course. Meetings can be scheduled easily; users of the channel receive an invitation and they are also able to see if a meeting is in progress. An interesting feature is the video recording of meetings and lectures that can be downloaded and saved, which allow students to review them later. This can at least partially compensate potential lack of attention by the students during the lectures. Files can be shared through chats or by uploading them in a file repository of the channel.

Within a channel, team members can communicate through chats without the use of email. Chats can be one-on-one as well as group chats, and they are persistent in the channel. In addition, direct messages allow users to send private messages to a specific user rather than to the whole group of people.

For tutorial sessions, instant video conferencing is possible within or out the channels.

2.2 Digital drawing tablet

A digital drawing tablet enables to hand-draw images, equations and graphics, with a special pen-like stylus, similar to the way one can draw images with a pencil and paper. During online teaching, the tablet allows to add handwritten notes to the shared presentations, especially where more complex visual information or mathematical equations are required. They facilitate the smooth online teaching process and are popularly used in conjunction with the front-facing camera to mimic the classroom experience. An example can be seen in figure 1. The hand notes can be recorded with the presentation or discarded.

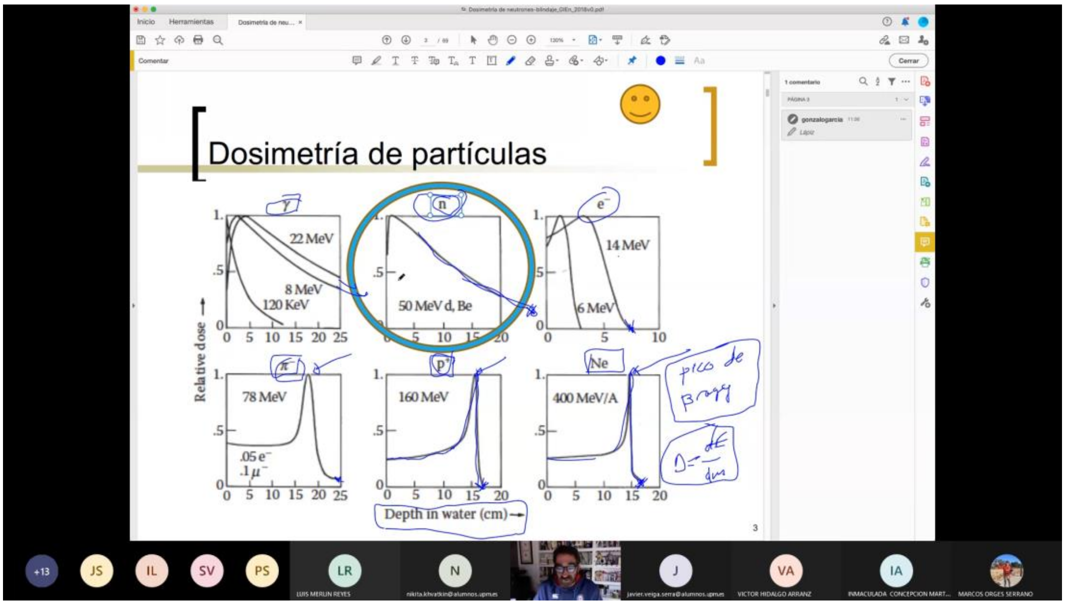

Figure 1. Example of use of a digital drawing tablet during an online presentation.

2.3 Moodle

Moodle is a learning platform commonly used to supplement existing learning environments online. The acronym “Moodle” officially stands for “modular object-oriented dynamic learning environment”. UPM used Moodle regularly before 2020, but with the need to teach online, its use has been boosted. Figure 2 is a screenshot of the Moodle space used for the UPM course on Radiation Protection.
Each official course has its own Moodle space. Inside, there is a general online forum and the possibility of posting announcements of general interest that can be also distributed by email to all registered participants/students. Perhaps the most useful feature of Moodle is the organization of a course by topics/lessons/chapters. Inside each lesson area, there is an organized repository of all relevant material, like presentations of each lesson in the most convenient format (pdf, PowerPoint, etc.), written texts of the lessons, collections of solved practical problems, scripts of the practical laboratory session, direct links to videos (either hosted in the cloud or from URL), to websites of interest, to video recordings of the lectures, etc.
An interesting element of Moodle is that it allows to propose assessment tasks –for example, exercises proposed as personal tasks to be considered in the continuous evaluation of the student–, which each student uploads in their personal area and that the teacher can review online or download to review and evaluate it offline.

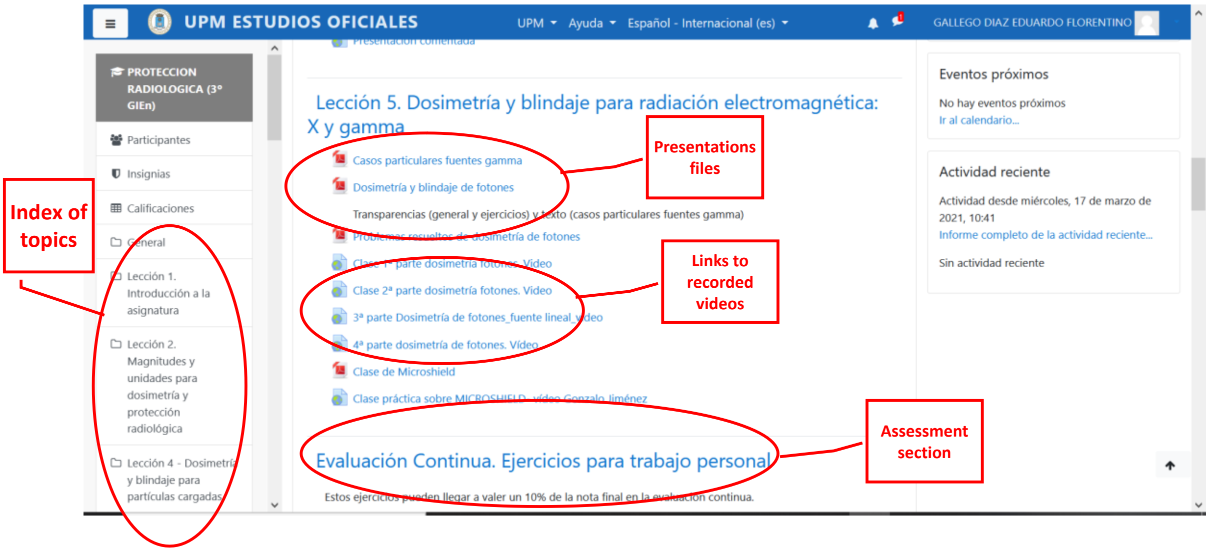

Figure 2. Screenshot of the Moodle space used for the UPM course on Radiation Protection. It shows the archives of a given lesson, with presentation files, links to videos, a practical class and the assessment section in which the exercises are submitted by students

3 Practical activities

In any Radiation Protection Course, practical activities are an essential part. Being restricted by the protective measures against COVID-19, the face-to-face laboratory practices were limited to the minimum. Therefore, many of the practical activities were also online. Practices on solving radiation dose calculations and simple shielding problems were developed in the Teams channel. Also, there was a demo session on a commercial software for photon/gamma ray shielding and dose assessment.
A first practice on gaseous ionization detectors and the study of the Geiger-Müller counter, was recorded in video in the laboratory (figure 3) and assessed with individual online questionnaires for the students in Moodle.

The only in-person practical laboratory session was aimed at giving the students their first contact with ionizing radiation detection and measurement systems. It was focused on radiation protection instruments, with different types of radiation monitors studied and tested: contamination monitors, monitors for identifying radioactive sources, gamma and neutron area dosimeters (see figure 4).
The students visited the laboratory in small teams, where the instructors made a live demonstration for them. The preventive measures against COVID-19 imposed limitations but nonetheless it has been possible for students to see the instruments' operation and main properties, asking questions and observing real field measurements.
This practice also served to establish personal, albeit limited, contact between the teachers and the students.

Figure 3. Screenshot of the video session showing gaseous ionization detectors and the Geiger-Müller counter.

Figure 4. Radiation Protection instruments used during the in-person practical activity in the laboratory.

4 Assessment activities, methods and results

The university decided that the final evaluations would be done through written exams carried out in person, with all the preventive measures of COVID-19 duly applied (figure 5). The assessment of each student was complemented by their attendance record to the online classes in Teams, their individual personal work –radiation shielding and dose calculation problems to solve as homework in Moodle– and by their performance during the practical activities, evaluated by short questionnaires and written reports.

Figure 5. A view of the exams room, in which proper ventilation, personal distance, face masks use and cleaning were duly assured.

Compared to previous courses, the results obtained in the course 2020-21, with a small fraction of "no shows", indicate however a slight decrease in the overall performance of the students, with a 25% of "suspense" (see figure 6). However, the percentage of good students (with a "remarkable", "outstanding" or "with honours" qualification) is similar to previous years.

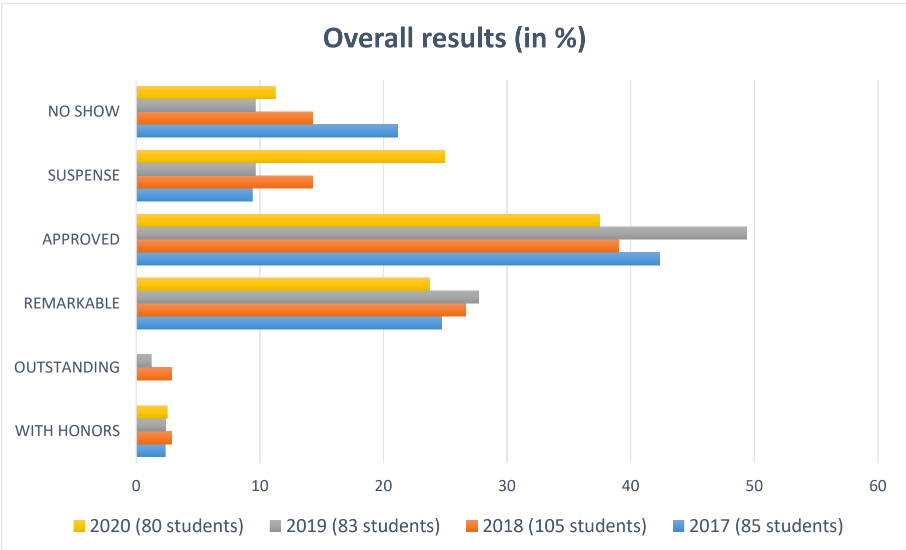

Figure 6. Historical results of the assessment during the last four years. 2020 shows a clear increase in fails.

5 Conclusion

The COVID-19 pandemic forced a transition to online teaching and make use of tools that have been very practical. The aim of not losing contents of the curriculum usually taught and ensuring a correct acquisition of skills by the students was achieved, however observing a slight decrease in the overall performance of the students.
Some of the tools and methods employed, like Teams, the digital drawing tablet or video recordings could be maintained in future courses as a useful complement to teaching in traditional mode.

TRANSFORMATION OF FACE-TO-FACE EDUCATION INTO VIRTUAL – EXPERIENCE OF ARGENTINA

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Online education opened a great number of challenges and benefits. In 2020, the Argentine Radiation Protection Society (SAR) successfully shifted their traditional face-to-face courses into e-learning courses. Regarding its courses, SAR has achieved the recognition of the Nuclear Regulatory Authority (ARN), due to its alignment with the national safety standards.
The COVID-19 pandemic made it necessary to direct educational efforts towards e-learning. That implied tackling not only with the necessity of upgrading the hardware and the software, but also the well-intentioned teachers and instructors that faced a wide and unknown range of possibilities.
This paper describes some good practices for shifting face-to-face courses into virtual courses and highlights aspects brought by virtuality.

1 SAR efforts´ to promote remote education – a new opportunity

Argentine Radiation Protection Society (SAR) has more than 50 years of experience educating students in classrooms "face-to-face" on radiation protection. By the early March of 2020, the COVID 19 pandemic surprised the world. By that time, E&T courses chronograms had already been established at SAR. That unexpected situation affected teachers engaged in the SAR courses and also facilities which designated attendants to get their authorization and licensing or even their renewals. The pandemic also impacted in budgets, as by that moment air tickets and hotels reservations had been made. Those were good reasons for SAR become fully engaged in reengineering its E&T offer because the courses should go on.
From the moment the classroom courses were put off a hard work was headed by SAR, initiated by urgently call for meetings in which the difficulties in implementing remote education needed to be considered. A relevant conclusion was that most of the staff at SAR involved in courses, needed to improve their home technology structure. The compromise of the SAR staff and the collaboration among colleagues made it possible to succeed and go on. SAR also faced the difficulty of the selection of software tools and educational platforms considering the possibilities of the staff at SAR. Encourage teachers to shift to a completely new methodology of work was a difficulty considering that everything should be done in a hurry to cope with the settled responsibilities.
The extreme situation brought by the pandemic, offered also possibilities to look around and see SAR availabilities and so the Latin American Network for Education in Nuclear Technology (LANENT) became visible. SAR is a member of the LANENT since its creation and so the opportunity of using the Moodle platform administrated by the net was at hand reach. Another advantage in approaching to LANENT was its contribution to the diffusion of SAR courses in the Latin America nuclear community.

2 E-learning offer at SAR

At present, SAR shifted five (5) face-to-face into e-learning courses and all of them designed on the LANENT Moodle platform. A characteristic of all the SAR courses is that they are completely aligned to the current regulatory safety standards emitted by the Argentine Nuclear Regulatory Authority (ARN).

SAR courses already shifted to e-learning are:

- Basic Formation Course: Radiological Safety on Radioactive Sources (BC), destined to professionals and technicians starting in the nuclear field. The approval of this course is a requisite to take up the following ones (FCC, SC, UC).
- Complementary Course: Radiological Safety for radioactive facilities in the nuclear fuel cycle (FCC), destined to professionals and technicians working at nuclear fuel cycle facilities.
- Specialization Course on Radiological Safety for the use of industrial measurement equipment's (SC), destined to professionals and technicians who need a license or authorization for the operation of equipment with sources in the industry and in practices.
- Updating Course on Radiological safety for operators of industrial measurement equipment's (UC), destined to professionals and technicians that after 5 years work need to renew their license with the ARN.
- Course on Management System for safety at facilities and practices (MSC). This is a NEW course and the very first edition was provided in November 2020. This course is destined to regulators, operators from the nuclear fuel cycle, medical services, nuclear power plants operators, gammagraphy industries, and the nuclear industry in general. This course is a support to implement a new Argentine Standard on Management System for safety at facilities and practises, emitted by the ARN and entering into force 1st April 2021, AR 10.16.1.
- SAR also offers some other on demand courses.

3 SAR work methodology to undergo the pandemic. Good practices & experience

SAR e-learning courses include asynchronous and synchronous methodology. Related to the asynchronous, in the Moodle platform, the videos and the study booklets are released in advance to each synchronous meeting and at certain day of the week to dosage the dropping of audio visual & reading academic material. This commits the participants to go through the material before the synchronous meeting what really is an advantage for the better understanding of the lecture.
The lecture itself may be focused on a relevant chapter aspect. SAR encourage the lecturers not to repeat the platform contains but to complement and highlight the very important aspects to optimize the academic results. Related to synchronicity, the meetings are carried out by using Big Blue Button (BBB), which is offered at the LANENT Moodle platform, and the classes are recorded and uploaded to the platform. The classes recordings have the double function to let attendants revise the highlighted aspects at the meetings and also serve as a backup in case of any attendant´s non assistance, which should be duly justified. The recordings with BBB system stay uploaded in the Moodle platform for a week time due to its settings by the administrator. Instead, at certain courses, synchronous meetings were carried out using Skype or Zoom and this change is mainly related to the teachers' internet connection possibilities or also their preferences. In those cases, the recordings were uploaded to the Moodle platform after the synchronous meeting, with the access time limitation to them, given by the course duration.

The academic material offered at SAR courses are mp4 videos made from power point (PPT) presentations, optionally settled on an institutional SAR template. Also, we offer the traditional study booklets in pdf format and some simulators which are considered a valuable tool. Besides and depending on the course type, some short films are selected and offered for encouraging a further discussion through the forums. Also asynchronously, attendants to SAR courses are requested to comply with activities in a settled timeframe.

At SAR, this was identified as a good practice to keep the courses properly advancing, although some flexibility duly justified, can always be accepted. The activities handed receive personalized, and in some cases generalized, feedback. The Forums is a resource that can be exploded at different levels and not only for answering general questions but also to wrap up a chapter, promote discussion and keep students interested in the course.

The requisites for satisfactorily finish SAR courses are to attend the synchronous meetings with the lecturers, comply with the satisfactory resolution of the mandatory activities what may imply redo some of them and finally pass the final examination, which constitute a relevant part of the educational process at SAR. There are two opportunities to pass the final exam and they consist of an on line examination designed to be completed using all the material distributed in the course. It is also a requisite that the exam date, the attendants switch on their cameras and mics during the whole exam. Once the attendants handed the exams at SAR, it is verified the proper reception, and then the exams are revised by at least two lecturers. In case doubts are presented during the corrections, the attendants may be asked to take in an on line meeting for an oral examination. The examination process is very carefully approached and at SAR we consider it is in a consolidation phase.
Below It is shown a picture of an e-learning exam, for SAR Updating Course using the Big Blue Button (BBB) at the Moodle platform.

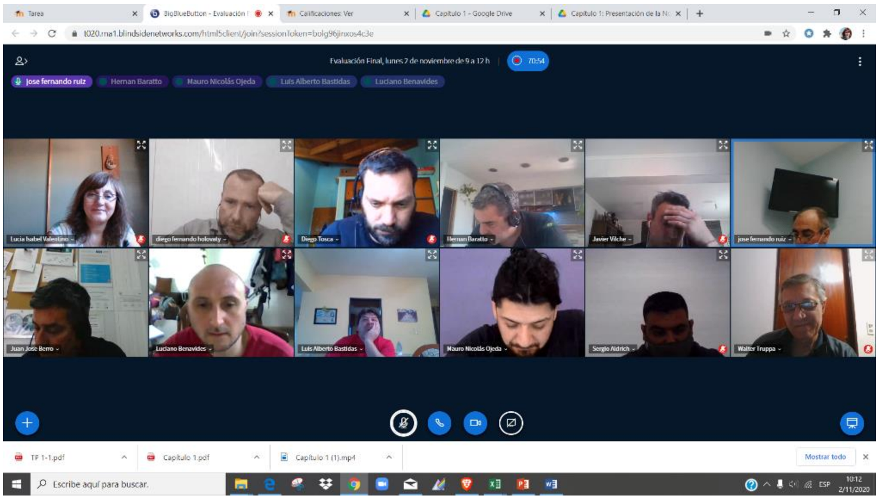

Figure 1: picture of a real e learning exam

From SAR experience what really made it possible to manage the shifting from face-to-face to the e-learning courses, in a very short period of time and under sudden pressure, was that SAR designated a coordination group transversal to all SAR academic courses. Although coordination has always been part of the classroom courses, in the becoming to virtual courses it was of fundamental importance not only to design and aligned the academic material in cooperation with the teachers but also to keep the courses running through their different editions. At SAR the coordination team is integrated by three professionals that also act themselves in the role of teachers. The coordination team is in constant interactions with the attendants and the teachers and strongly watch the evolution of the courses and stand for any difficult or need that could arise. They also assume the moderation role to keep the courses interesting and with the compromise of teachers and attendants. Also, the coordination team is in charge of analysing the optional anonymous satisfaction survey and produce all the necessary changes in pro of the courses improvements.

By the time being, the arrival of the e-learning methodology as the only possible way to go on with the scheduled courses brought new rules and an adaptation of the etiquettes rules in use. There is a new way and a new order and both students and teachers have to cope with the situation to get the best possible results. For instance, in a face-to-face course the interaction was easy as there was the opportunity to know at each other. Now in the e-learning format, the own lecturers may get forced to ask the students to switch off their cameras for a better internet connection and that of course, doesn´t mean that a lecturer does not want to meet the course attendants. In that situation, the lecturers have to manage with the feeling that they are talking to no one at the other end. There is a change in the signals and so there must be a change in the way we perceive them. This is an already started process.

4 E-learning courses evaluation

At SAR some aspects were identified as important and the impact to the E&T e-learning and face-to-face format were analysed and compared. These aspects where reflected in the anonymous and non-obligatory satisfaction survey taken from the attendants in the virtual classroom campus for each course at their ends.

The aspects considered were:

- Motivation transmitted by the students,
- Personalization towards the attendants carried out by the lecturers,
- Satisfactory feedback to the attendants, accordingly to their expectations,
- Interaction between attendants and lecturers,
- Discipline adopted by the students,
- Attendants´ prioritization of the course requirements,
- Attendants´ mobility aspect was also considered,
- Technical structure available by both lecturers and attendants,
- Tracking and control of the attendants´ participation,
- Study time,
- Reduction in the delivery cost in charge of SAR to individual attendants and to industries sending its personnel for capacitation at SAR headquarters and,
- The global reach of SAR academic offer.

By analyzing the aspects above mentioned, it was concluded that the interaction is stronger in face-to face than in e-learning E&T format. The technology structure needed by SAR staff and the attendants is more robust than for classroom E&T format. It was also concluded that the tracking and control of the evolution of the attendants is more easily performed for e-learning and this is possible due to the fact that in the platform, it is possible to know how often and how long the attendants´ stay in the virtual campus, how often the videos were played or the study booklets were opened or even it is possible to know how long it took to an attendant to comply with a mandatory activity. All these facts may be evaluated to conclude on attendants´ motivation or even the complexity of the activities and the relevance of the study audio visual & reading academic material.
In the table 1 below the aspects mentioned are listed for the two courses format, face-to-face & e-learning and its impact for each aspect is marked with X to represent influence and with double X to represent an increase in the impact for the specific aspect on the course format. When no X is placed, it means that the specific aspect does not impact at all in the course format, according to the analysis performed.

Table 1: aspects´ impact on the e-learning & face-to-face course format

Aspects	E-learning	Classroom
Motivation	X	X
Personalization	X	X
Feedback	X	X
Interaction	X	XX
Discipline	X	X
Relevance	X	X
Mobility	X	
Tech Structure	X	
Tracking & control	XX	X
Study time	XX	X
Reduced cost	X	
Global reach	X	

5 E-learning results

As a result of the hard work done during the year 2020 in the shifting of the classroom courses towards e-learning courses, at SAR the original working plan was finally complied although it was necessary to make a re-scheduling. Finally, all the face-to-face courses were adapted to e-learning in 2020 and intensive courses were shifted to regular courses.
SAR academic material was reviewed and updated and new material was developed for e-learning courses thanks to the effort of the coordination team and the teachers.
At SAR it was given two (2) editions of the BC (Basic Course), two editions of the SC (Specialization Course), three editions of the UC (Updating Course), and one edition of the FCC (Fuel Cycle Course). Also a new course on MSC (Management System Course) was developed and imparted in November 2020 for the first time.
The overall result can be observed in the graphic 1 below, where it was pointed out an increase in the number of attendants of approximately a 16% for the year 2020, in comparison with the year 2019. The number of participants pointed out in the graphic are for the face-to-face course in 2019 and for e-learning format in 2020.
Most of the teachers at SAR, could adjust to the e-learning methodology although the technology infrastructure and the understanding of the use of the e-learning tools were identified as huge difficulties to cope with. Most of the difficulties in the use of the software tools were solved with the proactive work and support of the coordination team. In relation to the lack of technical infrastructure for some of the teachers, SAR cannot facilitate equipment or internet connectivity but the enthusiastic teachers progressively are improving their infrastructure situation and also SAR is aware that some support must be considered in the future.
A strong coordination to successfully complete the developing of e-learning courses is required. Also, the moderation performed by the coordinators group, took a relevant influence in the quality of the courses. Proper moderation may make the big change in the e-learning as it may promote attendants´ participation, increase their motivation and promote the proper interaction between colleagues and with the lecturers.

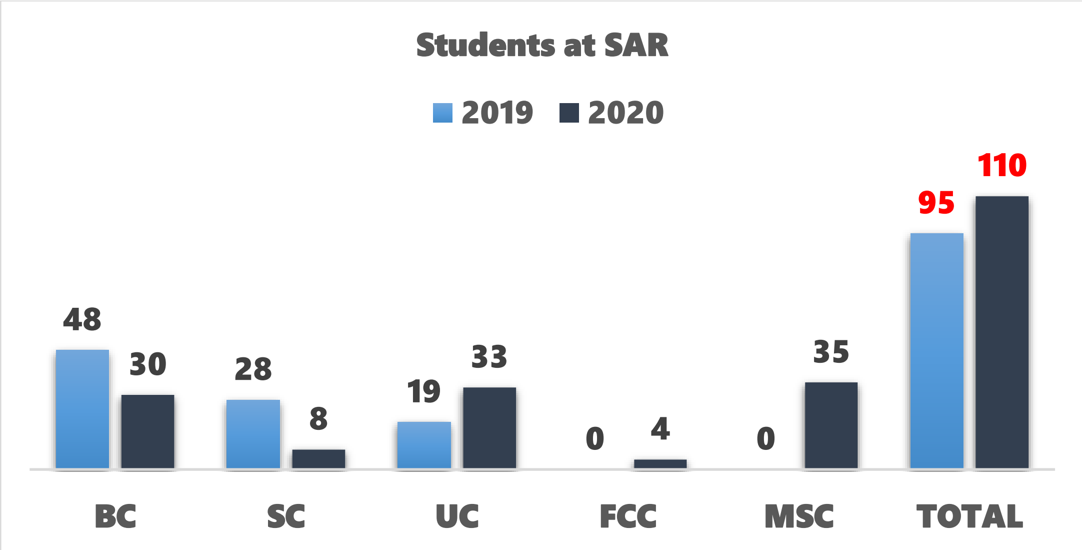

Figure 2: Attendance comparison of E&T courses in 2019 and 2020

6 Further perspectives with e-learning

At SAR it was considered the possibility to run twin parallel courses in case of high demand. This methodology consists of giving two identical courses for two different groups, in the same frame time. In this methodology the virtual classroom might be shared by both groups and so the academic material. Nevertheless, the synchronic meetings would be held for each separate group of students with no more than 15 participants each. This possibility to cover high courses demand still maintaining reduced attendants' groups satisfy the institutional politics at SAR. The offering of twin courses is technologically possible but could offer some possible constrain in the lecturer's availability. The fact that at SAR to give twin courses is considered as a possibility, supports the idea of a global reach with no mobility difficulties for attendants and lecturers.

7 Conclusions

- The challenges brought by the year 2020 were overcome.
- E-learning courses have benefits & advantages in several evaluated aspects such as the tracking and control of the attendants or their availability to surf in the platform to extend their study hours.
- Technology Structure is required for e-learning. Otherwise, it is not possible to attend these E&T courses format.
- A coordination team was essential for the development and performance of e-learning courses and included the moderation role.
- At SAR it was noted that the quality of the education was improved due to the study booklets were updated and more material such as videos, short films and simulators were added to the e-learning format.
- SAR expanded its academic offer with a new course. The necessity of offering a course on Management System was identified due to the fact that a new Regulatory Standard on Management System for safety at facilities and practices (AR 10.16.1), was to enter into force on April 1, 2021.

- An increase in the number of trained students was identified in 2020 in comparison with 2019. These attendants received SAR diploma, required for the personnel licenses or authorizations process.
- At SAR, imparting e-learning courses become an excellent experience. In the future, SAR courses will probably approach to blended learning (B learning). It may also be possible that some of them coexist in several formats, e-learning, b-learning and face-to-face courses.

The e-learning suddenly became necessary and come to stay and so it is useful to think in advance that when the world go out of the pandemic, the new e-learning modality, adopted compulsorily, will be kept and become part of the new methodology in E&T courses.

Acknowledgement

- Teaching staff for joining the virtual format enthusiastically and contributing with new and updated material overcoming the difficulties of a new methodology.
- Latin American Network for Education in Nuclear Technology (LANENT) for supplying Moodle Platform and contributing to the spread of SAR Courses through its website, Facebook & twitter.
- Participants for trusting SAR and letting us contribute to their intellectual capital.

THE IMPACT OF COVID-19 PANDEMIC RESTRICTIONS IN THE PROVISION OF TRAINING ON RADIATION PROTECTION AND SAFETY TO RADIATION PROTECTION OFFICERS (RPOs)

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The Greek Atomic Energy Commission (EEAE) continues to provide training on radiation protection and safety during the COVID-19 pandemic according to its legislative role. In the period March-November 2020, 5 training courses were organized by the Division of Education and Training of EEAE for Radiation Protection Officers (RPOs). The courses were conducted either on-line or face to face and concerned 49 RPOs engaged in practices with X-ray systems (for security and quality control purposes), and nuclear gauges (nucleonic control systems).
This work presents the challenges introduced by the COVID-19 pandemic to EEAE's training activities and the opportunities identified for their improvement.

1 Introduction

EEAE is the national regulatory authority, competent for the control, regulation, and supervision in the fields of nuclear energy, nuclear technology, radiological and nuclear safety, and radiation protection. One of its statutory responsibilities is the possibility to provide education and training (E&T) on radiation protection to scientists, technicians and personnel of emergency preparedness and response teams.

The national legislation sets as one of the overarching requirements the provision of appropriate radiation protection education, training and information to all individuals whose tasks require specific competences in radiation protection.

To fulfil its role, EEAE implements an E&T strategy through the development of appropriate programs which take into account the national needs, as well as the national capabilities and resources. The strategy was established and implemented in accordance with the IAEA general safety standards [1,2] and guides [3-5].

The development and conduct of the training activities are carried out in line with the corresponding procedures of the management system implemented by EEAE that meets the requirements of the ISO 29993:2017 standard [6].

This work presents the challenges introduced by the COVID-19 pandemic to EEAE's training activities and the opportunities identified for their improvement.

2 Requirements for the approval of RPO

Presidential Decree 101/2018 [7] transposes the Council Directive 2013/59/Euratom [8] to the national legislation and defines, *inter alia*, the roles and responsibilities of the Radiation Protection Officers (RPOs) which are designated by the undertakings for the applied practices.
Moreover, a Joint Ministerial Decision [9] sets the requirements regarding the qualifications and competences for the approval of the RPO including adequate training on radiation protection.

More specifically:

a. For medical practices which are subject to authorisation under registration the designated RPO can be a radiologist, nuclear medicine physician or dentist authorised to take the responsibility of individual medical exposures and 4 months of on the job training in the field of interest. To maintain the approval, the RPO shall demonstrate a non-formal training of 40 hours on radiation protection within a period of 7 years.
b. For medical practices subject to licensing the designated RPO shall have a professional license of Medical Radiation Physicist. To maintain the approval, the RPO shall demonstrate 60 hours of non-formal training on radiation protection within a period of 5 years.
c. For non-medical practices subject to registration, the designated RPO shall have an academic degree relevant to the practice of interest and 3 months on the job training under the supervision of an approved RPO or a Radiation Protection Expert (RPE). To maintain the approval, the RPO shall demonstrate 40 hours of non-formal training on radiation protection within a period of 7 years.
d. For non-medical practices subject to licensing, the designated RPO shall have an academic degree relevant to the practice of interest and 6 months on the job training under the supervision of an approved RPO or a RPE. To maintain the approval, the RPO shall demonstrate 60 hours of non-formal training on radiation protection within a period of 5 years.

EEAE evaluates the qualifications and competences and approves the designated RPOs during the authorization procedure.

3 EEAE's training activities during the COVID-19 pandemic

EEAE considering the E&T requirements set in the new legal and regulatory framework and in line with its implemented strategy has assessed the related training needs at national level. Based on the identified needs, EEAE develops and organises courses on radiation protection for workers involved in practices with radiation sources and persons with responsibilities regarding radiation safety. In this respect it conducted 5 training courses on radiation protection with 69 participants in the period March-November 2020.

3 courses (46 attendees) were carried out on-line using an appropriate web conference application. They concerned persons interested to be appointed as RPOs in organizations using radioactive sources for geological studies and industrial purposes, and X-ray systems for security purposes.

Additionally, 2 courses were conducted face to face (3 attendees) for persons interested to be appointed as RPOs in practices with X-ray systems for quality control purposes and nucleonic gauges.

EEAE also conducted an on-line training course on radiation protection (20 attendees) for vascular surgeons involved in fluoroscopically guided interventional procedures in the framework of their national conference.

It is stressed out that EEAE conducted in average 8 training courses per year in the last 5 years, while the average number of attendees per year was 100. The observed reduction in the number of EEAE's training activities can be attributed to the restrictions due to the COVID-19 pandemic which resulted in the cancelation or postponement of some planned training events. Moreover, there were persons interested to attend the on-line courses who did not manage it due to limitations in the availability of the necessary equipment or internet connection.

4 Challenges

EEAE encountered a number of challenges in organizing and conducting its training activities during the COVID-19 pandemic.

Although the capacity of EEAE's lecture room is 30 persons, the implementation of COVID-19 hygiene protocols resulted in a maximum number of 5 participants per face to face course. Moreover, the need to proper implement distancing and safety precautions caused an increased level of stress and anxiety to attendees and lecturers and affected partially the practical aspects of training (i.e. exercises and demonstration of radiation measuring instrumentation).

Regarding the on-line training, challenges were mainly related to technical issues, such as: limited internet bandwidth, problems in the use of microphone and video tools and difficulties for the lecturers to share training material during their presentations. The above are also related with time management issues resulting in the shortening of the available net training time during the courses.

The lack of face to face interaction restricted the ability of the lecturers to interpret properly the body language of the participants and manage to keep them motivated during the training. Even the lack of personal interaction during the coffee breaks should be considered as a disadvantage.

Additionally, it is stressed out that even an instant distraction of the lectures or attendees due to other activities running at the same time (either at home or work environment) may impact the smooth conduct of the courses and thus the accomplishment of the learning objectives set.

Finally, the courses' schedules and the corresponding training material had to be appropriately adapted to fit in the on-line environment. However, limitations in the virtual demonstration of practical exercises raise questions about the effectiveness of the practical training.

5 Opportunities in the COVID-19 era

Although the COVID-19 pandemic initially seemed to restrict on-going and planned training activities, eventually it proved to be a trigger for improvements.

Innovative communication modalities as well as audio and video technologies had to be introduced into training practices while maintaining high standards in the provided services. Moreover, lecturing approaches had to be adapted to the needs of a "virtual classroom" which accommodates attendees participating from the comfort of their working or home environment.

EEAE successfully managed to incorporate on-line courses in its training strategy by:

- using appropriate applications and tools to support training activities conducted as webinars,
- incorporating new audio and video means in order to enhance the communication and interaction with the participants, and
- appropriately adapting the training material and the related procedures in its management system to the virtual environment.

For the successful organization and conduct of the training activities it was necessary the effective involvement of EEAE's IT and Public Relations personnel. This, in turn, has contributed significantly in the enhancement of the team work culture within the organization.

It should be stressed out that EEAE's distance training initiative is acknowledged by the government as an innovative action of the public sector (https://bit.ly/3iJIxd1).

6 Conclusions

Appropriate training on radiation protection is one of the requirements for the approval of RPOs. EEAE in line with its legislative responsibilities has developed and conducted relative training courses. The COVID-19 pandemic resulted in a number of challenges to be encountered by EEAE in its training activities. However, these challenges were also a trigger for EEAE to evolve its training strategy by incorporating suitable procedures, applications and tools.

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A REMOTE RADIATION PROTECTION TRAINING INITIATIVE IN THE UK

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COVID-19 has had a significant impact on our ability to attend professional events such as conferences and training which has meant that many radiation protection professionals have struggled to obtain and maintain Continuing Professional Development (CPD). In the UK, the Society for Radiological Protection (SRP) and the Association of University Radiation Protection Officers (AURPO) have collaborated to develop and deliver a programme of free on-line webinars to support the needs of members and the profession as a whole, both nationally and around the rest of the world, along with other stakeholders such as the public, thereby acting to support CPD and outreach, and to promote international knowledge exchange. This paper will discuss the findings from these webinars, and aspirations for continuing this method of education and knowledge sharing.

1 Introduction

These unprecedented times of COVID-19 have had a significant impact on our ability to travel to and attend professional events such as conferences and training. This in turn has meant that many radiation protection professionals have struggled to obtain and maintain Continuing Professional Development (CPD). This situation has been, and potentially will be, exacerbated by many organisations (particularly universities and the health service) attempting to financially economise by restricting training budgets to only what is 'absolutely essential'.

In the UK, the Society for Radiological Protection (SRP) and the Association of University Radiation Protection Officers (AURPO) have been collaborating for many months to develop and deliver a programme of on-line webinars. This is to support the needs of our members and the profession as a whole, both nationally and around the rest of the world, along with other stakeholders such as the public, thereby acting to support CPD, but also for outreach and engagement and to promote international knowledge exchange.

Both SRP and AURPO run active events programmes. On average SRP runs eight face to face events per year with attendance ranging from 20 – 100+ depending on the event, along with an Annual Conference attracting up to 350 attendees. AURPO also runs an Annual Conference along with ad-hoc workshops.

A decision was made to enter a partnership and trial a webinar programme consisting of 8 one-hour lunchtime learning sessions. The webinars would be delivered by expert members of both organisations and would be free to both members and non-members of the organisations.

The SRP exists as a Charity not just for its members, but for the wider society, and under normal circumstances would regularly take part in a number of public engagement events linked to science and engineering, including opportunities to meet members and join in a range of hands-on activities linked to our Schools Outreach Programme. With this in mind, it was decided that the webinars should be made accessible and available to the wider public audience, regardless of membership status, in order to further fulfil the objectives of the society, including to promote the science and art of radiation protection, disseminate knowledge and support relevant education, and promote high professional standards to the public benefit. It was also reported amongst SRP and AURPO members in the initial stages of the pandemic that there were feelings of isolation from work colleagues and professional bodies. These webinars were a response to this concern, with the aim of connecting members and non-members alike in a common aim of knowledge acquisition in a semi-formal setting. It was further decided, in light of the potential benefits to members and in meeting the aims of outreach and engagement with the public and other stakeholders, that the webinars should be free, to allow the webinars to be completely accessible for all.

1.1 About SRP and AURPO

Founded in 1963 and incorporated by Royal Charter in 2007, The Society for Radiological Protection (SRP) is the UK's Professional and Learned Society for the field of Radiation Safety. The objective of the Society is to "promote the science and art of radiation protection and allied fields for the public benefit" and it is the second largest professional body of its kind in the world.

The Association of University Radiation Protection Officers (AURPO) was founded in 1961 with the objective of promoting safety and knowledge in the use of ionising and non-ionizing radiations. Its membership primarily consists of radiation protection/safety professionals that work in higher education, research, and teaching establishments with the principal aim of increasing knowledge and understanding of radiation protection through the promotion and interchange of information and best practice.

2 Methods

The webinars are delivered via the Microsoft Teams Event Platform, which was chosen due to its ease of availability, and further noting that a number of our members are unable to use other platforms such as Zoom due to security restrictions set by their employers.

The format of each training session includes a talk lasting 45-60 minutes on a specific topic by an expert in that field followed by a live Q+A session of 15-20 minutes duration. Any attendees can 'register' for a webinar via the SRP website, without needing to be a member of SRP or AURPO. Most webinars are recorded for SRP's YouTube channel and all questions with responses from the experts are captured in a document posted on the SRP website. Occasionally, a speaker, or their employer, may not wish the content of their talk to be so widely disseminated on social media. SRP and AURPO respect these wishes.

Attendees are given a code during the webinar which can be sent back to SRP in order to formally claim CPD points for that particular webinar, which are accepted by the certification body for the UK as being appropriate for those seeking recognition equivalent to the Radiation Protection Expert.
It was aspired to run on average one webinar per month for the duration of the pandemic.

There have already been seminars on a variety of topics encompassing nuclear, non-nuclear, industrial, and medical aspects of radiation protection including:

- An Introduction to Liquid Scintillation Counting
- An Introduction to Decommissioning a Non-Nuclear Facility
- Introduction to Clearance
- Radioactive Decay Calculations
- Introduction to NORM
- Introduction to Proton Beam Therapy Design

Webinars are advertised via SRP and AURPO websites plus various social media platforms including Twitter, LinkedIn, Instagram and Facebook (Figures 1 and 2).

Figure 1: Example social media adverts for the webinars

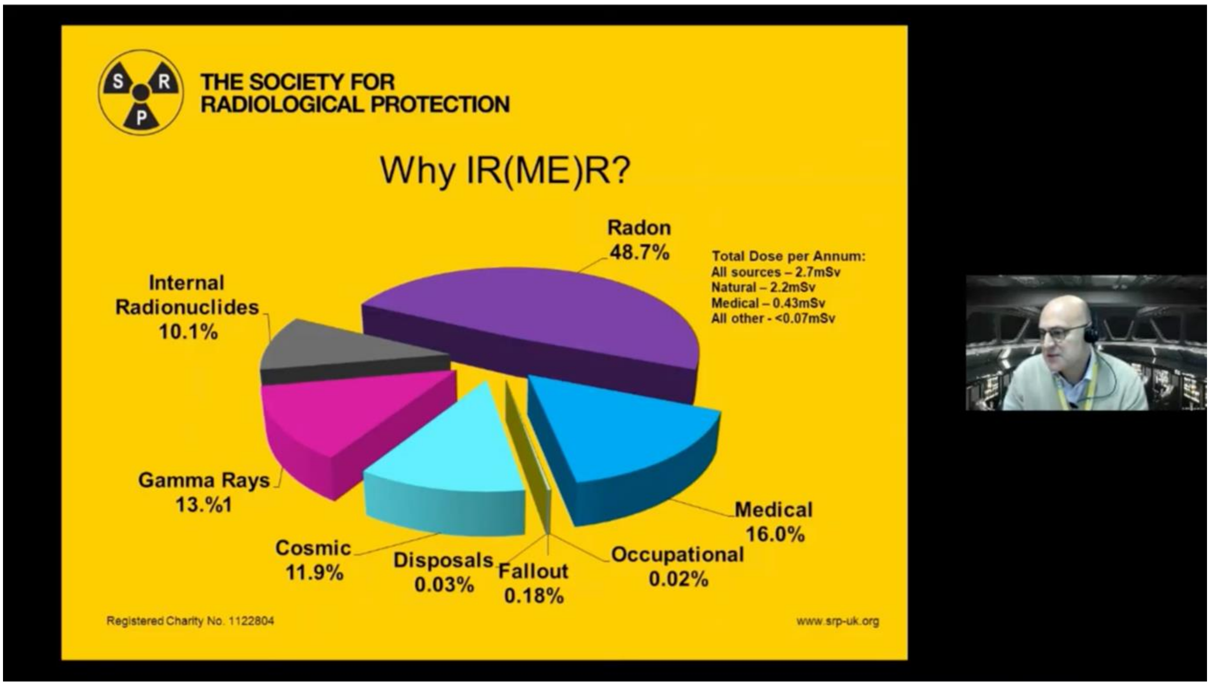

Figure 2: Example of a webinar screen shot.

3 Results

Given the success of the initial trial with between 207 – 320 attendees per webinar, including members from both organisations, the public and wider international radiation protection profession), in October 2020 a decision was made to continue the free webinar programme indefinitely and to establish a Webinar Working Group tasked with the management and development of the programme.

To date twelve webinars have been run broadly covering two cohorts, (a) those persons requiring introductory or refresher training on a certain subject and (b) those who wish for more advanced treatment of a specialised area. A further four webinars have been planned and scheduled over the spring and summer months of 2021 (Table 1).

Table 1: Programme to date, and number of attendees.

Year	Date	Webinar Topic	No. of Attendees
2020	07-May	Internal Dosimetry - A Beginners Guide	320
	15-May	An Introduction to Non-Ionising Radiation Safety Management	290
	19-Jun	An Introduction to Liquid Scintillation Counting	270
	02-Jul	An Introduction to Decommissioning a Non-Nuclear Facility	207
	24-Jul	An Introduction to Gamma Spectroscopy	261
	11-Sep	How to Read Legislation	228
	09-Oct	Radioactive Decay Calculations	260
	21-Jan	Introduction to NORM	240
2021	04-Feb	Introduction to IR(ME)R	168
	12-Feb	Introduction to Proton Beam Therapy Design	167
	11-Mar	Introduction to Clearance	412
	25-Mar	Review of Radioactive Liquids	270
	01-Apr	Activity Assessment of Radioactive Waste	-
	22-Apr	Radiological Risk Assessment	-
	27-May	ONR Safeguard Role	-
	03-Jun	Sealed Source Management and Security	-

A survey is run after each webinar to collect feedback from the audience and is periodically assessed by the Webinar Working Group. To date the following key feedback and observations have been made:

- The webinars have provided access to Continuing Professional Development to a much wider audience than would be able to attend a face-to-face event. This is due to both affordability, logistics and time commitment.
- Remote training does not obviate the necessity for practical training in some areas such as rehearsal of contingency plans however, it is a valuable method and resource that is both convenient and cost effective.

Quotes from the feedback gathered include:

- “The webinar is a great format. It's great to be able to do CPD when I can't travel.”
- “Loving these series of webinars … I hope after COVID-19 you will continue to offer … online webinars for those who can't travel easily …”

The collected statistics show that on average 58% of attendees were members of either SRP or AURPO with 42% coming from other interested stakeholders. The attendance figures show that 6.1% of attendees were non-UK – including from countries such as Nigeria, Australia and in the European Union. 51% of attendees have claimed CPD points or an official acknowledgement for attending these training webinars.

Feedback forms have also provided a way for attendees to suggest topics for future webinars, several of these suggestions have been realised.

MS Teams Live Events has proven to be a successful platform for these webinar events, allowing participants to interact with the speaker by asking questions live as they talk through the Q&A function. After feedback from attendees, the format of the webinar was modified slightly to include a live video of the speaker on screen as well as the slides, to allow attendees to see a "real presenter" speaking to them, giving a more traditional lecture feel. It has been noted that a normal MS Teams meeting as opposed to a Live Event would allow breakout groups of participants to be formed to aid discussion, and further increase audience engagement and participation. This is something that is being investigated for future webinars and events.

4 Conclusions and Moving Forward

The webinar programme run jointly by AURPO and SRP was first proposed in March 2020 as a result of the implementation of the first UK COVID-19 lockdown, recognising the need to provide ongoing opportunities for radiation protection/safety professionals to maintain competence during the lock down restrictions through Continuing Professional Development.

The programme began in May 2020 and so far twelve one-hour lunchtime webinars (i.e. more than one per month) have been run covering a range of subjects of interest to all sectors, with attendance from the UK, European Union, and other countries around the world such as Australia, Netherlands, Nigeria, and Ghana. A further four webinars have been scheduled in the coming months. The average attendance at each webinar has been over 250, and the feedback from participants has been universally positive. More than half of all attendees have claimed CPD points or an official acknowledgement for attending these webinars for training record purposes.

SRP and AURPO have established a 'Webinar Working Group' to ensure a continued programme of free webinars. The aspiration is to continue with these webinars even after the lockdown restrictions are finally eased because many organisations (such as universities) have been severely and adversely affected financially by the knock-on effects of the pandemic, whilst it also provides access to Continuing Professional Development for those who were already, or are now, unable to attend face-to-face training courses or conferences. Additionally, whilst the SRP has an already well-established Outreach Committee, and regularly attends and hosts events for schools and the general public, it is envisioned that this new platform for outreach and engagement will be continued well after the pandemic is over

Whilst it is recognised that such webinars cannot in themselves help to maintain practical competencies, in light of the successes to date and cost-effectiveness, it is intended for the programme to continue post-COVID restrictions and into the future "new normal" of the radiation protection / safety professional's working life.

What has been demonstrated is an appetite for this webinar form of remote theoretical training in the absence of 'real' training meetings and conferences. Both SRP and AURPO celebrate the altruistic nature of this endeavour to support out members and the radiation protection community worldwide. The webinar programme has revealed a potential for a 'new normal' of radiation protection training, at least for theoretical refreshers and updates. This project of free webinars has also outreached to, and engaged with many stakeholders who are not necessarily part of the official radiation protection community or as yet members of SRP or AURPO.

Acknowledgement

Both AURPO and SRP would like to acknowledge the administrative and technical assistance of Harris Associates in facilitating these webinars.

CURRICULUM DEVELOPMENT IN TIMES OF A PANDEMIC

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The European project MELODY is developing and evaluating a basic CBRN training curriculum for First responders and First receivers. As an adaptation to pandemic restrictions, pilot courses in form of face-to-face classroom lectures and hands-on training for end-users are partly supplemented with digital evaluation events focusing on eLearning and online webinars. Despite different settings, initial analysis of data from one face-to-face and one online evaluation event indicate that overall the curriculum is well-suited for its purpose. Results from both tests point towards the same weaknesses regarding specific learning objectives. Two more tests need to be performed and analysed. The conclusions will inform further improvement of the curriculum before its final validation in another round of pilot courses in four European countries.

1 Introduction

The ability of emergency response personnel to assess and to mitigate the risks of incidents with (potential) release of chemical, biological or radio-nuclear (CBRN) material is just as much a matter of civil protection as it is of occupational safety. Yet, in European countries few and varying resources are spent on basic CBRN awareness training of the average emergency response personnel.
Therefore, EU-project MELODY is developing a basic training curriculum on CBRN awareness and initial management of CBRN incidents. The curriculum is designed for personnel of the emergency services, from dispatch officers over the classical First Responders (police, ambulance and fire & rescue personnel) to First Receivers such as general practitioners and staff working at hospital emergency rooms. The MELODY team aims for an EU-wide harmonized curriculum that builds on existing CBRN training initiatives, suits the needs of the emergency response organisations and can be implemented in all EU Member States.

Early on in the project a gaps and needs analysis of current CBRN training in EU Member States was performed. One outcome from this analysis was insight into the varying investment of time for vocational CBRN training, differing considerably between services and countries. In response to the identified gaps the draft MELODY curriculum comprises of seven modules that can be combined into courses lasting from a couple of hours to several days (see Figure 1). The curriculum further builds on the Concept of Operational Functions, i.e. all emergency response activities that need to be performed in order to mitigate the risks of (CBRN) incidents [1, 2], and on the EDEN CBRN Training Framework for First Responders [3, 4].

Each module of the curriculum comprises of several topics. Learning objectives were specified and training material was developed using learning formats such as interactive classroom teaching, reflecting quiz questions, small group scenario discussion, hands-on practical training and table-top exercise.

Importantly, as much as possible and suitable, most parts of the curriculum are intended to be taught to mixed classes of participants, i.e. all professions targeted by MELODY should participate at the same time. Only the advanced module 6 consists of task-specific topics intended for individual target groups.
With the intention of maximum flexibility and in order to reach as many end-users as possible, the first two modules on CBRN terminology and basic CBRN knowledge were designed for both, traditional classroom and individual online-learning. This latter MELODY eLearning can be used stand-alone, as preparation for the more advanced modules 3 to 7 or as a brief refresher training.

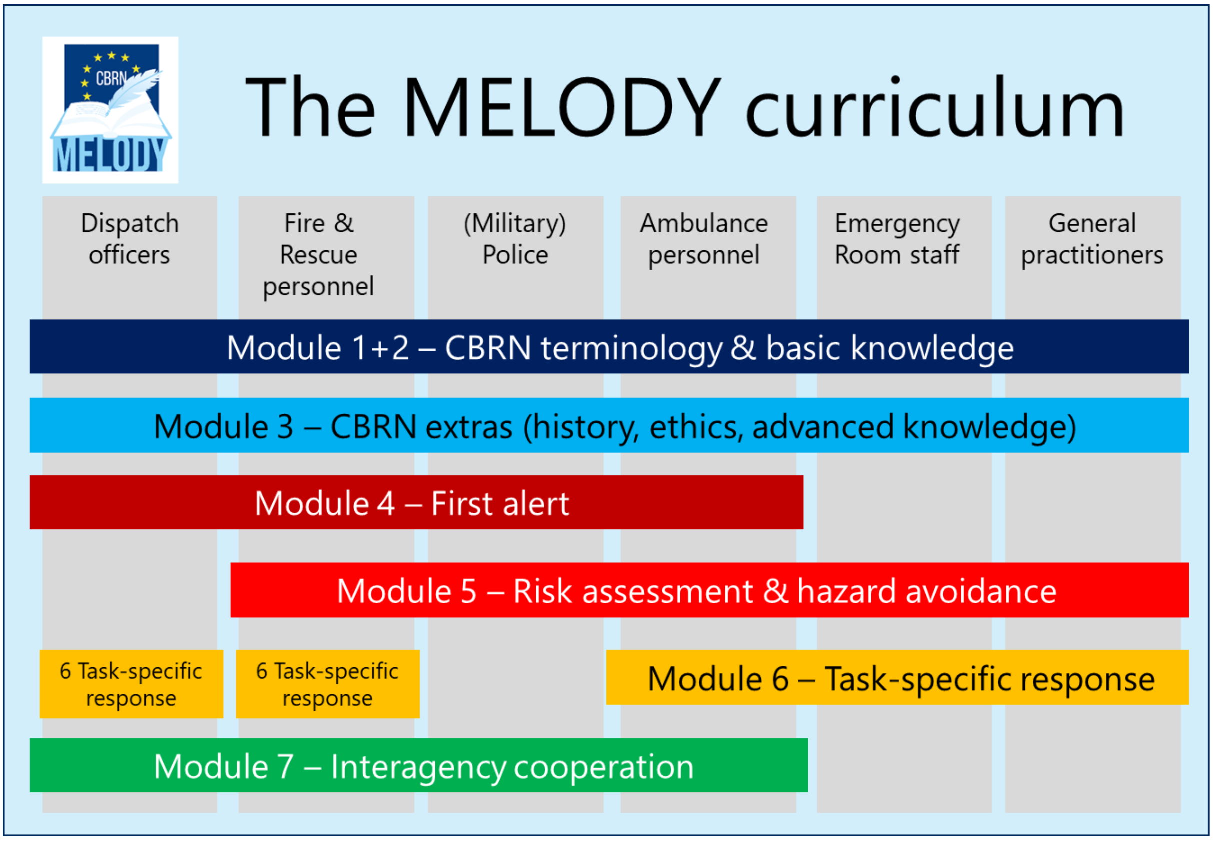

Figure 1. Outline of the MELODY CBRN training curriculum for First Responders and First Receivers.

2 Evaluation strategy

As part of the development process, the project team is testing and evaluating the curriculum together with end-users from several European countries. The evaluation strategy is inspired by evaluation literature such as Kirkpatrick's four levels of evaluation [5, 6], Biggs & Tang's work on constructive alignment [7] and the work by Vedung [8] on intervention theories as evaluation tools. We are looking at three aspects of the curriculum, i.e. its logic, its implementation and its effect, which together provide the possibility to evaluate the curriculum from different perspectives and which contribute to an in-depth understanding of the curriculum and its implementation (Figure 2). The evaluation aspect "Programme logic" focuses on the curriculum and the training contents in relation to the project objectives. "Programme implementation" asks how the training contents is deployed and perceived by the participants (trainees, trainers and expert observers). The third evaluation aspect, "Programme effect", focuses on the trainees' learning. For each of the three evaluation aspects the team defined evaluation criteria, which then guided the development of specific evaluation tools (see Table 1). The analysis of the evaluation data is then geared towards input to the evaluation criteria.

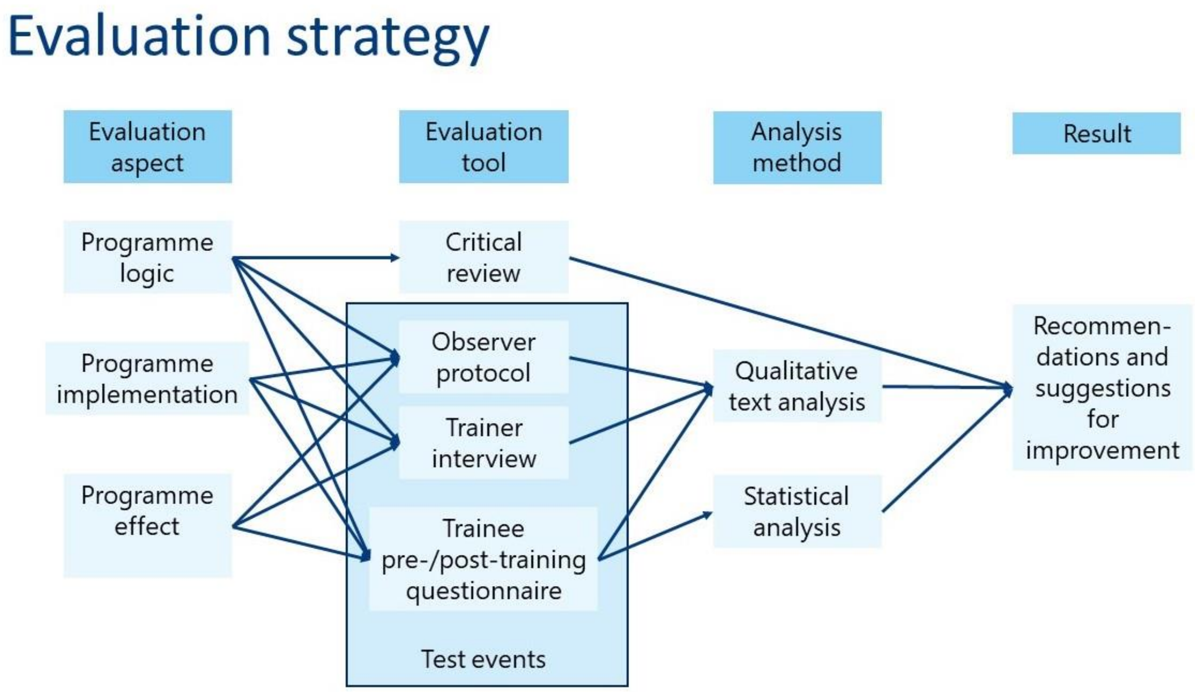

Figure 2. Illustration of the strategy used to evaluate the first version of the MELODY CBRN training curriculum for First Responders and First Receivers.

Table 1: Overview of evaluation aspects and criteria in relation to the evaluation tools developed.

Evaluation aspect	Evaluation criteria	Evaluation tools
Programme logic	1. Has the curriculum the potential to deliver the MELODY objectives and to close the gaps identified in the Needs Assessment? 2. Can the learning outcomes be achieved?	• Desktop review of curriculum and training content • Focus group interview with the trainers • Observation protocol for evaluators • Post-training questionnaire for trainees
Programme implementation	3. Do training contents and training method create opportunities for learning and do they support the learning process? 4. Is the context of the learning situation appropriate? 5. Does the curriculum meet end-users' needs and does it fit into their organization? 6. Are the trainees satisfied with the training?	• Desktop review of the Trainer Guide • Pre-/Post-training questionnaire for trainees • Focus group interview with trainers • Observation protocol for evaluators
Programme effect	7. What effect does the curriculum have on learning? What have the trainees learnt?	• Pre-/ post-knowledge test for trainees • Post-training questionnaire for trainees (self-reported learning)

The main evaluation tool for assessing the programme logic is a desktop review, a so-called constructive alignment, of the curriculum and of the training content, performed by subject matter experts of the MELODY team.
In order to collect empirical data for the assessment of programme implementation and programme effect, the team is organizing pilot courses, that are accompanied by evaluation sessions. During these sessions the following evaluation tools are used:

- A pre- and post-training questionnaire including a pre-/post-training knowledge test for trainees;
- An interview guide for focus group interviews with the trainers, who delivered the pilot course;
- An observation protocol for evaluators, who observed the pilot course.

Four national training centres for First Responders are MELODY partners and these are the hosts and facilitators of the so-called test events (pilot course plus evaluation sessions). These training centres are Central European CBRN-E Training Center of the Hungarian National Police in Budapest, Emergency Service Training Centre West Finland in Pori, Campus Vesta Training Center for Emergency Services in Ranst, Belgium, and the Defence CBRN Center in Vught, The Netherlands.
They recruit trainees, trainers and expert observers, organize the logistics and deploy the training material that is selected for the pilot course.
The overall plan for the test events was to organize one- to two-day live events with five representatives from each of the six MELODY target groups, a total of 30 "CBRN-naïve" trainees, and at least one expert observer from each of the target groups. The expert observers should be experienced trainers (not necessarily with CBRN expertise), responsible on regional or even national level for vocational training in their own organisation. All test events are to be held in the respective national language, which also means that training material and evaluation tools need to be translated from English and that free-text answers and comments written down by test participants need to be translated back to English, the working language of MELODY project members.

Since MELODY explicitly targets "CBRN-naïve" emergency response personnel, the two basic modules 1 and 2 are to be taught in all pilot courses. Apart from these two, additional training material from modules 3 to 7 is included as appropriate under the circumstances of each test event. Depending on the chosen training material, the evaluation tools are adjusted for each test event.

The evaluation data collected from all participants, i.e. trainees, trainers and expert observers, are compiled into a broad picture of the end-users' feedback to the respective pilot course. Qualitative data such as free-text answers and comments as well as the transcribed notes from trainer interviews are analysed by meaning condensation. Quantitative data is analysed simply by calculating mean values for each group of participants and for questions or statements relating to the same evaluation criterion or the same learning objective. In order to measure the effect of the pilot course on learning, the trainees' performance in the pre- and the post-training knowledge test is compared (the "learning delta"). Their performance in the post-training knowledge test, which includes more questions than the pre-training section, also provides information on the degree to which specific learning objectives are accomplished.

3 Evaluation in times of CoVID-19 – Challenges and opportunities

Four face-to-face test events in four countries, i.e. Hungary, Finland, The Netherlands and Belgium, had originally been planned in April-October 2020 for the purpose of collecting evaluation data. Due to the CoVID-19 pandemic these plans had to be changed.

Not only does the pandemic restrict the possibilities for travels and face-to-face test events, it also impacts on the availability of trainees, mainly from the medical professions.

Two face-to-face test events could nevertheless be performed (Hungary, Finland), if only with on-line participation of MELODY team members (see Table 2). Two test events are carried out completely in a digital on-line format (MELODY network-wide, combined Belgium/The Netherlands).

Table 2: Overview of MELODY test events performed during CoVID-19 pandemic and the parts of the MELODY curriculum that are included in each pilot course.

Module	Topics	Test [HU] 2x police, 8x medical staff, 2x fire/rescue	Test [FI] 30 trainees	Digital test 105 trainees [11 countries]	Digital test [NL/BE] 2x 30 trainees
CBRN Terminology & Basics	1.1 – 2.5	1.1 – 2.5	1.1 – 2.5	1.1 – 2.5	1.1 – 2.5
CBRN Extras	3.1-3.2				
First alert	4.1-4.2	4.1-4.2	4.1-4.2		4.1-4.2
Risk assessment	5.1-5.8	Parts of Topic 5.1	5.1, 5.4-5.7		5.1 – 5.8
Task-specific response	6.1-6.4				
Interagency cooperation	7.1-7.2				

The first test event had originally been scheduled for April 2020 but was postponed to 2 September 2020. When planning this event, the team had two major constraints to consider, i.e. the availability of already produced training material and the availability of trainees. It was clear early on that only material for Modules 1, 2, 4 and some parts of Topic 5.1 would be available for the pilot course. Based on the estimated times for teaching this material, the team decided on a one-day test event. This decision was also compatible with the limited access to trainees during the pandemic. In the end, only twelve trainees and two observers from the medical emergency response and the fire & rescue services, respectively, could participate. All training material was delivered by a single trainer and the entire test event was carried out in compliance with the local pandemic restrictions. Due to the pandemic it was not possible for MELODY members to participate in the event on site. Instead, the evaluation sessions before and after the pilot course were performed via video link.

The second test event was postponed from May to October 2020. It covered the same training material as the first test event plus additional topics of Module 5 that had recently been completed. Two days were reserved for the pilot course and the accompanying evaluation sessions, which again were performed via video link. Trainees were police officers, personnel from the fire & rescue services as well as from various emergency medical services.

The pilot course was delivered by four trainers, who also served as expert observers, when they themselves did not teach. Due to the pandemic, no independent expert observers could be invited. The results from this test event are not available yet.

Early on in the project it was decided to produce an eLearning version of the basic Modules 1 and 2 (in English), as an alternative learning format. While the live test events of the classroom training were suffering from shifting restrictions due to the ongoing CoVID-19 pandemic, the project team experienced a strong interest in the online learning format. Thus, when the team called for an online evaluation of the MELODY eLearning, project partners recruited interested volunteers within a very short time. During one week in November 2020 these volunteers were given access to the eLearning and to an online version of the pre- and post-training questionnaire for trainees. The two parts of the questionnaire together with the eLearning were provided as a "link sandwich" and trainees were referred from one link to the next so that they could work their way through the entire sequence. The links were open throughout the entire week and could be accessed at any time. The eLearning could be accessed multiple times, but for the evaluation tools trainees were asked to complete each questionnaire in one consecutive session.

Initially, 143 volunteers from 13 countries registered for this digital test event. At the end of the week, a total of 105 volunteers representing 11 countries had completed both the pre- and the post-training questionnaire. This digital test did not engage trainers or observers but judging from their contact details many of the participants appeared to be in a leadership position and/or being responsible for vocational training in their organization.

The third and fourth test event were postponed to January 2021 (The Netherlands) and March 2021 (Belgium), respectively, in the hope of fewer pandemic restrictions. However, in the light of recent and ongoing CoVID-19 developments, these two live test events are now being transformed into one 2-day digital online test event scheduled for May. It will be held in Dutch jointly for trainees from Belgium and The Netherlands. The online setting may come with challenges for all involved, but it also bears an opportunity for the two hosting MELODY partners to develop novel learning formats and to push forward the boundaries of traditional vocational training for First Responders.

4 Preliminary results and other observations

The evaluation results from the first test event (Modules 1, 2, 4 and parts of 5.1) show that the pilot course was successful. The trainees were eager to learn how they could be better in handling CBRN incidents and how to strengthen their cooperation with other emergency services. The trainees felt that the pilot course offered good possibilities for learning.

With regard to program logic, the MELODY curriculum was perceived as having the potential to deliver the overall MELODY objectives and as providing possibilities for achieving the specific learning objectives of the pilot course. Even though the overall perceptions of the pilot course were positive, our results also demonstrate the challenge of developing a curriculum that suits all target groups. Some of the medical emergency staff felt that parts of the training material were too basic. This view can however be explained by a higher level of previous CBRN knowledge in these trainees as compared to the rest of the trainees.

Concerning program implementation both the training methods and training material got positive reviews. The trainer and the two expert observers thought that the amount of material to be presented was too much for the available time, limiting the possibilities for interaction between the participants. The trainees did not perceive this as problematic; they rather rated their possibilities for interaction as very high. They did however wish for more practical training elements.

Nevertheless, a good balance between the amount of training subjects and available time should be ensured as interactive discussions and feedback are essential prerequisites of learning. The general opinion of the participants was that the training subjects and the pilot course meet well the end-user's needs and fit the national context of their organizations.

According to our results concerning program effect most trainees felt that they had increased their CBRN knowledge with the pilot course. Only those trainees with high previous experience disagreed to have learned much new. Our quantitative data confirm a small increase in knowledge, with a learning delta of 13,3% for the whole group of trainees. The twelve learning objectives that were assessed during this test event were achieved to varying degree. Judging from the mean percentage of correct answers in the post-training knowledge test, most learning objectives were achieved to a high degree, but for four learning objectives the trainees had less than 50% correct answers. Two learning objectives were assessed through a vignette and here only half of the trainees presented acceptable or relevant solutions.

In conclusion, our results point towards a well-implemented pilot course during which the trainees gained basic CBRN knowledge. As only twelve trainees participated these results cannot be generalized too much. But, both the identified strengths and weaknesses will inform the upcoming improvement of the curriculum and its training material, e.g. a better balance between unidirectional lectures and trainer-trainee as well as trainee-trainee interaction, improved training material and/or training method for a higher learning delta, specifically for those learning objectives that were not or only just achieved.

Many of the trainees in the digital on-line test event (Modules 1+2, eLearning) turned out to be overqualified in terms of their CBRN knowledge. According to the demographic data collected in connection with the pre-training questionnaire 45% of the trainees had a Master's degree or even higher level of education. More than 70% had over ten years of professional experience. A small group of trainees defined themselves as having another profession than one of the six MELODY target groups, and these can even be considered CBRN specialists. When asked about their expectations, trainees stated either that they were interested in learning more about CBRN or that they were curious to see how the eLearning format would work for this kind of subject matter.

The results of the evaluation regarding program logic showed that the trainees believed the learning objectives to be achievable and the overarching logic of the eLearning to be good. Concerning program implementation the trainees were satisfied with the visual and multimedia design of the eLearning, its content and how it fitted into the national context of their organisation. Some participants asked for a version in their national language. The main opportunities for improvement were seen in the voice-over elements and the number of interactive elements, which trainees believed should be increased. Further, the project team learned that the position of this eLearning in relation to the whole MELODY curriculum needs to be explained more clearly. On the background of the rather high level of education and CBRN knowledge, it was probably not too surprising to read comments asking for more in-depth training; the content of the eLearning was perceived as too basic. The educational background of the trainees was also reflected in their overall good performance already in the pre-training knowledge test that we used to assess program effect. Accordingly, our data for the whole group of trainees demonstrated only a small learning delta. If the results for the CBRN specialists are removed from the analysis, the learning delta is more pronounced.

Even though the overall performance of the trainees in the knowledge test was high, our assessment of the learning objectives relating to Modules 1 and 2 shows that the same learning objectives as in the first test event were achieved to a lesser extent than the rest of the learning objectives.
Interestingly, we observed a difference between the trainees' self-reported learning and their performance in the knowledge test. While the trainees believed to have largely achieved all learning objectives, the results of the knowledge test do not entirely confirm this view.
In conclusion, the assessment of the eLearning overall re-iterates the findings of the first evaluation despite the differences between these two test events. It was unfortunate that the project team for the digital online test did not quite succeed in recruiting the intended end-users since this could have improved the usefulness and information content of our evaluation results. Nevertheless, the pool of useful data is still big enough for meaningful calculations. Moreover, with the digital online test event we reached out to a large number of potential end-user organisations. The experienced test participants might be in the position to raise sufficient interest for a future implementation of the final MELODY curriculum in their respective organization.

5 Outlook

The team is currently analysing the data from the second test event (in Finland) and preparing for the joint digital online test in May. Once all test events have been performed and all empirical data are analysed, the summarized findings will be used to further improve and harmonize the curriculum. The final version of the curriculum will then be validated again in close cooperation with end-users in order to ensure that it suits and serves emergency services all over Europe. Thus, a second suite of pilot courses is planned for winter-spring 2021/2022.

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FIRST EXPERIENCE IN THE VIRTUALIZATION OF RADIATION PROTECTION TRAINING AT HOSPITAL LEVEL

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Covid-19 pandemic crisis has triggered the need to virtualize radiation protection training. This training is very diverse in terms of objectives, target audience and must be carried out in agreement with other hospitals and institutions, which implies different tools and constraints. Moodle, different learning platforms, videoconferencing systems, office and google forms or Kahoot are tools that have been used depending on the case. In general, the change, although quite fast, has been simpler and smoother than expected, with a very good acceptance by the students, with the possibility of expanding contents, as well as adapting to different learning schedules and speeds. As it has been necessary to adapt and develop new content, whenever possible we have tried to share the effort with other hospitals with the same needs.

1 Introduction

In general, all occupationally exposed personnel are required to accredit a radiation protection training course in as well as continuous education on this area. Additionally, the training programs of medical students, interns and specialists and other health careers, include different levels of radiation protection contents.

While the virtualization of radiation protection education was already available many years ago, inertia in the use of pre-existing classical methods of teaching, the use of previous work (mainly presentations), the lack of knowledge on the tools to deliver online education and the obvious advantage of face-to-face interaction with the students made that, in our case, training kept in the classical scheme. That scheme consists basically of a traditional classroom setting with the teacher being at the same place and at the same time as the students. The Covid-19 pandemic crisis has made it impossible to carry out the usual on-site training programme and an ultra-fast adaptation has been needed.

Education and training in radiation protection is highly regulated in the Spanish legislation [1-3] for most of the medical applications of ionizing radiation. Additionally, the new Directive 2013/59/EURATOM [4], after its transposition to the Spanish regulation implies an increase and reinforcement of continuous training in radiation protection in all the areas.

Education and training in this field is mainly responsibility of Medical Physics and Radiation Protection Departments of University hospitals, especially those aspects of continuous education.

So, an attempt has been made to start the virtualization of the courses in which our department is involved. This has not only been a response to the new needs, but also a way to benefit from the advantages that involve online training.
The aim of this study is to present the virtualization of radiation protection training for exposed staff at a university Hospital.

2 Material and Methods

Our department, with some of the personnel also involved in university education, participates in various training activities in the field of radiation protection:

- Continuous training (at least biennially) of professionals working in radioactive installations (radiotherapy, nuclear medicine, laboratories…) (RP1).
- Continuous training of professionals (including security personnel) involved in the safety and security of high activity sealed sources (RP2).
- Training as part of the curriculum at the Medicine and Dentistry schools (RP3). Personnel from our Department is mainly involved in seminars and practices.
- Periodical and initial training of professionals working in diagnostic imaging facilities (RP4).
- Training in radiation protection as part of the training program of medical specialties (RP5), that is organized into two different levels, basic and advanced, according to the degree of involvement of the different specialities in radiological procedures.
- Training programs for the accreditation of operators and supervisors of medical radioactive installations, as well as operators and directors of X-ray facilities (RP6).

As there are different types of courses, different contents, different virtualization tools and some of them involved other Institutions, we have adapted to different scenarios. After exploring the technological and administrative constraints, as well as the support offered, we have chosen different solutions to each course, as shown in table 1.

Table 1: Tools used and collaboration in the different training programs

Course	**Tools used**		**Syncronous training**	**Collaboration with other hospitals and Institutions**
	Course	**Evaluation**		
RP1 and RP2	Moodle [5] on the 'virtual knowledge platform' of the hospital	Moodle	No	No
RP3 (Medicine, only involved in seminars)	Moodle platform and Blackboard Collaborate [6] on the Virtual campus. Kahoot [7] for gamifying online classes.	Moodle, Office forms [8] and Classical live exams	Yes	Yes
RP3 (Dentistry, only involved in practices)	Practices recorded with OBS [9] and shown and commented in small groups with social distancing.	Moodle	Yes	Yes
RP4 (dentist and hygienists)	A one-day course for dentist using Zoom video conferencing [10] .	Google forms [11]	Yes	Yes
RP4 (other professionals	Moodle, on the 'virtual knowledge platform' of	Moodle	No	No

working with X-rays)	the hospital			
RP5	Training platform ForMadrid from the Autonomous Community of Madrid. Powerpoint presentations and videos of all the lessons. Integration of this material in the Learning Suite from CSOD [12]	Training platform ForMadrid	No	Yes
RP6	Moodle on the Virtual classroom from the CIEMAT Zoom video conferencing	Classical live exams	Yes	Yes

3 Results

Face-to-face teaching and learning was the only option until the beginning of 2020. Now, the training is almost fully online. Video conferencing is the only synchronous sessions of training, so we have passed from a 100% live teaching to an almost 0% that, in addition, is mostly asynchronous, that is, with the teacher and students working at different times.

Figure 1. Main page on the "virtual knowledge platform" of the hospital with the access to some of the courses prepared.

There are many different tools for virtualizing radiation protection training. The tools available at our hospital have been used to develop specific continuous training (see figure 1) for hospital facilities (RP1, RP2 and partly RP4). This training includes information from specific work procedures to the use of specific equipment producing ionizing radiation, measurement and control used in the hospital. New online procedures have brought out the possibility of longer contents, with a higher attendance rate and a very considerable acceptance from the trainees. In fact, previous face-to-face training was limited to a one-hour talk and with limited attendance because part of the professionals were too busy to attend or had a day off on the training day.

The virtualization of the training has allowed to extend the contents and duration of the training (7-hour courses), as the trainees have access along one whole month to accomplish the education. It has been followed by virtually all the professionals and, being an official accredited activity, they therefore obtain an official diploma. In addition, an anonymous satisfaction survey was proposed at the end of the activity, and results are shown on table 2.

Table 2: Results of the anonymous satisfaction surveys at the end of training activities RP1 and RP2. The scale goes from 1 (least agree) to 10 (most agree).

Feature	Mean value
Do you consider that the duration of the course is adequate?	9
Do the proposed course content and structure seem adequate to you?	9,3
Did the explanations seem clear to you?	9,2
Does the platform operation seems intuitive and simple?	9,1
Did the teaching staff respond quickly and adequately to the questions that arose?	9,3
Do you consider the course useful for your work?	9,7
Overall rating of the course	9,5
Would you recommend taking this course?	Yes (100%)

Our Department also collaborates in radiation protection training with other institutions that have partially or totally virtualized the training (RP3 and RP6). In this case, we have adapted to the available tools on the learning platforms of these institutions: videoconference for classes (using Zoom or Collaborate) with support for complementary documentation through Moodle (see figure 2). It is worth mentioning the solution given to practices in the Dentistry Faculty, where face-to-face classes continue, but with measures to avoid contagion.

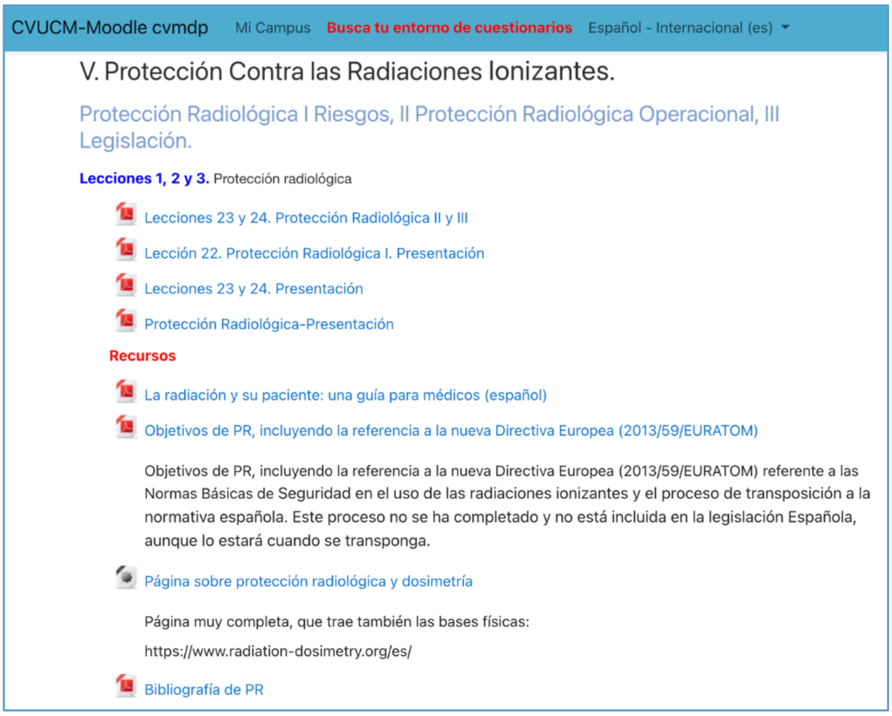

Figure 2. Detail of the contents on Radiation Protection of the virtual campus in Medicine

Since at practice lectures it was not possible to maintain a safe distance, contents have been recorded with OBS, a free and open-source software that allows simultaneous recording with several cameras to show different angles and a zoom with the reading of the instruments along the different practical exercises.

For the rest of the training where we are involved in (RP5 and partly RP4), an attempt has been made to carry it out in collaboration with other hospitals and institutions, in order to reduce the workload for developing new materials and benefit from the experience of external professionals. This has meant, on the other hand, the need to adapt the training to other available tools, according to the agreements that have been reached.

4 Discussion

The virtualization of radiation protection training has involved a very important effort to adapt previous material, develop new material and adapt to tools that, apart from being new, have been very diverse depending on the course and the institution where the program of training was developed. However, the change in the teaching environment has been swift and smoother than we expected and has brought some advantages such as:

- In many cases, the material is available for review and reflection for a longer time. It is not knowledge that have to be understood in real time during the live class. It is not only possible to learn at the time that best suits each student, but also at a personalized pace, repeating as many times as necessary.
- Greater flexibility and accessibility in online training, which implies greater possibilities to follow the course (more attendees), which means that the training reaches a higher percentage of the target group.
- Possibility of using different multimedia learning media.
- Possibility of grouping efforts between different hospitals to offer a common training.

5 Conclusions

The virtualization of radiation protection training has been a challenge that had to be addressed in a very short time. Far from posing a threat, virtualization became an opportunity to adapt training to modern methodologies, making it more flexible and accessible.

Acknowledgement

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ONLINE LABORATORY WORKS FOR PGEC

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An example of e-learning approach to online implementation of laboratory works on basic nuclear physics, interaction of ionizing radiation with matter, radiation detection and measurement applicable to the Parts I and II of the IAEA PGEC Syllabus is demonstrated. The technology of remote implementation of labs, testing knowledge and keeping records using one of educational LMS platforms available for undergraduate students and PGEC participants is described.

1 Introduction

E-learning in current pandemic situation has explosively pushed the development of training tools to fit them for on-line format with opportunity to organize the education and training process remotely under the control of an instructor with the opportunity to:

- interfere in the studying process for corrections,
- evaluate a student's knowledge and skills,
- keep records of the a student's progress.

But such avalanched development would not had a chance if appropriate preliminary works on the way of on-line learning would not be carried out throughout the world. Among them, the most famous platform Coursera that collected more than 130000 of different learning courses for the moment [1]. But there are only a few scientific and engineering online courses on Coursera that can be implemented completely on-line and recognized by universities.
One of the most important part of the scientific and engineering training is the providing practical skills by remote implementing laboratory works. They are realized on Coursera via simulations only. Such approach have essential restrictions in practical skills that may be gained especially for scientists and engineers. That is why any opportunity to overcome such restrictions even in particular case may be of interest for providers of education and training services.
The purpose of this paper is to demonstrate the possibility to implement real laboratory works on basic nuclear physics, radiation detection and measurement and related parts of nuclear and radiation education in on-line mode. This possibility has been realized at the nuclear physics department of Belarusian State University, Minsk, Belarus in 2020 and is in application now for different education and training courses from undergraduate ones to PGEC.

2 Main advantages of e-learning and peculiarities of its organization and implementation

E-learning comprises several components as any form of education and training: goals, content, methods, organizing forms, education and training tools. The last three components are defined by the specificity of a technological platform used. On the base of wide and accessible offers of the web ware, especially on the base of resources of distance learning management systems the realization of classical didactical principles of education is going along another forms of education and training material delivering and forms of lecturers/instructors interface with students/participants.

The e-learning may be carried out in a fully or semi-automatic mode due to the opportunities provided by contemporary learning management systems.
These forms of the e-learning are principally new against the conventional ones. Thus, the training material delivering cannot be only in the form of electronic version of lectures, laboratory work manuals and electronic copies of supporting materials. The central issue of the e-learning is the provisions to the studying process scenario for both a particular course and its different modules, topics. The correctly formed scenario may help to address to the main challenge of an e-learning that is lack of motivation of a student/participant to study supporting the self-control during studying a particular subject. In this capacity, e-learning serves for more rapid and qualitative assuming a course/module/topic content.

3 Interface types within the on-line learning and some of its advantages against conventional education and training

Development and adjustment of the education and training to the contemporary conditions, its modernization anticipate changes in principles of the education and training process organization, namely, it should create conditions to realization of flexible and individualized education. Use of virtual information-educational environment is one of the extensive tools targeted to provide such conditions. Development and expanding accessibility new information-communication technologies have become a vital factor in integration of e-learning technologies in classical education and training forms both face-to-face and vocational ones. The advantages of such integration are in provisions to optimize education and training process, to make it more flexible and more being controlled in relation to self-work of students/participants, etc. These features of the e-learning education lead to understanding the sense of e-learning entirely as a new form of education and training subordinated to its inherent didactical laws.
These laws are specifically act at different types of the learning interface [2]:

- lecturer/instructor – student/participant;
- student/participant – student/participant;
- student/participant – resources (education and training electronic tools and materials);
- lecturer/instructor – lecturer/instructor;
- lecturer/instructor – resources;
- resources – resources.

The interface types included in the first three bullets are the key elements in every e-learning process. However, all interface types listed above play their role in the distance implementation of laboratory works (see section 5).

Organization of an interaction of students/participants and a lecturer/instructor is arranging within the promulgated concept of education and training but it is implemented with the help of the web technologies. Because of that, the area of activity of a lecturer/instructor is considerably expanded. Except standard roles (an author and developer of a course, methodological materials to it, group communication/discussion organizer, appraiser, motivator, etc.) a lecturer/instructor starts to be an education and training moderator (tutor). Except the creation and correctness of the course during its implementation and subsequent evaluation the remote lecturer/instructor builds up a personal education roadmap for students/participants, carries out e-learning events, assist to a student/participant to implement different parts of the course, contribute to the solution of technical and academic programmes arisen related to the course. The organization of operational and systematic interface of students/participants with a lecturer/instructor is the fundamental point and may be fulfilled either in a synchronous or asynchronous mode.

The last issue provides the additional featuring the education and training process that is not used in conventional approach to it.

One of the most difficult forms of lessons to be transferred from off-line to on-line mode is the 'laboratory work'. During such a work, a student/participant must learn the brief theoretical description of an experiment to be done, study the recommended 'logistics' of the work implementation, then use equipment for measurements, get readings, process measurement results and make conclusions. The results and conclusions must be discussed with a lecturer/instructor and subject to evaluation. It takes much time that easily exceeds the time allocated for proper work implementation in an academic plan. In addition, the difference in academic hours allocated for implementation of laboratory works on the same topics in different academic plans requires appropriate flexibility of using standardized training material, road mapping implementation of the work, changing the list and content of questions for quizzes that are used for evaluation of a student/participant performance. For example, in case of PGEC, the topics of labs of Part I and Part II of the syllabus are the same that are assigned to the undergraduate students of the Faculty of Physics of Belarusian State University within the subjects "Physics of a nucleus and ionizing radiation" and "Radiation detection and measurement". It is required to draw more attention to the self-work of PGEC participants before and after the implementation of a work and to provide them more didactical support. The preliminary online training of a student/participant before a 'laboratory work' event or seminar is required to implement successfully such a piece of the academic work. Using an appropriately prepared e-learning tools make this task easier for implementation.

The contemporary learning management system based on Moodle technologies are the base of application of e-learning tools processed for organization and moderation of a student/participant self-work. It is well-known that a Moodle wise platform provides access to all kinds of electronic study packs, other forms of electronic education and training materials, reference and supplementary materials, collected by a lecturer/instructor, etc. It supports the operation with multimedia, different forms of knowledge control and other forms of interface (charts, conferences, etc.) between the participants of e-learning process.

Not all laboratory works in physics can be implemented remotely with use of all advantages of the Moodle platform. But in case of many of laboratory works in studying of basic nuclear physics, interaction of ionising radiation with matter, radiation detection and measurement can be implemented in such a way. The technical possibility to do that provides, inter alia, the universal laboratory set-up designed, developed and compiled at the nuclear physics department of Belarusian State University with the assistance of enterprises "Atomtex" and "ADANI".

4 Technical possibility to implement laboratory works at the nuclear physic department of Belarusian State University

The universal laboratory equipment for radiation measurements that 'open doors' for its remote use had been developed at the nuclear physics department of Belarusian State University many years ago. The first attempts to organize remote training were entertained in few last years and was reported at the previous ETRAP conference in Valencia in 2017. However, it was really applied for distance learning only in spring, 2020.

Each laboratory work has the following common structure:

- Introductory part;
- Theoretical part;
- Experimental part.

The roles of the "Theoretical part" and "Experimental part" will be described in the section 5.

The "Introductory part" provides the full description of the *universal laboratory set-up* for each laboratory work (the first photo on the Figure 1). The universal laboratory set-up allows carry out almost all laboratory works at one complex.

There are three main parts of the universal laboratory set-up [3]:

- *Detector*, scintillation or semiconductor one, produced by “Atomtex” and connected to the electronic module;
- *Electronic module* produced by “Atomtex” or “ADANI” with software designed and developed together with the nuclear physics department staff;
- *PC* with appropriate characteristics fitted to interface with the electronic module.

The detector is formed from replaceable blocks for detection and measurement of α-, β-, γ- radiation, and basic unit for formation and amplification of an electric signal (see the second row of the Figure 1). Each replaceable block has accessories providing space configuration of an experiment and shielding against radiation.

The Electronic module is intended to generate and amplify an electric signal caused by ionising particles in the detector working body (see the left photo on the third row of Figure 1). It also transforms the amplitude of an output electric pulse in the digital code in dat. file mode that is then delivering to the PC. The testing signal for electric calibration of a spectrometer is also produced by the electronic module. It contains one or two basic amplifiers, coincidence scheme, scheme for the signal selection, B low- and high-voltage power sources. All control functions are implemented by the PC.

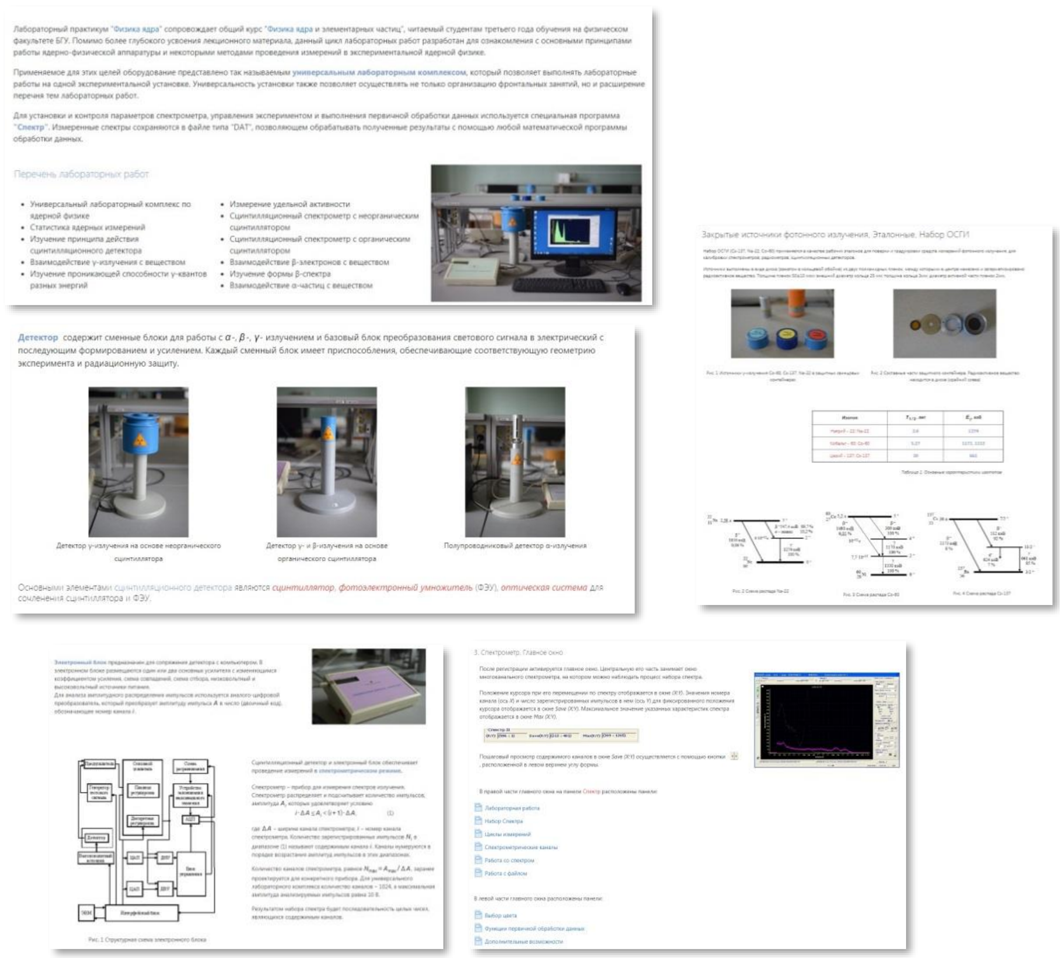

Figure 1. Fragments of introductory part of a laboratory work description

The software ”Spectrum” developed by ”Atomtex” is used to set up and control the spectrometer parameters, parameters of an experiment and primary data processing.
Because spectrometer operation modes are set by the software that also visualizes the measurement process there is the possibility to organize remote access to the set-up control with the help of any available remote access programme.

5 Implementing laboratory works in an e-mode or b-mode at the nuclear physic department of Belarusian State University

The application of e-learning technologies at the nuclear physics department of Belarusian State University is going during last 4 years. There are e-learning courses that follow some kinds of lessons for several disciplines were worked out with some methodological techniques of their implementation. They are performed mainly in the b-learning format today on the base of the BSU LMS and on the base of the STAR-NET LMS. This experience is used for e-learning at the PGEC.
Let us demonstrate the peculiarities of the operation of such a course on the example of on-line laboratory “Physics of a nucleus and ionizing radiation” deployed on the STAR-NET LMS.
The organization of the laboratory works in the e-learning format has the following *three components*:

1. Organization and control of a participant/participant’s self-work on studying of the theoretical part of a laboratory work;
2. Remote access to control of an experimental set-up;
3. Control and accompanying of a student/participant operation during the work implementation and processing of experimental data with their interpretation, conclusions and assessment how a student/participants has understood the results obtained, has evinced his/her knowledge, skills and, possibly, attitudes.

The first component is realized due to Moodle tools that possesses by the wide spectrum of opportunities to study theoretical background of the physical phenomena and its experimental investigation in a particular laboratory work in the form of self-learning in which the interface type “student/participant – resources” (see section 3) is operating. The course creator (a lecturer/instructor) establish a specific scenario (roadmap) for the course or its particular part to make the acquisition of knowledge by a student/participant more effective. Such scenario is realized automatically by the platform software tools via creation of a definite control/reference points on it.
It is well-known, there is the element of a Moodle system “Lecture” allows to code the roadmap of a material study in dependence of results of intermediate questioning (quiz). The formal chart of study of the course element “Theoretical background” to any laboratory work is shown on the Figure 2.
Finishing the Part 1 one ought to answer on a set of questions sequenced in an special order. Only correct answer on a question allows to move to the next one. If the answer is incorrect or uncompleted, the system launch a student/participant back to study material again. After that it is accessible to repeat the attempt but the questions are follow each other in the prior order.

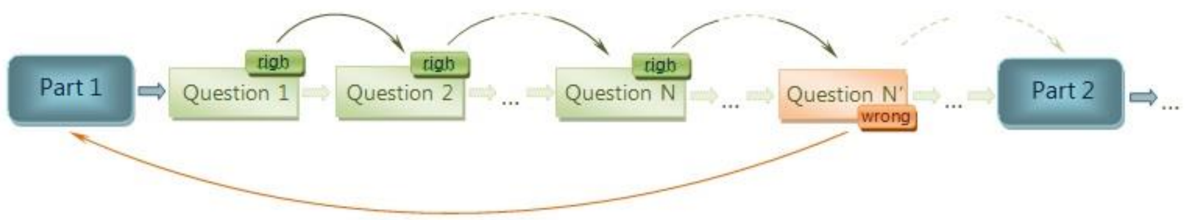

Figure 2: chart of study of the course element “Theoretical background” to a laboratory work

On the Figure 3 the screenshots of some implementation stages of the lab element “Theoretical part” are demonstrated.
After going through all parts of the element “Theoretical part” and answering on all questions the system alerts on successful implementation of the element and permits to begin studying the “Experimental part” that is also realised with the help of the Moodle element “Lecture”.
The “Experimental part” of each laboratory work contains the description of experimental methodology using in the work and a set of questions the correct answer on which are important both for the correct implementation of the experiment and for the interpretation of the results obtained.

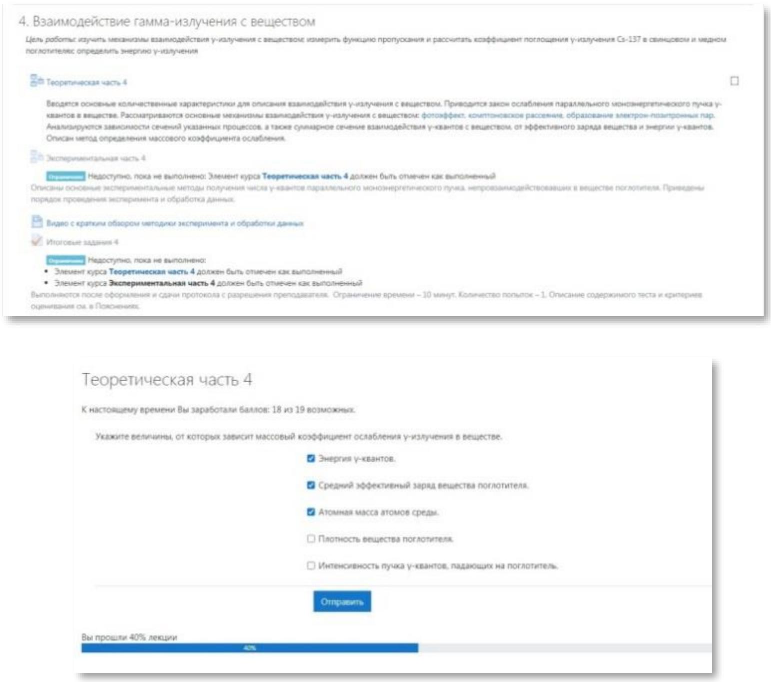

Figure 3. Progress in studying of the lab element “Theoretical part” on example of topic “Interaction of gamma-radiation with matter”.

It should be noted, that the education and training material of described elements of a laboratory work is prepared in html format, i.e. in hypertext mode. There are hyperlinks on Glossary and the part of the Course with reference data, full description of the set-up (see the section 4) and software recommended for data processing.
To realize the remote interface “Lecturer/instructor – student/participant” (see section 3) with shared access to the screen for all counterparts and also to provide access to the computers and experimental units of the laboratory a wide world used video communication tools like Zoom, Microsoft Teams, WebEx or TeamViewer is needed. We did not test all the existing tools of such kind, so we will describe the communication via only one widget “Screen demonstration” of the function “Conference” od the software TeamViewer. In such a mode it is possible to organize an introductory lesson on demonstration of how the experimental set up works, how to run and operate with it, to explain the approach to the measurement techniques, clarify the options of the software “Spectrum” and also to demonstrate how to manage with the software Mathcad for data processing. The communication of a lecturer/instructor with students/participants is going on-line with the help of widgets of the TeamViewer in the real time. An example how the shared screen may looks like is given on the Figure 4.

The mode "Conference" is launched from every working place at the lessons (students/participants implement laboratory works with different topics). The access code or id of a conference is sent to the students/participants group by the messages of the platform in the beginning of a lesson. A lecturer/instructor activates sharing the role of a lesson manager to a student/participant providing to him/her by that the right on the remote control of the set-up under the lecturer/instructor supervision.
After completion of all measurements according to recommendations given in the "Experimental part" students/participants download the obtained data files on their personal computers for further processing.

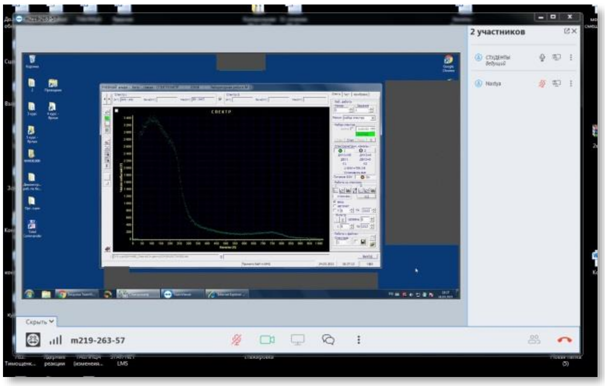

Figure 4: Example of the screen appearance (TeamViewer software)

Measurement results are composed in the data-files with extension "*.dat". That is why they can be processed in any mathematical software. Going to the mode "Conference" and demonstrating his/her personal computer screen to a lecturer/instructor the students/participants process data in accordance to the methodology described in the "Experimental part" of a laboratory work. The screen demonstration mode (Figure 5) allows a lecturer/instructor to follow a student/participant work, promptly react on difficulties that a student/participant meets, correct mistakes, discuss the questions arisen and results obtained in the *real time mode*.

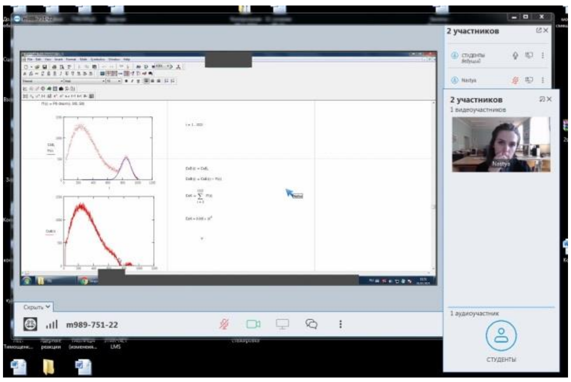

Figure 5. Appearance of a student/participant screen with experimental data processing

It was found that one lecturer/instructor is capable easily to monitor implementation of four different laboratory works during the allocated time.
After completion of the processing measurement data the final stage follows. At this stage, a student/participant has a restricted time to pass the final quiz comprising 10 open and closed type questions. The open questions are assessed by a lecturer/instructor during the questioning session on-line. There is an opportunity to change the scores for the answers on the closed questions during the conversation with a lecturer/instructor.

The results of the final quiz are deployed on the LMS (Figure 6).

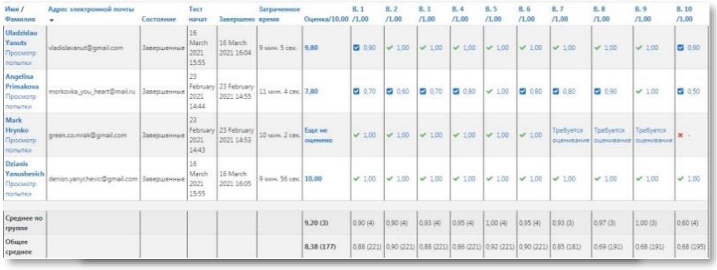

Figure 6: One question from the final quiz to a laboratory work and results of assessment of the students/participants performance

The course records provide the data on the students/participants progress both individual and in the group with notes on how students/participants completed the particular elements of the laboratory work and other relevant information on activities of the students/participants at the LMS. The example of data presenting at the LMS after completing all course elements by a group and each student in particular are shown on the Figure 7.

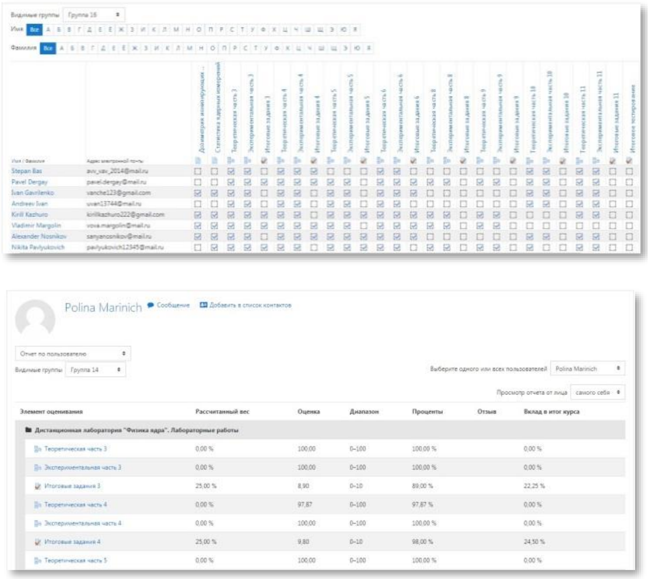

Figure 7: Appearance of the final results of a group with detail scoring of each student/participant

6 Conclusions

The on-line course consisting of 10 laboratory works on basic nuclear physics, interaction of ionising radiation with matter, radiation detection and measurement developed at the Nuclear Physics Department of the Faculty of Physics of Belarusian State University is realised due to the combination of inherent features of the studying phenomena, measuring and processing data equipment and software developed at the Nuclear Physics Department in a partnership with enterprises “Atomtex” and “ADANI”. These inherent features are:

- basic nuclear phenomena can be registered and studied due to detection and measurement of ionising radiation produced in nuclear events;
- the radiation detection and measurement is based onto electric signals correspondent to the ionising radiation impact on matter;

- these signals can be converted in a digital form, collected and sorted in a dat-file that can be processed by widespread software like MathCad, MathLab, Mathematica, and others.

The organization of the practical course implementation on-line with input and output checking a student/participant knowledge, sharing access to the control of equipment used during the practical exercise, methodological approach developed to facilitate the course implementation provides enhanced opportunities for control of a student/participant self-work, for assistance to him/her at the implementation stage and to monitor of his/her the progress after the completion of each work and of the course in a whole. We hope, that course has become self-consistent and completed e-learning training tool adapted to use not only for remote studies but also for self-work. It can be easily expanded for any laboratory works in the field of interaction of ionizing radiation with matter, radiation detection and measurement, dosimetry, radiation shielding and related topics. That is why the course is applicable to train not only undergraduate students but also participants of PGEC and other relevant professional updating courses.

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BIOLOGICAL DOSIMETRY TRAINING USING A WEB-BASED FACILITY

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This paper describes the experience in a training exercise on biological dosimetry (BD) using a web-based training facility. The exercise was organized by the Latin American Biological Dosimetry Network. Four countries of the region interested in the introduction of BD but with limitations in obtain the necessary training material participated in the exercise conducted by the staff of qualified laboratory. The BioDoseNet image repository (BIR) was used as BD training tool. The training was planned in three phases, two of them virtual from November 2016 up to October 2018. The results of this exercise demonstrate the utility of the BIR as a training tool for the BD. The training provided an opportunity for four cytogenetic laboratories, previously inexperienced in biodosimetry, and with problems in getting access to suitable national radiation sources to gain familiarity with the BD.

1 Introduction

The 'gold standard' for BD is the dicentric assay (DCA). The DCA has been used since the mid-1960s and actually is a routine component of the radiation protection programs of many Member States [1]. The DCA is essentially a cytogenetic technique applied to human lymphocytes. The lab involved in such technique should be able to perform the culture of the lymphocytes up to the metaphase stay, and them scoring aberrations, essentially dicentrics, induced by the radiation. The scoring is essential for all the process, as it provide the primary data for calibration curve generation and when necessary for dose estimation in exposed persons. The calibration curve should be generated in each lab. The preparation of a calibration curve must be supported by reliable and accurate physical dosimetry. Several technical considerations are necessary for dose response construction including the availability of a suitable radiation sources and appropriate dosimetry techniques. These are, in some countries, significant limitations for the implementation of the DCA. Another important limitations of the DCA for use in emergency response is the extensive time and expertise required to perform the scoring. To minimize this limitation, several approaches have been developed, including the creation of networks to share the scoring process and overcome the bottleneck in the assay which is the time-consuming microscopy.

The Latin American Biological Dosimetry Network (LBDNet) was created in 2007 in a framework of an IAEA regional project to strengthen emergency response in Latin America. The LBDNet was originally set up by established biological dosimetry laboratories from Argentina, Brazil, Chile, Cuba, Mexico, Peru and Uruguay, all of them involved in national emergency response systems [2]. Several countries in Latin America were interested in join the LBDNet activities.

These countries were invited to identify clinical or research cytogenetic laboratories with the purpose of collaborating with the LBDNet in case of a national radiation emergency response. Finally, Bolivia, Costa Rica, Paraguay, Ecuador and Venezuela identified such laboratories.

The specialist of these labs were experienced in clinical cytogenetic but had no previous experience with the DCA, particularly in the identification of dicentric chromosomes (DC). The background frequencies of DC is very low and consequently are not observed in the routine cases analyzed in a clinical cytogenetic laboratory. Additionally, it was known that Bolivia, Paraguay, Ecuador and Venezuela have problems in obtaining access to suitable radiation sources that would enable them to construct their own calibrations curves. In this context, it was proposed, and accepted by these four laboratories, to use the BioDoseNet (BIR) image repository as a DCA training tool. The identified labs designated two specialist for the training that was organized by a Cuban laboratory specialized in BD.

The BIR is a databank of around 25,000 images of metaphase cells captured from slides prepared for DCA after different radiation exposure conditions [3]. The DCA require qualified training staff for the identification of aberrations, essentially DC. The classical training is conducted directly on the microscope. Early in this decade was demonstrated that is also possible the identification of DC on electronically transmitted images. Several labs with images used in different intercomparison exercises created the BIR. The BIR was established on behalf of the WHO and is hosted on the server of BfS in Germany. The BIR include, in some modules, the information of experienced scorers and consequently is a helpful tool for the training of new biodosimetry service laboratories. [3]

2 Training plan

The training described here was focused exclusively on the scoring process. The training was planned in three phases, introduction to dicentric scoring, dose response curve construction and a dose assessment exercise. All the training activities and associated ideas were included in a small project. The project was agreed initially with the BIR coordinator, and further discussed with members of the WHO BioDoseNet Working Group experts 'Developing the image repository based training tool'. The training was a combination of lecture and class discussion conducted by a trainer during workshops and virtual activities performed by the participants during workshops or at home. Important support was obtained from the IAEA. Three workshops, supported by IAEA regional projects, were organized between November 2016 and October 2018.

All the training was preceded by the distribution of relevant technical documents i.e. papers describing the characteristic of the BIR [3], papers with detailed explanation of scoring method to be used during the training [4] and instructions on how to access the image repository. Each participant was requested to verify that they had achieved online connection to the web site containing the image repository using the same computers that they intended to use during the initial workshop of the training.

2.1 Introduction to dicentric scoring

The learning objective of this phase was the identification of the DC. This phase was implemented in a one week workshop. The first activities in a workshop were three introductory conferences focused on a) biological effect of radiation and cytogenetic dosimetry, b) dose response curve elaboration and c) technical details of the activities including in the training. The objective of the conferences was provide all theoretical aspect relevant for biological dosimetry and for the training.

Three modules of the repository were used in this phase. The MULTIBIODOSE picture book, the first and the second BioDoseNet trial exercise. The characteristic and origin of all modules are described in [3].

The MULTIBIODOSE "picture book" is a set of 46 reference images which was established to harmonize the scoring criteria. The module is designed essentially to show different qualities of images and to provide instructions about deciding whether a metaphase spread should be analyzed or rejected. The module contain a short introduction to dicentric scoring, including some examples of different qualities of images and instructions about deciding whether a metaphase spread should be analyzed or rejected. These images demonstrate with examples a good analyzable metaphase and defined criteria of morphology, chromosomes condensation, and centromeres identification, all critical elements for the identification of the DC. The module was analyzed with all the participants in a group discussion. The images were projected and the opinions of all participants were discussed and analyzed with a final scoring outcome provide by the lecturer. The purpose was to start the training with some 'harmonization' of the scoring and rejection criteria and learn about DC. The participants in the training were Clinical cytogenetics. These specialist are familiar with the analysis of small number of cells for constitutional chromosome anomalies, while in the DCA is necessary the analysis of hundreds of cells for the identification of rare random aberrations, mainly DC, that look different from the familiar translocations. Consequently a correct identification of DC was considering critical point in the training process. The identification of DC is essential for the elaboration of calibration curve that subsequently is used for the radiation dose estimation based on the presence of DC in the exposed to radiation person.

The second module of the BIR i.e. the first BioDoseNet trial exercise was used next. The 20 images of this module are presented in the image repository twice. Initially, the images are presented alone and then again together with the scoring results from experienced laboratories. This allows new scorers to analyze the images unbiased and then compare their performance with the consensus opinion from expert scorers. The module was analyzed by each country organized as a team. Each team was requested to analyze the images and report the result back to the coordinator. After this initial scoring the results of each team was compared with the repository data. Each team was invited to explain the arguments used for dicentric identification and this also included metaphase acceptance and rejection criteria.
All the discordant images, i.e. those where the aberration analyses differed between the participants and/or with the repository were detailed analyzed in a group discussion.

The third module of the BIR i.e. the second BioDoseNet trial exercise was used next. The 50 cells included in this module are presented as a gallery together with a scoring sheet, which offers feedback on each cell. Furthermore, statistical tests are included, which enable the scorer to immediately compare their observed dicentric yield with the average of the 20 scorers.

This was the first test to evaluate the teams' performance. Each team was requested to score the 50 images of the module and to report back to the coordinator the number of dicentrics observed and their intercellular distribution. During the workshop, image by image comparison between all teams was organized. The outcome was analyzed by the coordinator and discussed with all participants. The statistical comparison with repository results, using the tool provided in the repository, was performed. Only one unsatisfactory result according to the statistical test used was obtained, the reasons were discussed during the exercise debate.

After this exercise was considered that the labs are ready for the independent work at home and schedule for the analysis of images for elaboration of dose response curve was agree.

2.2 Dose response curve construction

The MULTIBIODOSE module 'A dose response calibration curve and nine blinded samples' was used in this and the next phase of the training.

The module contain more than 23 000 high resolution images of metaphase spreads , and nine dose pint , for dose response calibration curve construction. The module was presented to the participants during the first workshop after the introduction to the dicentric scoring was completed. The participants received a detailed instruction for the analysis of the module and for the results presentation. A timetable of 6 months was agree for the analysis of all the images. The results were send to the coordinator for compilation and statistical analysis. The planed results of this phase was a ready to use calibration curve in each country. But this results was not archived after this initial attempt, essentially because only two labs were able to produce the expected linear quadratic dose response calibration curve. The coordinator identified the reason, not all DC were correctly identified by the other two labs, consequently was necessary to organize the joint analysis of discordant images by the difference in dicentric scoring. A collaborative learning was organized. The four labs were divided in two teams. The team's composition was one lab with expected results and one lab without expected results. The teams' objective was to discuss those images where there was not complete agreement and to reach a consensus view. The discussion was planned for the second one week workshop. However, discussion was not completed for all images during the workshop so that the scoring was finalized at home by each team using virtual tools. The new data were sent back to the coordinator for new statistical evaluation. The results of this second evaluation of the module were considered satisfactory by the coordinators, and consequently the data were used for the fitting of a definitive dose response curve to be used for the dose assessment exercise.

This phase of the training was considering essential to evaluate whether relatively inexperienced laboratories can generate the classical dose effect curve but at the same time was considering as a check point for training evaluation. This part of the exercise was essential to warranty that the participants were ready to move to the next and final phase of the training
i.e. the dose assessment exercise.

2.3 Dose assessment exercise

The MULTIBIODOSE module 'A dose response calibration curve and nine blinded samples' was used again in this phase of the training. The expected output of this phase was a satisfactory estimation of dose using the calibration curves previously obtained by the labs. The participants were instructed to analyses 6 galleries of images at home. Five months were assigned for this evaluation. These galleries contain blind samples of simulated acute whole body (0.5, 2.0 and 4.0 Gy) and partial body irradiation body (2.0, 4.0 and 6.0 Gy to 50% of the blood). In this exercise was used the typical scoring approach when a suspected over exposition is analyzed i.e. the scoring of 500 cells or to stop at 100 dicentrics in each simulation. Results were sent to the coordinator for compilation and statistical evaluation. The results obtained by the labs in the dose assessment exercise were classified as satisfactory according to the procedures used for intercomparison exercise evaluation. Moreover, it should be stressed that had the images analyzed during this hypothetical exercise been cells from real irradiated persons the dose estimates from all labs were sufficiently accurate to allow the correct medical classification for treatment and would not have misled the clinicians.

3 Conclusions

The BIR offers a suitable set of options for training, starting with modules already analyzed by qualified scorers and finishing with modules only partially analyzed previously. The results of this exercise demonstrate the utility of the BIR as a training tool for the DCA. The training was arduous, thousands of cells were analyzing according to the schedule established by consensus by the participants with a regular follow-up by the coordinator. The first workshop was organized in November 2016 and the final results were analyzing in October 2018. During all this time, the laboratories had to generate the training data alongside their regular clinical cytogenetics services.

The training provided an opportunity for four cytogenetic laboratories in different countries, previously inexperienced in biodosimetry, and with problems in getting access to suitable national radiation sources to gain familiarity with the DCA. The criteria for cell selection/rejection and for dicentric scoring were discussed in detail on a cell-by-cell basis facilitating the learning process and contributing to consensus. The labs were able to generate data for producing a dose response curve for themselves and then using it to estimate successfully doses and irradiated fraction in blind samples similar to many intercomparison exercises performed by recognized laboratories. Some modules of the very extensive repository were fully analyzed for the first time during this exercise; consequently, the results provided in the exercise may be useful for those interesting in use BIR as a training tool. The exercise also confirms the utility of web based scoring for the DCA community. More specific technical details and experimental result can be obtained at [5].

Acknowledgement

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A NEW ATTRACTIVE CURRICULUM MODEL FOR ATTRACTING PHYSICS STUDENTS TO RADIATION PROTECTION AND MEDICAL PHYSICS

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In Malta the Radiation Protection and Medical Physics professions faced a shortage of entrants to the professions owing to the low popularity of two year masters programmes and the irregular number of physics/engineering graduates. A formula needed to be found to (a) address the paradox of having to reduce the masters programme to one year at a time when the knowledge-skills-competences required for modern practice are expanding (b) ensure that the potential stock of entrants to the professions would be independent of erratic student numbers in physics/engineering. The best way forward was to opt for a pre-Masters undergraduate Bachelor's programme that combined Physics, Medical Physics and Radiation Protection. This innovative curricular experiment has been a great success and has provided a welcome boost for both professions.

1 Introduction

In Malta the Radiation Protection and Medical Physics professions faced an acute shortage of entrants to the professions owing to the low popularity of two year masters programmes and the irregular number of physics/engineering graduates. Under such conditions of uncertainty the two professions would not only fail to grow but inevitably decline, leaving patients, workers and the public without the radiation protection and medical physics services required by EU directive 2013/59/EURATOM. A formula needed to be found to: (a) address the paradox of having to reduce the masters programme to one year at a time when the knowledge-skills-competences required for modern radiation protection and medical physics practice are expanding rapidly owing to the increasing complexity of medical device technology, (b) ensure that the potential stock of entrants to the profession would be independent of erratic student numbers in physics/engineering.

2 Methodology

A comprehensive survey of taught Medical Physics and Radiation Protection university Masters programmes was carried out. We also surveyed undergraduate physics courses which included components of Medical Physics and Radiation Protection. All relevant documentation concerning learning outcomes and qualification frameworks for clinical Medical Physics and Radiation Protection was meticulously scrutinised. The most significant documents were the 'European Guidelines on the Medical Physics Expert' and the 'European Federation of Organizations for Medical Physics Policy Statement 12.1 Recommendations on medical physics education and training in Europe' for Medical Physicists and the ENETRAP III document 'European Guidance on the Implementation of the Requirements of the Euratom BSS with respect to the Radiation Protection Expert and the Radiation Protection Office' and the IRPA 'Guidance on Certification of a Radiation Protection Expert' for Radiation Protection Experts [1 – 4]. Recommended qualification frameworks, learning outcomes and elements of good practice were identified, inventoried and applied in the design of the programme.

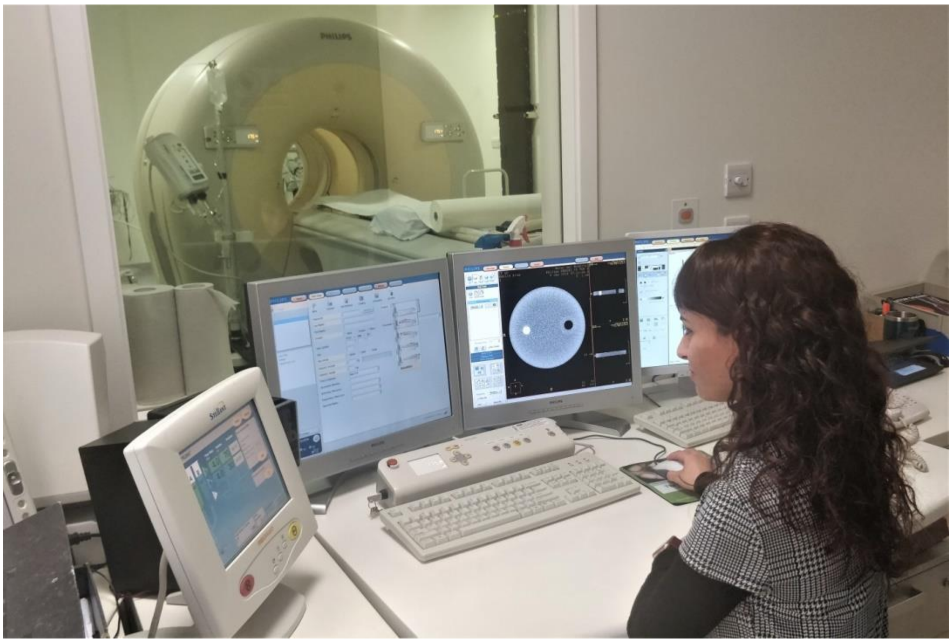

Figure 1. Demonstrations of measurements on a PET/CT scanner during hospital placements

3 Results

3.1 General structure of the programme

Since Malta has a relatively small population it was not deemed feasible to have separate undergraduate programmes for Medical Physics and Radiation Protection. In addition since EFOMP, ENETRAP and IRPA all rightly insist that students should have a good background in physics and mathematics it was decided that the best way forward would be to opt for an undergraduate inter-faculty programme that combined Physics, Medical Physics and Radiation Protection. The resulting four year programme consists of 5 parallel strands namely physics/mathematics/statistics, radiation-protection/medical-physics, basic-medical-sciences, research/ethics/legislation/professional-issues and hospital placements (see Table 1, the number of asterisks indicates the weighting of the strand in that particular year). The first two strands are the major components. The basic medical sciences were included because Medical Physics is considered a healthcare profession in many countries and it was important that students have a good foundation in these subjects. Hence, in addition to study units in Physics, Medical Physics and Radiation Protection the programme includes also study units in anatomy, physiology and pathology. Research methods include not only physics research methods but also methods used in healthcare research and health research ethics. Students join classes with regular undergraduate physics students for the physics study units and classes with regular healthcare professional students such as physiotherapy, radiography and medical laboratory technologists for anatomy, physiology, pathology and healthcare ethics classes. This arrangement ensures that we produce students that are comfortable with both scientific and healthcare professional perspectives. An overview of the programme can be found here:
https://www.um.edu.mt/courses/overview/UBSCHPMRFT-2020-1-O

Table 1: The five parallel strand of the curriculum

Year	Physics Mathematics Statistics	Anatomy Physiology Pathology	Medical Physics & Radiation Protection	Hospital Placement	Research Ethics Legislation Professional Issues
Year 4	**		*****	*	***
Year 3	***	*	****	*	*
Year 2	****	**	**	*	*
Year 1	****	****	*		*

3.2 Detailed curriculum

The full curriculum by year and semester is given below. Curriculum details including a description of each study unit (including learning outcomes, assessment mode and reading list) can be found here: https://www.um.edu.mt/courses/programme/UBSCHPMRFT-2020-1-O

YEAR ONE

Year (This/these unit/s start/s in Semester 1 and continue/s in Semester 2)

MPH1002	Fundam of Medical Physics & Radiation Protection & Safety Culture	4 ECTS
PHY1105	Fundamentals of Experimental Physics	4 ECTS
PHY1197	Introduction to Classical Mechanics and Waves	6 ECTS
SOR1201	Probability, Sampling and Estimation	4 ECTS
Semester 1		
ANA1500	General Anatomy 1	2 ECTS
ANA1503	Regional Anatomy: Thorax	2 ECTS
ANA1507	Regional Anatomy: Abdomen and Pelvis	4 ECTS
PHB1101	Body Fluids, Cells, Cardiovascular and Respiratory Physiology	4 ECTS
PHY1125	Mathematics for Physicists 1	4 ECTS
PHY1135	Introduction to Computational Physics	6 ECTS
Semester 2		
ANA1508	Regional Anatomy: Neuroanatomy (including Dissection)	4 ECTS
HSC1003	An Introduction to Research Methods in the Health Sciences	2 ECTS
PHB1102	Renal Physiology and Haematology	4 ECTS
PHY1145	Electricity and Magnetism and Optics	6 ECTS
PHY1193	Thermodynamics and Kinetic Theory	4 ECTS

YEAR TWO

Year (This/these unit/s start/s in Semester 1 and continue/s in Semester 2)

IHC2012	Ethics for Health Professions and Ethical Dilemmas	4 ECTS
MPH2002	Applications Software and Programming for Med Phys & Rad Protect	4 ECTS
MPH2003	Medical Physics and Radiation Protection Placement 1	5 ECTS
PHY2230	Experimental Physics	4 ECTS
Semester 1		
MPH2001	Medical Radiation Physics and Biology	3 ECTS
PAT2121	Pathology	4 ECTS
PHB2101	Gastrointestinal and the Endocrine System	4 ECTS
PHY2195	Classical and Relativistic Mechanics	6 ECTS
PHY2210	Mathematics for Physicists 2	4 ECTS

Semester 2

ANA2509	Regional Anatomy: Head, Neck and Vertebral Column	4 ECTS
LIN1063	Academic Reading and Writing in English	2 ECTS
PHB2015	Neurophysiology	2 ECTS
PHY2140	Quantum Mechanics	6 ECTS
PHY2145	Electromagnetism	4 ECTS
PHY3110	Physical Optics	4 ECTS

YEAR THREE

Year (This/these unit/s start/s in Semester 1 and continue/s in Semester 2)

ANA3224	Sectional Anatomy 2	2 ECTS
MED3100	Medicine	4 ECTS
MPH3003	Core Medical Physics and Radiation Protection	5 ECTS
MPH3007	Medical Physics and Radiation Protection Placement 2	5 ECTS
PHY3111	Advanced Experimental Physics	6 ECTS
PHY3145	Statistical Mechanics	5 ECTS
SCE3021	Biomedical Signal and Image Processing for Medical Physics	6 ECTS

Semester 1

ANA3223	Sectional Anatomy 1	2 ECTS
CPH2402	Pharmacology for Allied Health Care Professionals	4 ECTS
HSC3002	Research Methods in the Health Sciences	2 ECTS
PHY3130	Atomic Physics	4 ECTS
PHY3225	Fluid Mechanics	4 ECTS

Semester 2

PHY3155	Solid State Physics	5 ECTS
MPH3004	Professional Issues in Medical Physics and Radiation Protection	2 ECTS
MPH3005	Monte Carlo Methods for Medical Physics and Radiation Protection	2 ECTS
MPH3006	European and National Legislation and Roles in Medical Physics and Radiation Protection	2 ECTS

YEAR FOUR

Year

MPH3013	Special Project: Medical Physics and/or Radiation Protection	10 ECTS
MPH3014	Medical Physics and Radiation Protection Placement 3	5 ECTS
PHY3208*	Short Review Paper and Philosophy of Science	6 ECTS
PHY3232	Nuclear and Particle Physics	6 ECTS
PHY3277	Bioelectromagnetism	4 ECTS

Semester 1

HSM3001	Introduction to Health Service Management	4 ECTS
MPH3008	Medical Physics and Radiation Protection in Diagnostic and Interventional Radiology and Dentistry (Minor)	5 ECTS
MPH3009	Medical Physics and Radiation Protection in Nuclear Medicine and Radioisotope Cyclotron Facilities (Minor)	5 ECTS
MPH3010	Medical Physics and Radiation Protection in Radiation Oncology (Minor)	5 ECTS
MPH3011	Emerging Areas of Medical Physics and Radiation Protection	5 ECTS
MPH3012	Environmental and Industrial Radiation Protection	5 ECTS

*Students are required to choose topics linked to MPH3013.

3.3 Pre-programme preparatory summer school in the medical sciences

The entry requirements for the programme are the same as all other physics programmes of the university i.e., physics and mathematics. Hence, whilst healthcare professional students would have a pre-university background in biology (biology is a requirement to enter the bachelor programme of these professions) our students do not - putting them at a relative disadvantage. To address the concerns of our students, it was imperative to set up a pre-bachelor summer school in anatomy and physiology specifically dedicated to our students. We studied the curriculum of pre-university biology and elicited the sections on human biology (we omitted plant, animal and environmental biology). We also identified the main text-book used by undergraduate non-medical healthcare professionals such as radiographers, nurses, physiotherapists in our university (although resources for these subjects are very common and freely available on the internet). Since we envisaged that the first year will be the hardest for our students we focused extra attention on those aspects of anatomy and physiology that students would be important in the first year of the Bachelor's programme.

The topics addressed during the summer school are the following:
An orientation to the human body
Basic chemistry and biochemistry
Cells and Tissues
Skin and body membranes
The skeletal system
The nervous system
Blood
The cardiovascular system
The respiratory system
The digestive system (including food metabolism)
The urinary system

During the lectures we constantly referred to the importance of the above topics in Medical Physics and Radiation Protection e.g., which tissues/organs are the most radiosensitive, which organs are organs at risk in radiotherapy planning.

4 Discussion

This innovative curricular experiment has been a great success. The combination of pure and applied physics, the inter-faculty nature of the programme (where students share lectures with both physics and healthcare professions students) together with the element of clinical practice have been found to be the most attractive features. We are pleased to report that the summer school has also been an unprecedented success. Indeed the summer school itself has bolstered student enrolment for the bachelor programme. It has indeed been surprising with what enthusiasm physics and mathematics students have taken anatomy and physiology on board. We are also very much pleased to report that the examination results in these two subjects of our students have been totally at par with those of students from the other healthcare professions. The BSc(Hons) Physics, Medical Physics and Radiation Protection programme has provided a welcome boost for both Radiation Protection and Medical Physics in our country.


Figure 2. Demonstration of quality control of a radiotherapy linac during hospital placements

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DESIGN AND USE OF TOOLS FOR E&T IN MEDICINE WITH IONIZING RADIATIONS AND RELATED TRANSPORT OPERATIONS OF RADIOACTIVE MATERIAL

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The objective of this study is to design and use two tools for E&T on risk analysis, for the staff from medicine with ionizing radiations and from related transport operations of radioactive material. The first one is an informative compendium made in html with Macromedia Dreamweaver 8, with 427 components. The second one is an international incident database belonging to an incident learning system for these practices with more than 1660 records until November 2019 and 1490 of these are matching to medicine. About 30 years of published events and near misses is covering from more than 16 countries mainly Australia, the United States of America, United Kingdom and France. In addition, there were adapted the European ENER/D4/160-2011 ACCIRAD project recommendations on training for risk management as a complement of these tools.

1 Introduction

The education and training (E&T) on risk analysis is a basic process of the cycle for the continuous improvement of quality and safety. In the other hand, the safety assessment and risk analysis in practices with ionizing radiations is a regulatory requirement in Cuba.
As an answer of the Bon Call for action and in the framework of the Cuban project on strengthening of quality management in medicine, these identified the creation of two tools for E&T of staff. Furthermore, taking into account the incidence of the transport of radioactive material in the input and output of the studied processes, this purpose included operations for the consignor, carrier and consignee.
The goal of this study is to design and use in seven Cuban organizations of an informative compendium on risk management and an international incident database (IDB) inside an incident learning system (IL) with an integrated use of methods for risk analysis as tools for E&T in cited practices.

2 Materials and methods

For collecting updated information on management of risk a wide research made by INTERNET from specialized sites as International Atomic Energy Agency (IAEA) web site and international events like Latin-American congresses of the International Radiation Protection Association (IRPA). [1-9]
The first tool is an informative compendium made with Macromedia Dreamweaver 8 in format html. This structured in two access menus. The main and secondary menus cover components that are in Table 1.

Table 1: Structure of the informative compendium with two access menus

Main menu	Secondary menu
Terminology	Bibliography
Processes	References
Methodologies	--
Tools	

The bibliography included six practices with ionizing radiations as radiotherapy, radiosurgery, brachytherapy, nuclear medicine (NM), radiopharmaceuticals production and clinical laboratories. Moreover, this considered supplementary publications on quality management and adverse effects.

The references envisage documents on external context for nuclear medicine, IAEA publications, from Cuban regulatory bodies as the National Centre for Nuclear Safety (CNSN) and the Regulatory Authority for Medicines, Equipment and Medical Devices (CECMED) and from the International Standard Organization (ISO) and those standards adjusted by Cuba (NC ISO). World Health Organization (WHO) publications are also incorporated. In addition, considered methodologies for risk analysis are risk matrix (RM), failures and modes effects analysis (FMEA), ILS and the integrated approach with their combined use.

Creation of an IDB with information from articles and published reports is mainly from Australia (ARIR [10]), the United States of America [11], United Kingdom and France. The first case is for nuclear medicines and the rest is for transport.

The adopted structure for IDB is similar to SAFRON [12]. This includes around 30 years of published events and near misses. For the last case it was used an adapted Nyflot´s level scale [13]. In addition, there are a standard list of root causes and adapted SAFRON´s severity scale. [12] Acquired information take into account some experiences from ROSIS [14].

Before adaptation made of FMEA scale from the publication TG-100 of the American Association of Physicists in Medicine (AAPM) for patients, workers and public according to radionuclide therapy and transport, respectively. [15]

In all cases, an expert group integrated by seven safety specialists and medical physicist from the Cuban organizations, determined root causes for each defence from risk matrix (barrier, reducers of frequency and reducers of consequences). A wide applied standardized list of root causes includes other influence areas in the human behaviour and patient’s factors. [16]

The main recorded root causes in the ILS determined with the Cuban code SECURE MR-FMEA version 3.0, which developed in the Higher Institute of Advanced Technologies and Sciences (INSTEC) [17]. In addition, synergy RM-ILS delivers initiating events matching with records and allows validation of model of process.

For ongoing learning procured the results of European project for radiotherapy and adapted them to Cuban context and other practices. [18]

The E&T activities for staff from seven Cuban organizations took place with these tools in order to uptake the risk analysis methodology with the showing holistic approach. [19]

3 Results and discussion

A picture of the home web page for the informative compendium displays in Fig 1. This made in Spanish but for this paper translated to English. In spite of this applied for nuclear medicine services, also it is useful for all organizations using ionizing radiations.

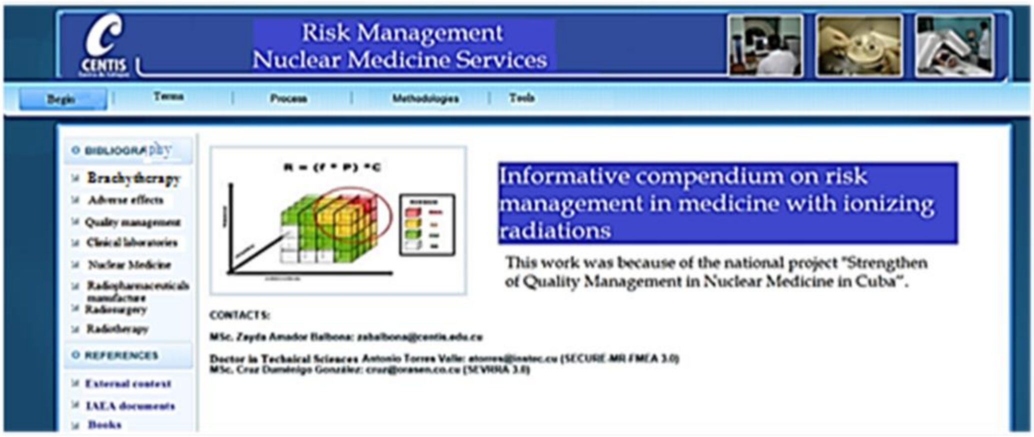

Figure 1. View of home web page for the informative compendium on risk management

There are 427 materials, SEVRRA instructions, a SECURE-MR-FMEA brochure and a video on the last, covered in the compendium as showing in Fig 2.

The quantity of materials from bibliography and references is in Fig 3. It highlights the highest figure belongs to incident learning.

The created IDB has more than 1660 records until November 2019 and 1490 of these are matching to medicine with ionizing radiations. There is highest number of records for radiotherapy as can be seen in Fig 4.

In the other hand, there are included more events for the transport of unsealed radioactive sources than sealed radioactive sources because they have more often operations (Fig 5). In total, they are 170 events.

Event behaviour by year is in Fig 6 for nuclear medicine and by country in Fig 7 for transport of radioactive material. For the first are reports from 12 countries and IAEA. In the last case if, sealed sources included, are 16 countries in the IDB.

Five nuclear medicine services and two carriers were in the application of holistic approach for risk analysis using this tool and stablishing synergies FMEA-ILS and RM-ILS.

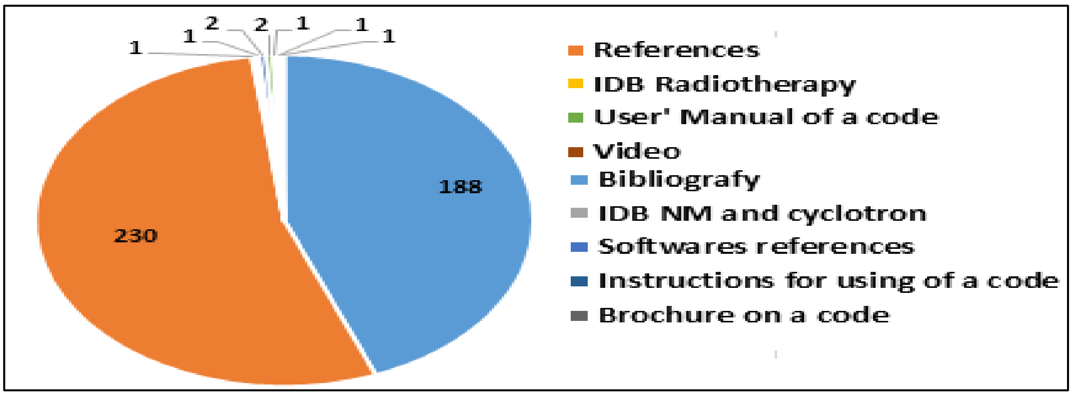

Figure 2. Amount of materials included in the informative compendium on risk management

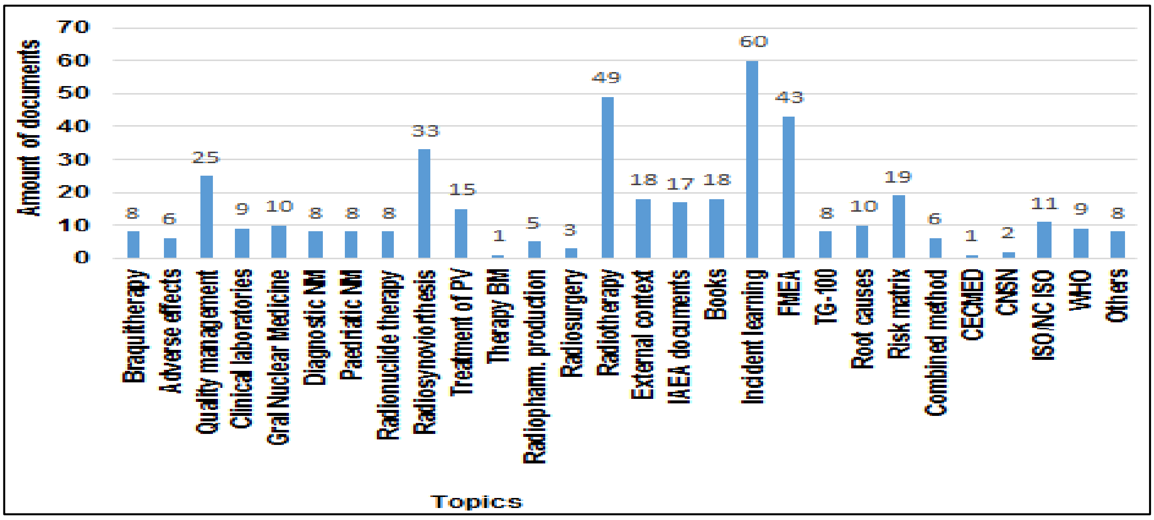

Figure 3. Amount of materials like bibliography and references included in the informative compendium on risk management

The synergy FMEA-ILS focused in root causes of radionuclide therapy delivers the main contributors displayed in Fig 8 for the studied case with worst safety culture because risk matrix methods delivers more accidental sequences with high level versus total of these. It highlights the lacking or inadequate development skills and knowledge is the most important root cause and this highlight the basic role of E&T activities in the operations with ionizing radiations.

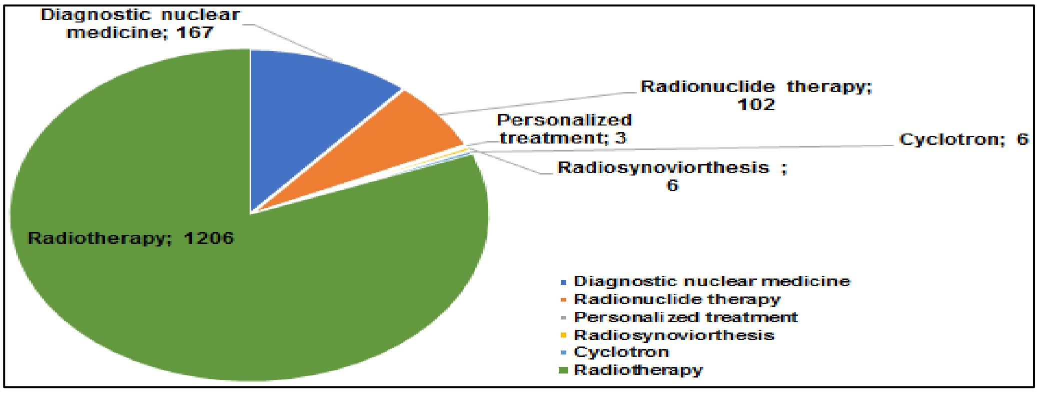

Figure 4. Amount of records in the IDB from medical practices

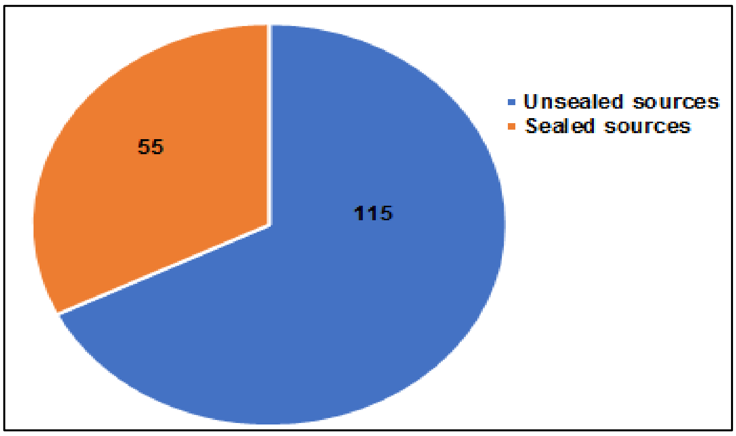

Figure 5. Amount of records in the IDB from transport of radioactive sources

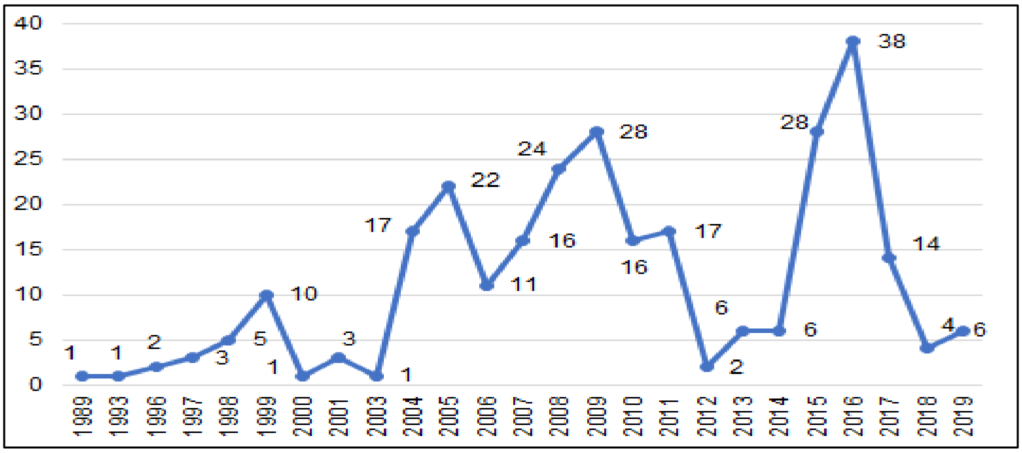

Figure 6. Amount of radiological event by year in the international incident database for nuclear medicine until November 2019

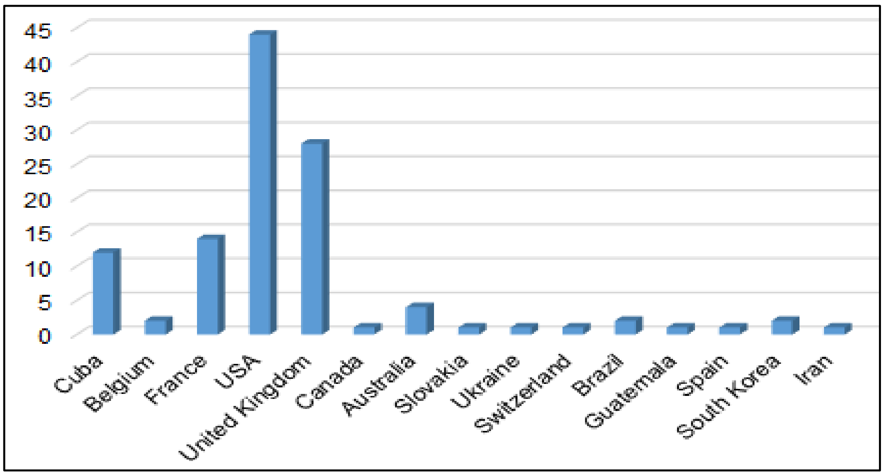

Figure 7. Amount of radiological event by country in the international incident database for transport of unsealed sources until November 2019

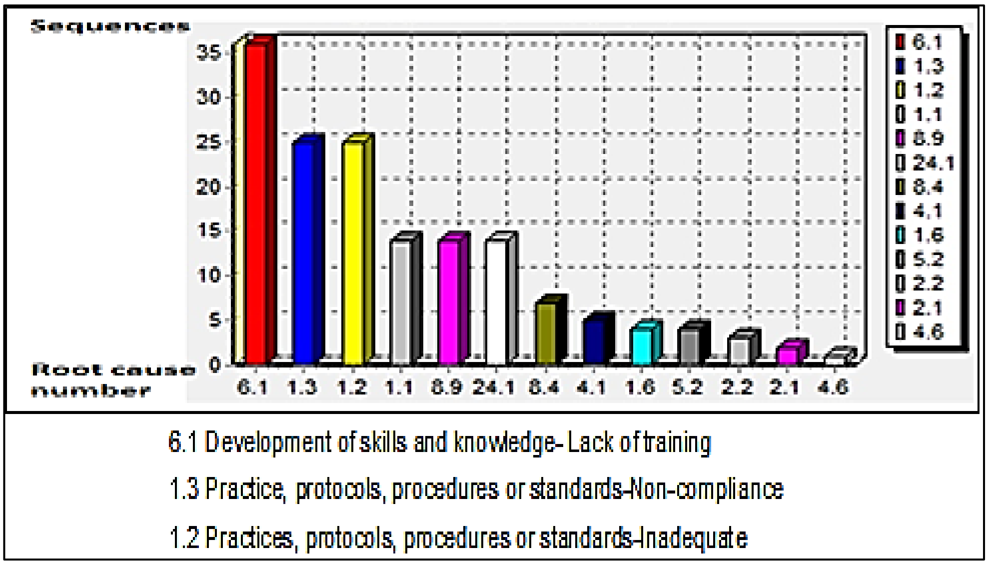

Figure 8. Histogram of root causes recorded in ILS for radionuclide therapy in the studied case of worst safety culture (from synergy FMEA-ILS)

The non-compliance of practices, procedures or standards prevails as the main root cause in the transport of unsealed sources. This behaviour displays in Fig 9 and it is a result of the other mirrored causes. The adding new corrective or preventive actions for these, together with defences incorporated from obtaining residual risk, are a complement for this analysis. In the other hand, these represents a meaningful tool for decision makers and follow-up implementation of them is required.
This study also includes operations related transport by road of disused sealed sources and radioactive wastes.
Synergy of RM-ILS provides the initiating events (IE) with better matching from IDB and this is in Fig 10 for both cases of transportations. This highlights the validation of each model in risk matrix and the importance to attend this kind of events and reinforce their defences in these organizations.

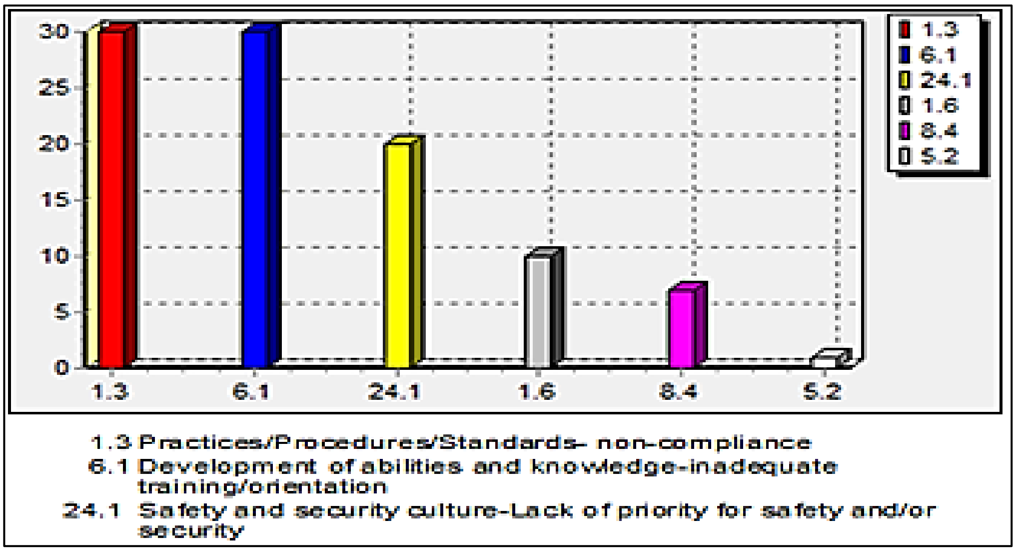

Figure 9. Histograms root causes recorded in ILS for carrier of unsealed sources

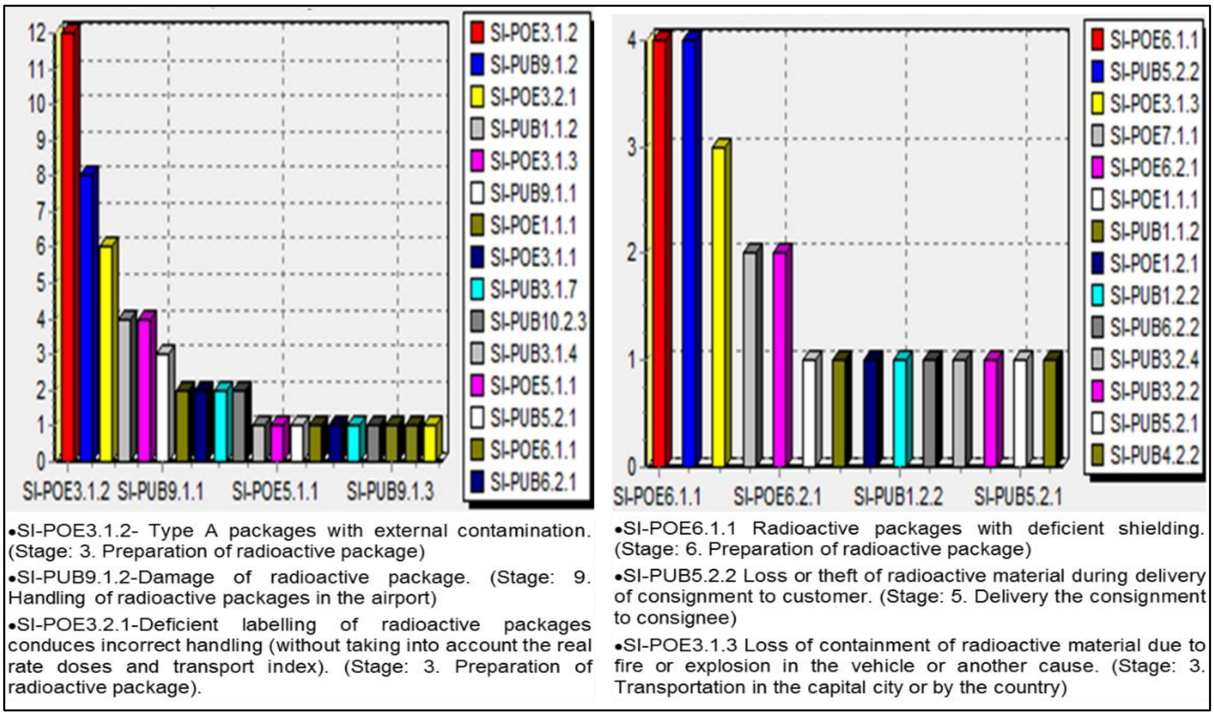

Figure 10. Histograms of the initiating events (IE) with better matching from synergy RM-ILS for carrier of unsealed sources (left side) and carrier for disused sealed sources and radioactive wastes (right side)

The recommendations to organizations and regulatory bodies from the European project for radiotherapy bring that there is three types of training needed for risk management, including risk assessment and analysis and reporting of events. [18] These comprise management staff, risk managers and a multidisciplinary working group. Their adaptation to Cuba aimed to building the reporting culture in organizations and these are:

1. Use ILS with developed IDB in the E&T activities.
2. Create an own incident database and use it with that ILS.
3. Create conditions for reporting by own network in anonymised way with access to all staff in organization with respective measures for security of information.
4. Make often meeting for lessons learned and collective approval of corrective and preventive actions.
5. Encourage award for near misses or event reporting, but firstly make E&T activities with staff. After reporting include the measures prevented the near miss escalation in procedures or instructions.
6. Training leaders and selected one of them as the responsible for updating the IDB.
7. Encourage internal auditory develop and the follow-up of nonconformities.
8. Assess the closing of the nonconformities in a collective way.
9. Develop and maintain a collective working environment and the continuous improvement of service performance with encourage ward for good practices and reporting.
10. Keep informed from patients´ opinions and points of view in all possible ways. Define a proactive communication strategy, particularly when there are adverse consequences for a cohort of patients or serious adverse effects to one patient. Work the strategy to inform the public in collaboration with the authorities.

For regulatory bodies there are recommendations on seven areas as updated regulations, methodology for quality and risk management, dissemination of information on risk management, training in risk management and safety culture, informing patients and the public to increase trust in the health care system, clinical audit and regulatory inspections. [20]

Developed tools for E&T on risk analysis allow building safety culture in related organizations with this study since they could improvement safety and quality management in an effective way for making decisions. Nevertheless, this requires more E&T activities within these organizations and in a permanent way for the continuous cycle of upgrading. It is necessary to cover all staff related with ionizing radiations in dependence on their functions. Besides, the internal quality documentation and staff training programmes should include the results of proactive risk assessment and reactive analysis of events as a holistic approach.

4 Conclusions

As an answer of the Bon Call for action and the Cuban project on strengthening of quality management in medicine with ionizing radiations, two tools for E&T on risk analysis are available with this study. These are an informative compendium in html format and an IDB, applied with a holistic approach of combined use of proactive and reactive methods in seven Cuban organizations, included two main carriers. Results deliver an effective way for improvement safety culture and making decisions for continuous enhance of safety and quality management.

The recommendations provided here, aimed at upgrading reporting culture in organizations promoting the harmonisation of risk management systems included the regulatory bodies and complementing the learning developed tools.

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MEDICAL PHYSICS AND RADIATION PROTECTION SKILLS TRAINING THROUGH UNDERGRADUATE FINAL DEGREE THESIS

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The Final Degree Thesis represents the last stage of undergraduate students training. The students from Biomedical Engineering, taught in the Technical School of Industrial Engineers of the Universitat Politècnica de València, can develop their projects related with medical physics and radiation protection, in collaboration with the Hospital Universitari i Politècnic La Fe of València. These projects involve geometry modelling of different medical devices and Monte Carlo simulation for several clinical treatments, solving real problems of the radio physical department. Online didactic methodologies have recently been applied to carry out these works during the pandemic situation. These kinds of final degree thesis help the students to know how to work in multidisciplinary teams reproducing real contexts which turn into good results in their project evaluation.

1 Introduction

Spain was one of the 29 European countries signing the Bologna Declaration on June 19, 1999. Since then, Spain has actively participated in the successive Ministerial Conferences, adopting the corresponding Ministerial Communiqués and launching the European Higher Education Area.
In 2010, degree structure was adopted: Degree, master and doctorate. This structure consists of four courses for the 1st cycle degree (240 ECTS), a 2nd cycle or Master level with a duration from 1 to 2 courses (60 to 120 ECTS) and a 3rd cycle, the Doctorate level of advanced training in research, equivalent to 600 hours of effective research, not measured in ECTS.
Engineering degree studies offer general training oriented to the performance of engineering professions and include three subject types:

- Basic subjects: they are mandatory and are linked to the different branches of knowledge in which degree teachings are organized. A minimum of 60 basic subject credits must be completed in each degree.
- Compulsory subjects: subjects with specific content of the degree that must be taken by all students.
- Optional subjects: these are subjects that the student choose from the proposals for the degree, based on their academic or professional interests.

In addition, the curriculum of a university degree necessarily culminates with the elaboration of the **Final Degree Thesis (FDT),** corresponding of 12 ECTS (300-360 effective hours of student work).
The FDT represents the last stage of graduate training, and it must be an autonomous student activity with the support of one or more tutors. Finally, the individual student work, is defended in court.
Biomedical Engineering is a recent degree (it **began in 2015**) of the Universitat Politècnica de València, UPV (internationally certified with the EUR-ACE quality label) that applies engineering principles and methods to the solution of problems in biology and medicine, and to the improvement of prevention, diagnosis, treatment and rehabilitation methods.

It is an area in continuous growth with great demand for professionals capable of integrating into interdisciplinary teams to take on new challenges in the improvement of healthcare technology.
The Degree in Biomedical Engineering of the UPV trains students in technologies such as biomechanics, biomaterials, bioelectronics, biomedical instrumentation, signal processing, telemedicine, biotechnology or clinical engineering and management among others.
The Chemical and Nuclear Engineering Department participates in this degree teaching two compulsory subjects:
Radiotherapy and Radiation Protection: This subject aims to introduce the student in the field of radiological protection with special interest in the radiotherapy techniques currently used in the hospital field.
Biomedical Imaging Techniques: This course is focused on the student's knowledge of medical imaging techniques: radiography, mammography, Computer Tomography, Nuclear Magnetic Resonance and Ultrasound.

Many of the students who go through these subjects have an interest in doing their FDT at the Institute for Industrial, Radiophysical and Environmental Safety (ISIRYM) research group in projects related to Monte Carlo (MC) simulations in real medical applications.

As a training activity, FDTs offered by the ISIRYM, intends the student to carry out, actively, applied and joint work, preferably multidisciplinary tasks, equal to or similar to engineering work in the exercise of the biomedical profession. To that, the projects undergone are normally based on using particle transport Monte Carlo simulations in clinical cases solving real problems in different medical techniques currently used in the hospital setting, introducing the students into the field of particle physics transport, simulations, experimental set up and dose calculations. When doing this kind of projects, the students reinforce the knowledge of particle physics, dosimetric system, dose calculation, radiation detection, general nuclear regulations and the specific clinical field explained in the cited previous subjects.

2 Monte Carlo simulation applied to medical projects

Monte Carlo methods are statistically based methods that can be used to solve radiation transport problems by random sampling. These techniques are widely used to solve complex physical problems providing accurate and detailed results on radiation transport through matter, reproducing real situations. The Monte Carlo simulation codes are designed to track many particle types over broad ranges of energies, which can be used for several areas of application, including medical physics. In this field, Monte Carlo simulations are used to simulate the transport and interaction of the particles with medical treatment devices, patients or phantoms. Dosimetric applications in medical field span from external beam radiotherapeutic planning, teletherapy and braquitherapy treatments, to the radiation dose distribution assessment in patients or medical facilities for radiation protection.

The projects offered for the FDTs are focused on the techniques used in these kinds of treatments, as well as on the nuclear medicine techniques and equipment used to support radiation therapy. There are some projects also centered in Nuclear Medicine images (Gammagraphy, SPECT, PET), Nuclear Magnetic Resonance images (principles, image production and reconstruction, sequences, image characteristics and artifacts), and other imaging techniques in medical field. All of these works involve simulations using MC codes.

Because of Monte Carlo methods provide detailed and accurate results of the simulated problem, the students can reproduce a wide set of medical environments and validate their results with data provided by the hospitals. With these projects, the students learn to use a powerful tool that allows medical physicists and physicians to obtain accurate results for calculus necessaries for their clinical practice, including radiation protection.

1.1 Monte Carlo techniques and MCNP6 code

Currently, exist different Monte Carlo code system packages as EGS [1], PENELOPE [2], MCNP [3] or GEANT IV [4]. The code used to perform the simulations of the FDTs explained in the ISIRYM, is MCNP6, (Monte Carlo N-Particle) versions 6.1 and 6.2, due to the wide experience of the teachers team using this code.

MCNP6 is a radiation transport code including photons, electrons and neutrons that allows the estimation of dosimetric magnitudes such as flux or energy deposited by unit mass, all of them normalized by the number of simulated histories. MCNP provides a wide variety of resource to configure a several type of sources, such as isotropic source, particle beam introducing their energy spectra and probabilities of emission, particle emission of a specific volume etc. This fact covers a wide set of medical problems that can be simulated using this code.

One of the interesting capabilities of MCNP6 is the possibility to embed a file containing the meshed geometry of the configuration system which can be easily created with Computer Assisted Design (CAD) program. To introduce the medical device or detector geometry into the MCNP6 simulation, the students model the system using the 3D Modeling Software for Engineering ANSYS SpaceClaim, and the solid model has been meshed with Abaqus/CAE [5]. Some examples of the modeled and meshed geometry are shown in Figure 1. The blueprints necessary to build these geometries, are provided by manufacturers of therapy units, as Varian, Elekta and Sordina, and manufacturers of dosimetry measurements devices as PTW, under confidential agreements.

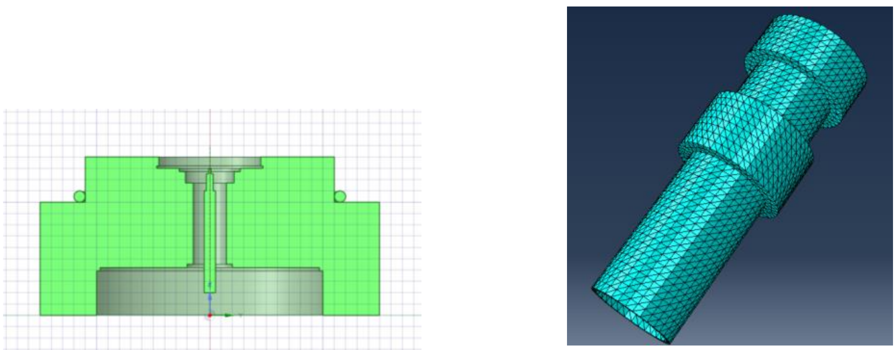

Figure 1. Geometry of ionization chamber modeled with SpaceClaim (left), and medical applicator for intraoperative treatments meshed with Abaqus (right).

The use of Monte Carlo techniques simulation codes has a high complexity associated which typically requires a great deal of experience, time, effort and deep knowledge in all the simulations parameters related with radiation physics and matter-radiation interaction. This learning is outside the subjects of the Biomedical degree, so in these FDTs, the students are introduced in a simple way to the use of simulations as a computational tool to develop their work. The relevant sections for the students to develop their works in the input file consists of a geometry description, including material definition, source configuration, tallies or results registration and definition of the physics parameters.

With this method, the students can understand the behavior of different particles beams and many medical devices using ionizing radiation, avoiding the need to know in detail all the capabilities offered by the code and thus, be able to focus on main interests of their work.

The knowledge of Monte Carlo techniques acquired during the development of their FDTs allow the students to use powerful computational tools to obtain accurate results that can be compared with experimental data.

1.2 Development of work in collaboration with hospitals

ISIRYM research group work in collaboration mainly with the Hospital Universitari i Politècnic La Fe of València, but also with other hospitals of the Comunitat Valenciana. This allows students develop their FDTs in a medical field increasing their knowledge in radiation treatment techniques currently used in the hospital setting and solving real problems of the hospital radiophysical department. In addition, the hospital provides experimental data to validate the results obtained by the students.

Performing the FDTs in collaboration of a hospital is an opportunity to introduce the students into the field of particle physics transport, simulations, experimental set up and dose calculations. Moreover, they can apply the knowledge acquired during the degree and their ability to solve problems in medical environments within broader contexts related to their field of study. Furthermore, this kind of FDT offers them the opportunity of having contact with the radiation-based machinery, hospital professionals, protocols and practices.

The FDT are focused to show the different cases in which these tools can be used in the field of medical physics: external radiotherapy, intraoperative radiotherapy, brachytherapy or dose measurements with different detectors. The projects proposed, are bounded to real clinical needs, therefore it means an additional motivation when carrying out the project development.

1.3 Titles of the projects developed

Since the implementation of the degree of Biomedical Engineering, different FDT projects related to Monte Carlo simulation have been tutored in the medical environment.

These kind of FDT projects radiation oriented biomedical engineering offer students an opportunity to gain real-world experience prior to graduation.

Some of biomedical engineering students are interested in research projects, and ISIRYM group prepares them beginning at a low level and working toward more intensive involvement in the radiation transport simulation activities. Such experiences are excellent preparation for future graduate study and are especially valuable for students planning to go on to the Master or PhD degrees. The following table lists some of FDT tutored in the last years.

Table 1: Titles of FDT projects developed in ISIRYM group.

Application field	Title of the work
Medical Imaging	• Study and validation of the spatial resolution of a digital gamma radiation detector type "Flat Panel" with a mixed Monte Carlo-Experimental methodology.
Radiotherapy	• Radiation therapy planning by using customized realistic patient models from CT imaging with unstructured mesh. • Development of a methodology for X-ray spectrum reconstruction of the flat positioning panel of a linear particle accelerator (LinAc) for radiation therapy.
Computed Tomography	• Calculation of organ dose estimation in CT using Monte Carlo simulations: Methodology and experimental validation.
Radiation protection	• Study of the generation of photoneutrons in the Berilium filter of a linear medical accelerator Clinac Varian with a beam of 6 MeV. • Study of the dose received by workers of the installations of a linear electron accelerator (LinAc) due to the contribution of photoneutrons and activation products. • Application of the Monte Carlo code for the study of the 3D distribution of neutrons in a radiotherapy and validation bunker with experimental measurements. • Monte Carlo Model of an industrial X-ray room shielded with Barium concrete for the study of the three-dimensional dose. • Radiological protection study against peripheral dose originated around a Linear Accelerator (LinAc) for intraoperative radiation therapy using Monte Carlo simulations. • Modeling of Varian TrueBeam LinAc geometry and dose calculations in a water phantom using Monte Carlo simulation, validating results with measured data.
Nuclear Medicine	• Study of radionuclide production in a cyclotron for Positron Emission Tomography (PET). • Three-dimensional dose calculation in CT/SPECT treatments with Internal Emitter Lu-177 using Monte Carlo techniques. • Monte Carlo simulations to estimate dose in risk organs of patients using Y-90 treatment for liver cancer.
Intraoperatory Radiotherapy	• Characterization of the calibration coefficients of an ionization chamber used in intraoperative radiation therapy by Monte Carlo simulation. • Flattering filter design for Intraoperative linear accelerator device

1.4 Skills acquired by the students

Science or technology FDT projects has both tangible and intangible components. The tangible components include the science as well as engineering design. The intangible components, often more important, include so-called “soft skills,” such as teamwork, practical experience, leadership, entrepreneurship, speaking, and writing—essentially a well-rounded background preparing the student for a wide variety of opportunities and challenges in life and career.

These FDT helps students in acquiring a variety of essential skills for Biomedical Sciences such as data and information handling, oral and written communication skills (including essay writing), experimental design, literature search techniques and appropriate use of referencing and citations in the biomedical sciences.

This kind of simulation projects, also help the students considering the role of biomedical sciences in the "real world". Through personal investigations, congress participation and a series of talks from medical professionals, students will be encouraged to consider the role of biomedical sciences in an applied context and gain a more global perspective of their discipline.

Moreover, this kind of FDT help the students exploring different Career Pathways, to reflect on their own career aspirations and to meet with professional scientists from diverse backgrounds.

All these gained skills, allows students working with real hospital projects in the field of medical technology, with the later possibility of taking on positions related to the assessment and management of health technology, and work in multidisciplinary environments.

3 Pandemic situation: online didactic methodologies

The COVID-19 was declared a global pandemic by the World Health Organization [6], on 11 March 2020, hence the some of FDTs projects developed in the academic courses 2019-2020 and 2020-2021 started before or during this pandemic period. As a consequence of the sanitary restrictions, the educational centers at all the stages were closed. This situation caused that universities worldwide, were constrained to carrying out their activity completely online, adopting this learning methodology as the only resource.

Although online teaching has been used in recent years in some activities, the pandemic caused, in the middle of the academic course, an abrupt change in the teaching of subjects that were programmed for face-to-face development. This also affected the FDTs that were started at that time and those that started later. Even today, meetings are still restricted due to the pandemic, so the teaching model continues to be hybrid. The experience of the teachers and their acquired knowledge related with online educational process, allow them to adapt to the new teaching conditions in a short time.

Moving to the virtual environment was particularly challenging for both university tutors and students, since all the face-to-face meetings and visits to the hospital were canceled. The challenge during all this time has been to ensure that the student's learning was useful, being able to develop the complete work, avoiding the obstacles in online learning, such as decreased motivation or delayed help or feedback while their learning process, despite of the sanitary circumstances. To ensure that this work can be performed online, the Microsoft Teams tool is used to track student’s work. The meetings are done using Teams frequently for several aspects. On the one hand, to do the meetings with the students and to answer their doubts.

On the other hand, this tool is used also to guide them during their autonomous work and to send the required information to proceed with their researches. For this purpose, the tutors provide them template input files to execute the simulation, leaving free only the parameters of interest in their problem. Using the input files template created for a general simulation, the students learn to modify it according to the needs of their cases, changing only the parameters of interests as energy source, beam spectrum or geometry file.

Moreover, to stablish contact with the hospital professionals, Teams tool is also used. However, when sanitary restrictions have been relaxed, some exceptional visits to hospitals are done to know the devices and make the necessary measurements.

When students finish their FDTs, they must defense it in front of a court for their evaluation. Until now, the presentations have been made in person at a public event, but since last year these defenses of the students are carrying out online too, using the same tool described. By this reason, the rehearsals of their defense are done also online. This is carried out in this way to reproduce the real situation and make the students feel comfortable at the time of the presentation in front of the court.

4 Conclusions

This work emphasizes the benefits for students of develop their FDT in the medical physics field, reinforcing their knowledge of dosimetry, particle physics, and radiation detection among other concepts explained in some subjects of the degree, applying it in to the clinical field. These projects offer the students the valuable opportunity to work with professionals from the hospitals and know the medical devices currently used in these facilities.

The methodology proposed, covers all of the basic, general and transversal skills required to acquire the degree, and train the students in medical geometry modelling and Monte Carlo simulations. Biomedical engineers work in industry, academic institutions, hospitals, and government agencies. In Spain, the Biomedical Engineer job market is still small, but fast growing percentage-wise.

The knowledge acquired during the degree and the FDT can offer to the students career opportunities related with medical physics as hospital radiophysics, among others.

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INFORMATION FOR PATIENTS AND CARERS INVOLVED IN MEDICAL EXPOSURES

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It is the responsibility of the medical physicist to ensure radiation protection, and therefore it is necessary to provide information to patients and carers about ionizing radiation prior to medical exposures.
Because of the Covid-19 crisis, it has been necessary to adapt the way this information is delivered to patients and carers, with face-to-face communication taking a back seat and online platforms becoming more important. This adaptation has made the information accessible not only to patients who come to the hospital, but also to anyone who is interested.

1 Introduction

One of the highlights of Royal Decree (RD) 601/2019 (1), a consequence of partial transposition of 2013/59/Euratom Directive (2), is the importance of ionizing radiation information to patients and general public, as well as some aspects of radiological protection. The lack of information about radiation exposures, in addition to an excess of unverified information, increases the widespread feeling of fear in patients undergoing diagnostic X-rays and nuclear medicine procedures, as well as in patient carers, who voluntarily undergo radiation exposure in order to contribute to the patient's well-being. Hence, there is a need for both patients and their relatives or carers to receive adequate and simple information and instructions, adjusted to the level of associated risk, in order to calm them about the procedure and to limit, as far as possible, the doses to carers and other relatives for nuclear medicine tests.
According to current Spanish legislation, every person subjected to a medical exposure must receive adequate information on the benefits and risks associated with the radiation dose resulting from the exposure. Article 7 of RD 601/2019 describes carers as persons who collaborate in the well-being of patients subjected to medical exposures. Exposure of carers is only justified if it is of substantial benefit to the successful outcome of the procedure.
Before 2020, information for those patients and carers was provided face-to-face, with the staff member answering any questions and concerns about medical exposure. The current Covid-19 pandemic crisis has been an impediment to provide this information in the usual way.
The purpose of this study is to show the information developed on ionizing radiation and its effects, both for patients undergoing diagnostic procedures with X-rays and/or radionuclides, and for those who care for them when necessary, as well as the way it has been adapted to be effectively provided despite the current situation.

2 Methods

Following the partial transposition of 2013/59/Euratom Directive, information material (leaflets, posters and videos) has been created by the Medical Physics and Radiation Protection Department of the Hospital Universitario La Princesa (Madrid, Spain) to implement this regulation.
The information has been developed considering both the regulatory texts and some basic information provided to patients by national and international organizations, such as the International Atomic Energy Agency (IAEA) (3), or the website of the Spanish Society of Medical Physics (SEFM) (4).

Table 1 shows a resume of the radiation protection information prepared.

Table 1: Information material designed

Information material	Who it is aimed at	Where to find it
Poster	Women who voluntarily assist in the welfare of the patient undergoing diagnostic X-ray procedures and who are or may be pregnant.	Paediatric waiting rooms
Video	Women who are or may be pregnant, who have doubts about medical exposure.	The Hospital Universitario La Princesa webside.
Leaflet 1	Carers who voluntarily collaborate in the well-being of the patient undergoing diagnostic X-ray procedures.	Radiology department waiting rooms and website.
Leaflet 2	Patients undergoing a diagnostic Nuclear Medicine procedure.	Nuclear Medicine patient waiting rooms and webside.
Leaflet 3	Patients with hyperthyroidism disease undergoing metabolic treatment with I-131.	Nuclear Medicine patient waiting rooms and webside.
Frequently asked questions	Patients, carers and staff.	The Hospital Universitario La Princesa webside

A poster is designed for women who are or may be pregnant who voluntarily assist in the welfare of patients undergoing diagnostic X-ray procedures. This situation can be quite common at children's hospitals or paediatric radiology departments. According to RD 601/2019, article 7.2, exposure to ionizing radiation during pregnancy should be avoided, but most parents do not know or not have to know this, so it seemed appropriate to prepare a simple poster with clear information to warn these women.

A video has been prepared, aimed at women who are or may be pregnant, and its purpose is to respond in a dynamic way to the doubts and concerns associated with medical exposures, as in many cases the lack of information is the reason for an excess of anxiety, sometimes even termination of pregnancy, which is most probably unnecessary.

The first leaflet is aimed at carers who voluntarily collaborate in the well-being of the patient undergoing diagnostic X-ray procedures as, in accordance with article 7 of the mentioned RD, it is necessary to provide them with basic information on the effects of ionizing radiation.

The second leaflet is aimed at patients undergoing diagnostic Nuclear Medicine procedures, in accordance with article 3.10 of the RD, which establishes that all persons subjected to medical exposure, before the study, must receive adequate information on the benefits and risks associated with the radiation dose caused by the exposure.

The third triptych or leaflet is aimed at patients with hyperthyroidism disease undergoing metabolic treatment with I-131, including the restrictions and recommendations that patients shall follow in order to protect the people around them.

The most relevant aspects of information needed by patients and carers on diagnostic procedures as well as metabolic treatments for hyperthyroidism have been studied and included in these leaflets to answer possible concerns about these procedures. The information has been provided as questions

and answers, with pictures and a simple and direct vocabulary to be easily understood and catch the attention, so that a wider audience is reached.
An opinion survey has been included in each leaflet to evaluate its effectiveness and usefulness for patients. The survey can be accessed via QR code at the end of the leaflet.
The results of the survey will be considered for future revisions of the text.
The leaflets were originally designed to be available at the patient waiting rooms of radiology and nuclear medicine departments, but the Covid-19 pandemic crisis has forced us to adapt. For that purpose, the hospital's website (5) has been updated adding a radiation protection section, which includes different units (Figure 1). The first unit includes a short description of the radiological protection department, followed by a unit where the patient has access to the previously mentioned informative documents, as well as the possibility of downloading them (Figure 2).

Figure 1. Medical physics and radiological protection section of the Hospital Universitario La Princesa website

Figure 2. Links to download the leaflets

A frequently asked questions section for both patients, carers and staff has also been included, with questions and answers about radiation, radiological exams, interventional radiology, diagnostic and therapeutic nuclear medicine and radiotherapy (Figure 3). Both patients and members of public were asked about their concerns, questions and worries about radiation to elaborate this material.

Figure 3. Frequently asked questions section

In this way, patients and carers, but also professionals, have access to adequate information during this Covid-19 crisis, which has made it impossible to distribute leaflets in paper format at the hospital.

3 Results

Figure 4 presents the poster addressed to pregnant women, which has been implemented and well received at paediatric waiting rooms. The aim of this document is that more women advertise the technicians on their possible pregnancy before entering the x ray room with her child during the procedure.

Figure 4. Poster to pregnant women

30 people have answered the survey and the data have been analyzed in order to obtain some feedback. According to the surveys in both diagnostic leaflets (X-ray procedures and Nuclear Medicine), patients' and carers' main concern are the possible side effects of radiation.

The metabolic treatment leaflet survey shows that the most difficult restriction to follow is to keep distance with their own children, as approximately 40% of patients undergoing hyperthyroidism treatment responded. Absence from work is another restriction that is difficult to follow, according to 20% of patients.

92% of respondents considered the information provided to be adequate, and 88% of respondents thought that the information provided helped to keep calm during the medical exposure.

Figure 5 shows the front of the three information leaflets.

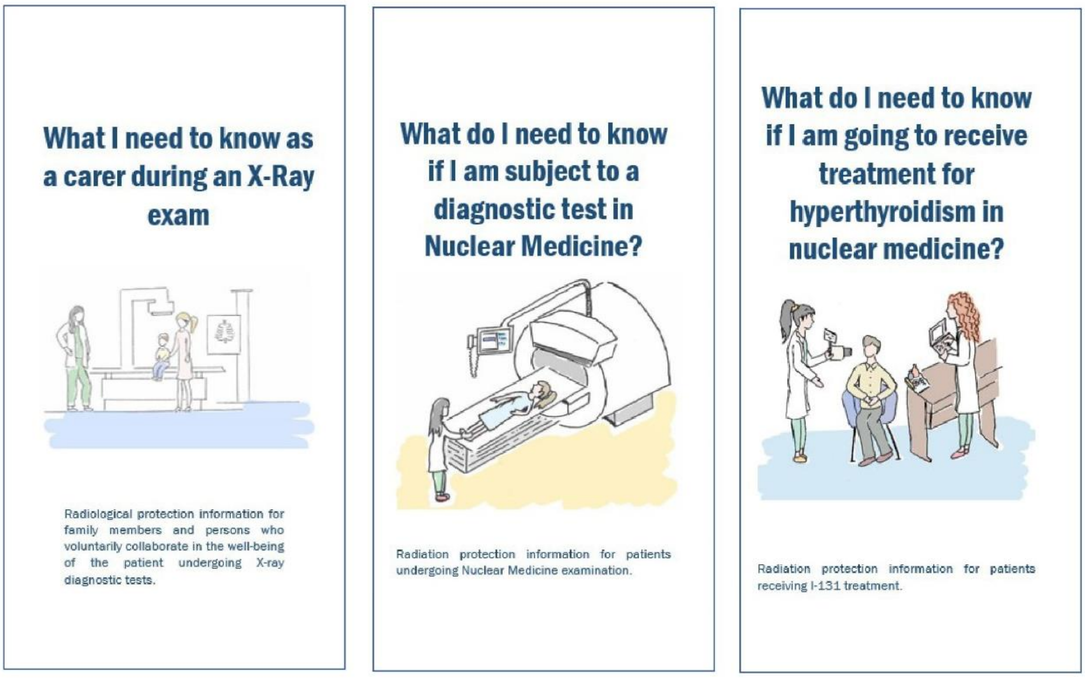

Figure 5. Information leaflets front

4 Conclusion

It is essential that both patients and carers who are subject to medical exposures are provided with clear and simple information to ensure radiological protection inside and outside hospital facilities. This information must be accessible and easy to be understood, and patient feedback is encouraged and discussed.
Because of the current situation, on-line adaptation is necessary in order to be able to continue providing patient information. This adaptation to the present situation can be seen as a step forward, for the information is much more accessible, taking into account that face-to-face mode was only accessible to the patients themselves that came to the hospital.

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EFFECTIVENESS OF POSSIBLE DISTANCE RADIATION PROTECTION TRAINING AND COMPLIANCE WITH THE SLOVENIAN LEGISLATION

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As a consequence of coronavirus disease pandemics technology of education and training has to be adapted to information technology. The infrastructure and the technology of distance education and training are available, but not widely accepted. Different approaches have their particular advantages and deficiencies. According to current Slovenian legislation, radiation protection training should be performed in a classroom with demonstrations and some exercises, and with a written examination. Refreshing training is not required (except for training for RPOP), and re-examination should be performed every five years. Analysis of requirements in relevant rules and authorised programs reveals that blended learning is the optimal approach to the implementation of initial and refreshing training courses. Analyses based on Bloom's taxonomy also supports this recommendation.

1 Introduction

Coronavirus disease (COVID-19) pandemic has influenced different aspects of our life and work, education of children, adolescents and people, as well as different training activities of people of all ages related to their hobbies, interests and also occupational obligations and aspirations.

While certain forms of work could be successfully performed from "home office", other forms either require certain tools or equipment or are a part of some chained operations and could not be successfully extracted from the production process. As far as education is considered, we have seen that existing communications system and information infrastructure could be used for the introduction of distance forms of learning. Since this transformation has happened practically overnight and teachers and students were unprepared, we can hardly say that everything went on without problems, complications and mistakes. The crucial requirement was that the education process is taking place, and problems should be solved "on the way". The most important problems to be addressed were (and still are) practical exercises, evaluation and grading. In the first months, possible problems and complications in these areas were outweighed by the requirement for strict implementation of health-protective measures. Therefore, the school and university semester in the coronavirus pandemic situation has been performed and concluded in the form of distance education. Only maturity examination at the end of secondary education has been performed traditionally, with the implementation of all recommended protective measures.

Most of the training activities were cancelled or postponed at the outbreak of the coronavirus pandemic. It was the consequence of the fact that in many cases training is not a part of some binding process and broader effort, and is practically always organised for smaller groups of participants and targeted on the acquirement of certain skills, abilities or special knowledge. Implementation of training is therefore always targeted to certain groups of participants and focused on particular and specific outcomes which must be verifiable. As a result, training should be concluded in such a way that proof of attained skills, abilities or knowledge is provided. Legally required training (like training in driving schools) must be therefore terminated with the official examination. This applies to numerous forms of training and is often referred to as (a part of) final certification.

Training in radiation protection is also an example of a temporarily cancelled and postponed type of training. It is a category of occupational training required by regulations for people using or handling sources of ionising radiation. Training is required for beginners (these courses are regulated), and also applied for experienced users in the form of refresher courses.
In Slovenia, an examination is obligatory at the beginning of the professional involvement, and regular re-examination is required every 5 years. There is an established and approved system of radiation protection training in Slovenia based on the conventional direct learning method, which has been practised for years now. After the outbreak of coronavirus disease and the fast introduction of distance learning in education, it was normal that the idea of the introduction of similar "technology" emerged also for radiation protection training. While this approach looks very tempting, it is also clear that the standards established in radiation protection require an effective approach to training, and that the whole process of training and examination must be verified and also approved to be acceptable for regulators.
In the continuation, we would like to discuss the possibility to use modern methods of training in radiation protection in Slovenia, determine categories and program segments that could be transferred to distance forms of training, and propose some changes to legislation to enable implementation of this modernized radiation protection training.

2 Possible forms of training and learning in an environment with modern information infrastructure

Until the last decade of the previous century, the only form of learning and training were either self-study or in a classroom learning with a teacher. Teaching content was either comprehended by a student from a textbook or some other type of teaching material or communicated directly (face-to-face) by a teacher, who is competent in a particular subject and trained for an educational activity.
The introduction of information technologies has provided tools and means to introduce "live" textbooks in the form of interactive materials and searchable libraries at the student's disposal. First floppy disks and later compact disks were used for dispatching teaching materials. The introduction of the internet, which serves as an information highway, has expanded possibilities for the distribution of any type of information and also enabled live interaction between teachers and students. Of course, this is just "infrastructure" which could be used in different ways, and the transformation of training and learning methods to fully discover and utilise new possibilities will take some time. Up to a few months ago, motivation for this development was a possibility to access a broader number of students, decrease in costs of learning and training, increase the effectiveness, the possibility to perform different programs without constraints imposed by limited space. Coronavirus disease has added one ultimate argument to this list, namely the possibility to communicate with students and other people without physical contact.
However, the introduction of new methods and tools requires some transition period for teachers to learn and become familiar with new tools, and also to prepare lectures and other materials in compliance with new requirements. Therefore, the transition could be time-consuming and costly, especially when the costs of new software solutions are considered.

If we consider ”old” (face-to-face) and ”new” (distance) methods of training and learning, we have the following options:

- **Classroom training and learning**: Ideal for smaller groups in a case when interaction, bonding and communications are vital to achieving learning objectives. The organisation of classroom training could be difficult when coordination and scheduling of people living in different places are required, or training should be organised for larger groups (which is one of the problems in coronavirus conditions, when rules of social distancing should be followed).

- **Live internet**: Live online training is a flexible and cost-effective alternative to classroom training and learning and is achieved by using a Web conferencing platform. Such training is easy to scale and distribute, and by incorporating video, the trainer becomes alive for participants. All participants must log in at the same time for the session (although they can sometimes access a recording after the event). There is limited opportunity for interaction and participant cannot speed up or slow down the training to match his/her learning needs. Therefore, highly complex or technical topics should be avoided.
- **Self-paced online learning:** This is on-demand e-learning provided through locally or cloud-based software where the trainer uploads existing content into templates and develop multimedia courses. A participant can run the training when it is convenient for them and in smaller "chunks", and also replay the chapter (or particular slides) if they want. Different types of devices could be used for training. e-learning could be sued for teaching complex subject matter, and also quizzes could be included to test knowledge. Unfortunately, the opportunity for interaction with participants is limited and getting feedback can be difficult.
- **Blended learning**: It is a combination of classroom (live) training with live internet or on-demand e-learning. In this way, the best of all worlds could be accessed. For example, the on-demand platform could be used for delivering foundations before the live classroom session. Another possibility is to use an on-demand platform for prerequisite course and classroom for users to apply the knowledge, and an on-demand platform again for examination.

3 Software tools for modern forms of training and learning

Software tools for distance training changed from simple editing tools to complex systems that require the support of dedicated professionals and considerable investments. Special training and familiarisation with tools are needed for teachers and trainers before they start using them. Also, content preparation and implementation require the cooperation of different persons if high standards of e-learning should be achieved. Unfortunately, there are no shortcuts here: software and development tools are specialised and therefore price (one-time or subscription) must be paid.

Basic tools for remote e-learning content preparation are common office suites like Microsoft Office 365 [1], or Google G Suite [2]. These suites are distributed through educational or business subscriptions and have tools for video and voice conferencing and streaming built-in. Microsoft Teams and Google Meet are therefore directly available to group (team) members with a possibility to also invite “outside” participants. There are also other tools included in these suites which are useful for group work and cooperation, but as we have mentioned, the involvement of dedicated professionals (or involvement of some service) is required to support these (extended) activities. Typically, teachers or trainers in a training department or some school will not be able to efficiently arrange and service these activities.

Using office suites, or just some programs for presentations creation, word processing, spreadsheets (like PowerPoint, Word, Excel, Slides, Docs, Sheets, etc.), learning material could be prepared and used for live online training. As we have seen, Microsoft Teams and Google Meet are intended for that purpose and are now part of office suites, but few already established dedicated programs are available for some years now and have been used on many occasions. The most popular is Zoom [3], which has been widely accepted due to the simplicity of installation and use but has been banned from certain environments due to some security issues. Other platforms like Cisco WebEx, Skype (for small groups), and others are also available [4]. They support even more than 100 participants (different subscriptions are available), screen sharing, whiteboard, and meeting recording, which are the most popular features required by the users.

But there is one problem with all these platforms, namely that they emphasise unidirectional communication from speaker to listener, who can be passive or completely unconcerned about the presentation. Therefore, it is necessary to introduce some additional activities in lectures to motivate participants and award watchful listeners.
The approach that we have just described is the simplest and the fastest way to transform a classroom approach to remote learning. As we mentioned at the end of the previous paragraph, it is not very effective and should be modified to ensure effective learning. All process from content shaping and preparation to tools for delivery of materials, different activities for students, grading and examinations must be prepared and designed appropriately. There are several (free and payable) authoring tools ([5], [6]) that can be used to produce graphics, animations, videos, audio, and to facilitate interactions and assessment.
The best way to deliver these contents is not through "one time" event, but to offer it to students as accessible units on some server or in the cloud, where a student can learn and work, solve problems, answer questions when he/she is confident and prepared to do that. This requires that materials are prepared in some standard way and are available in such a manner, that student can access materials and work on them. These software applications are usually referred to as Learning Management System (LMS) and they enable teacher/trainer to perform administration, registration, tracking reporting, creation, and delivery of e-learning courses or training programs. In Google G Suite Google Classroom [7] is used as LMS, but it is a new module, which is not popular yet. Much more popular is Moodle [8], which is free and extensively used also in Slovenia (e. g. University of Maribor), and also in IAEA [9].
While LMS enables overseeing of the students' progress and grading (e. g. in Google G Suite module Forms), there are also several specialised software applications for testing and grading students during the e-learning process [10] and are compatible with popular LMS. They enable different questions types, evaluation, grading, preparation of reports etc. This type of application can be useful to support education, but it is not possible to exclude the possibility of cheating during testing.

4 Characteristics of radiation protection training

4.1 Legal requirements for training

Training in general and especially different forms of occupational training in “normal” conditions are usually a mixture of classroom lectures, demonstrations and practical exercises. Duration is normally limited (hours, days, weeks) since objectives are precisely defined. This requires more practical involvement from training participants and focused evaluation which is formally required for final certification. Considering the purpose of occupational training, it is not possible simply to readjust (or transform) the process, criteria and evaluation due to some other requirements. This is the reason why many training events were postponed or cancelled and not simply transferred to the internet.
According to current Slovenian legislation, radiation protection training should be implemented in the form of a course that consists of classroom lectures and practical demonstrations and exercises (also duration is prescribed). Institutions that organize training and the course programs are approved, as well as authorized radiation protection experts involved in the course implementation. A written examination is required and passing criteria prescribed. Considering all these requirements, it seems that it is not possible to implement some modern forms of distance training and examination. However, this has been already done in other countries in the past (e. g. in Spain, France, Croatia, EU CINCH II project [11], etc.) where the training of certain categories of workers (in Croatia all categories [12]) is implemented in the form of web courses, and examination is also performed through "electronic forms". We are not aware of some evaluation of the actual effectiveness of these training processes, therefore we cannot use them as a basis for the decision of remote training relevance in the case of Slovenia.

4.2 Use of Bloom's Taxonomy for training development and evaluation

Bloom's Taxonomy is a model of classifying thinking according to six cognitive levels of complexity. It is used for the classification of the different objectives and skills that educators set for their students. These levels can be used to structure the learning objectives, lessons, and assessments of a course.
The terminology has been updated to include the following six levels of learning (see e.g. [13]):

1. **Remembering**: Retrieving, recognizing, and recalling relevant knowledge from long-term memory.
2. **Understanding**: Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
3. **Applying**: Carrying out or using a procedure for executing, or implementing.
4. **Analysing**: Breaking material into constituent parts, determining how the parts relate to one another and an overall structure or purpose through differentiating, organizing, and attributing.
5. **Evaluating**: Making judgments based on criteria and standards through checking and critiquing.
6. **Creating**: Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

The taxonomy is hierarchical, meaning that learning at the higher levels is dependent on having attained prerequisite knowledge and skills at lower levels. Therefore:

- Before you can understand a concept, you must remember it.
- To apply a concept, you must first understand it.
- To evaluate a process, you must have analysed it.
- To create an accurate conclusion, you must have completed a thorough evaluation.

4.3 Possibilities for improvements

Analysis of radiation protection training programs based on the Bloom's taxonomy reveals that most of the learning objectives in the programs belong to the lowest cognitive levels (level 6 – remembering, level 5 – understanding, and level 4 - applying). Higher cognitive levels (level 3 – analysing, level 2 – evaluating, and level 1 – creating) belong to expert level knowledge and are not a part of training for exposed workers.
Considering the experience from other fields of training and education in different environments (see chapter 2), remote forms of learning could be successfully implemented when cognitive level 6 (remembering), and, in some cases, level 5 (understanding) are required. Cognitive level 4 (applying) is probably beyond the capability of simple methods of remote learning and should be supported by classroom training and practical exercises.
In the Slovenian rules on radiation protection training [14] requirements for training course contents are listed. Requirements for general knowledge for all categories of workers are stated, specific knowledge, and also requirements for practical exercises. If we consider our approved programs, we can conclude that many of the learning objectives related to specific knowledge, and practically all objectives related to practical exercises require a classroom training approach. Therefore, it seems that just introductory and general parts of training could be implemented in the form of remote learning. Specific knowledge and exercises must be delivered in the classroom (direct learning) environment with the personal involvement of trainers. Blended learning, i. e. a combination of distance and classroom training, seems to be an optimal approach for initial training.

4.4 Refreshing courses and re-examination

Slovenian legislation requires that re-examination is performed every five years. Refreshing courses are required (and regulated) only for professionals which are involved in the radiation protection of patients (RPOPs), where the complete repetition of lectures related to the protection of patients is required with the involvement of an authorised medical physics expert. Considering these facts, it is possible to perform refreshing courses in any form of distance learning, as far as the contents relate to occupational protection, but re-examination should be done in the "classical" way. Requirements of legislation are fulfilled and there are no obstacles to implement refreshing courses in this way. Classroom training could be substituted with live internet, and the only examination should be done as a written examination in the limited time on previously agreed premises. The disadvantage of this approach is that all participants must have access to information equipment and adequate space to take part in the session without disturbances, which is not necessarily available in all organisations or companies. Of course, this approach has also all disadvantages that we have mentioned discussing live internet in chapter 2.

The absence of a legal requirement for refreshing courses enables us to choose from some other form of distance learning form as preparation for re-examination. Remote learning could be also provided through written materials in pdf format distributed to participants through some portal or distributed directly through e-mail, but this is not the optimal approach. Arguments described in the previous subchapter applies also here and the optimal approach should be blended learning, where participants refresh knowledge on basics through some distance learning mode and discuss some more demanding issues in the classroom in direct contact with trainers.

5 Conclusions

Modern information technologies enable us to use different methods of learning and training instead, or in addition to classroom training and learning. It seems that blended learning, which is a combination of classroom training with live internet or on-demand e-learning, is the most suitable for radiation protection training since it is possible to include different categories of cognitive levels.

In Slovenian legislation, distance learning is not anticipated for radiation protection training. Classroom training with practical exercises and demonstrations are prescribed and written exams are required. Refreshing courses are not required except for training of persons that must be trained in RPOPs. Re-examination (written exams) is required every five years.

Transferring examination or re-examination to some Learning Management System platform would require additional approval from authorities. If we want to introduce some forms of distance learning, the legislation will have to state that possibility. But for refreshing courses, the introduction of distance learning is possible now.

For Slovenia, blended learning with the preservation of written examination should be optimal for radiation protection training. This conclusion is also supported by the analysis based on Bloom's taxonomy. Blended learning could be applied to refresher training and re-examination without additional approval from authorities, while the possibility to use blended learning for initial training has to be approved in legislation yet.

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CHALLENGES DUE TO COVID-19 RESTRICTIONS IN IMPLEMENTING THE NATIONAL LEGISLATIVE FRAMEWORK FOR THE RECOGNITION OF RADIATION PROTECTION EXPERTS (RPEs) AND MEDICAL PHYSICS EXPERTS (MPEs)

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The new radiation protection regulations transposing the Council Directive 2013/59/Euratom to the national legislation, define, *inter alia*, the role and responsibilities of RPEs, MPEs, as well as the corresponding requirements and mechanisms for their recognition.
This work presents the mechanism and requirements for the recognition of RPEs and MPEs, and the challenges encountered in the implementation of the associated legal and regulatory framework due to the COVID-19 restrictions.
Moreover, it demonstrates the results of a preliminary analysis, based on data from the national radiation database kept by the Greek Atomic Energy Commission (EEAE), concerning the implemented practices and the related needs at national level.

1 Background

EEAE, as the competent authority in aspects related to radiation protection, nuclear safety and security, had the main responsibility for the transposition of the Council Directive 2013/59/Euratom [1] in the national legislation. The transposition was performed through the Presidential Decree 101/2018 [2] which, *inter alia*, defines in detail the role and responsibilities of RPEs, MPEs as well as the need for a recognition framework (figure 1).

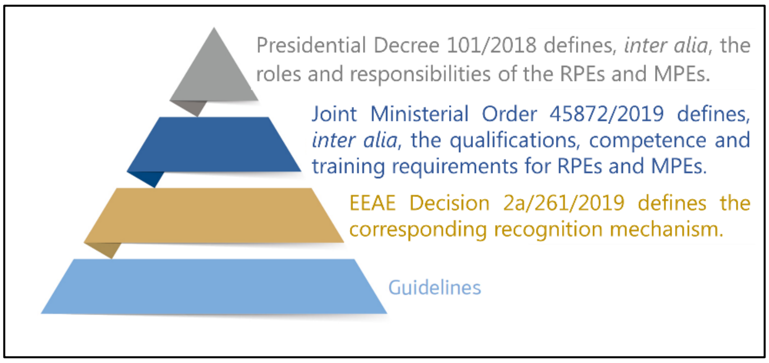

Figure 1: Legislative documents defining the requirements and the mechanism for the RPEs and MPEs recognition

The RPEs and MPEs recognition framework includes two additional legal documents; a Ministerial Decision [3] setting the respective qualification, competence and training requirements, and an EEAE Decision [4] that describes the recognition mechanism itself.

This work presents the requirements and the related mechanism for the recognition of RPEs and MPEs, as well as the challenges encountered in the implementation of the associated legislative framework due to the COVID-19 pandemic.

Moreover, it demonstrates the results of an analysis for the assessment of RPE and MPE needs at national level based on the methodology defined in the established national strategy.

2 Requirements and mechanism for the recognition of RPEs and MPEs

The qualifications, competence and training requirements for the recognition of RPEs for medical and non-medical practices include:

a. an academic degree,
b. postgraduate of formal education in a subject relevant to radiation protection,
c. proven experience in the provision of advice for radiation protection issues in the field of recognition, and
d. a professional license of Medical Radiation Physicist for experts interested to be involved as RPEs in medical practices.

The respective requirements for the recognition of MPEs are:

a. a professional license of Medical Radiation Physicist
b. proof of non-formal education on medical exposures by national or international bodies, and
c. a proven 3 year work experience as a Medical Radiation Physicist.

The recognition requests submitted to EEAE are evaluated by a three-member committee consisting of:

a. a University faculty member (Chairman),
b. a member of EEAE's scientific staff, and
c. a representative from a scientific, educational or professional body related to the field of recognition.

The validity period of the recognition is 7 years and for its renewal the experts shall demonstrate a minimum of 60 hours of non-formal training in radiation protection relevant to the field of recognition for RPEs, or medical exposures for MPEs.
EEAE maintains a list of the recognized RPEs and MPEs on its website, accessible by any interested party. The list includes the name of the recognized individuals, the field of recognition and the expiration date of the recognition.

3 Current situation

Despite the difficulties introduced by the COVID-19 pandemic, 136 RPEs and 139 MPEs for medical and 37 RPEs for non-medical practices have been recognised by the respective evaluation committees in the last 18 months. The first meeting of the committees was carried out face to face before the starting of the pandemic and the rest on-line using a web-conference application.

EEAE conducted a preliminary analysis based on data from the National Database it keeps to identify the national needs concerning the RPEs for non-medical practices. For the analysis purposes, the number and the type of facilities with radiation sources as well as the type of the applied practices at national level were taken into account. Moreover, the assessment of the RPE needs was based on the related authorisation requirements for radiation practices and in line with a graded approach.

According to Table 1 the number of the RPEs already recognised is sufficient to cover the needs of non-medical practices with respect to the corresponding regulatory requirements.

Table 1: National needs in RPEs for non-medical facilities

Type of facility	Type of activity	No of facilities	RPEs	
			Total needs	No of recognitions
Industry and research	Industrial radiography	20	32	34
	Irradiator facilities	1		
	Industrial gauges and well logging	18		
	Research	22		
Other	Isotope production	2	2	2
	Waste Management	1	1	1

A similar analysis is planned for the assessment of MPEs and RPEs needs in medical facilities. However, considering the specificities of medical exposures, this task requires more time and effort, as well as the collection of additional data and information, e.g., organisational structure and geographical distribution of health services, complexity of applied practices, priorities concerning the operation of new health units due to COVID-19 pandemic, etc.

4 Challenges

The main challenges encountered in the implementation of the new legislative framework regarding the RPEs and MPEs concern:

a. The large number of recognition requests submitted to EEAE due to the implementation of the new regulatory framework and the expiration of the corresponding transition period.
b. The limitations impacted the operation of the evaluation committees due to the restrictions introduced by the COVID-19 pandemic. Although, their meetings were initially arranged to take place face to face, this initial planning had to be adapted appropriately due to the pandemic restrictions. Therefore, only the first meeting was carried out face to face and the rest on-line.
c. Difficulties in the verification of the validity of the electronically submitted certificates of the applicants due to the large number of the submitted requests.
d. The planning of activities in line with the requirements for the renewal of recognitions. This challenge is related to the difficulty in planning and conducting courses for the provision of non-formal training due to the COVID-19 restrictions.

5 Conclusions

173 RPEs and 139 MPEs have been recognized in the last 18 months by the corresponding evaluation committees. Despite the large number of recognition requests, the evaluation committees have efficiently managed to overcome any operational limitations due to the COVID-19 pandemic using the advantages of web conferencing. The preliminary results of an analysis carried out by EEAE shows that the number of the RPEs already recognised is sufficient to cover the needs of non-medical practices.

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TEACHING THE TEACHERS: A SERIES OF INTERACTIVE TEACHING-THEMED WORKSHOPS FOR HEALTHCARE AND RADIATION PROTECTION EXPERTS

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Teaching Studios were developed at the LRCB to provide the experts with knowledge on educational topics, in order to create and carry out better, more effective courses. The Teaching Studios are two to four hour workshops, each on a different teaching-related topic. The experts felt more confident about and interested in educational topics and teaching, due to the Teaching Studios. As a result, sixteen courses were redesigned in order to integrate more effective teaching methods. Feedback from attendees of the courses showed they felt more engaged and that they highly appreciated the newly added elements.

1 Introduction

The Dutch Expert Centre for Screening aims to improve breast cancer screening programs, not only by performing audits and research, but also training. Carrying out training programs that are effective in transferring the necessary knowledge and skills, including radiation protection in the use of x rays, to screening personnel is crucial to achieve the goal of improving screening programs. The teachers who work at the centre and train the screening personnel are all healthcare experts, with extensive knowledge in their field of expertise. However, they lack formal training on teaching skills and educational concepts, as is the case in many other knowledge centres. This often resulted in choosing PowerPoint presentations as their main teaching method, since they did not know about other, more effective, teaching methods. Training the trainers on these concepts holds the promise of improving their performance.

2 Teaching Studios

Teaching Studios were introduced to offer the (radiation) experts knowledge on educational concepts and teaching skills. These are two- to three-hour-long workshops, each one on a relevant theme, which is often requested by the participants themselves. Examples of themes that have been covered are: *How to handle difficult groups*, *Presenting*, and *Teaching online*. A list of topics is available in table 1.

Table 2: Examples of Teaching Studio Topics

Examples of Teaching Studio Topics
Teaching Methods
Presenting
Learning and the brain
How to handle difficult groups
Online teaching
Applying educational concepts
Effective learning strategies

The aim of the Teaching Studios is to provide knowledge about educational concepts, and opportunities to practice teaching skills. Furthermore, it was regarded as critical that the participants are stimulated to reflect on their own experiences in teaching and learning, in a highly interactive and safe learning environment. Therefore, to demonstrate the practical effects of incorporating the previously taught concepts into their teaching responsibilities, one of the Teaching Studios was devoted to redesigning one of the current courses, applying the several concepts taught in previous Teaching Studios.
Also, by designing the Teaching Studios in a way that different teaching methods and online tools were demonstrated, participants could experience these themselves, lowering the threshold to incorporate these methods into their own teaching sessions.
To gauge the effectiveness of the Studios, feedback from the participants and anonymous feedback surveys from attendees of the courses were obtained.

3 Design of the Teaching Studios

The Teaching Studios were, in general, designed following a specific structure, although deviating from this structure was also possible if that would suit the situation or topic better. In this section the standard elements are described, using one specific Teaching Studio example, "Effective learning strategies", to illustrate each element.

3.1 Opening

Each Studio starts with an 'energizer' or 'icebreaker', in order to create a positive and open atmosphere. This is a chance for the participants to get to know each other better, and hence make it easier to open up in discussing one's own experiences. These short icebreakers also contribute to the team feeling among the teachers at the expert centre. Moreover, a warm environment contributes to the learning process [1].
In the case of the "Effective learning strategies" Teaching Studio, the workshop opened with each participant choosing a small card, each having a different question regarding their personal experience with something related to the topic that would be addressed during the Studio. Each participant would then answer their question.

3.2 Activating prior knowledge

The next element involves activating prior knowledge. Activating prior knowledge is an important strategy to help participants remember new knowledge more easily, since the new knowledge can be more easily connected to existing knowledge [2, 3, 4]. There are many ways to do this. The simplest way is to ask the participants what they already know about the subject. Other options are starting off with a quiz, let the participants make a mind map about what they already know about the subject, or let them write down the questions they have regarding the topic.
During the "Effective learning strategies" Teaching Studio, the participants were asked to think one minute about the question: "What is learning?", followed by a short discussion about what learning really is.

3.3 Presentation

During the Teaching Studios, new information is usually presented to the participants in a highly interactive way, asking the participants many questions, in order to not only engage them but more importantly to make them think. Care is put into the design and development of the presentation, to make sure the topics are introduced using a step-by-step approach, in order to control the cognitive load [5].

Adding structure to presentations not only makes it easier to remember new knowledge, but also helps to see it as an integrated whole. In addition, the presentations are illustrated with examples, analogies, and visuals, since these all improve understanding of the content [6].
The participants of the “Effective learning strategies” Teaching Studio did a quiz, using their phones, to discover misconceptions about learning. This was followed by an interactive presentation about effective learning strategies, asking the participants questions, and discussing the different strategies.

3.4 Assignment

In order to help the participants apply the knowledge gained, an assignment is always part of the workshop program. By integrating their own job context, and their own courses, the transfer of the new knowledge is stimulated. To include an assignment is important because participants will remember more of what you have taught them, when they have to produce knowledge themselves. This is called the *generation effect* [7, 8].
A very simple, though very effective learning strategy was chosen to include in the “Effective learning strategies” Teaching Studio. Worksheets to be filled out by each participant were prepared. The participants had to retrieve all strategies from memory and fill in what they remembered of each strategy (appendix 1).

3.5 Wrap up

At the end of each Teaching Studio there is some time reserved for looking back, repeating the most important concepts that were taught, and, in order to promote knowledge transfer, a job aid is provided, if this is relevant to the topic. Also, feedback from the participants is sought during this phase.

At the end of the “Effective Learning Strategies” Teaching Studio, future topics for the Teaching Studios were discussed and participants received a handout (appendix 2).

4 Results

Since the introduction of the Teaching Studios three years ago, sixteen courses were redesigned. Examples of changes that were made to the courses are:

- More images and visuals are used in PowerPoint presentations, as opposed to text.
- More assignments and quizzes are included in the courses.
- When presenting the teachers interact more with the participants.

Feedback from the participants showed that they have become more aware of teaching skills as an important factor in their educational responsibilities. Teachers feel more confident, and more enthusiastic about teaching, and about learning about teaching. Now they understand there is more to teaching than just presenting content.
As a secondary positive outcome, the Studio participants have become more interested in gaining knowledge on educational concepts and innovative teaching methods.

Table 3: Examples of feedback from Teaching Studio participants

“During the Teaching Studios I feel like everything is possible. Nothing seems wrong, stupid or dumb. There’s a safe environment”
“Makes me think about how to improve my classes, with concrete tips.”

Qualitative surveys from the attendees to the redesigned courses showed that they highly appreciate the redesigned parts of the courses. In the evaluation forms it was specifically asked when new elements were introduced to the courses.

Table 4: Examples of feedback from attendees of LRCB courses

"Nice! Because of the assignments we were actively involved with the content" "This way even physics is fun" *"My compliments! Very nice way of working and learning, and discovering what we know, and sharing knowledge. If it's up to me you should apply more of these methods."*

5 Challenges

Even though the Teaching Studios are a success, there are also a few challenges to deal with.
First, the experts who teach at the centre participate in the Teaching Studios as a side-activity, and might have very busy schedules. Sometimes it can be a challenge to make them prioritize the Teaching Studios. However, as a principle, the Teaching Studios are not mandatory. Participants should join the Teaching Studios because they are motivated and enthusiastic. Forcing teachers to attend would detract from the positive learning environment during the Studios. Therefore, it is meaningful to discuss participation of the Studios with participants and management, so that all parties involved see the value of the Studios and make it a priority.

Another challenge is that real learning is only valuable when a transfer of knowledge and skills takes place. It is clear that participants have started using a lot of educational concepts that were taught during the Studios. However, there is a recognition that there is a need for more than just the Teaching Studios to create a long-term change in the knowledge and skills of the teachers. At the LRCB, ongoing advice, coaching, discussion, and cooperation with the learning expert of the centre, are all factors that contribute to this transfer.

6 Conclusion

A concept like Teaching Studios is an effective approach to involve teaching staff in improving their teaching skills. The Studio participants have gained more confidence in their approach to teaching, changing from a content-centered to a learning-based approach, during both designing and giving courses. Teaching Studios, aimed at providing knowledge of educational concepts and teaching skills, improve the quality of courses designed and taught by experts with teaching responsibilities who have no formal teaching training.

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Appendix 1: Assignment "Effective Learning Strategies"

Strategy
Visual
Example
Why does this strategy work?
How does it work?
How can I apply this to my teaching?

Appendix 2: Handout "Effective Learning Strategies"

ENEN+: ATTRACTING, DEVELOPING AND RETAINING NEW TALENTS TO CAREERS IN THE NUCLEAR FIELDS

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The ENEN+ project aims at reviving the interest of young generations in the nuclear sector. Accordingly, its main objectives are to attract new talents to careers in nuclear and to develop them beyond academic curricula. It is also crucial to increase the retention of the attracted talents in nuclear careers and to involve the nuclear stakeholders within the EU and beyond. Another purpose is to sustain the interest of young generations for nuclear professions in order to make sure that the project successfully contributes to the revival of interest in nuclear disciplines. The most important nuclear fields of the project are nuclear reactor engineering and safety, waste management and geological disposal and radiation protection and medical applications.

1 Introduction

The European Nuclear Education Network (ENEN) is an international non-profit organization (aisbl) established under the Belgian law. The main purpose of the ENEN Association is the preservation and further development of expertise in the nuclear fields through supporting and organizing higher education and training in Europe. Following a tradition of more than 17 years, the main objective of ENEN can be realized through the co-operation between universities, research organizations, regulatory bodies, the nuclear industry and any other organizations involved in the application of nuclear science and ionising radiation.

Nuclear technologies today exhibit unparalleled levels of safety and reliability. This has been made possible through considerable and long-term efforts of the excellently educated and trained employees with outstanding safety culture in the industry, competent regulatory authorities, research, higher education and technical support communities worldwide.
Early warning signs have started to emerge in the 90s in various European countries underlining the possible shortage of human resources and requirements for replacement of qualified nuclear personnel. The retirement of ageing workers, the lack of anticipation for preparing new generations of skilled workforce, negative public perception of nuclear and the lack of interest of young people to enter nuclear careers have been recognized as major difficulties encountered in just about all nuclear disciplines. This situation may give rise to the loss of nuclear knowledge, which might have already contributed to the reduced competitiveness of EU nuclear industry and could, in the future, also contribute to reduced safety and security of nuclear activities and installations.

2 The aim of the ENEN+ project

The lack of new talents electing nuclear careers is closely linked to an early loss of interest in nuclear sciences and insufficient information about the nuclear careers available to both secondary school pupils and university students entering the Bachelor, Master of Science and PhD levels.
The primary motivation of the ENEN+ project is to substantially contribute to the revival of the interest of young generations in careers in the nuclear sector. This is to be achieved by pursuing the following main objectives:

- Attract new talents to careers in nuclear.
- Develop the attracted talents beyond academic curricula.
- Increase the retention of attracted talents in nuclear careers.
- Involve the nuclear stakeholders within the EU and beyond.
- Sustain the revived interest for nuclear careers.

The ENEN+ consortium will focus on the learners and careers in the following nuclear disciplines:

- Nuclear reactor engineering and safety,
- Waste management and geological disposal,
- Radiation protection and
- Medical applications.

For the ENEN+ project it is imperative to provide activities focused on the three main target groups of potential talents:

- Secondary school pupils. Attractive basic information on careers in nuclear has been developed, made available in national languages and complemented with an EU wide competition of pupils. Summer camps are organized. Electronic tools, including social media, are used.
- Bachelor students. Most of the nuclear academic curricula within the ENEN association concentrate on master students. The existing efforts to attract bachelor students to pursue master education in nuclear will be strengthened by increasing the level of academic preparation for bachelor students. This may involve the reform of the pedagogy and culture of teaching in order to create exciting and engaging learning experiences, including opportunities for individual guidance towards nuclear careers and opportunities to interact with practitioners of nuclear.
- Young professionals after graduation. The nuclearization of graduates of non-nuclear sciences and technologies has been a considerable source of the nuclear talent throughout the nuclear era. Attracting more graduates to nuclearization may require strong support from the end-user and will be put in place through attractive e-information and opportunities for individual guidance towards nuclear careers coupled with opportunities to interact with practitioners of nuclear.

3 The activities of the ENEN+ project

Several different events have already been organised within the frames of the ENEN+ project. ENEN+ project organized the First European Nuclear Competition for Secondary School Pupils during 2019 as part of its project to revive the interest of young generations in the nuclear sector. Teams had to have two pupil members and one teacher. The task of the participants was to compose a 3-minute video on one or more of the four nuclear disciplines. The fifteen winner teams travelled to Budapest, Hungary on 1-5 July 2019 where they presented their project live at the First European Nuclear Competition and Summer School (Figure 1.). The Nuclear Competition for Secondary School Pupils will be organized online in 2021; webpage: http://nuclearcompetition.enen.bme.hu/

Figure 1. The participants of the First European Nuclear Competition and ENEN Science Camp

The BSc Summer Schools are specifically organised for undergraduate students. More than 70 BSc students applied for the first ENEN BSc Summer School and 45 BSc students participated from ten European countries in 2019 (Italy, Spain, Lithuania, Malta, Poland, Ukraine, Serbia, Russia, Romania and Hungary). During the Summer School, various programmes provided the students with the opportunity to obtain practical information while attending a memorable social event. Interesting lectures were given on all the nuclear fields and each nuclear profession was introduced in detail. The students could visit nuclear facilities, for example; research centres, nuclear power plants and medical facilities. Practical activities were performed in nuclear labs and training centres as well. The ENEN BSc Summer School will be organized online in 2021. webpage: https://summerschool2020.enen.bme.hu/registration/

Another yearly event is the ENEN PhD Event & Prize, which supports young researchers and scientists, who can present their research work and compete in a professional environment. Up to 12 PhD presentations are nominated by ENEN Members and selected by the ENEN PhD Prize Jury. The ENEN Association supports travel expenses as well as registration fee of the conference for the finalists; however, last year the competition was held online, in the framework of the NESTet 2020 Virtual Conference, in Brussels, Belgium. For the 3 ENEN PhD prizes, ENEN Association grants 1000€ to the winners in order to cover the expenses of attending an international conference and presenting the result of their research work.

Figure 2. The participants of the ENEN PhD Event & Prize in 2020.

The possibility to organise the PhD Event& Prize action in 2021 will depend on the evolution of the COVID-19 pandemic.

The ENEN+ project focuses on supporting students interested in nuclear reactor engineering and safety, waste management and geological disposal, radiation protection and medical applications. The integration of further nuclear disciplines and sustainability of the ENEN+ accomplishments beyond the project life will be given due attention. Career guidance with mobility support exceeding 1.000.000 EUR is envisioned.

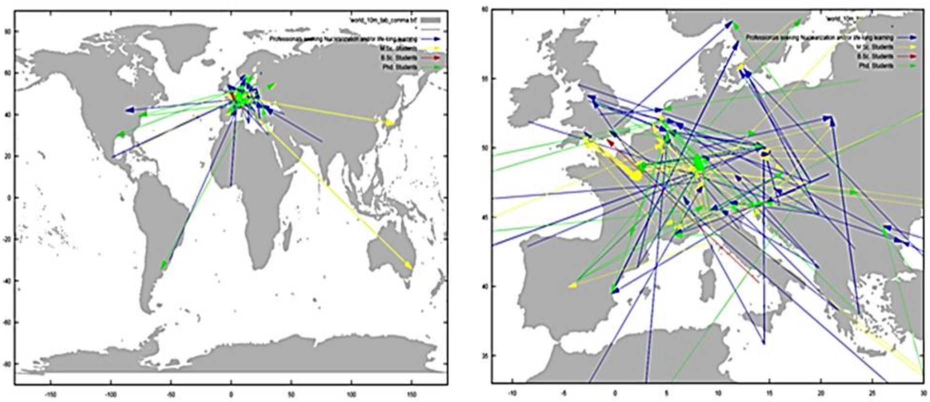

Figure 3. The ENEN+ activities in Europe (right side) and in the world (left side).

4 Conclusion

The ENEN+ project proposes cost-effective actions to attract, develop and retain new talents in nuclear professions. The project aims to reach out to secondary school pupils, students at various stages of the nuclear higher education, postdocs and candidates for nuclearization.
This project is a contribution of the ENEN Association, supported by the European Commission, to the common strategic objective of all nuclear stakeholders: to preserve, maintain and further develop the valuable nuclear knowledge for present and future generations.

Acknowledgement

The ENEN (the European Nuclear Education Network) Association, through the ENEN+ project co-funded by the EURATOM research and training Work Programme 2016 – 2017 – 1 (#755576) of the European Commission (H2020), provides mobility grants for learners, who would like to improve their knowledge, skills and competitiveness for career opportunities in the nuclear fields.

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ETRAP

International Conference on Education and Training in Radiation Protection

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