IMPACT EVALUATION OF IAEA'S POSTGRADUATE EDUCATIONAL COURSE IN RADIATION PROTECTION AND THE SAFETY OF RADIATION SOURCES

A. LUCIANI, J. WHEATELY, S. TICEVIC

Division of Radiation, Transport and Waste Safety
Department of Nuclear Safety and Security, International Atomic Energy Agency (IAEA)
Vienna International Centre, PO Box 100, 1400 Vienna, Austria

ABSTRACT

The Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources (PGEC) is a flagship course of the International Atomic Energy Agency (IAEA). It was established in order to provide the basic professional training in radiation protection and the safety of radiation sources for young professional graduates, especially those from Member States receiving technical assistance from the IAEA. The course also provides support for those participants who will become trainers in radiation protection in their home countries. The PGEC syllabus is based on the IAEA Safety Standards and includes both theoretical knowledge and practical, hands-on training. The course follows a blended learning approach, combining on-line learning with traditional face-to-face techniques.

The PGEC was first conducted in Argentina in 1981 and it is now regularly delivered at nine Regional Training Centres (RTCs) around the world in English, French, Arabic, Spanish, Russian and Portuguese. In 2016, IAEA's Division of Radiation, Transport and Waste Safety initiated an impact evaluation of 77 PGECs that have been conducted in Africa, Asia and the Pacific, Europe and Latin America and the Caribbean from 1981 to the end of 2015. The methodology of the four-level Kirkpatrick evaluation model provided the basis for measuring effectiveness in an objective way. The aim was to evaluate the extent to which the PGEC has had an impact on: a) participants' professional career and personal development; and b) the application of knowledge and skills in support of the development and strengthening of radiation safety infrastructure at the organizational and/or national level.

This paper therefore describes the methodological basis of the impact evaluation of the PGEC; presents the results in a qualitative and quantitative manner; draws key conclusions; and reflects on the sustainability of the course.

1. Introduction

The Statute of the International Atomic Energy Agency includes the establishment of, and provision for, the application of Safety Standards for the protection of health, life and property against ionizing radiation. IAEA offers several approaches and mechanisms to support Member States to apply its Safety Standards, including rendering radiation safety services, providing technical cooperation, fostering information exchange, encouraging knowledge management and networking, and promoting education and training. The education and training activities that are supported and promoted by the IAEA are therefore aimed at fulfilling its statutory safety functions to assist Member States in their application of the Safety Standards.

IAEA's education and training activities are in-line with the resolutions of the General Conference and reflect IAEA Safety Standards [1, 2, 3]. A comprehensive portfolio of training packages and material in the field of radiation, transport and waste safety has been developed by IAEA, including:

- The Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources (PGEC) is a comprehensive and multidisciplinary 5.5-month long programme aimed at young professionals who may in later years become senior managers or high-level decision makers with responsibilities related to radiation protection. The PGEC was first run in Argentina in 1981 and is now offered at IAEA Regional Training Centres (RTCs) in Africa (English and French), Europe (English and Russian), Latin America and the Caribbean (Spanish and Portuguese), and Asia (Arabic and English);
- Specialized training courses of shorter duration (between 3 days to 6 weeks) that cover a range of subjects (e.g. regulatory framework; occupational protection; patient protection; radioactive waste management; transport of radioactive materials; and the safety of radioactive sources) and are offered for various target audiences (such as regulators; workers in industry, medicine and research; and medical staff);
- A training course for Radiation Protection Officers (RPO)[1] is based on a syllabus with a core module and practice-specific modules. The core module is aimed at providing a basic understanding of radiation protection principles and source safety, the general requirements of the IAEA Basic Safety Standards [1] and the duties of the radiation protection officer. Practice-specific modules cover the additional topics to be covered by RPOs at a range of medical and industrial facilities;
- Train-the-Trainers (TTT) courses are aimed at developing participant's communication and presentation skills and familiarizing them with various training methodologies. The course is aimed at building a core of national trainers in radiation protection and it is highly interactive with an emphasis on practicing the required skills. TTT courses for RPOs in medical and industrial applications have been conducted around the world at both national and regional levels.

In 2016, IAEA's Division of Radiation, Transport and Waste Safety (who are responsible for the technical oversight of the PGEC) decided to initiate an evaluation of the PGEC with regard to its long- and short-term impact on: a) the career and professional development of the participants; and b) the utilization of their new knowledge and skills towards strengthening the radiation safety infrastructure in their home country. This paper presents the findings of that impact evaluation at the individual and organizational/national level.

2. Overview of the PGEC

IAEA's PGEC is based on a standard syllabus [4] that is derived from the IAEA Safety Standards. The syllabus is currently being updated to take account of the most recent IAEA Safety Standards and to ensure its consistency with the International Commission on Radiological Protection´s (ICRP) recommendations. The updated course syllabus covers: Review of Fundamentals; Quantities and Measurements; Biological Effects of Ionizing Radiation; International System of Radiation Protection and the Regulatory Framework; General Requirements for Protection and Safety; Assessment of External and Internal Exposures (other than medical); Planned Exposure Situations - Generic Requirements; Planned Exposure Situations – non-medical applications and medical applications; Emergency Exposure Situations; Existing Exposure Situations. The PGEC also includes a module on 'Train the Trainers' as well as a work (research) project in which participants are encouraged to focus on a topic that will be of direct benefit to their institution or home country.

[1] Radiation Protection Officer, according to the IAEA Basic Safety Standards, is a person technically competent in radiation protection matters relevant for a given type of practice who is designated by the registrant, licensee or employer to oversee the application of relevant requirements.

Figure I.1 in Annex I provides a detailed overview of the course structure. The course is implemented through a blended learning approach (Table I.1), where specific activities (e.g. pre-training, collection of course feedback and implementation of the training impact evaluation) are conducted online through the IAEA Cyber Learning Platform for Network Education and Training (CLP4NET), whereas the rest of the course includes face-to-face components, (e.g. lectures, assessments of competence, laboratory exercises, technical visits etc.). Assessment and evaluation mechanisms are included in the course structure (definitions and objectives of such mechanisms are provided in Table I.2). The impact evaluation of the present paper refers to the B4 evaluation, i.e. the impact questionnaires (see Figure I.1 and Table I.2).

2. PGEC impact evaluation: Methodology

In 2016, an impact evaluation of the PGEC was initiated, through the collection of data based on self-assessment, to review the impact the course has had in terms of:

- Participants' career and professional development (individual level) (see sections 3.1-3.2);
- Utilization of knowledge and skills towards strengthening radiation safety infrastructures (organizational and/or national level) (see section 3.3).

The impact evaluation also included questions to evaluate the sustainability and effectiveness of the PGEC (see section 3.4). The evaluation of training activities can be divided into four different levels according to the Kirkpatrick Model, namely reaction (level 1), learning (level 2), behaviour (level 3) and results (level 4). The PGEC impact evaluation is based on this model, which was developed by Dr Donald Kirkpatrick, focusing on the training evaluation levels of behaviour, which seeks to demonstrate to what degree the acquired knowledge, skills and attitudes are being implemented on the job, and results, which seeks to establish the organizational outcomes as a result of training efforts [5].

In total, the impact evaluation was conducted for 77 PGECs hosted at the IAEA RTCs in the regions of Africa, Asia and the Pacific, Europe and Latin America and the Caribbean from 1981, when the first course was hosted in Argentina, to the end of 2015. Questionnaires were developed to follow-up with the participants 1, 3 and 5 years after they completed the course. An additional one-off evaluation was made for the PGEC courses that were conducted prior to this time frame (i.e.: more than 5 years after the completion of the course). This is referred to as the 'historic evaluation'. Table 1 provides an overview of the PGEC courses covered by the impact evaluation. The total number of participants eligible for the survey in the 1, 3 and 5 years' time frame is 1404.

The data collection process involved: registering all PGEC participants in IAEA's Moodle platform for e-learning (CLP4NET); distributing the questionnaire in the same language as course implementation (Arabic, English, French, Portuguese, Russian and Spanish) with an initial deadline of three weeks; and following-up with participants who did not respond to the initial questionnaire. The response rates varied across the various RTCs: for surveys conducted 1 year after the end of the PGEC the response rates ranged from 72% to 100%; after 3 and 5 years from 58% to 92%; and for surveys conducted more than 5 years after course completion (the 'historic evaluation'), the response rate was between 33% to 69% (See Table 1).

1 YEAR			3 YEARS			5 YEARS			More than 5 years (historic evaluation)		
RTC	No. of participants (No. of courses)	Response rate	RTC	No. of participants (No. of courses)	Response rate	RTC	No. of participants (No. of courses)	Response rate	RTC	No. of participants (No. of courses)	Response rate
ALG	23 (1)	74%	ALG	20 (1)	70%	ARG	11 (1)	82%	ARG	482 (29)	33%
ARG	12 (1)	92%	GHA	20 (1)	80%	MAL	27 (1)	70%	BYE	142 (7)	38%
BRA	1 (1)	100%	BYE	13 (1)	92%	MOR	20 (1)	75%	GRE	57 (3)	69%
GHA	18 (1)	100%	MAL	47 (2)	58%				MAL	145 (7)	52%
GRE	13 (1)	100%							MOR	121 (6)	48%
MAL	61 (2)	72%							SYR	171 (10)	33%
Total of surveyed participants (courses): 128 (7)			Total of surveyed participants (courses): 100 (5)			Total of surveyed participants (courses): 58 (3)			Total of surveyed participants (courses): 1118 (62)		

Legenda: IAEA RTC hosted in Algeria (ALG), Argentina (ARG), Brazil (BRA), Belarus (BYE), Ghana (GHA), Greece (GRE), Malaysia (MAL), Morocco (MOR), and Syria (SYR).

Table 1: Impact evaluation conducted 1, 3, 5 and more than 5 years (historic evaluation) after course completion.

3. Results

3.1 PGEC participants' work category

The PGEC is run on a regional basis and is open to participants from Member States that are receiving technical assistance from the IAEA. Recognizing that many such Member States need to build or strengthen their regulatory competence in radiation protection and the safety of radiation sources, priority is often given to young professionals who have recently joined a regulatory body. This can be seen in Fig 1 (a), which also shows that while some participants have moved to work in a regulatory body shortly after recently completing the course, this is balanced out in the longer term (Fig 1 (b)). After regulators, the next most common work categories are participants from the medical/health care professions and Radiation Protection Officers. This is show in Fig 1, along with the other work categories of PGEC participants. For all courses, and as shown below, an increase can be observed in the percentage of participants currently working as qualified experts (QE) and radiation protection officers (RPO). However, it should be noted that comments provided by participants indicated that the functions of QE and RPO are often in addition to other responsibilities.

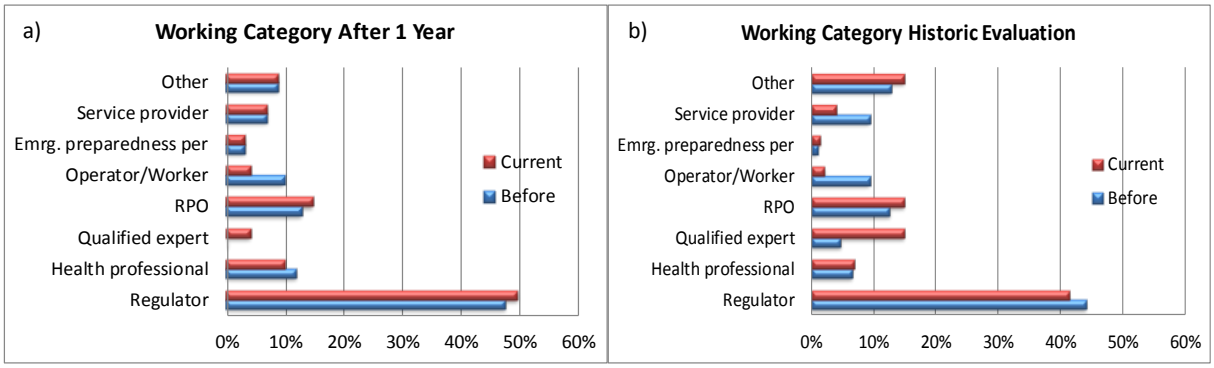

Fig 1. Percentage of participants' working categories, before attending the course and after course completion (1 year (a), and more than 5 years (historic evaluation) (b)).

3.2. Impact of the PGEC on professional career and development

Current and previous professional levels

More than 80% of the surveyed participants were at the staff-level before the course. As can be seen in Figure 2 there is a distinctive shift from staff-level to managerial and senior managerial positions after completion of the course. The percentage of participants gaining a managerial position constantly increases with time after having completed the PGEC. In fact, the total percentage of participants at the managerial and senior managerial level increased by a factor 1.4 after 1 year (from 16% to 23% - Figure 2(a)), 1.9 after 3 years (from 20% to 38% - Figure 2(b)), 2.2 after 5 years (from 21% to 46% - Figure 2(c)), and 3.4 after more than 5 years (historic evaluation) (from 16% to 54% - Figure 2(d)).

Comments provided by participants gave further evidence to support that the PGEC contributed to improving their professional development. Many participants reported that after the course they were assigned additional/new managerial responsibilities and some were promoted to be the Head of Authorizing or Licensing Divisions/Section, Director of the Regulatory Body, or even assigned governmental functions up to the Ministerial level.

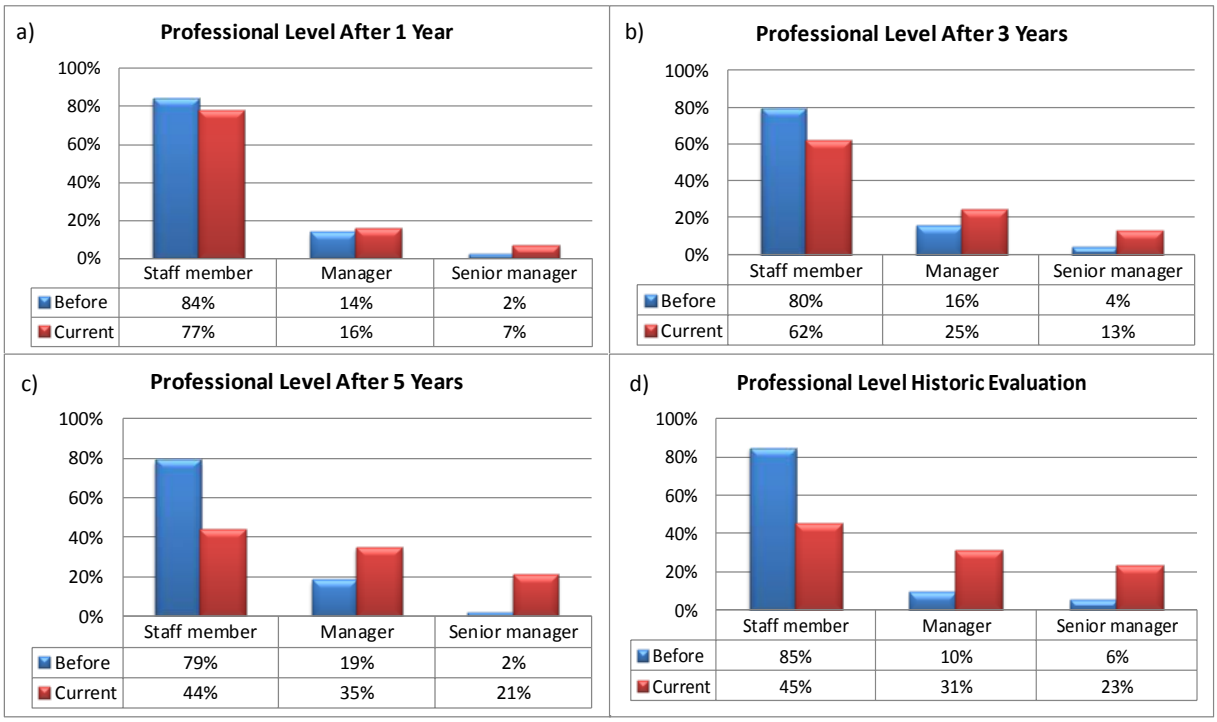

Fig 2. Percentage of participants` professional levels before attending the course and after course completion (1 year (a), 3 years (b), 5 years (c) and more than 5 years (historic evaluation) (d)).

Impact of the PGEC on professional development

Overall, the majority of surveyed participants confirmed that the PGEC has had a positive impact on their professional development irrespective of the time period passed since they completed the course. About 50% of the participants rated the PGEC as having a 'high' impact on their professional development 1, 3, and 5 years after the completion of the course (Figure 3(a) shows the results after 1 year). Longer-term, (more than 5 years after course completion (Figure 3(b)), the percentage of participants rating the impact of the PGEC as being 'high' on their professional development increases up to 74%.

The impact of the PGEC can also be related to the number of participants who acquired additional tasks and/or responsibilities as a direct result of attending the PGEC. This means that even if the participants did not necessarily climb in professional level (Figure 2(a)), the

PGEC still had a significant impact as it assisted participants to attain more responsibilities. As shown in Figure 4(a), this was the case for 51% of the participants. According to participants' comments, additional responsibilities included, for example: the development of radiation safety legislation; engagement in emergency preparedness and waste management projects; conducting medical radiation survey program; and planning training for medical physicists. The impact evaluation for the same period also indicated that the job performance had improved either significantly or partially as a result of attending the PGEC for nearly all of the participants (94% - Figure 4(b)), with the majority (67%) rating the impact to be significant.

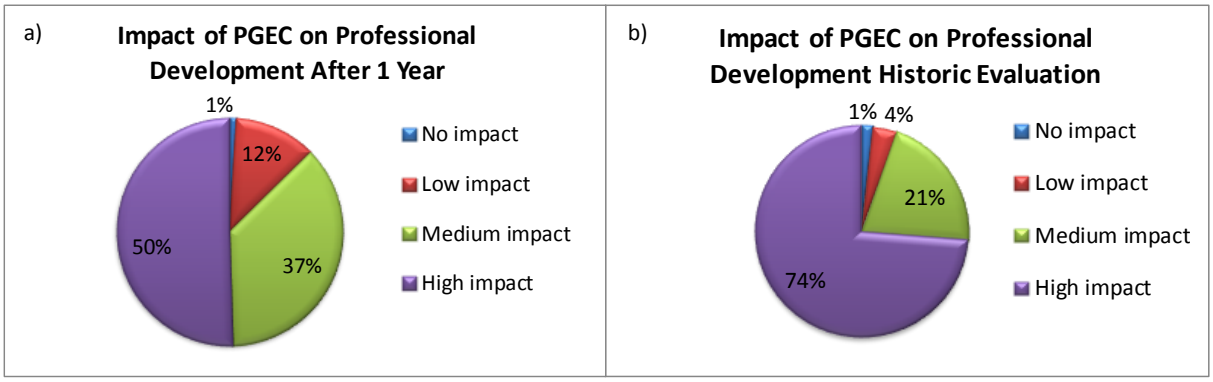

Fig 3. Percentage of participants stating that the PGEC had a positive impact on their professional development (1 year (a) and more than 5 years (historic evaluation) (b) after course completion).

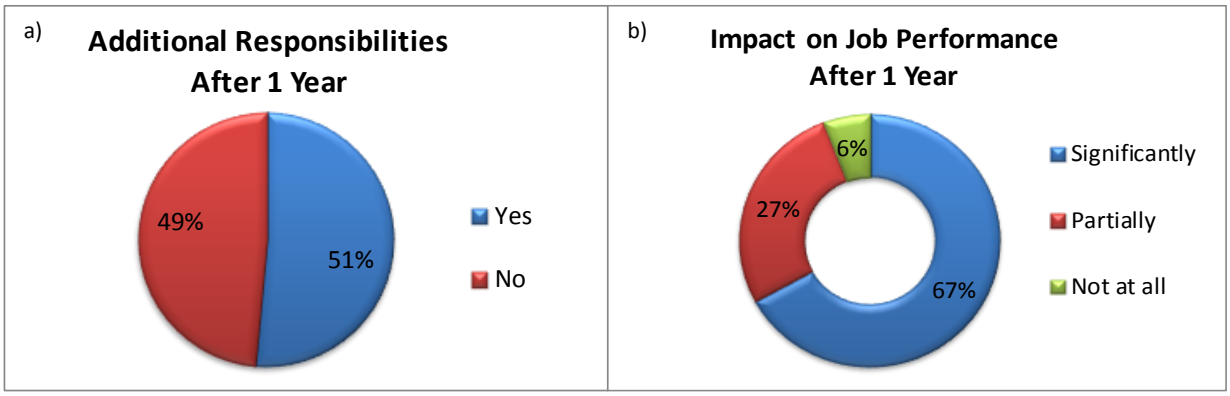

Fig 4. Percentage of participants stating that the PGEC had an impact on acquiring additional tasks (a) and improving job performance (b) (1 year after course completion).

3.3. Impact of the PGEC on Radiation Safety Infrastructure

IAEA categorises Member States' radiation safety infrastructure in terms of Thematic Safety Areas (TSA) to ensure that all aspects of the relevant IAEA Safety Standards are covered in a comprehensive and consistent manner:

- TSA1: Regulatory Infrastructure;
- TSA2: Radiological Protection in Occupational Exposure;
- TSA3: Radiological Protection in Medical Exposure;
- TSA4: Public and Environmental Radiological Protection;
- TSA5: Emergency Preparedness and Response;
- TSA6: Education and Training in Radiation Protection; and
- TSA7: Transport safety.

Surveyed participants were requested to rate the extent to which they used their knowledge and skills gained from the PGEC to have an impact in areas pertaining to the various TSAs.

The results of the evaluation show that the impact of the course has been multifaceted in terms of improving the national radiation safety infrastructure. In particular, some correlation has been observed among the job category of the surveyed participants and to what degree they have impacted the various activities associated with each TSA. In the questionnaire, participants were asked to evaluate the extent to which the knowledge and skills gained in the PGEC has had an impact on each TSA. In case of a sample including all participants (Figure 5(a)), there is some evidence that the percentage of answers stating that the PGEC has had a high-moderate impact on TSA1, TSA2 and TSA6 is significantly higher than the percentage of answers for the low-no impact. On the other hand the percentage of answers for the impact on TSA3, TSA4, TSA5 and TSA7 seems to be equally distributed between high-moderate and low-no impact. If the same analysis is conducted for a subsample of participants (regulators), there is clear evidence that the course has impacted on most of the TSAs, with the highest rate associated to TSA1: this reflects the fact that all the TSAs include activities related to the development and establishment of regulations and guidance (often associated to the regulators' functions) and that TSA1 is the TSA specifically focused on regulatory aspects. On the other side, if the same analysis is conducted for a subsample of health professionals, the course seems to have significantly impacted activities related to TSA3: this reflects the fact that TSA3 covers all the aspects related to radiological protection in medical exposure. Some impact of the course on TSA6 can also be pointed out, while all the other TSAs have been significantly less impacted. Similar trends can also be observed for the impact evaluation conducted 3, 5 and more than 5 years after completion of the PGEC.

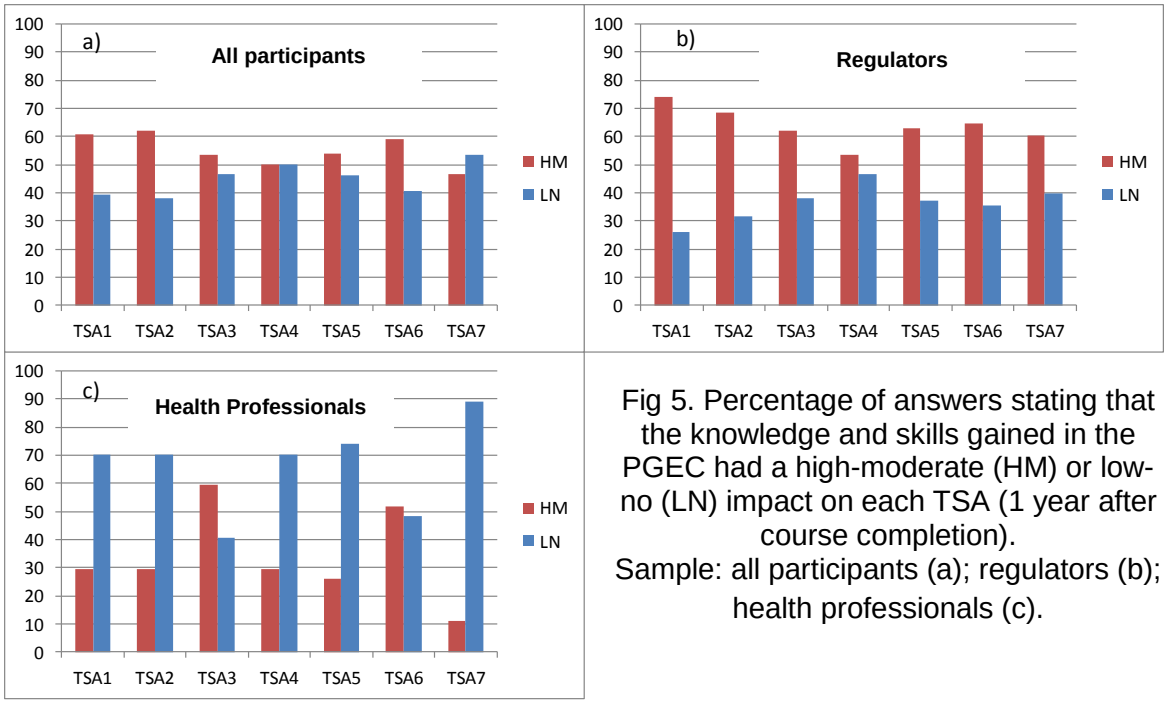

Fig 5. Percentage of answers stating that the knowledge and skills gained in the PGEC had a high-moderate (HM) or low-no (LN) impact on each TSA (1 year after course completion).
Sample: all participants (a); regulators (b); health professionals (c).

3.4. Sustainability and effectiveness of the PGEC

Continuity of the PGEC work project

Participants are required to carry out a work (research) project to demonstrate their ability to apply the knowledge and skills acquired during the course; and to present the results and outcomes of their project at the end of the course. The project should be aimed at solving a specific radiation protection problem in the participant's home country. Suitable ideas/topics for the project should be identified by each participant in consultation with their national authorities. Participants are expected to continue performing follow-up activities related to their work project after they have completed the PGEC.

The fact that many participants reported that they do continue with their work project when they get home is a good indicator of the sustainability of the course. The results of the impact evaluation show that 1 year after completing the PGEC, 56% of the participants confirmed that they have been able to conduct follow-up activities planned in their work project.

Sharing knowledge and skills

Acquiring the necessary basic skills to become trainers in radiation protection is one of the objectives of the PGEC, as the sharing of knowledge and skills acquired during the course is a key factor in supporting sustainability. The majority of the participants confirmed that they have used the knowledge and skills acquired during the PGEC to organize and/or implement a training event in radiation protection and the safe use of radiation sources. The affirmative response tends to increase with time completion of the PGEC, from 54% after 1 year, to 64% after 3 years, and 72% after 5 years (Figure 6).

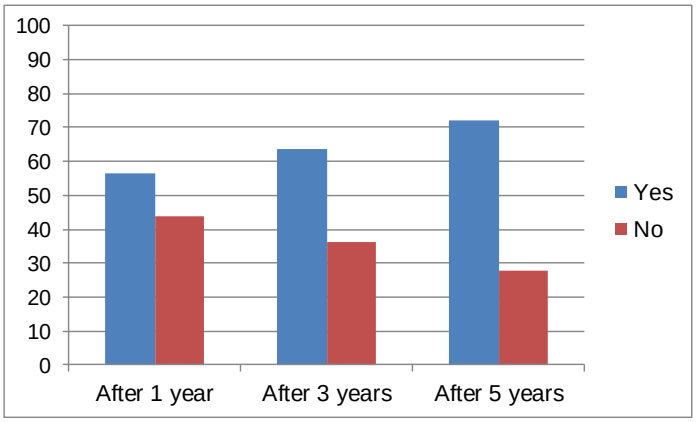

Fig 6. Percentage of participants sharing knowledge and skills gained in the PGEC, by organizing or implementing training events (1, 3 and 5 years after course completion).

Contribution towards academic and/or professional development

The sustainability of the PGEC can also be attributed to the development of the professional and/or academic development of the participants. Feedback from the participants confirms that the knowledge and skills acquired during the PGEC enabled them to attend specialized training courses (35% of answers), train-the-trainers events (26%), and high-level academic programmes (26% for masters and PhD).

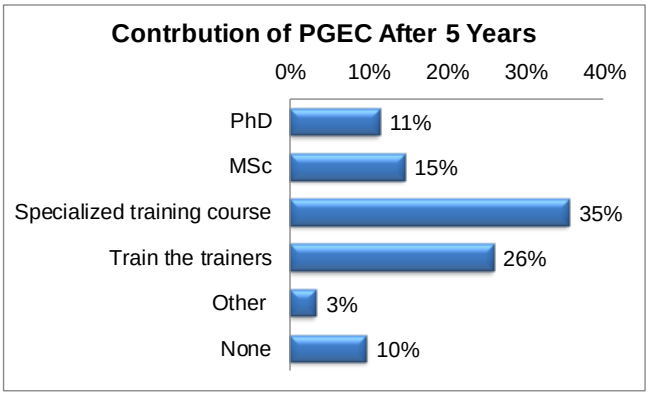

Fig 7. Percentage of affirmative answers for the contribution of the PGEC towards specific professional and/or academic development (5 years after course completion).

On-going success of the PGEC

More than 90% of participants recommended attending the PGEC to their colleagues and/or employees, irrespective of the time passed since course completion. This reflects the usefulness, value and relevance of the course.

4. Conclusions

The responses from the PGEC participants, confirmed that the course has had a positive impact on their professional careers. Furthermore the utilization of knowledge and skills acquired during the course has made a significant contribution towards strengthening the radiation safety infrastructure in their home country or institution.

The course is clearly highly valued and well-respected. Completion of the PGEC has helped participants gain additional responsibilities and duties, and it has had a substantial impact on their personal development, irrespective of the time passed since they completed the course. The PGEC has also contributed towards their academic advancement in terms of attaining an MSc or PhD.

Moreover, the impact evaluation confirmed the sustainability of the PGEC in several aspects, such as continuation of the work project, sharing knowledge and skills through implementation of training events in radiation protection, and an ongoing recommendation from participants to their colleagues to attend the course.

In conclusion, the impact evaluation of the PGEC confirmed that the course plays an important and remarkable role by building a core of competent professionals in radiation protection and in strengthening the radiation safety infrastructure at the institutional and/or national levels.

Annex I: PGEC: assessment and evaluation; blended learning approach

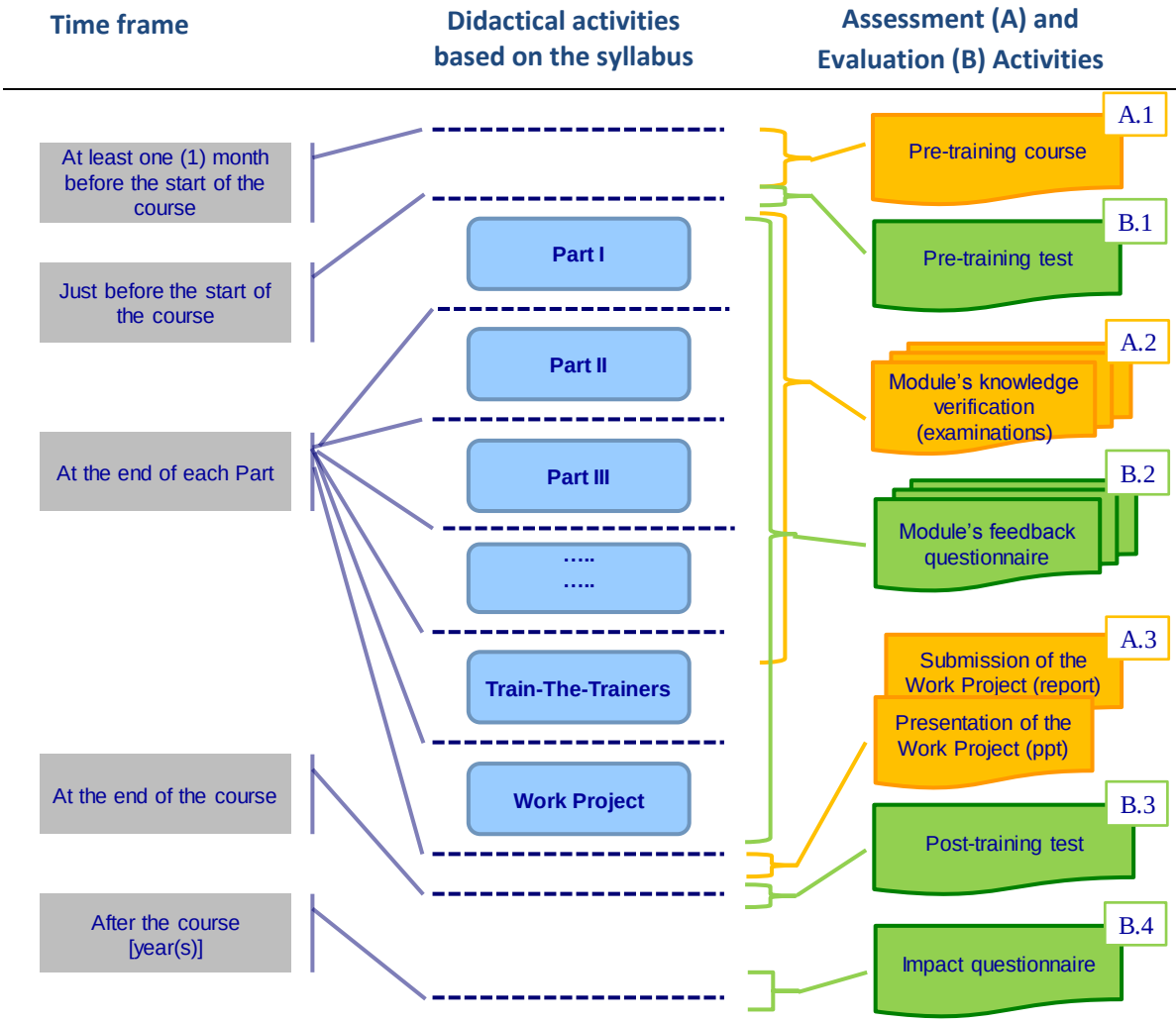

Fig. I.1 Structure and time frame for the conduction of the PGEC (see also Table 2 for definitions and objectives of the evaluation and assessment mechanisms)

Activity	Blended learning components of PGEC			
	Current		*Future*	
Didactical				
All Parts	CR		CR	DL (e-learning)
Assessment				
A.1		DL (e-learning)		DL (e-learning)
A.2	CR		CR	
A.3	CR		CR	
Evaluation				
B.1, B.3	CR			DL (e-learning)
B.2		DL (e-learning)		DL (e-learning)
B.4		DL (e-learning)		DL (e-learning)

Tab. I.1 Current status and future initiatives to expand the blended learning approach for the PGEC (CR: class room/face-to-face; DL: distance learning)

ASSESSMENT A structured activity by which the knowledge and/or skills and/or attitudes of an individual are measured using one or more methods. Assessment is often conducted at the end of a training session or course to determine the extent to which trainees have met the training objectives **Objectives:**	
A.1	To refresh the knowledge of the participants on basic subjects to facilitate their attendance at the PGEC To get information on possible gaps in participants competence
A.2	To evaluate participants' knowledge and understating of the subject presented in each Module
A.3	To evaluate participants' capability to make use of the knowledge gained in the course to address a specific issue of radiation protection, relevant to the national contest To provide an opportunity to evaluate participants' knowledge and understanding of the subject presented in the Module "Train-the-Trainers (TTT)'
EVALUATION A series of activities used to measure the *adequacy and effectiveness* of a training session, course or programme (Evaluation is of "things" in contrast to an Assessment which is used as a measure of individuals). **Objectives:**	
B.1	To have an overall evaluation of the gain of knowledge (coupled with B.3)
B.2	To collect participants' (and lecturers') feedback on the delivery of the Module and on Lecturers' performance
B.3	To have an overall evaluation of the gain of knowledge (coupled with B.1)
B.4	To evaluate the long-term impact of the course (*cold assessment*)

Table I.2: Evaluation and assessment mechanisms: definitions and objectives.

References

[1] EUROPEAN COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Building Competence in Radiation Protection and the Safe Use of Radiation Sources, IAEA Safety Standards Series No. RS-G-1.4, IAEA, Vienna (2001).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Training in Radiation Protection and the Safe Use of Radiation Sources, Safety Reports Series No. 20, IAEA, Vienna (2001).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Postgraduate Educational Course in Radiation Protection and the Safe Use of Radiation Sources, Standard Syllabus, Training Course Series No. 18, IAEA, Vienna (2002).

[5] KIRKPATRICK, DONALD L. & KIRKPATRICK, JAMES D., Evaluating Training Programs: The Four Levels, Berrett-Koehler Publishers; 3rd edition (2006).