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IAEA-TECDOC-1882

Impact of the IAEA Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources (1981–2015)

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IMPACT OF THE IAEA POSTGRADUATE EDUCATIONAL COURSE IN RADIATION PROTECTION AND THE SAFETY OF RADIATION SOURCES (1981–2015)

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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2019

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Printed by the IAEA in Austria
Septemeber 2019

IAEA Library Cataloguing in Publication Data

Names: International Atomic Energy Agency.
Title: Impact of the IAEA postgraduate educational course in radiation protection and the safety of radiation sources (1981-2015) / International Atomic Energy Agency.
Description: Vienna : International Atomic Energy Agency, 2019. | Series: IAEA TECDOC series, ISSN 1011–4289 ; no. 1882 | Includes bibliographical references.
Identifiers: IAEAL 19-01262 | ISBN 978–92–0–159319–1 (paperback : alk. paper) | ISBN 978–92–0–159419–8 (pdf)
Subjects: LCSH: Radiation — Safety measures. | Impact assessment. | Professional development. | International Atomic Energy Agency.

FOREWORD

The IAEA promotes peaceful uses of nuclear energy, while recognizing that the safe use of radiation technology and nuclear applications depends on maintaining a competent and skilled workforce. The IAEA Statute authorizes the IAEA to encourage the exchange and training of scientists and experts in peaceful uses of nuclear energy, and to provide for the application of standards of safety for protection of health and minimization of danger to life and property, at the request of a State, to any of that State's activities in the field of atomic energy. Each of these elements is essential to ensuring the suitable qualification of personnel and the protection of people and the environment from harmful effects of ionizing radiation.

The IAEA's Postgraduate Educational Course (PGEC) in Radiation Protection and the Safety of Radiation Sources is a central part of the IAEA's training and education programme. The PGEC is intended to assist Member States in acquiring the radiation protection knowledge and skills necessary for the safe use of radiation sources. The course includes a 'train the trainers' module for participants who may themselves become trainers, thus supporting the sustainability of the training delivered by providing participants with the necessary skills to organize and deliver similar training courses in turn.

The first PGEC in Radiation Protection and the Safety of Radiation Sources was conducted in Argentina in 1981; since then, the course has been delivered in Asia, Africa, Europe and Latin America. The PGEC is held regularly at nine IAEA Regional Training Centres and is conducted in Arabic, English, French, Portuguese, Russian and Spanish. To date, over 1900 participants from more than 120 IAEA Member States have successfully completed the PGEC.

This publication reports on an evaluation of the impact of the PGEC on the professional development of its participants, on use of the knowledge and skills acquired by the participants during the course, and on the strengthening of Member State radiation safety infrastructures. The evaluation covers 77 PGECs held between 1981 and 2015.

The IAEA would like to thank all the PGEC participants who participated in the evaluation and expresses its appreciation to all the participants who contributed to this publication. Particular thanks are due to G. Jorant (France) and S. Ticevic (Norway) for their assistance in the drafting and reviewing of this publication. The IAEA officer responsible for this publication was A. Luciani of the Division of Radiation, Transport and Waste Safety.

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CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

The peaceful uses of radiation have many beneficial applications and have an increasing importance in a wide range of areas.

Radiation is commonly used in industry (e.g. to irradiate food, to sterilize goods, to measure the properties of materials and to check their structural integrity). It is also widely used in the field of medicine, such as in diagnostic examinations (e.g. to detect and diagnose injury) and, at higher doses, in radiotherapy (to treat patients with cancer).

Radiation is also used in research and education for a number of purposes, including in geological testing and in biological and medical research.

A highly competent and well-educated workforce is needed to ensure that the use of radiation technologies, the transport of radioactive materials and dealing with radioactive waste are controlled within an appropriate legal and regulatory infrastructure, thus protecting people and the environment from potential harmful effects of radiation.

The Statute of the International Atomic Energy Agency authorizes the Agency to encourage the exchange and training of scientists and experts in the field of peaceful uses of atomic energy (Article III.A.4).

The Statute (Article III.A.6) also authorizes the Agency to establish standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards to the operations making use of materials, services, equipment, facilities, and information made available by the Agency or at its request or under its control or supervision; and to provide for the application of these standards, at the request of the parties, to operations under any bilateral or multilateral arrangement, or, at the request of a State, to any of that State's activities in the field of atomic energy.

The IAEA has developed several approaches and mechanisms to fulfil its statutory function of supporting Member States in applying the IAEA 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 conducted, supported and promoted by the IAEA are aimed specifically at supporting Member States in the application of IAEA safety standards.

The education and training activities of the IAEA follow the resolutions of IAEA General Conferences and reflect IAEA safety standards and guidance [1–4]. The IAEA's Division of Radiation, Transport and Waste Safety has developed a comprehensive portfolio of training packages and material.

The IAEA Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources (PGEC) is a central part of the programme to address Member States' needs for education and training.

The PGEC features a comprehensive and multidisciplinary programme targeting young professionals who may in later years become senior managers or decision makers with responsibilities relating to radiation protection. The course is hosted by designated IAEA Regional Training Centres (RTCs) in Africa, Asia, Europe and Latin America [5, 6].

Over the years of its existence, the PGEC has been constantly updated, enhanced and improved to meet changing requirements.

The IAEA Steering Committee on Education and Training in Radiation, Transport and Waste Safety recommended that specific impact evaluations be conducted. The impact evaluation should ensure a consistent approach to the process of continuous improvement for the programme and to generate evidence on its effectiveness [7].

As a result of this recommendation, a pilot evaluation was devised and conducted which covered four sample PGEC courses, from the Latin America and the Caribbean Region and from the Europe Region.

The findings highlighted the importance of the PGEC in developing the basic competence of participants in radiation protection and the safety of radiation sources.

Building on the lessons learned from the pilot evaluation, the evaluation questionnaires were redesigned to include specific questions on the application of knowledge and skills by the participants.

A wider impact evaluation was initiated in 2016 which covered 77 PGECs held between 1981 and 2015. The results of this wider impact evaluation are presented here.

1.2. OBJECTIVE

This report presents the results of the impact evaluation for the IAEA Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources (PGEC) for the period 1981 to 2015.

The report considers both the professional development of the participants (at the individual level) and the use of their learning towards strengthening radiation safety infrastructure (at the organizational level and at the national level).

The report also provides organizations offering education and training in the field of radiation protection and safety with a methodology for conducting their own impact evaluation.

1.3. SCOPE

The report describes the methodology and results of an impact evaluation of the IAEA PGEC. The impact evaluation was conducted in terms of the professional development of the participants, as well as the utilization of knowledge and skills acquired during the PGEC in strengthening the radiation safety infrastructure at the organizational level and at the national level.

The evaluation covers 77 PGECs that were conducted at the current IAEA Regional Training Centres in Algeria, Argentina, Belarus, Brazil, Ghana, Greece, Malaysia, Morocco and Syria between 1981 and 2015.

1.4. STRUCTURE

This report has nine sections including this introduction (Section 1).

Sections 2 introduces the programme structure (course structure and delivery modes) of the IAEA Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources (PGEC).

Section 3 presents the approach to and method of the evaluation of the impact of the PGEC.

Sections 4 to 8 present the findings of the impact evaluation.

Section 4 provides a cross-regional overview of the impact evaluation.

Sections 5 to 8 present results for each of the four world regions covered by the programme, namely: Africa Region; Asia and the Pacific Region; Europe Region; and Latin America and the Caribbean Region.

Section 9 presents conclusions with the key findings of the impact evaluation for the PGEC.

Finally, Annexes I to III present the four questionnaires submitted to the participants.

2. COURSE STRUCTURE AND MODES OF DELIVERY OF THE PGEC

2.1. THE PGEC PROGRAMME

The IAEA PGEC programme provides young professionals with a solid foundation in radiation protection and radiation safety.

The course content is based on IAEA safety standards and other international norms, recommendations and guidance. The course includes a ‘train the trainers’ module to provide participants with the necessary skills to organize and deliver similar training courses themselves.

The PGEC, lasting between 21 and 26 weeks to take account of local circumstances, entails three discrete types of activity: didactic (educational) activities, assessment activities and evaluation activities.

The didactic activities include theoretical and practical training based on the PGEC syllabus published in the IAEA Training Course Series [5].

The syllabus reflects current IAEA safety standards. The syllabus includes the following 12 parts:

- Part I: Review of fundamentals;
- Part II: Quantities and measurements;
- Part III: Biological effects of ionizing radiation;
- Part IV: The international system of radiation protection and the regulatory framework;
- Part V: Assessment of external and internal exposures (other than medical exposures);
- Part VI: Planned exposure situations: generic requirements;
- Part VII: Planned exposure situations: medical applications;
- Part VIII: Planned exposure situations: non-medical applications;
- Part IX: Emergency exposure situations;
- Part X: Existing exposure situations;
- Part XI: Training the trainers;
- Part XII: Work projects.

Didactic activities include:

- Lectures provided by local and international experts in the subject matter;
- Individual and/or group laboratory exercises;
- Technical visits and case studies;
- Work projects.

Assessment activities are used to measure the knowledge and skills gained by the students at various points throughout the course (see Fig. 1). Assessment activities include:

- On-line pre-training (A.1 in Fig. 1) and testing, which is done on-line prior to classroom learning;
- Verification (examination) of knowledge and skills gained for each part (A.2 in Fig. 1);
- Individual work projects (A.3 in Fig. 1), which are aimed at giving participants the opportunity to apply their knowledge and skills in addressing a real-life scenario, such as a specific problem in radiation protection in their Member State).

Evaluation activities focus on the adequacy and effectiveness of the course (see Fig. 1). Evaluation activities include:

- pre-training and post-training tests (B.1 and B.3 in Fig. 1) to assess knowledge gained in the training;
- feedback questionnaires collected after completion of each part of the course (B.2 in Fig. 1);
- a questionnaire on evaluation of impacts (B.4 in Fig. 1), the results of which are included in this report; these questionnaires enable the long term follow-up of the participants after one year, three years and five years.

Figure 1 provides an overview of the didactic activities, assessment activities and evaluation activities of the PGEC, as well as of the time-frame for their conduct.

2.2. A ‘BLENDED LEARNING’ APPROACH TO THE PGEC

The PGEC was delivered in a purely didactic manner until the end of 2012. In 2013 the PGEC adopted a ‘blended learning’ approach that combines e-learning with face-to-face learning, to utilize the best aspects of both.

The blended learning approach to the PGEC optimizes the use of available resources, facilitates the various activities, and provides a platform for future networking and for engaging course participants interactively. The blended learning approach also facilitates assessment and evaluation activities for the PGEC [8].

The blended learning approach is enabled by the IAEA's on-line education and training platform, the Cyber Learning Platform for Network Education and Training (CLP4NET).

The blended learning approach involves close collaboration between the IAEA and the PGEC directors at the IAEA Regional Training Centres. Activities to further develop the blended learning approach are currently under consideration, as indicated in Table 1.

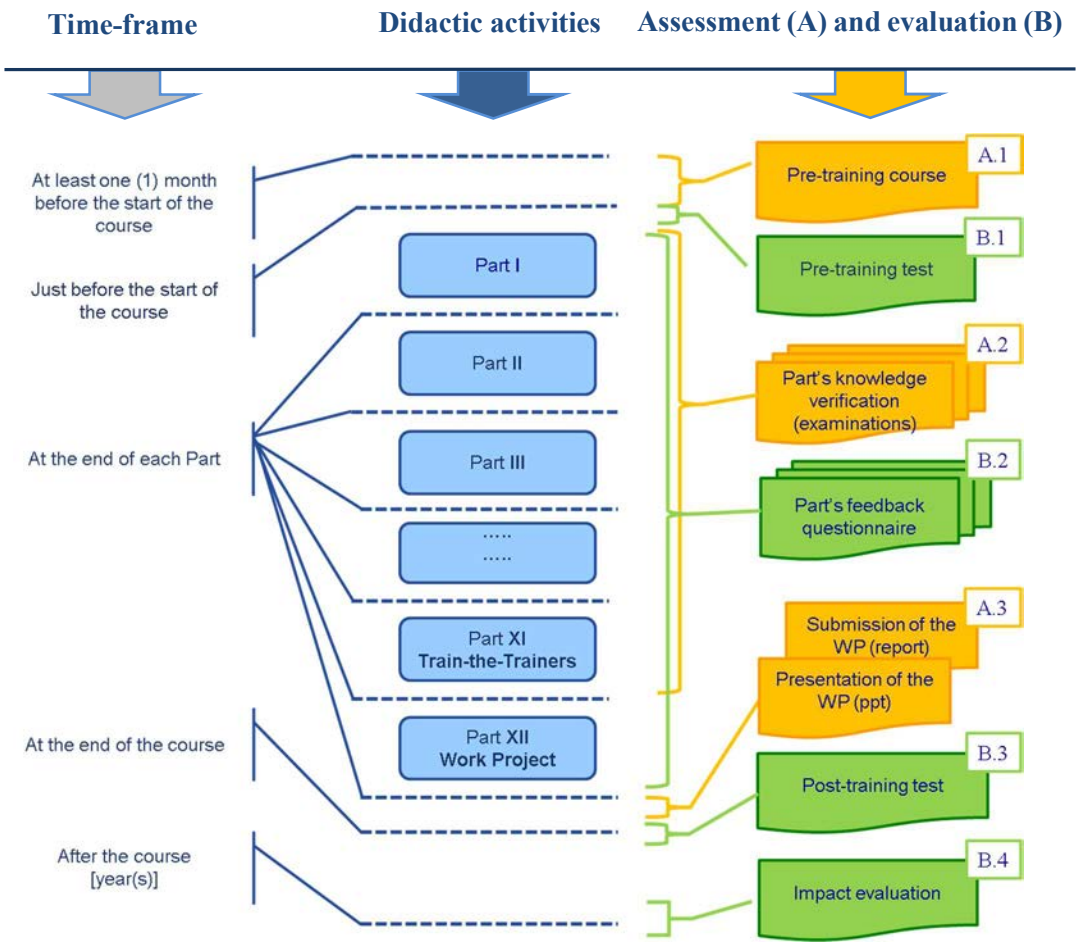

FIG. 1. Didactic activities, assessment activities and evaluation activities of the PGEC. Note: 'Part' refers to the parts the syllabus is structured into.

TABLE 1. 'BLENDED LEARNING': CURRENT AND FUTURE STATUS. OVERVIEW OF THE ASSESSMENT (A.1–A.3) AND THE EVALUATION (B.1–B.4)

Activity	PGEC blended learning components			
	Current		Future	
Didactic				
All parts	CL		CL	EL
Assessment				
Pre-training course (A.1)		EL		EL
Examinations (A.2)	CL		CL	
Work projects (A.3)	CL		CL	
Evaluation				
Pre-training and post-training tests (B.1, B.3)	CL			CL/EL
Participants' feedback questionnaires (B.2)		EL		EL
Impact evaluation (B.4)		EL		EL
Note: See the mechanism shown in Fig. 1. Note: CL: classroom learning; EL: e-learning.				

3. METHOD FOR THE IMPACT EVALUATION FOR THE PGEC

3.1. OBJECTIVES OF THE IMPACT EVALUATION FOR THE PGEC

The basis for the impact evaluation for the PGEC is derived from the Kirkpatrick model. The Kirkpatrick model, one of the most widely used models for the evaluation of training, uses four levels of evaluation to judge the effectiveness of a training programme [9].

The impact evaluation is geared towards two main objectives [10]. One seeks to understand the effects of the PGEC on the daily practice and the careers of its participants. The other examines the outcomes of the PGEC for local and national radiation safety infrastructures.

3.1.1. Professional development of participants

Participants need to be able to apply their competence and to transfer it readily from the PGEC to their organization and their daily work. In practice, however, local and specific circumstances may slow or even restrict such a transfer.

The impact evaluation, by means of recurrent and coordinated questionnaires (B.4), looked at the extent to which participants apply their newly acquired competence after they return to work in their Member States. It also sought to identify any barriers stopping them from doing so.

Additionally, the impact evaluation questionnaire records changes, prompted by the PGEC, that have occurred in the professional positions of the participants in terms of decision-making responsibilities and additional responsibilities.

3.1.2. Organizational and national radiation safety infrastructure

Beyond following the professional development of PGEC participants, the impact evaluation also focused on the degree to which targeted outcomes have been achieved as a result of the training [11].

To do so, the general outcomes of the programme were determined in relation to the seven thematic safety areas (TSAs) in radiation protection by which the IAEA categorizes the radiation safety infrastructure in its Member States.

This is done to ensure that all relevant IAEA safety standards are covered in a comprehensive and consistent manner [12].

The seven TSAs are:

- TSA1: Regulatory infrastructure;
- TSA2: Radiological protection in occupational exposure;
- TSA3: Radiological protection in medical exposure;
- TSA4: Public radiological protection and environmental protection;
- TSA5: Emergency preparedness and response;
- TSA6: Education and training in radiation, transport and waste safety;
- TSA7: Transport safety.

Participants surveyed were invited to state the extent to which the knowledge they had gained from the PGEC had been used to improve the national radiation safety infrastructure (see Annexes I and III, Part 3, for the questions relating to the different TSAs)[1].

The impact evaluation for the PGEC combines what is referred to in the Kirkpatrick model as Level 3 (behaviour) and Level 4 (results), following the approach to the evaluation as described here.

[1] For a general overview of the different TSAs covered by the evaluation questionnaires and for more details, refer to Annex I, Part III, Question 13 and Annex II, Part III, Question 14.

3.2. PARTICIPANTS SURVEYED FOR THE IMPACT EVALUATION

3.2.1. Short term and long term follow-up of the impact of the PGEC

Impact evaluations were conducted following a recommendation of the IAEA Steering Committee on Education and Training in Radiation, Transport and Waste Safety, to ensure a consistent approach to the process of continuous improvement for the PGEC and to generate evidence on its effectiveness.

The evaluation process followed an approach of surveying groups of participants one year, three years or five years after completion of the courses, as agreed with the directors of the PGEC Regional Training Centres.

This was the first impact evaluation for the PGEC, and participants were thus surveyed after only one of the time intervals (i.e. after one year, after three years or after five years). In the future, surveying the same groups of participants at further intervals, and thus after successively greater time periods, would provide valuable data, notably in terms of professional development.

The two-year differences between the intervals for the surveys for different groups did take account in general of participants' progressive application of their PGEC related learning in their daily practice.

Completing the periodic surveys, a one-off 'historical evaluation' (hereinafter termed the 'historical evaluation') includes those courses organized before 2011 whose impacts were not recorded in the previous surveys. The historical evaluation offered an opportunity to access a larger number of participants, in addition to providing insights on the long term effects of the PGEC.

Altogether, since the first PGEC was held (in 1981) in Argentina, 90 courses have been conducted, training over 1600 participants from more than 120 Member States. The impact evaluation, conducted from 2016, covered 77 courses run between 1981 and 2015, for which 1404 participants were eligible for the survey.

3.2.2. Response rates for the impact evaluation

Figure 2 shows the response rates in relation to the total number of participants completing the courses (i.e. the 'respondents'). It was observed that the response rates decrease over time, with a high of 81% and a low of 38%. This was especially true for the historical evaluation, which covered courses that took place from 1981 to 2010.

3.3. QUESTIONNAIRES FOR THE IMPACT EVALUATION

In line with the aforementioned approach of periodic surveys (see Section 3.2.1), three questionnaire templates were developed to conduct the impact evaluation for the PGEC course, namely[2]:

- a follow-up questionnaire after one year;
- a follow-up questionnaire after three to five years;
- for the historical evaluation, a follow-up questionnaire after more than five years.

[2] The questionnaire templates are provided in Annexes I to III.

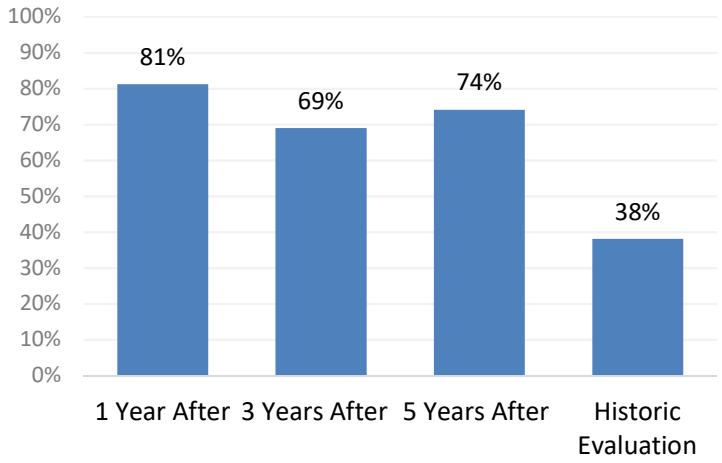

FIG. 2. Response rates for the impact evaluation questionnaire after completion of the courses: after one year, T (total respondents) = 103; after three years, T = 69; after five years, T = 43; historical evaluation, T = 431.

All questionnaires share the same three parts: (1) 'personal background'; (2) 'professional development' (notably identifying the participants' working areas and professional levels before and after of the course); and (3) 'using and sharing what you learned' (identifying the participants' impact on the local and national radiation safety infrastructure).

Beyond a shared core of questions, the questionnaires differ from each other partly in order to capture the most from the different survey times. The 'one year after' questionnaire focuses on the short term effects of the PGEC, such as its impact on the participants' performance and additional responsibilities.

Both the 'three years after' and the 'five years after' questionnaires examine whether participating in the PGEC helped participants to take other, more specialized, courses and/or training. Finally, the historical evaluation broadly covered the same areas at a relatively higher level.

The questionnaires were provided in the language of the course, i.e. in either Arabic, English, French, Portuguese, Russian or Spanish. Answers were translated into English for the evaluation.

3.4. ANALYSIS AND REPORTING OF OUTCOMES OF THE IMPACT EVALUATION: KEY CONSIDERATIONS

3.4.1. A regional overview of the impact evaluation

The outcomes of the impact evaluation are organized to provide a regional overview in line with the allocation by the IAEA Department of Technical Cooperation of IAEA Member States to four world regions: Africa Region; Asia and the Pacific Region; Europe Region; and Latin America and the Caribbean Region.

In general, when two or more courses were conducted in the same year, or in the same period for a given location, the data have been merged; e.g. PGEC courses held in Algeria and Ghana in 2013 (Africa Region), or courses held in Malaysia in 2014 and 2015 (Asia and the Pacific Region): refer to Table 2 for the complete overview.

Similarly, if for a given Region the impact evaluation has been conducted for only one PGEC course, then the outcomes have been reported for that course only; e.g. for the PGEC course offered in Belarus in 2013 (Europe Region).

As for the historical evaluation, results have been merged for each Region to evaluate the long term impact of the courses.

TABLE 2. OVERVIEW OF THE IMPACT EVALUATIONS FOR TRAINING COURSES HELD AT THE VARIOUS IAEA REGIONAL TRAINING CENTRES

After one year	After three years	After five years	Historical evaluation
Algeria	Algeria	Argentina	Argentina (29 courses)
Argentina	Belarus	Malaysia	Belarus (7 courses)
Brazil	Ghana	Morocco	Greece (3 courses)
Ghana	Malaysia (2 courses)		Malaysia (7 courses)
Greece			Morocco (6 courses)
Malaysia (2 courses)			Syrian Arab Rep. (10 courses)

3.4.2. Quantitative and qualitative answers in the evaluation

While ratings (quantitative answers) of participants who had responded (i.e. respondents) provide an overview of the various aspects of the impact of the courses, the open questions (with qualitative answers) allow for a more specific understanding[3].

Examples and quotes are included throughout the report to highlight the diversity of those answers.

3.4.3. Factors in applying knowledge and skills that are unrelated to training

Many factors unrelated to attending the PGEC can influence the participant's level of application of knowledge, skills and attitudes gained from the course.

Such factors that may have a negative effect include a lack of resources, lack of encouragement and lack of opportunities within the organization. Merit awards, recognition and praise from managers or an encouraging atmosphere at work have a positive influence on the application of learning [13].

These factors are often mentioned in comments by participants, but they are difficult to record meaningfully and their effects cannot be accurately estimated.

3.5. THE DATA COLLECTION PROCESS FOR THE EVALUATION

3.5.1. Distribution of questionnaires

The IAEA's on-line education and training platform, the Cyber Learning Platform for Network Education and Training (CLP4NET), was used to distribute the questionnaires and to serve as a repository for the replies, for several reasons.

Firstly, CLP4NET provides support to its users and serves as a secure repository for data collected. Secondly, as the platform hosts the PGEC's on-line pre-training course, participants already had access to the platform. Thirdly, embedding the impact evaluation into the course as an on-line activity, and as an integral part of the blended learning approach, made it easier to conduct long term follow-up.

The initial step of the data collection process consisted in registering the participants in the PGEC course on the platform (see Fig. 3). A link to the on-line questionnaire was distributed with a submission deadline of three weeks.

FIG. 3. Data collection process for the impact evaluation for the PGEC course. NLO: national liaison officer; PMO: programme management officer.

[3] Qualitative answers were interpreted by grouping them according to the working categories of the participants, with priority given to the PGEC's target group, those working for the regulatory body (i.e. 'regulators').

Follow-up reminders, primarily per e-mail, were sent to participants who had not responded in the first or second week after distribution of the on-line questionnaire.

Finally, upon expiry of the deadline, national liaison officers of the respective Member States of the participants as well as IAEA programme management officers for the relevant courses were contacted.

3.5.2. Challenges in collecting responses to the questionnaires

Two main challenges were faced in collecting responses to the questionnaires: in contacting the participants and in ensuring successful completion of the questionnaires.

The main difficulty in contacting the participants concerned the differing availability of their contact details. Since the PGEC impact evaluation extended back to 1981, e-mail addresses were often lacking.

Outdated work e-mail addresses, closed e-mail accounts and errors in databases likewise made it difficult to reach participants.

These issues were partly resolved by involving IAEA Regional Training Centres and cross-matching databases. Contacting participants who had responded and requesting alternative contact details for participants who had not responded proved to be another effective approach. Frequently, PGEC participants had formed professional relationships and had kept in touch with one another after the course.

The second challenge concerned non-completion of the questionnaires. Heavy workloads, low interest in the follow-up or other issues may explain the absence of responses.

Additional reasons for non-completion of the questionnaires originated from technical difficulties, such as difficulties with the on-line connection of the participant.

4. RESULTS OF THE IMPACT EVALUATION FOR THE PGEC: GENERAL OVERVIEW

4.1. CONDUCT OF THE PGEC

The PGEC has been conducted regularly at IAEA Regional Training Centres since 1981 to train participants from Member States that receive technical assistance from the IAEA.

The first ever IAEA PGEC was held in Argentina in Spanish for the Latin America and the Caribbean Region in 1981.

The PGEC is currently run worldwide on a regional basis and is delivered in six different languages (Arabic, English, French, Portuguese, Russian and Spanish) at seven IAEA Regional Training Centres:

- in the Africa Region (Algeria, Ghana and Morocco);
- in the Latin America and the Caribbean Region (Argentina and Brazil);
- in the Europe Region (Greece and Belarus);
- in the Asia and the Pacific Region (Malaysia)[4].

The impact evaluation for the PGEC presented in this TECDOC includes answers from 646 respondents from the 1404 participants in 77 courses that were run between 1981 and 2015 (see Table 3).

4.2. PROFESSIONAL BACKGROUND OF PARTICIPANTS

In recognition of the fact that Member States need to establish or to strengthen their regulatory competence in radiation protection and the safety of radiation sources, priority in the selection of participants is given to young professionals who had recently joined a regulatory body.

[4] The four regions correspond to the IAEA Department of Technical Cooperation's four regions: Africa Region; Asia and the Pacific Region; Europe Region; and Latin America and the Caribbean Region.

TABLE 3. IMPACT EVALUATION CONDUCTED ONE YEAR, THREE YEARS AND FIVE YEARS AFTER COMPLETION OF THE COURSE, PLUS HISTORICAL EVALUATION, UP TO 2015: IAEA REGIONAL TRAINING CENTRES IN ALGERIA (ALG), ARGENTINA (ARG), BRAZIL (BRA), BELARUS (BYE), GHANA (GHA), GREECE (GRE), MALAYSIA (MAL), MOROCCO (MOR) AND SYRIAN ARAB REPUBLIC (SYR)

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	484 (29)	30%
ARG	12 (1)	92%	GHA	20 (1)	80%	MAL	27 (1)	70%	BYE	142 (7)	37%
BRA	1 (1)	100%	BYE	13 (1)	92%	MOR	20 (1)	75%	GRE	55 (3)	69%
GHA	18 (1)	100%	MAL	47 (2)	58%				MAL	145 (7)	53%
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)		

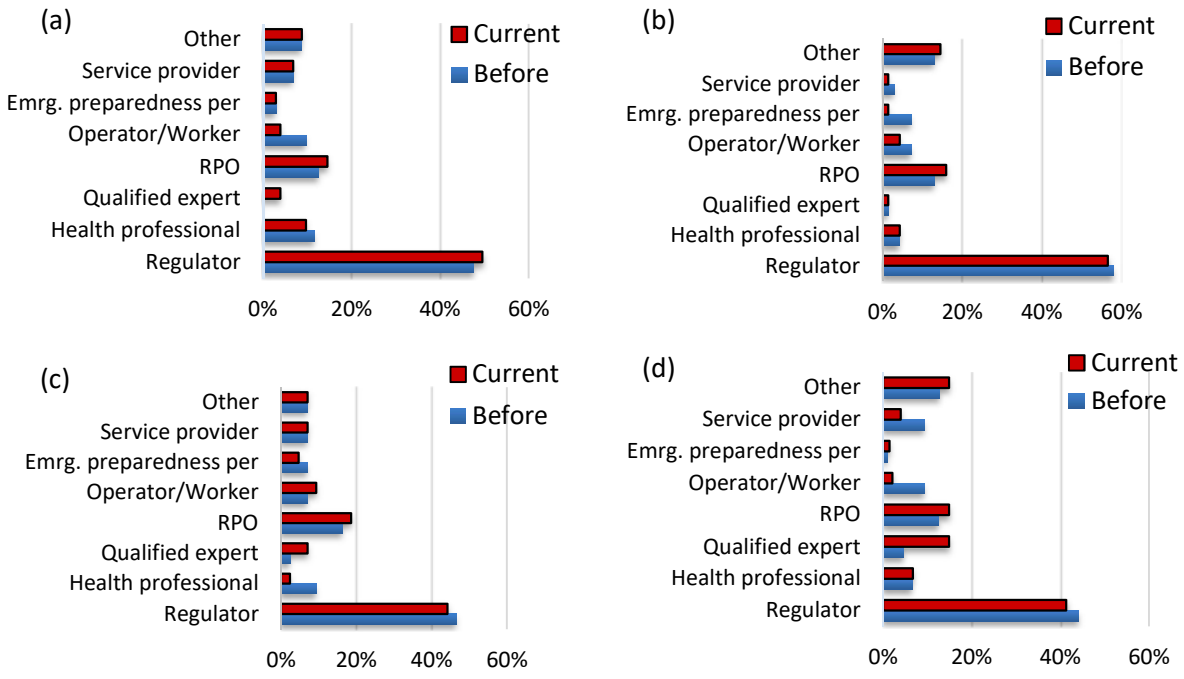

FIG. 4. Distribution of respondents per category of work, before and after attending the course: (a) after one year, T (total respondents) = 103; (b) after three years, T = 69; (c) after five years, T = 43; (d) historical evaluation, T = 431. Note: Emrg. preparedness per: emergency preparedness personnel; RPO: radiation protection officer.

The predominance of those working for regulatory bodies reflects the fact that priority was given to those applicants. The next most well represented working category is 'radiation protection officer' (RPO), as shown in Fig. 4.

In all periods considered, an increase in the percentage of participants currently working as 'qualified experts' and as 'radiation protection officers' was observed. In their comments, respondents often reported performing the functions of 'qualified expert' and of 'radiation protection officer' in addition to other responsibilities.

4.3. IMPACT OF THE PGEC ON PARTICIPANTS

4.3.1. Pre-PGEC versus post-PGEC professional levels

Monitoring the professional progress of PGEC participants helps in understanding the influence of the programme over time.

As shown in Fig. 5, about 80% of the participants surveyed worked at staff level before the course. The percentage of participants in a managerial position increased continuously with time. In fact, the total percentage of participants at the managerial level and the senior managerial level had already increased by a factor of 1.4 (i.e. by 40%) by one year after their participation in the course.

The longer ago the participant had taken part in the course, the more this shift from 'staff member' towards managerial positions had increased — to an increase by a factor of up to 3.4 (i.e. by 240%) in the historical evaluation from staff to managerial and senior managerial positions (see Fig. 5(d)).

To some extent, this reflects a typical career progression: as staff who were PGEC participants gained experience, staff were promoted to higher positions.

Beyond the typical career path, a certain boosting effect of the PGEC on the careers of its participants can be inferred. Comments of respondents also bear out the observation of a noticeable influence of the PGEC on their professional development.

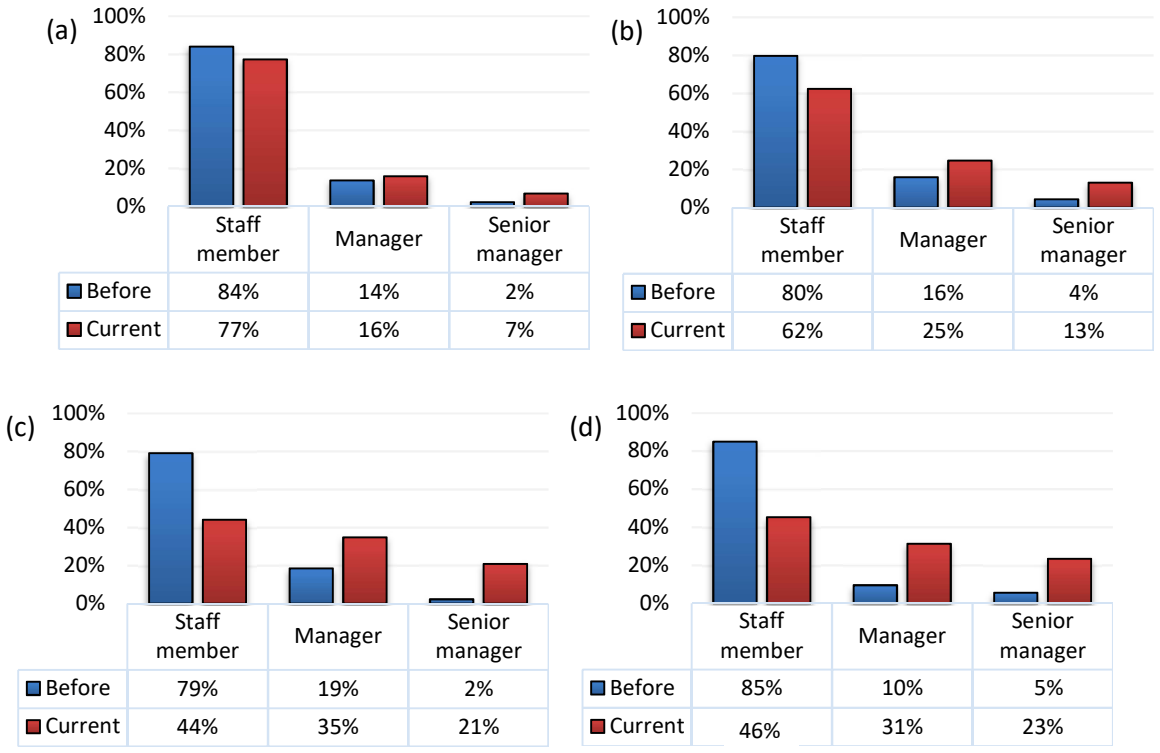

FIG. 5. Percentage of participants per professional level before attending and after completion of the course: (a) after one year, T (total respondents) = 103; (b) after three years, T = 69; (c) after five years, T = 43; (d) historical evaluation, T= 431.

4.3.2. Effects of the PGEC on the professional development of participants

Overall, a clear majority of respondents reported that the PGEC had a beneficial impact on their professional development (see Fig. 6).

After just 1 year, about half the respondents stated that the PGEC had had a 'high' impact on their professional development. In the longer term, the proportion increased even further, up to 74%, as shown in Fig. 6(d).

In addition to evaluating the professional development of participants, increases in work performance and gaining of additional responsibilities were also considered. Figures 7 (a) and (b) shows that one year after completion of the PGEC, more than half the participants had gained additional responsibilities and stated that their work performance had generally improved.

As such, although some respondents remained at the same hierarchical level, e.g. 'staff member', the PGEC had already contributed to their professional development in the short term.

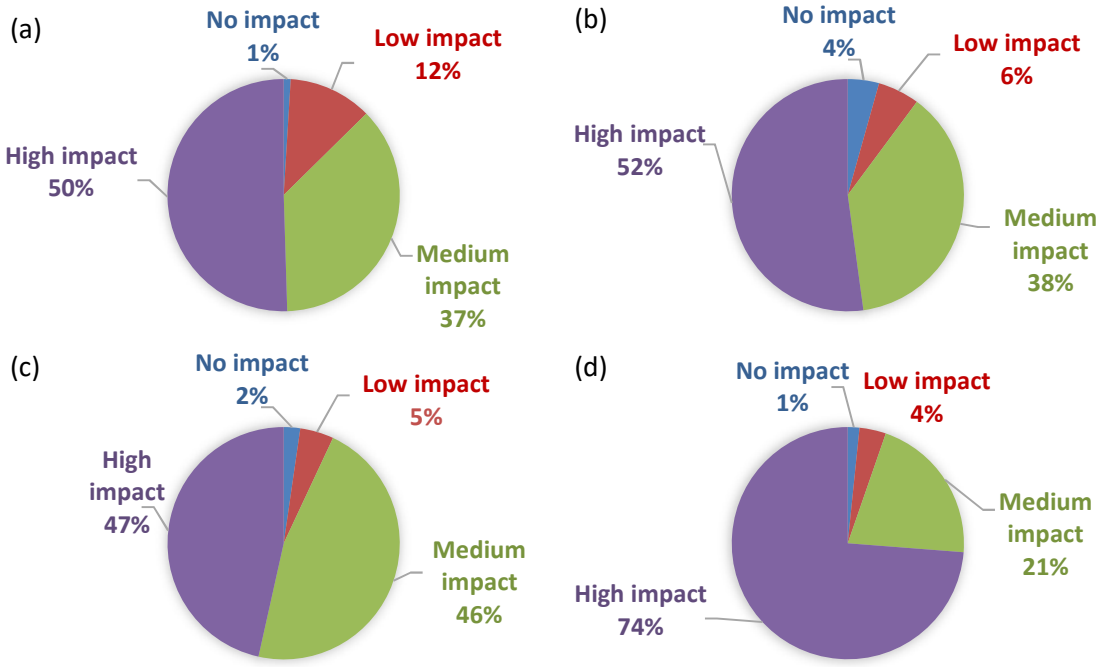

FIG. 6. Participants stating that the PGEC had had a positive impact on their professional development after completion of the course: (a) after one year, T (total respondents) = 103; (b) after three years, T = 69; (c) after five years, T = 43; (d) historical evaluation, T = 431.

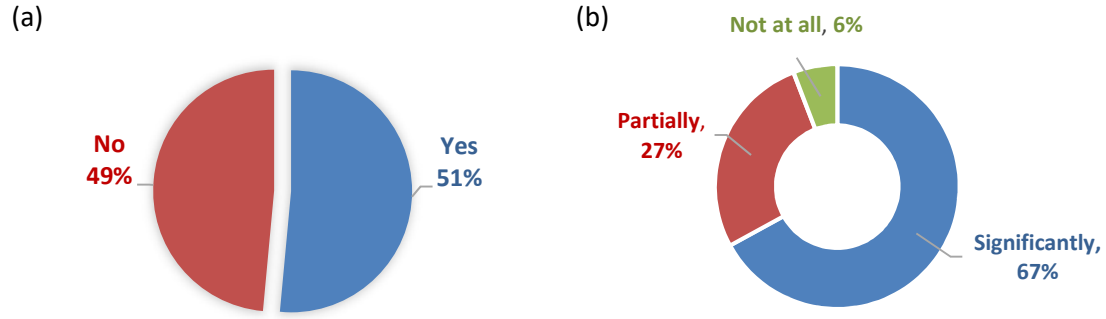

FIG. 7. Participants stating one year after completion of the course that the PGEC had had an impact on: (a) acquiring additional tasks; (b) their job performance. Total respondents T = 103.

4.4. IMPACT OF THE PGEC ON RADIATION SAFETY INFRASTRUCTURE

The results of the evaluation showed that participants attending the PGEC subsequently had a positive impact on the national radiation safety infrastructure (see Fig. 8). The results also revealed a correlation between the working category and the impact in the different thematic safety areas (TSAs) (see Section 3.1).

In general, the percentage of respondents stating that the knowledge and skills that they had acquired in the PGEC had had a high or medium (HM) impact on TSA1, TSA2 and TSA6 was higher than the percentage of respondents stating that there was only a low or no impact (LN) (see Fig. 8(a)). For thematic safety areas TSA3, TSA4, TSA5 and TSA7, respondents seemed to be equally distributed between those stating that there was a high or medium impact and those stating that there was a low or no impact.

For those respondents in the working category 'regulators', the PGEC had a positive effect on all TSAs; altogether relatively evenly, as shown in Fig. 8(b). It is worth noting that all TSAs include specific activities relating to the development and establishment of regulations and guidance (often associated with the functions of the regulatory body), for which regulators are responsible. As TSA1 is focused specifically on regulatory aspects, those PGEC participants from regulatory body clearly had a higher positive impact in this area.

Similar results can also be observed for the impact evaluation conducted after three years and after five years and for the historical evaluation.

In looking at other working categories, such as health professionals, the PGEC course seems to have had an impact mainly on activities relating to one TSA, while barely affecting the other TSAs. For health professionals, the course had an impact on TSA3, which covers radiological protection in medicine (see Fig. 8(c)).

The analysis specific to regions mostly focused on the PGEC's principal grouping of respondents and main target group, namely, respondents from the regulatory body.

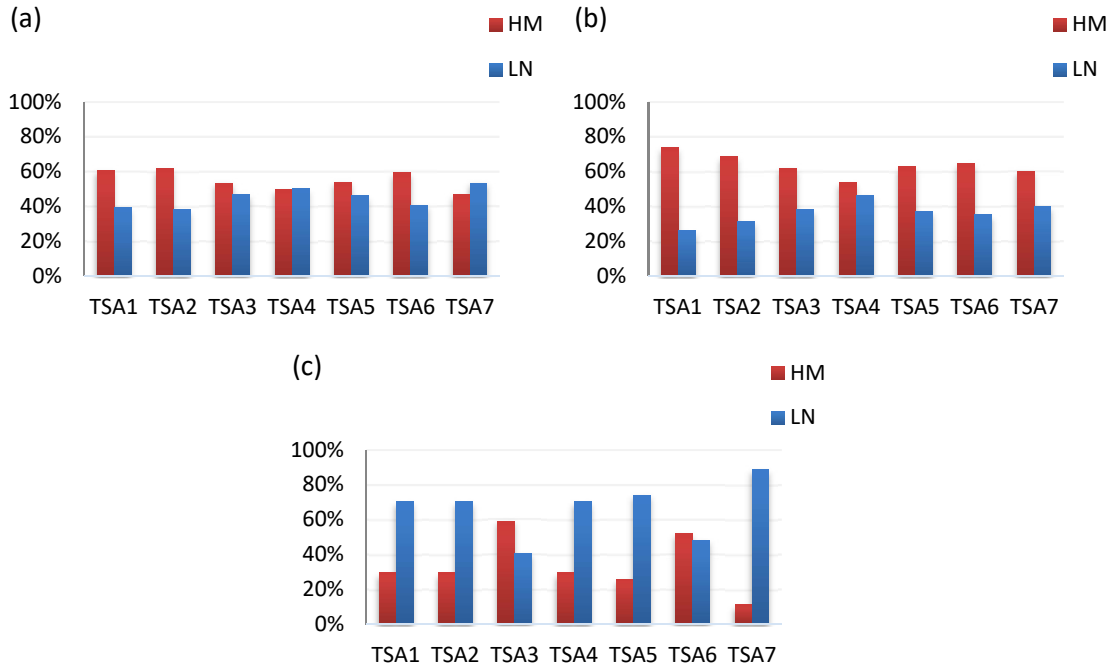

FIG. 8. Responses from participants who were from a regulatory body stating that one year after completion of the course, the knowledge and skills gained in the PGEC had had a high to medium (HM) or a low or no (LN) impact on each TSA: (a) all participants, T (total respondents) = 103; (b) 'regulators', T = 51; (c) 'health professionals', T = 9.

4.5. SUSTAINABILITY AND EFFECTIVENESS OF THE PGEC

'Sustainability and effectiveness' together refer to the ability to apply the competences acquired during the PGEC, as well as the end-of course work projects, to the radiation safety infrastructure in Member States.

To support the beneficial impact of the course, the use of newly acquired competences is monitored through four indicators: the follow-up of work projects (Section 4.5.1); the sharing or dissemination of the knowledge acquired (Section 4.5.2); the contribution of the PGEC to academic development (Section 4.5.3); and the readiness of participants to recommend the PGEC to their peers (Section 4.5.4).

4.5.1. Continuation of the PGEC work projects

Participants in the PGEC each carried out a work project or research project that targeted a specific and relevant challenge in their home country. The results and expected outcomes were presented at the end of the course. This enabled participants to demonstrate and practice their new competences and show their ability to pursue their efforts on returning home, thereby contributing directly to strengthening local and national infrastructure in the Member States.

A majority of the participants reported pursuing their work projects beyond the PGEC.

4.5.2. Sharing knowledge and skills

Acquiring the necessary competences to become a trainer and to organize training in radiation protection is one of the PGEC's essential objectives, as it fosters sustainability and amplifies the local effects of the course. Indeed, spreading of the competences acquired in the course is key to ensuring a lasting impact.

Most of the respondents confirmed having made use of the competences acquired in the PGEC in order to organize and hold training events in radiation protection and the safe use of radiation sources.

The affirmative responses tend to increase over time, from 54% one year after completion of the course, to 64% three years after completion of the course and 72% five years after completion of the course (see Fig. 9).

4.5.3. Contribution of the PGEC to development of competence

As shown in Fig. 10, the PGEC's sustainability can also be expressed through its boosting effects on the professional and/or academic development of participants. Feedback from participants confirms that their participation in the PGEC enabled them to further develop their competences.

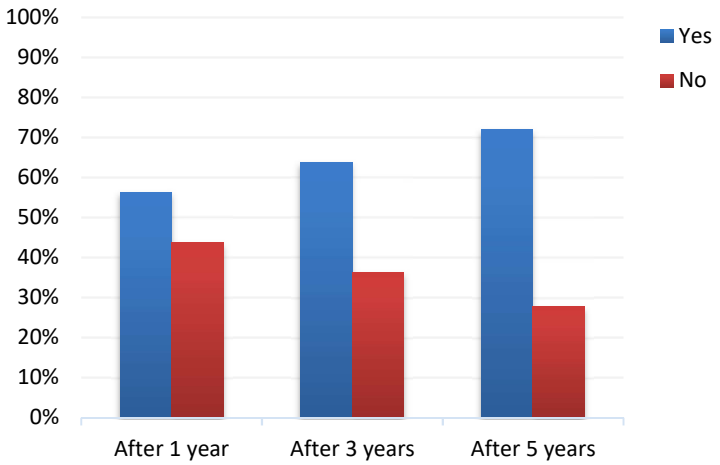

FIG. 9. Respondents' sharing of knowledge and skills gained in the PGEC by organizing or implementing training events after completion of the course: (a) after one year, T (total respondents) = 103; (b) after three years, T = 69; (c) after five years, T =43.

This was achieved mainly by participants attending specialized training courses (24% after three years and 35% after five years), 'train the trainers' events (24% after three years and 26% after five years), and higher level academic programmes (19% after three years and 26% after five years for master's degrees or doctorates).

4.5.4. Recommending the PGEC: ongoing success of the PGEC

Regardless of the time passed since participation in the course, about 90% or more of respondents had recommended the PGEC to their colleagues or employees, as shown in Fig. 11. This testified to the perceived usefulness, value and relevance of the course.

4.6. AREAS FOR IMPROVEMENT FOR THE PGEC

In addition to the general positive evaluation of the PGEC and in view of the aforementioned limiting factors (see Section 3.4.3), various areas of improvement were identified from both the quantitative responses and the qualitative responses that were collected.

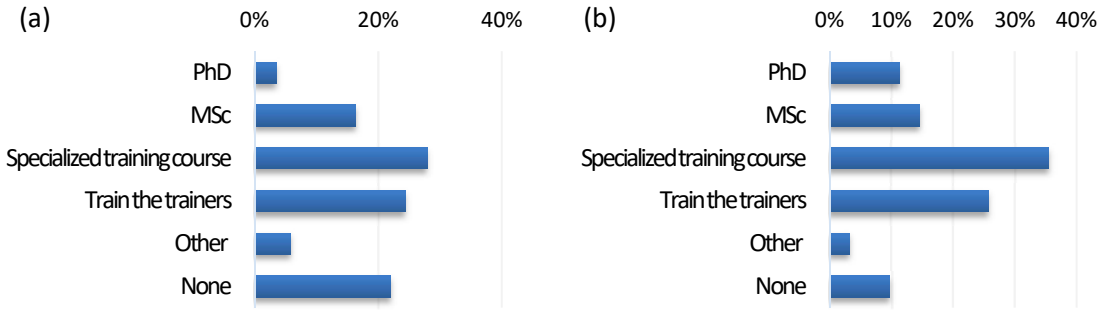

FIG. 10. Percentage of affirmative answers for the contribution of the PGEC towards specific professional or academic development: more than one answer could be selected: (a) after three years, T (total respondents) = 69; (b) after five years, T = 43.

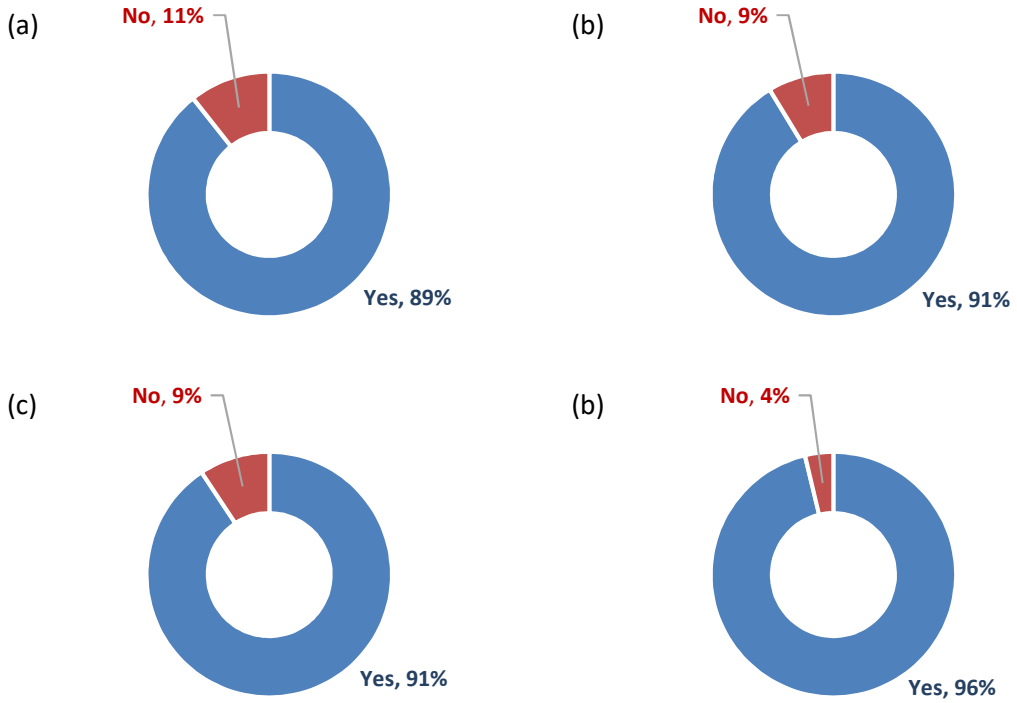

FIG. 11. Percentage of respondents recommending the PGEC to their colleagues or employees for all time periods (after completion of the course) of the impact evaluation: (a) after one year, T (total respondents) = 103; (b) after three years, T = 69; (c) after five years, T = 43; (d) historical evaluation, T = 431.

Five particular areas of improvement emerged that could further enhance the PGEC's benefits:

- Increasing the share of practical exercises;
- Fostering the PGEC's (formal) recognition;
- Enhancing work projects;
- Introducing refresher courses;
- Involving more participants in the PGEC programme and creating a community of current and former participants (i.e. 'alumni').

These five areas of improvement for enhancing the benefits of the PGEC programme are discussed below.

4.6.1. Increasing the practical exercises

Practical exercises, especially when coupled with visits, are an effective way to acquire skills and competences. Participants themselves called for an increasing share of practical exercises in the programme. Action to increase the share of practical work and visits will further increase the benefits derived from the PGEC.

4.6.2. Fostering formal recognition of the PGEC

Fostering the course's formal recognition is another area that would yield benefits. In terms of its length, and the depth and breadth of its subject matter, the PGEC is a one-of-a-kind programme.

This that makes the PGEC an attractive programme for young professionals from all over the world and for those Member States that year after year send young professionals to participate in the course.

However, this uniqueness also makes it difficult for the PGEC to be recognized formally in the Member States of the participants.

As the report shows, many participants pursued academic degrees and other training after attending their PGEC. The comments of participants also reflected the desire for more formal recognition of the course in their Member States.

For example, the fact that some IAEA Regional Training Centres partner with universities to confer academic recognition of the PGEC is considered to be very beneficial.

Exploring ways to foster further recognition of the knowledge and skills gained on the course by participants would help the PGEC in achieving a greater impact on national radiation safety infrastructure and in supporting the professional careers of its participants.

4.6.3. Enhancing work projects

Work projects are an essential element of the PGEC and would benefit from further enhancement.

As mentioned by participants, their PGEC work project often led to further academic development. However, although many such projects had been put into effect and pursued, a number were found to have been discontinued or to have gone unheeded.

Respondents often called for more time and support for developing their work projects. Finding ways to support and improve the design, development and application of work projects could lead to further impacts on local or national radiation safety infrastructure.

4.6.4. Envisaging refresher courses

Refresher courses and activities to help in bringing up to date the knowledge of former participants, and to spread the learning of present and past participants, would help in sustaining and updating the knowledge and skills imparted by the course.

4.6.5. Creating a community of participants

Involving former participants in the PGEC programme, for example by inviting them to lecture on the course, and creating a community of participants (Alumni) could also enhance the programme's benefits.

5. RESULTS OF THE IMPACT EVALUATION FOR THE PGEC: AFRICA REGION

5.1. CONDUCT OF THE PGEC

The PGEC is currently conducted at three IAEA Regional Training Centres in the Africa Region: in Algeria (since 2013) and in Morocco (since 2003) in French, and in Ghana (since 2012) in English.

Portuguese speaking applicants from the Africa Region could apply to participate in the course conducted on an ad hoc basis at the IAEA Regional Training Centre in Brazil. For the period covered by the present impact evaluation, this has occurred just once, for a participant from Angola; that participant has been included in the impact evaluation for the Africa Region.

The impact evaluation for the PGEC for these RTCs in the Africa Region was based on answers from 139 participants in 12 PGEC courses (see Table 4).

5.2. PROFESSIONAL BACKGROUND OF PARTICIPANTS

The majority of PGEC participants were from, and remain in, the regulatory body (see Fig. 12).

TABLE 4. IMPACT EVALUATION CONDUCTED ONE YEAR, THREE YEARS AND FIVE YEARS AFTER COMPLETION OF THE PGEC COURSE PLUS HISTORICAL EVALUATION UP TO 2015: IAEA REGIONAL TRAINING CENTRES IN ALGERIA (ALG), GHANA (GHA) AND MOROCCO (MOR)

1 YEAR			3 YEARS			5 YEARS			HISTORIC EVALUATION		
RTC	No. of participants	Response rate	RTC	No. of participants	Response rate	RTC	No. of participants	Response rate	RTC	No. of participants	Response rate
ALG	23	74%	ALG	20	70%	MOR	20	75%	MOR	121	48%
GHA	18	100%	GHA	20	80%						
BRA	1	100%									
Total Respondents		36			30			15			58
YEAR WHEN THE PGEC WAS CONCLUDED FOR EACH REGIONAL TRAINING CENTRE IN THE REGION (RTC)											
ALG 2015			ALG 2013			MOR 2011			MOR (6 courses) 2003 2004 2005 2006 2007 2009		
GHA 2015			GHA 2013								
BRA 2015											

Regardless of the time passed since completion of the course, former participants who work as radiation protection officers constitute the PGEC's second biggest group[5]. Although potentially significant, this fact needs to be qualified.

Firstly, the title 'radiation protection officer' benefits from a high level of social recognition.

Also, many of the radiation protection officer's tasks and activities are often assumed in addition to their actual occupation, which pertains to one of the other working categories mentioned in Fig. 12.

Finally, in some legislation, the job description for 'radiation protection officer' includes tasks that elsewhere would pertain to the working category of 'regulator'.

Experience shows that medical physicists ('health professionals'), managers ('operators') and inspectors ('regulators') often also perform the duties of the radiation protection officer at their work places.

For all the aforementioned reasons, some of the respondents may have favoured declaring themselves as radiation protection officers, even though another category might have been more appropriate.

[5] A 'radiation protection officer' is defined as 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 regulatory requirements (Ref. [2], p.410): http://www.pub.iaea.org/MTCD/publications/PDF/Pub1578_web-57265295.pdf.

Other working categories, including the category 'regulator', may therefore have been even better represented among the overall number of respondents than is suggested by the data provided here.

The other categories considered (e.g. 'service providers' and 'qualified experts') were less well represented in the short term as they were not the primary target audience for the courses.

Lastly, participants who declared themselves as belonging to the working category 'other' stated that they worked in areas such as environmental control and monitoring, industry (product and quality management), research (e.g. for a Ph.D.) or national institutions.

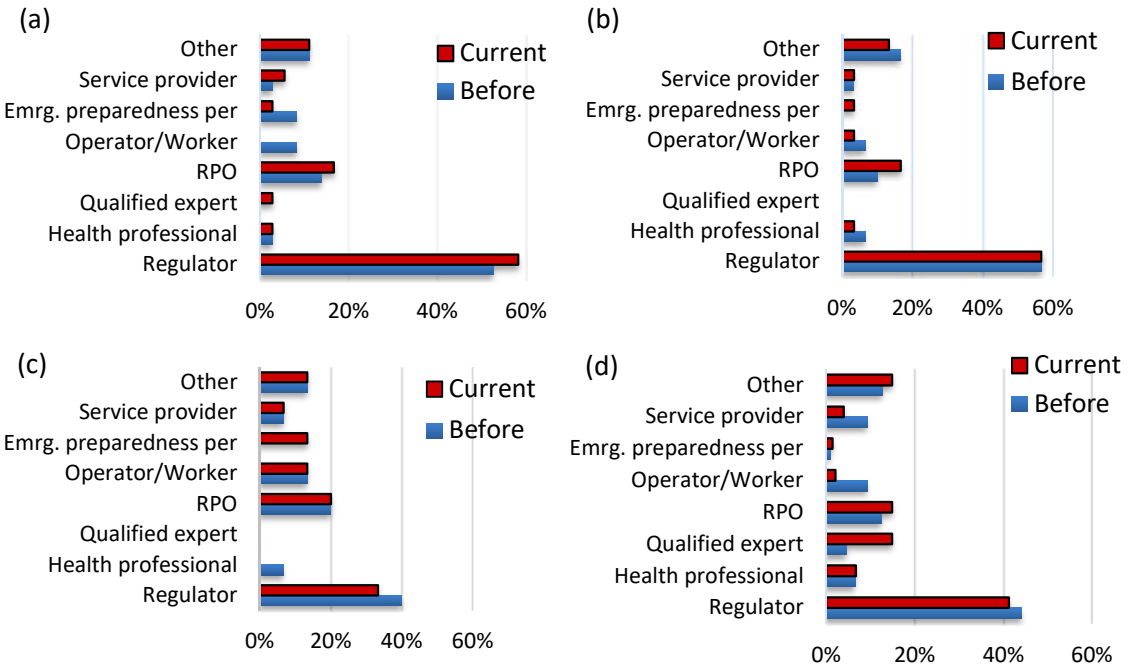

FIG. 12. Distribution of respondents by working category, before and after attending the course: (a) after one year, T (total respondents) = 36; (b) after three years, T = 30; (c) after five years, T = 15; (d) historical evaluation, T = 58.

5.3. IMPACT OF THE PGEC ON PARTICIPANTS

5.3.1. Pre-PGEC versus post-PGEC professional levels

Monitoring the professional progress of PGEC participants helps in understanding the influence of the programme over time (see Fig. 13).

Overall, for the Africa Region, a general increase in the number of PGEC participants moving over time from a staff position to a managerial position can be observed.

To some extent, this reflects a typical career progression: as staff who were PGEC participants gained experience, they were promoted to higher positions. However, other reasons discussed in the following might play a part in furthering the careers of PGEC participants.

5.3.2. Effects of the PGEC on the professional development of participants

Regardless of the time passed since participation in the course, the majority of respondents stated that the PGEC had had a 'high or medium' impact on their professional development, with an increasing trend over time.

For example, 71% of the respondents in the historical evaluation who completed the course in Morocco rated the PGEC's impact as 'high' (see Fig. 14(d)), whereas 56% did so after one year.

Such a result could suggest a lapse of time before the impact of the PGEC becomes apparent.

In addition to evaluating the professional development of participants, increases in work performance and gaining of additional responsibilities were also considered. Figure 15 (a) and (b) show that one year after completion of the PGEC, more than half the participants had gained additional responsibilities and stated that their work performance had generally improved.[6]

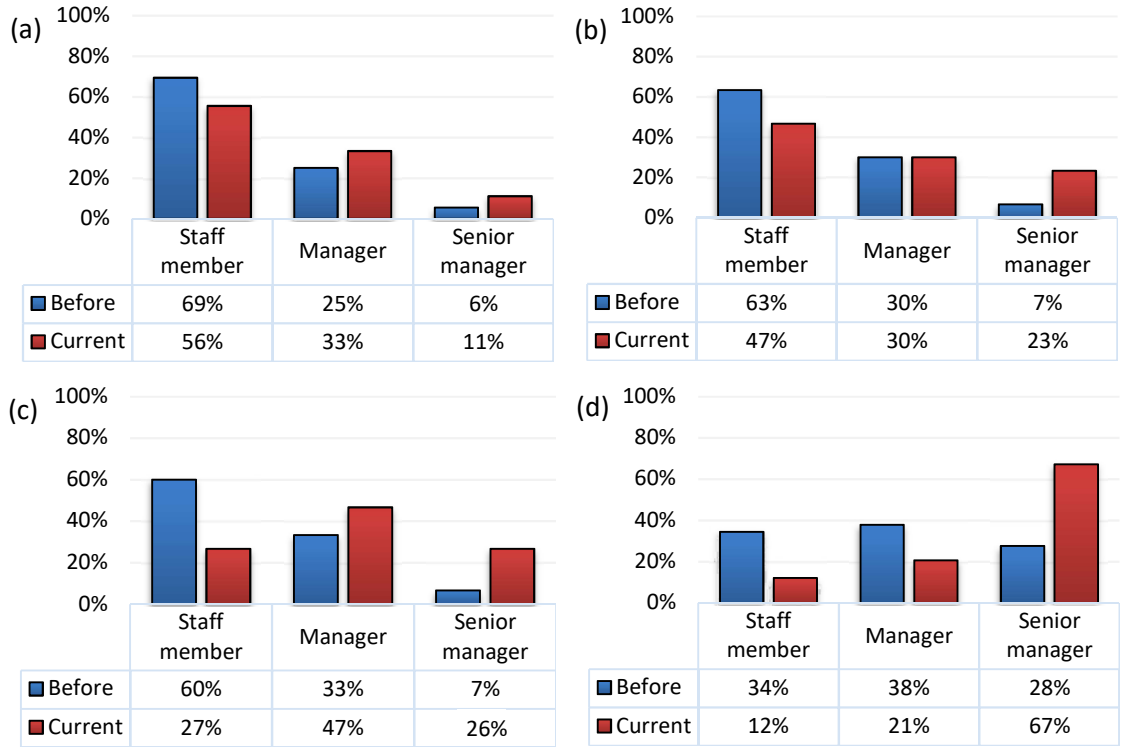

FIG. 13. Participants per professional level before attending and after completion of the course: (a) after one year, T (total respondents) = 36; (b) after three years, T = 30; (c) after five years, T = 15; (d) historical evaluation, T = 58.

[6] Examples provided by participants of additional responsibilities included: assessing and inspecting radiation facilities; participating in the development of regulations; training of operators; engaging in emergency preparedness projects and waste management projects; and developing internal assessment services and monitoring services.

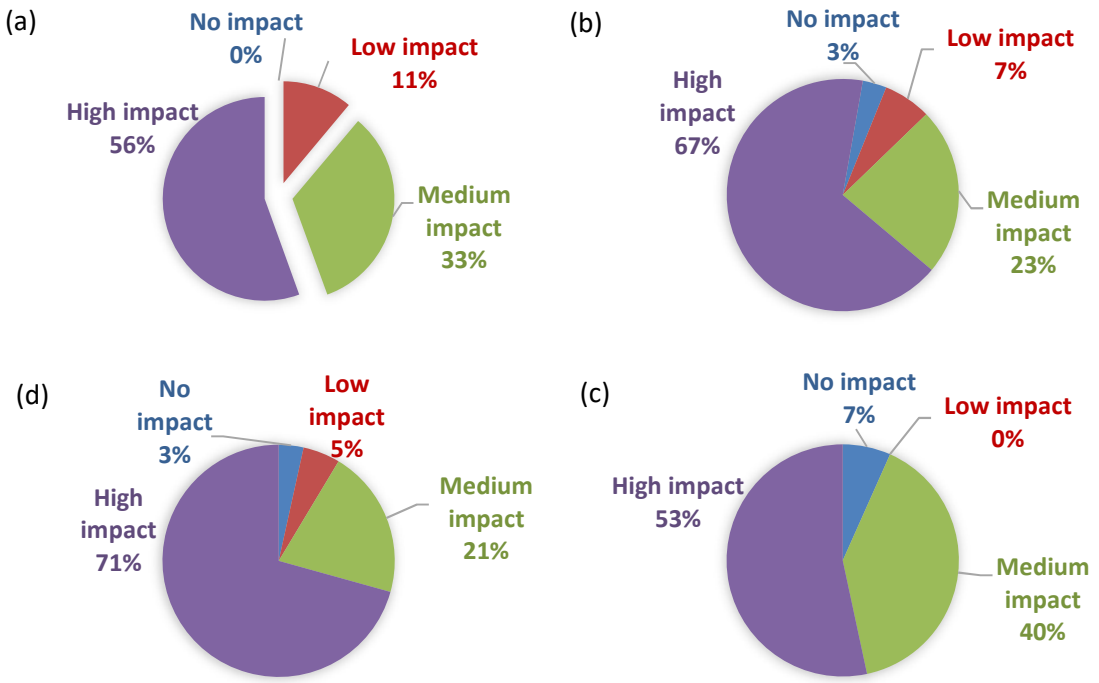

FIG. 14. Participants stating that the PGEC had had a positive impact on their professional development after completion of the course: (a) after one year, T (total respondents) = 36; (b) after three years, T = 30; (c) after five years, T = 15; (d) historical evaluation, T = 58.

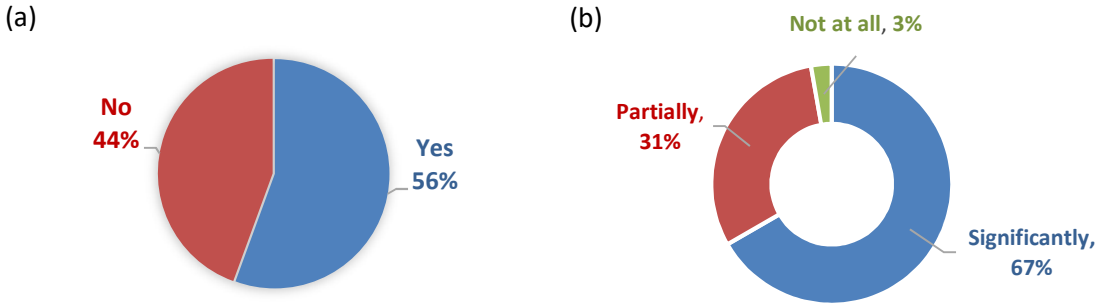

FIG. 15. Participants stating one year after the course that the PGEC had had a positive impact: (a) on acquiring additional tasks, T (total respondents) = 36;(b) on their work performance, T=30.

These findings supported the inference that attending the PGEC had benefited the careers of the participants and had furthered upward mobility in the organization.

Among the many responses specifying their progress since participation, several participants emphasized the international nature of the programme as being of advantage to their professional advancement:

- "Currently, I am the Chief of the Department of Dosimetry in the… Agency for Radiation Protection and Nuclear Safety (ATRSN). The PGEC was a springboard […] allow[ing] me to acquire knowledge and competences in the field of radiation protection to help my country in nuclear related matters." (PGEC in Morocco, 2007.)
- "[I am] Head of Energy Management Division, which is… in the nuclear technology applications section. This is the training which has enabled me to have a better foothold in nuclear activities even though I'm working on aspects relating to the use of technical and project management activities in the area. This also facilitated my continuation of studies in the AFRA [African Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology] master's programme in nuclear science and technology. It enhanced my role as the national liaison officer…" (PGEC in Morocco, 2005.)

– “[I am] Advisor Executive Secretary of the [national] Agency for Nuclear Safety and Security. Participation in the PGEC helped me to acquire a promotion within the regulatory authority which was still in its infancy.” (PGEC in Morocco, 2003.)

– “Participation in the PGEC was undoubtedly very significant in influencing my professional life as a competent person in radiation protection. The IAEA certificate has contributed to my work in the area of radiation safety. Most of my colleagues consider me to have an international certification. Presentation of my PGEC diploma in my recruitment allowed me to obtain a title of senior manager in the company. My job title is Senior Health Physicist.” (PGEC in Morocco, 2002.)

5.4. IMPACT OF THE PGEC ON RADIATION SAFETY INFRASTRUCTURE

Examining the impact of PGEC participants on their local radiation safety infrastructure helped to show how the knowledge and skills learned from the PGEC had been translated into concrete outcomes.

Although PGEC participants are from a range of working categories, this part focuses on participants from the regulatory body, who form the largest category.

5.4.1. Findings after one year, after three years and after five years

The impact that participation in the PGEC had had on the local radiation safety infrastructure was evaluated. Participants were requested to indicate the extent to which they had affected key aspects of radiation safety in the seven thematic safety areas (TSAs) mentioned earlier (see Section 3.1).

Regardless of the time passed since participation in the course, the results showed that in the Africa Region respondents had applied the knowledge and skills acquired from the PGEC in their daily practices to strengthen the radiation safety infrastructure in the Member States.

As Fig. 16 shows, most participants from regulatory bodies declared that the PGEC had had a significant impact in helping them to enhance radiation safety across all areas. This impact tends to increase with time.

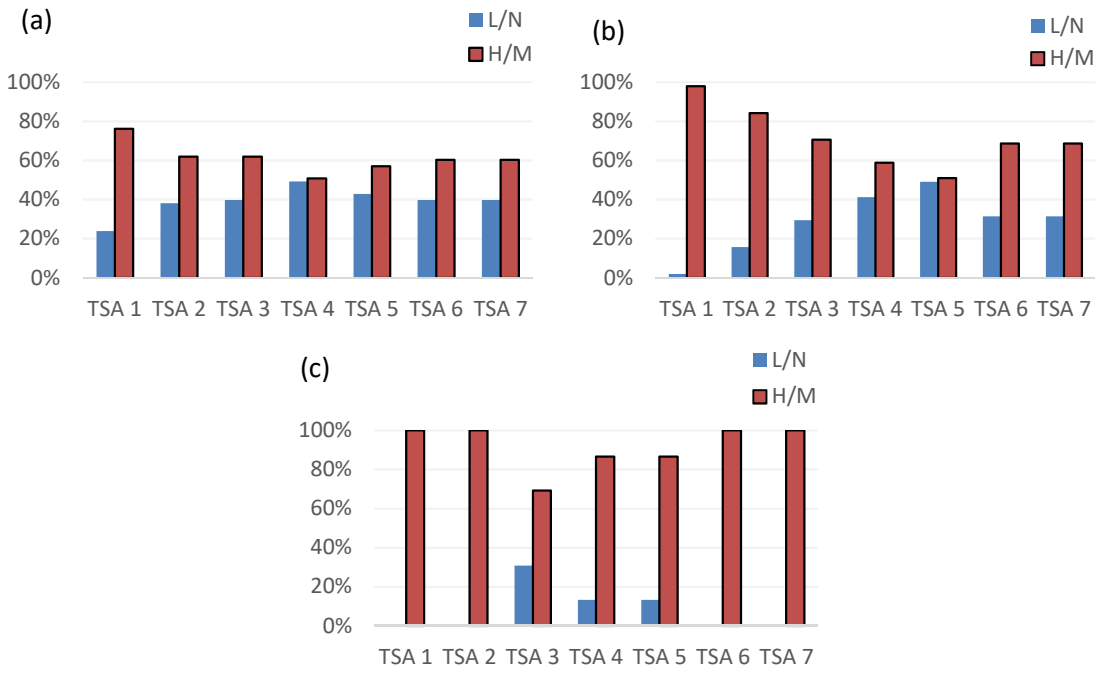

FIG. 16. Responses from participants who were from a regulatory body stating that after completion of the course, the knowledge and skills gained in the PGEC had had a high or medium (HM) impact or a low or no (LN) impact on each TSA: (a) after one year, T (total respondents) = 21; (b) after three years, T = 17; (c) after five years, T = 5.

Participants who were employed as regulators provided the following feedback:

- "[I] served on a committee that was tasked to develop regulations on NORM and transport of radioactive material, and my contribution… was enhanced… by my participation…" (PGEC in Ghana, 2015.)
- "Most of the impact has been on improving the draft legislation, based on training from the PGEC course. Other areas of impact are based on inspections being carried out where licensees are made aware of the dangers of radiation exposure and how to comply with legislation; and the drafting of guidelines to help in reviewing applications, inspections, etc." (PGEC in Ghana, 2015.)
- "[The PGEC] contributed extremely to establishing regulations for medical facilities which use or intend to utilize radioactive sources; licensing, inspection and enforcement." (PGEC in Ghana, 2015.)
- "With the skills I acquired during the PGECcourse, the Director of Radiological Safety and Nuclear Security always asked me to share with others my ideas about the development of various regulations on radiation safety suitable for [my Member State] for each practice." (PGEC in Algeria, 2015.)
- "This training has [had] a significant impact [on the]: participation in the preparation of regulations; specialized training for civil protection agents on radiological and nuclear risks; the review and approval of emergency plans, radioactive source users, intervention and organization in case of emergency." (PGEC in Algeria, 2015.)
- "I joined the team of the regulatory authority in 2013 right after my training in the PGEC... the same year as the establishment of the [national] Agency for Radiation Protection. Elements related to the regulatory texts in our different areas of activities, transport of radioactive materials, evaluation of occupational exposure and training of exposed workers were developed, either partially or totally, thanks to the knowledge acquired during the training in the PGEC...." (PGEC in Algeria, 2013.)
- "I have made informed contributions to the review of our Act and Regulations using the knowledge gathered from PGEC." (PGEC in Ghana, 2013.)

Explanations were given by participants from a regulatory body for not applying the knowledge and skills gained during the PGEC course in some TSAs. These included situations in which there was, for example, no ongoing work in some TSAs being implemented by their respective regulatory authority.

Sometimes participants or their Member States were not currently involved in activities mentioned in the questionnaire.

Other reasons included: not having a position of responsibility or decision making power; lack of equipment; poor management and follow-up; a 'discouragement of youth' policy at the workplace.

Some wished to have more in-depth training in all areas in the PGEC so as to be able to impact their national radiation safety infrastructure more significantly.

5.4.2. Findings of the historical evaluation

The historical evaluation covered six PGECs that were held in the Africa Region prior to 2011.

Simpler than that used for the evaluations after one year, after three years and after five years, the historical evaluation questionnaire (see Annex III, Part 3) asked only whether or not there had been impacts in each of the seven TSAs.

For the six courses concerned, all but one participant indicated having had an impact in at least one of the TSAs.

Figure 17 shows that every TSA had had impacts through participants applying the knowledge, skills and attitudes acquired during the PGEC. For instance, over 70% of the participants declared having had impacts in TSAs 1, 2 and 6 thanks to the competences gained during the PGEC.

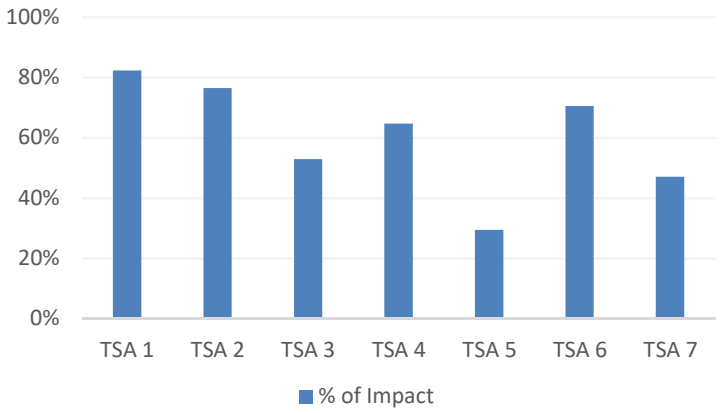

FIG. 17. Percentage of participants from a regulatory body stating that the PGEC had had positive impacts in each specific TSA: Total respondents = 17.

In comparing those results with the results of the evaluations after one year, after three years and after five years mentioned earlier, some similarities can be observed.

Participants' specific comments provided further insights:

- "Regulatory controls at national level in the industrial and medical environment. Issuance of authorizations for dosimetry workers." (PGEC in Morocco, 2007.)
- "I participated in committees to develop regulatory control standards and guides for radiological facilities in industrial environments." (PGEC in Morocco, 2007.)
- "The development of inspection procedures in industrial [applications] and uranium mining." (PGEC in Morocco, 2005.)
- "Strong impact on the development of legislation and regulations. Other IAEA training courses, including authorization and inspections, have complemented this impact." (PGEC in Morocco, 2005.)
- "I participated in the drafting of national legislation on radiation safety that was enacted in 2013 (by Act No. 2013-701 of 10 October 2013 concerning nuclear safety and security and protection against the dangers of ionizing radiation) and its implementing regulations." (PGEC in Morocco, 2003.)
- "I was one of the members of 2004, a participant in the national intervention team in case of a nuclear or radiological emergency; I contributed in the development of the national plan for a radiological or nuclear emergency." (PGEC in Morocco, 2004.)
- "Creation of new authority [national regulatory authority for radiation protection and nuclear safety and security] meeting the requirements of the IAEA. Development of texts in the form of regulations, guides and procedures." (PGEC in Morocco, 2003.)
- "The knowledge gained has allowed us to update our working procedures for authorization and inspection and review our application forms for authorization and inspection. These achievements have also allowed us to contribute to effectively drafting a law establishing an independent authority on radiation protection. We have enough knowledge to assess the radioactive packages during inspection." (PGEC in Morocco, 2011.)
- "My participation in the PGEC course reinforced my radiation protection skills, allowing me to treat with professionalism files that were entrusted to me in radiation protection, nuclear safety and security. This contributed to my appointment to a senior position." (PGEC in Morocco, 2011.)

5.5. SUSTAINABILITY AND EFFECTIVENESS OF THE PGEC

'Sustainability and effectiveness' together refer to the ability to transfer the projects developed and the competences acquired by participants in the PGEC via various channels into the radiation safety infrastructure in Member States.

To support the beneficial impacts of the course, this transfer is monitored by means of four indicators: the follow-up of work projects (Section 5.5.1); the sharing and dissemination of the knowledge acquired (Section 5.5.2); the contribution of the PGEC to academic development (Section 5.5.3); and the readiness of participants to recommend the PGEC to their peers (Section 5.5.4).

5.5.1. Continuation of the PGEC work projects

PGEC work projects were aimed at helping participants to solve specific problems in radiation protection in their Member States. In practice, participants conducted the work projects during the course on a topic that was initially identified with their direct supervisors and was then further developed with their trainers. Participants were then expected to follow through on the work when they returned home.

Most respondents (61%) confirmed one year after completion of the course that they had performed follow-up activities on their work projects (see Fig. 18).

The work projects, which were started during the course and were intended to be implemented when the participants returned home, served to link the training itself, the professional lives of the PGEC participants and ultimately the radiation safety infrastructure in the Member States.

Respondents provided specific examples illustrating how and on what subject they had implemented their work projects and had contributed to strengthening the national radiation safety infrastructure:

- "My project work involved radiation protection in terms of the IAEA Fundamental Safety Principles; I am currently working on a waste management policy and strategy for Zambia in terms of the Fundamental Safety Principles." (PGEC in Ghana, 2015.)
- "Submission of an IAEA project of national scope." (PGEC in Brazil, 2015.)
- "I have since led an audit of a radioisotope production facility." (PGEC in Ghana, 2015.)
- "Review of the radiation protection programme for a nuclear medicine facility submitted to our regulatory authority." (PGEC in Ghana, 2015.)
- "Dose measurements in radiotherapy." (PGEC in Ghana, 2015.)

5.5.2. Sharing knowledge and skills

In addition to the work projects, the extent to which participants had shared or disseminated their new knowledge and skills also testified to the sustainability and the effectiveness of the PGEC courses.

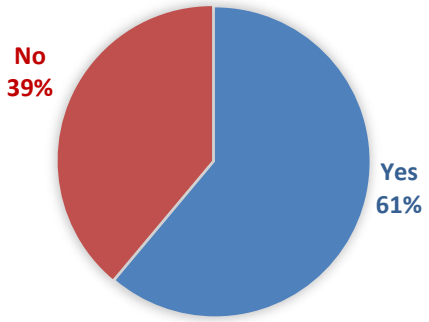

FIG. 18. Percentage of participants who had conducted follow-up activities to their PGEC work project one year after completion of the course; total respondents = 36.

An integral element of the PGEC is therefore devoted to 'training the trainers'. PGEC participants equipped with the necessary basic skills and tools to become trainers trained other personnel locally in radiation protection in line with international standards. Within a reasonable time-frame, this promulgation of the impacts enhanced the pool of trained personnel locally both quantitatively and qualitatively.

A total of 61% of respondents after one year confirmed having organized or implemented one or more training events in radiation protection and the safe use of radiation sources, and for subsequent years this increased to 73% (see Fig. 19).

The training courses delivered by the PGEC's participants included events for various operators in the medical industry and in industrial radiography and for customs officials; national seminars for decision makers, users and other regulatory authorities such as customs services and security services; and training of national first responders in case of a radiological emergency. The diversity of the training reflected the broad range of topics covered by the PGEC.

5.5.3. Contribution of the PGEC to development of competence

The contribution of the PGEC to specific professional or academic development was recorded three years and five years after completion of the course (see Fig. 20). After three years and after five years, most respondents affirmed that the knowledge and skills acquired in the PGEC had enabled them to attend specific training courses and to further enhance their competences.

These training courses were on specialized topics and 'train the trainers' events. The competences acquired in the PGEC had enabled some participants to undertake academic degree courses to obtain master's degrees or doctorates. Some respondents stressed the part that the work projects had played in enabling their subsequent academic development and achievements.

The PGEC programme served to increase the pool of qualified learners and trainees locally, which in turn strengthened the national educational and training infrastructure.

5.5.4. Recommending the PGEC: ongoing success of the PGEC

Regardless of the time that had passed since their participation in the course, about 90% or more of the respondents had recommended the PGEC to their colleagues or employees. These results seem to hold in the longer term, with the highest of all recommendation rates being from the respondents in the historical evaluation. Such a high level of recommendation reflected the esteem in which the PGEC is held in the Region (see Fig. 21).

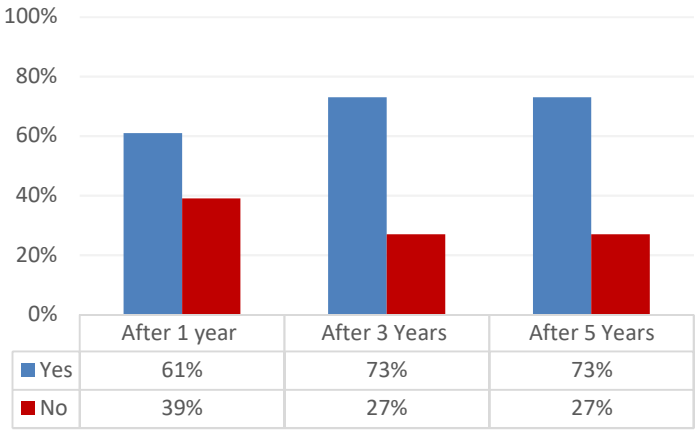

FIG. 19. Respondents sharing knowledge and skills gained in the PGEC by organizing or implementing training events after completion of the course: after one year, T (total respondents) = 36; after three years, T = 30; and after five years, T = 15.

5.5.5. Final comments and suggestions of participants

The answers to the ultimate questions of the questionnaires also bear out the findings mentioned previously. Participants were asked whether they wished to make any additional comments (after three years, after five years and in the historical evaluation). They were also asked for suggestions on how to improve the course to make it more applicable to their duties (after one year). Participants generally praised the course but they also identified areas for improvement.

Some testimonials on the PGEC's benefits are listed in the following:

– "Given its importance to our regulators for the quality of its programme, I wish the PGEC is maintained in order to produce more professionals in the field of radiation protection and radiation safety to contribute to the establishment of regulatory agencies with proven expertise." (PGEC in Algeria, 2013.)

– "The PGEC was of strong interest to my professional career. I am currently a senior manager in the regulatory authority. Each year, one or two of our colleagues participate in the PGEC." (PGEC in Algeria, 2013.)

– "The PGEC opened my spirit regarding my knowledge of radiation protection materials and I wish it were the same for all the other young [nationals] who wish to work in this complex field of radiation protection. That is why I would like this training to continue and that it has an equivalence of a degree." (PGEC in Morocco, 2011.)

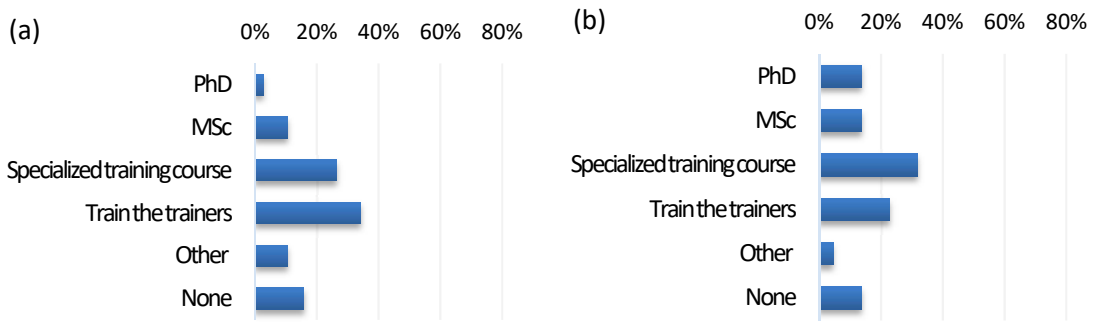

FIG. 20. Percentage of affirmative answers for the contribution of the PGEC towards specific professional and academic development: (a) three years after completion of the course, T (total respondents) = 30; (b) five years after completion of the course, T = 15. Note that giving more than one answer was possible.

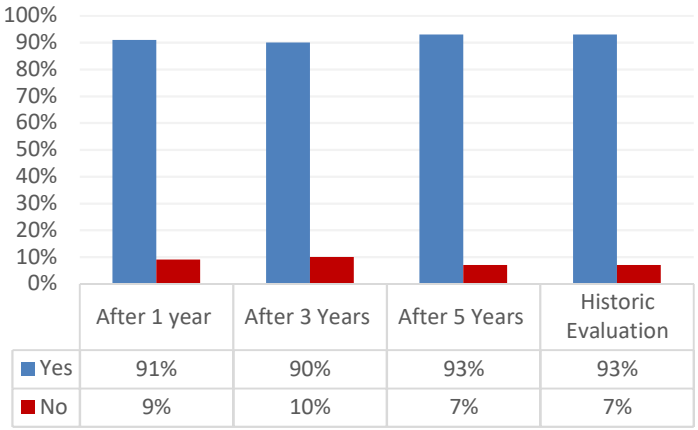

FIG. 21. Percentage of participants who had recommended the PGEC to their colleagues or employees in the Africa Region in all IAEA Regional Training Centres and for all time periods of the impact evaluation (after one year, after three years, after five years and in the historical evaluation, respectively). Total respondents (T) = 36; T = 30; T = 15; T = 58.

- "The PGEC allowed me to develop my professional career in radiation protection. I am currently responsible for the preparation of the authorization for users of radiation sources and also the source inventories." (PGEC in Morocco, 2006–2007.)
- "I thank the IAEA for the opportunity because thanks to the PGEC completed in 2004–2005, I am what I am today." (PGEC in Morocco, 2005.)
- "It was this training which has allowed me today to exercise (after doing several internships abroad) as a qualified expert in radiation protection in private. And I sincerely hope that it is maintained to sustain the training of African professionals' high levels in the radiation protection field." (PGEC in Morocco, 2004.)
- "The training was excellent, beneficial, it was especially rich on theoretical and practical information with the actual visits; there remains a small problem which is the duration; it is very short, and the courses are condensed." (PGEC in Algeria, 2015.)

Besides the praise, margins for improvement were identified — more so after one year given that the questionnaire specifically asked for suggestions for improvements.

Participants consistently suggested that the part of the training dedicated to practical exercises be increased. They suggested better accommodating the workload to the time available (either by increasing the duration of the course or by focusing the workload).

The possibility for the course to acquire some kind of (academic) recognition was often stressed. Generally, some kind of follow-up actions were also suggested.

Some suggestions on potential improvements to the PGEC:

- "We want the Agency to organize meetings between professionals, particularly those who have completed the PGEC, to create enthusiasm; and [we want] to be directly informed concerning possible training, seminars, conferences, etc." (PGEC in Morocco, 2007.)
- "We suggest the IAEA find a mechanism for acquiring validation (by training courses, workshops plus PGEC) for a diploma in radiation protection (master's [degree] in radiation protection) recognized at the international level for those who have completed the PGEC." (PGEC in Morocco, 2011.)
- "The PGEC is a great door for radiation protection knowledge. A suggestion that could be made would be to review the time for mini-projects. With the time allocated it is not always possible to become familiar with the laboratory." (PGEC in Algeria, 2013.)
- "It is good to add additional [refresher] programmes related to safety and security of radiation sources." (PGEC in Ghana, 2013.)
- "I believe the course content is fantastic, but it involves [mostly] theoretical work. A lot of practicals should be introduced and then limit the classroom work." (PGEC in Ghana, 2015.)

Altogether, notwithstanding the scope for improvement, on the basis of the data gathered so far, participants in the course in the Africa Region generally recognized the course's positive impact on their daily professional lives, regardless of the time passed since their participation in the course. This was apparent in increased competences, greater responsibilities, promotions and opportunities.

The participants also considered that their local and national radiation safety infrastructure had benefited from the course.

6. RESULTS OF THE IMPACT EVALUATION FOR THE PGEC: ASIA AND THE PACIFIC REGION

6.1. CONDUCT OF THE PGEC

The PGEC has been conducted regularly at two IAEA Regional Training Centres in the Asia and the Pacific Region: in Malaysia (since 2001) in English and in the Syrian Arab Republic (from 2001 until 2010) in Arabic.

The PGEC in the Syrian Arab Republic under the IAEA Technical Cooperation programme ceased in 2010. The University of Damascus still offers a PGEC-like course of study in its local master's degree study programmes, however. The courses held in the Syrian Arab Republic are reported only in the historical evaluation in this report.

The impact evaluation for the PGEC for the Asia and the Pacific Region was based on answers from 238 participants in 22 PGEC courses (see Table 5).

6.2. PROFESSIONAL BACKGROUND OF PARTICIPANTS

Regardless of the time passed since participation in the course, and even for the historical evaluation of course going back 17 years, the participants in the PGEC were working primarily for the regulatory body (48% after one year, 52% after three years and 47% after five years; 51% in the historical evaluation) (see Fig. 22).

Since the working category 'regulator' comprises most of the course's participants, this is an expected result.

Participants who worked as 'radiation protection officers' constituted the second most well represented working category among PGEC participants[7].

The other categories considered (e.g. 'service providers' and 'qualified experts') were less well represented in the short term as they were not the primary target groups for the courses.

Lastly, participants who declared themselves as belonging to the working category 'other' generally worked in areas relating to radiation protection, e.g. nuclear physics laboratory supervisor; radiation control officer; supervisor of doctorate in medical radiation physics; specialist in education and training.

TABLE 5. IMPACT EVALUATION CONDUCTED ONE YEAR, THREE YEARS AND FIVE YEARS AFTER COMPLETION OF THE PGEC COURSE PLUS HISTORICAL EVALUATION, UP TO 2015: IAEA REGIONAL TRAINING CENTRES IN MALAYSIA (MAL) AND THE SYRIAN ARAB REPUBLIC (SYR)

1 YEAR			3 YEARS			5 YEARS			HISTORIC EVALUATION		
RTC	No. of participant	Response rate	RTC	No. of participant	Response rate	RTC	No. of participant	Response rate	RTC	No. of participant	Response rate
MAL	30	73%	MAL	23	61%	MAL	27	70%	MAL	145	53%
MAL	31	71%	MAL	24	54%				SYR	171	33%
Total Respondents:		44			27			19			134
YEAR WHEN THE PGEC WAS CONDUCTED AT THE REGIONAL TRAINING CENTRE (RTC)											
MAL 2014			MAL 2013			MAL 2011			MAL (7 courses) 2001 2003 2004 2006 2007 2009 2010 SYR (10 courses) 2001 2002 2003 2004 2005 2006 2007 2009 2010 (x2)		
MAL 2015			MAL 2013								

[7] A 'radiation protection officer' is defined as 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 regulatory requirements (Ref. [2], p. 410): http://www.pub.iaea.org/MTCD/publications/PDF/Pub1578_web-57265295.pdf).

6.3. IMPACT OF THE PGEC ON PARTICIPANTS

6.3.1. Pre-PGEC versus post-PGEC professional levels

Monitoring the professional progress of PGEC participants helps in understanding the influence of the programme over time (see Fig. 23).

Following their participation (after one year, after three years and after five years), most respondents in the Asia and the Pacific Region remain at staff member level.

With a higher proportion of respondents accessing managerial positions (58% and 60%, respectively, for five years after and for the historical evaluation), their situation improves in the longer term.

To some extent, this reflects a typical career progression: as staff who were PGEC participants gained experience, they were promoted to higher positions. However, other reasons discussed in the following might play a part in furthering the careers of PGEC participants.

6.3.2. Effects of the PGEC on the professional development of participants

Regardless of the time passed since participation in the course, the majority of respondents stated that the PGEC had had a significant impact on their professional development.

Altogether, 93% after one year, 92% after three years, 89% after five years and 94% for the historical evaluation recognized that the PGEC had had a 'high or medium' impact on their professional development (see Fig. 24).

Such a result could suggest a lapse of time before the impact of the PGEC becomes apparent.

In addition to evaluating the professional development of participants, increases in work performance and gaining of additional responsibilities were also considered.

Figure 25 (a) and (b) show that one year after completion of the PGEC, more than half the participants had gained additional responsibilities and that their work performance had generally improved.

These findings support the inference that attending the PGEC had benefited the careers of the participants and had furthered upward mobility in the organization.

Among the many responses specifying their progression since participation, participants generally considered the PGEC to have been a fundamental experience and emphasized that the skills that they had gained had contributed substantially to their professional advancement:

- "I am staff of regulation development for radiation facilities and radioactive sources. As regulation development staff, I have to draft regulations, whether government regulations or chairman's regulations. For one cycle of regulation drafting, we have to assess why we need to develop that regulation, and then we have to communicate to stakeholders in the form of public consultation. After finishing the PGEC, I feel confident to communicate about regulations we draft. I also have the chance to teach radiation safety to stakeholders and also students." (PGEC in Malaysia, 2010.)
- "My current job is Secretary General of the National Atomic Energy Commission. The benefit yielded by my participation in the PGEC on my current job was great, which enabled me to develop my knowledge and improve my skills and abilities in radiation science and applications and in radiation safety. During the PGEC, I gained great knowledge, experience and skills in several areas and I published an article with my supervisor at the end of the PGEC. Finally, when I came back to my country, I participated in several scientific, technical and regulatory works. The PGEC was the gate which led me to broader fields and to this new position." (PGEC in the Syrian Arab Republic, 2009.)
- "I am doing my Ph.D. in medical radiation physics now. The radiation protection course was great, and I got very good experience which has proven useful to me now during my studies. Before starting the Ph.D., I was working for the… Atomic Energy Commission as a radiation protection inspector; the course was so helpful to my former work." (PGEC in the Syrian Arab Republic, 2009.)

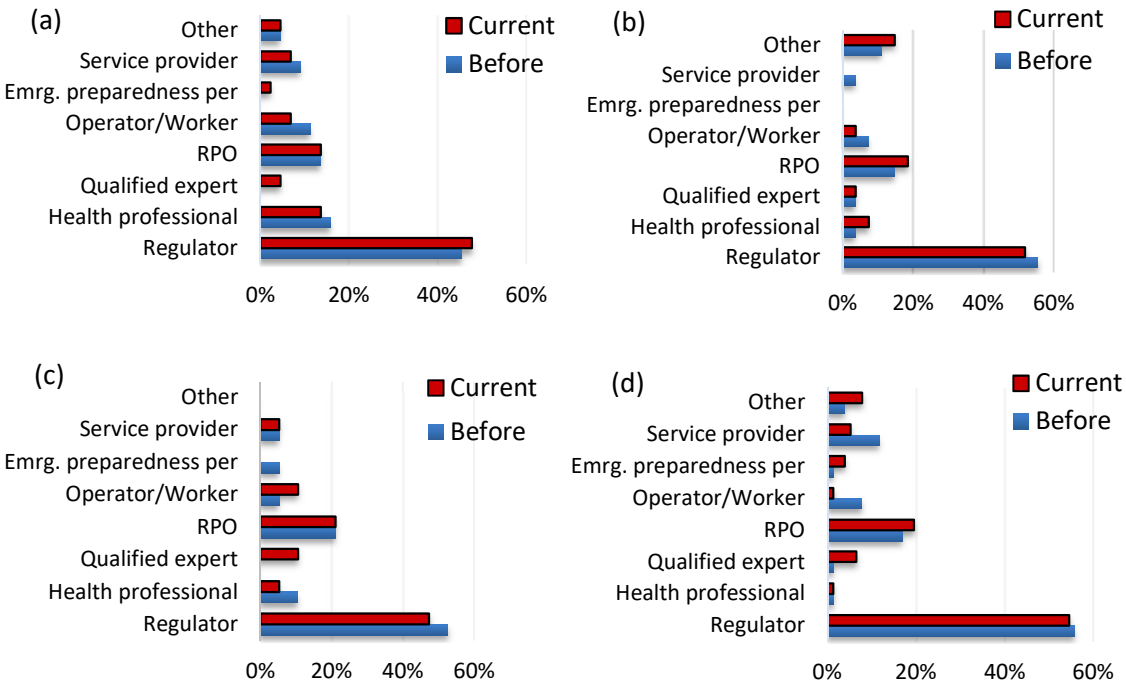

FIG. 22. Percentages of working categories for participants, before attending the course and after completion of the course: (a) after one year, T (total respondents) = 44; (b) after three years, T = 27; (c) after five years, T = 19; (d) historical evaluation, T = 134.

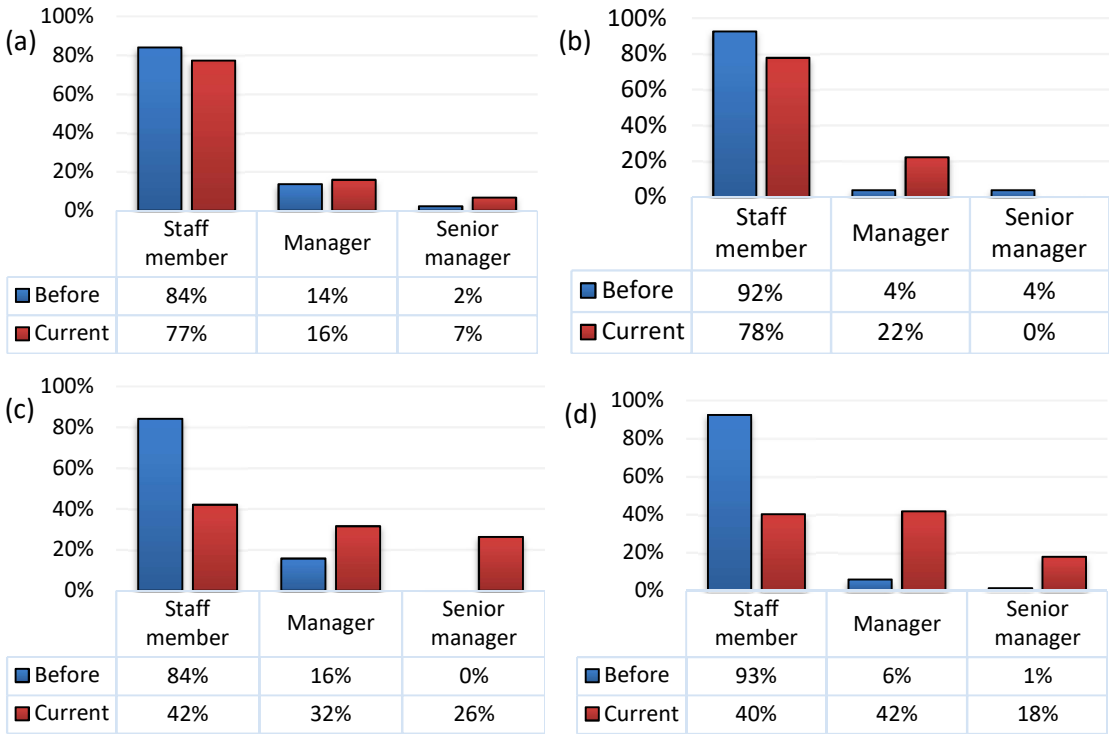

FIG. 23. Participants by professional level before attending the course and after completion of the course: (a) after one year, T (total respondents) = 44; (b) after three years, T = 29; (c) after five years, T = 19; (d) historical evaluation, T = 146.

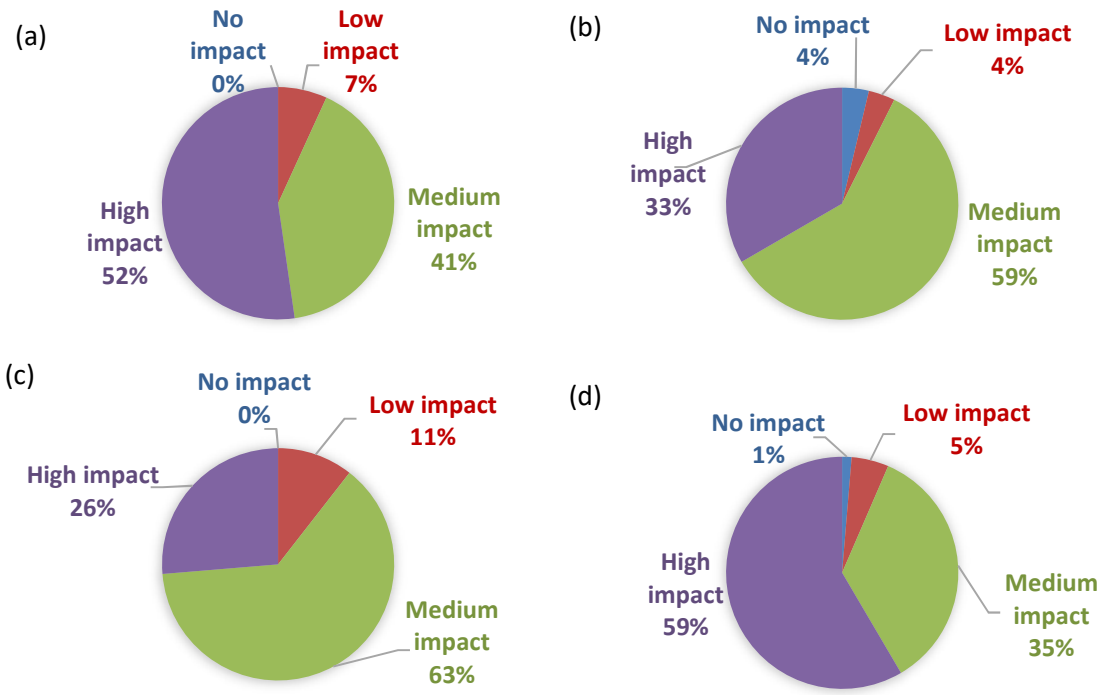

FIG. 24. Participants stating that the PGEC had had a positive impact on their professional development after completion of the course: (a) after one year, T (total respondents) = 44; (b) after three years, T = 29; (c) after five years, T = 19; (d) historical evaluation, T = 134.

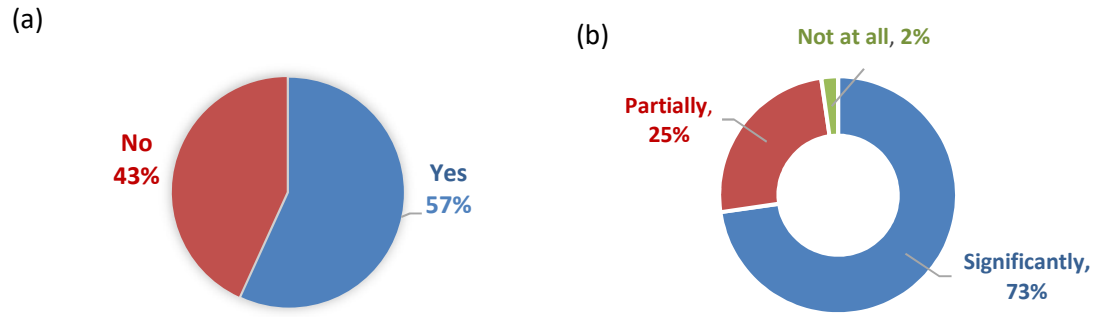

FIG. 25. Participants stating one year after completion of the course that the PGEC had had an impact on: (a) acquiring additional responsibilities; (b) their work performance; T (total respondents) = 44.

– "My current job title is coordinator of legal drafting at Directorate for Regulation of Radiation Facilities and Radioactive Material, Nuclear Energy Regulatory Agency. My current job description is to formulate and to revise regulations related to safety and security for radiation facilities and radioactive material, and this year I have to compose the academic paper for the amendment of [the national] nuclear law (Act Number 10, Year 1997). I [employed] all of the knowledge I got from the PGEC to formulate and to revise the nuclear law and regulations." (PGEC in Malaysia, 2007.)

– "Head of Training Division — knowledge and skills learned from the PGEC programme helped me to gain a professional level in radiation protection. This achievement supports effectively the planning for education and training programmes related to ionizing radiation; it is also very helpful for me for becoming a lecturer in radiation protection training courses provided for radiation workers nationwide." (PGEC in Malaysia, 2005–2006.)

– “Chief Scientific Officer and Director in Radiation Control Division, Atomic Energy Regulatory Authority. The experience of the PGEC course contributed a lot to [my] becoming an expert in the radiation safety area.” (PGEC in Malaysia, 2004.)
– “Director of Radiation Inspection Department. The postgraduate course had a positive impact on my current job, which provided me with a lot of skills and scientific and technical expertise in various fields of medical and industrial radiation protection, and this is significantly relevant to my current position.” (PGEC in the Syrian Arab Republic, 2004.)

6.4. IMPACT OF THE PGEC ON RADIATION SAFETY INFRASTRUCTURE

Examining the impact that PGEC participants had had on the local radiation safety infrastructure helped to show how the knowledge and skills learned from the PGEC had been translated into concrete outcomes.

Although PGEC participants were from a range of working categories, this part focuses on participants from the regulatory body, who formed the largest category.

6.4.1. Findings after one year, after three years and after five years

The impact that participation in the PGEC had had on the local radiation safety infrastructure was evaluated. Participants were requested to indicate the extent to which they had affected key aspects of radiation safety in the seven thematic safety areas (TSAs) mentioned earlier (see Section 3.1).

Regardless of the time passed since participation in the course, the results showed that in the Asia and the Pacific Region respondents had applied the knowledge and skills acquired from the PGEC in their daily practice to strengthen the radiation safety infrastructure in the Member States.

As Fig. 26 shows, most participants who were from regulatory bodies declared that the PGEC had had a significant impact in helping them to enhance radiation safety in all areas. In the longer term, this impact is noticeable for TSAs 1, 2 and 6, but less so for TSAs 4, 5 and 7.

Comments of the participants who were employed as regulators suggest that competences acquired in the PGEC were instrumental to developing, reviewing and updating the regulatory framework, and for licensing and inspection activities, as well as for developing guides and inspection procedures.

Participants who were employed as regulators provided the following feedback:

– “I have impacted organizationally and nationally by developing regulations related to radiation protection and safety for radiation facilities and radioactive material. Because my work is drafting regulations, all of my knowledge from PGEC 12 I use for developing regulations.” (PGEC in Malaysia, 2015.)
– “[I am] currently involved in licensing and inspection of various different types of radiation facilities in the medical, industrial, and research and education sectors as well as training of occupational workers.” (PGEC in Malaysia, 2014.)
– “I have impacted national safety infrastructures as part of the regulatory authority through discussions on new regulations and implementation of regulations. I have also been assigned to the review committee for updated regulations on radiation protection.” (PGEC in Malaysia, 2015.)
– “We did not yet have a nuclear law or any nuclear regulatory authority, but we are preparing to do that presently. Therefore, I can use some of knowledge, skill and experience that I got from PGEC training to be one of the nuclear team working for establishing nuclear law in the future.” (PGEC in Malaysia, 2015.)
– “The government is committed… to building a nuclear power plant…. The Atomic Energy Commission is responsible for implementing the nuclear power plant programme. I am using the knowledge and experience that I gained through the training programme in trying to assess reactor safety, which is one of the national radiation safety infrastructures.” (PGEC in Malaysia, 2015.)

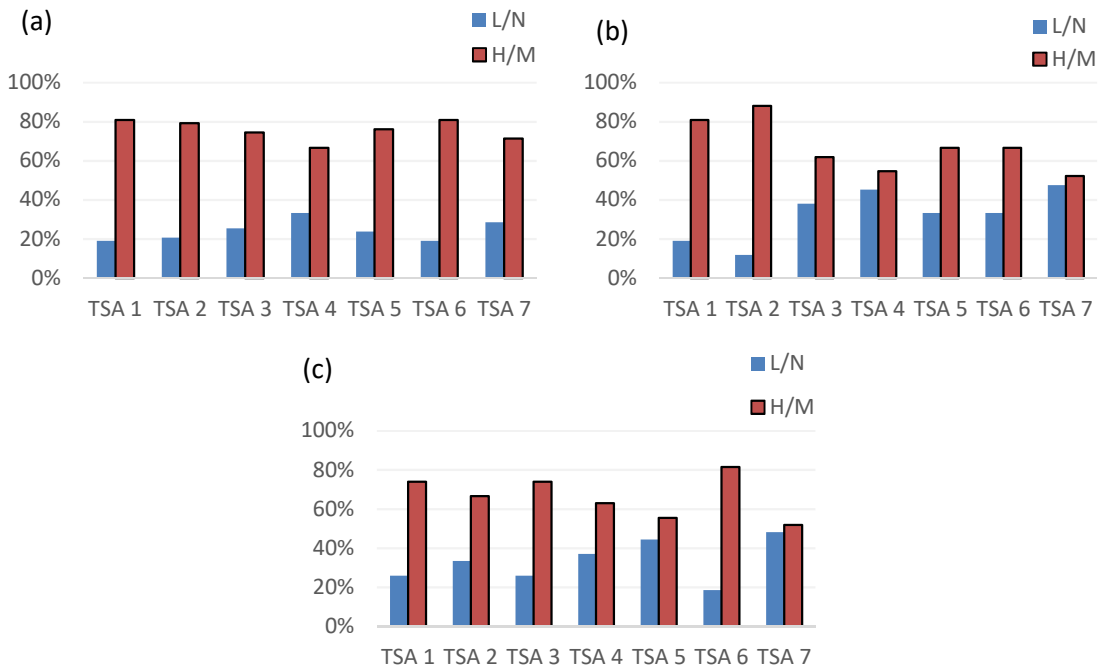

FIG. 26. Responses from participants who worked for a regulatory body stating that after completion of the course, the knowledge and skills gained in the PGEC had had a high to medium (HM) or low or no (LN) impact on each TSA: (a) after one year, T (total respondents) = 21; (b) after three years, T = 15; (c) after five years, T =9.

- "Been appointed in subcommittee related to organization radiation safety and security." (PGEC in Malaysia, 2015.)
- "Drafting law for inspection of safety of radioactive material in transport and for creating a new checklist for authorization and inspection of radioactive material." (PGEC in Malaysia, 2014.)
- "Developing and updating regulatory legal framework on field exploitation of radioactive minerals." (PGEC in Malaysia, 2014.)
- "Development of regulatory requirements on emergency exposure situations for development/optimization of protection strategies; criteria and operational intervention levels for decision making purposes." (PGEC in Malaysia, 2013.)
- "After attending the PGEC I have performed the following works to strengthen the regulatory infrastructure throughout the country according to the Atomic Energy Regulatory Act 2012 and Nuclear Safety and Radiation Control Rules 1997: 1. Inspection and re-inspection of radiological practices and preparation of inspection and re-inspection reports with some recommendations to rectify weaknesses regarding radiation protection. 2. Prepare and maintain regulatory inventory of radiation sources. 3. Assessment of design/layout of different radiation facilities from the radiation protection point of view. 4. Evaluation of radiation protection programme, quality assurance programme and emergency response plan for issuance or renewal of licence of nuclear medicine, laboratory and industrial facilities. 5. Assessment of annual reports of radiation control officers. 6. Arranging training courses to train radiation workers of different radiation facilities and deliver lectures on radiation protection and safe use of radiation sources." (PGEC in Malaysia, 2013.)
- "Attended in development of legal and regulatory requirements on the safe use of ionizing radiation, occupational exposure, the control of medical exposure, and the control of public exposure. Also attended in an inspection team for inspection of radiation facilities and a nuclear research reactor. Based on the knowledge I obtained from the PGEC programme, I have successfully completed my master's degree in nuclear engineering." (PGEC in Malaysia, December 2013.)

- "Develop a radiation protection programme for my organization (State Health Department)." (PGEC in Malaysia, 2013.)
- "Regarding environmental monitoring, the procedures we learned in the PGEC were transferred to colleagues to improve on the standard procedures we were following to have better compliance with standards. Regarding inspection for compliance for ionizing radiation sources in medical and industrial fields, the information we gained from the course was highly helpful to better assess situations and irregularities seen in some workplaces." (PGEC in Malaysia, 2011.)
- "I have used all the information I learned [in the PGEC] in my work as a manager of regulations and control unit." (PGEC in Malaysia, 2011.)
- "Impacts on understanding of the development of a new act that will be officially announced as soon as possible this year." (PGEC in Malaysia, 2011.)
- "Provided my input to prepare various local and national training courses on safety of radioactive sources, etc. Shared within the organization my international experience that gave highlights of international experience in these areas." (PGEC in Malaysia, 2011).

Explanations were given by participants from a regulatory body who declared having hardly or not at all (i.e. stating low to no impact) applied the course learning. These were either task related (e.g. respondent's areas of action did not cover those TSAs) or organization related (e.g. respondent's organization did not require much action in those areas).

Task related reasons included the respondent's lack of involvement in the national policy making process; not working specifically in a regulatory function in the regulatory body (but rather providing technical support or focusing on research activities); or not being responsible for some TSAs (which were covered by colleagues).

Organization related explanations included other organizational internal priorities for specific TSAs, notably when activities were already well established.

6.4.2. Findings of the historical evaluation

The historical evaluation covered 17 PGECs held in the Asia and the Pacific Region prior to 2011.

Simpler than that used for the evaluations after one year, after three years and after five years, the historical evaluation questionnaire (see Annex III, Part 3) asked only whether or not there had been impacts in each of the seven TSAs.

For the 17 courses concerned, all but two of the participants indicated having had an impact in at least one of the TSAs.

As Fig. 27 shows, every TSA had had impacts through participants applying the knowledge, skills and attitudes acquired in the PGEC. TSA1, TSA2 and TSA6 were the areas most frequently cited.

In comparing those results with the results of the evaluations after one year, after three years and after five years, some similarities can be observed.

Participants' specific comments provided further insights:

- "The course helped me with a lot of information in the field of the regulatory system, materials and procedures for the authorization and inspection practices of radiation in the industrial, medical and research fields. Also, in the evaluation of the regulatory requirements for the licensing and registration of radiological practices in the industrial field, including radiation protection programmes, in addition to my participation in projects and committees in the prevention of radiation [exposure]." (PGEC in the Syrian Arab Republic, 2010.)
- "Was actively involved as a key person in the drafting process of the Atomic Energy Regulatory Act 2012 which established the independent regulatory authority (from 2009 to 2012). Also initiated the drafting of a regulation on the authorization process for nuclear installations." (PGEC in Malaysia, 2008–2009.)

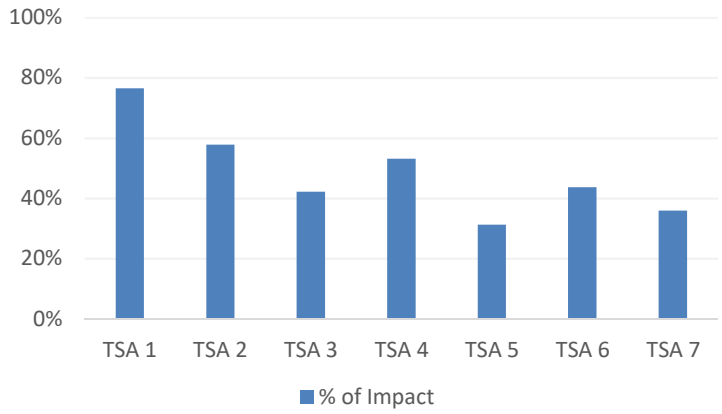

FIG. 27. Percentage of participants who were from a regulatory body who stated for each specific TSA that the PGEC had had a positive impact: Total respondents = 64.

- "Contributed in the preparation of drafts for act on the control of the use of radioactive sources and prepared many documents that fall within the management of regulatory action. Also contributed to the conduct of radiation surveys for most of the provinces in search of missing radioactive sources." (PGEC in the Syrian Arab Republic, 2007.)
- "As the staff member of the Environmental Radiological Protection Division of the National Radiation Protection Department, I've been involved in: the process of designing and developing a set of comprehensive environmental regulations to govern the safety regulatory process in nuclear programmes; the ALMERA activities in the National Radiation Protection Department radioecological laboratories; the monitoring team in a nuclear or radiological emergency; and the work group of environmental modelling for radiation safety and environmental dose assessment." (PGEC in Malaysia, 2007.)
- "I've participated in the development of the national nuclear law as well as in the development of the national regulatory system." (PGEC in the Syrian Arab Republic, 2007.)
- "As I am currently working in the Radioactive Waste Management Centre and have responsibilities in the management of liquid and solid radioactive waste, I will be able to apply the knowledge, skills and experience gained from the PGEC programme to improve and strengthen the safety and efficiency of future radioactive waste management activities to meet international standards." (PGEC in Malaysia, 2004.)
- "I had a role in the preparation and development of the legal and regulatory requirements of the National Committee of Atomic Energy, where I participated in the drafting of the manual for radiation protection officers." (PGEC in the Syrian Arab Republic, 2004.)
- "Reviewed the application of the activities and operations carried out by the Commission as a regulatory authority, modified and developed the legal and regulatory requirements." (PGEC in the Syrian Arab Republic, 2003.)
- "Using knowledge [that] I had obtained, I was involved in several working groups to establish national regulations and guides." (PGEC in Malaysia, 2001.)

6.5. SUSTAINABILITY AND EFFECTIVENESS OF THE PGEC

'Sustainability and effectiveness' together refer to the ability to transfer the projects developed and the competences acquired by participants in the PGEC via various channels into the radiation safety infrastructure in Member States.

This transfer is monitored by means of four indicators to assess the beneficial impact of the course: follow-up of work projects (Section 6.5.1); the sharing and dissemination of the knowledge acquired (Section 6.5.2); the contribution of the PGEC to academic development (Section 6.5.3); and the readiness of participants to recommend the PGEC to their peers (Section 6.5.4).

6.5.1. Continuation of the PGEC work projects

PGEC work projects were aimed at helping participants to solve specific problems in radiation protection in their Member States. In practice, participants conducted the work projects during the course on a topic that was initially identified with their direct supervisors and was then further developed with their trainers. Participants were then expected to follow through on the work when they returned home.

About half the respondents confirmed one year after completion of the course that they had performed follow-up activities on their work project (see Fig. 28).

The work projects, which were started during the course and were intended to be finished when the PGEC participants returned home, served to link the training itself, the professional life of the participants and ultimately the radiation safety infrastructure in their Member States.

Respondents provided specific examples illustrating how and on what subject they had done their work projects and had contributed to strengthening the national radiation safety infrastructure:

- "My mini-project in PGEC 12 last year is implementation of an integrated planning concept to strengthen capabilities for emergency response in the transport of radioactive material. This will be used for our project next year to develop regulations specifically about emergencies in transport." (PGEC in Malaysia, 2015.)
- "I did my mini-project in PGEC on radon measurement; in my country I am trying to establish a national radon measurement programme." (PGEC in Malaysia, 2015.)
- "Developing an inventory of radioactive waste." (PGEC in Malaysia, 2014.)
- "Drafting law for radiation safety in the transport of radioactive material." (PGEC in Malaysia, 2014.)
- "The nuclear regulatory authority is in the process of establishing a protection level calibration laboratory and therefore the work project of the PGEC is very helpful." (PGEC in Malaysia, 2014.)

6.5.2. Sharing knowledge and skills

In addition to the work projects, the extent to which participants had shared or disseminated their new knowledge and skills also testified to the sustainability and the effectiveness of the PGEC courses.

An integral element of the PGEC is therefore devoted to 'training the trainers'. PGEC participants equipped with the necessary basic skills and tools to become trainers trained other personnel locally in radiation protection in line with international standards. Within a reasonable time-frame, this promulgation of the impacts enhanced the pool of trained personnel locally both quantitatively and qualitatively.

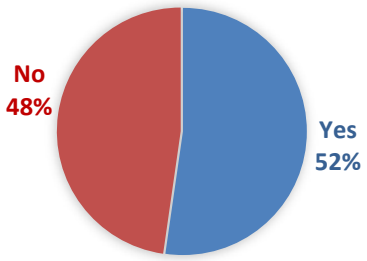

FIG. 28. Percentage of participants at one year after completion of the course who had conducted follow-up activities to their PGEC work project; total respondents = 44.

Fifty-five percent of respondents after one year confirmed having organized or implemented one or more training events in radiation protection and the safe use of radiation sources, and after five years this increased to 68% (see Fig. 29).

Among the training courses delivered by participants in the PGEC, some notably focused on radiation protection courses for nuclear medicine and radiotherapy technologists. Other training courses were for radiation protection officers of various radiation facilities, or presentations on radiation protection principles, emergency preparedness and the concept of 'as low as reasonably achievable'. The diversity of the training reflected the broad range of topics covered by the PGEC.

6.5.3. Contribution of the PGEC to development of competence

The contribution of the PGEC to specific professional or academic development was recorded three years and five years after completion of the course (see Fig. 30). After three years and after five years, a large majority of respondents affirmed that the knowledge and skills acquired in the PGEC had enabled them to attend specific training courses and to further enhance their competences.

These training courses were mostly specialized courses and 'train the trainers' events. However, the competences acquired in the PGEC had enabled some participants to undertake academic degrees such as master's degrees or doctorates. Some respondents stressed the part that the work projects had played in their later academic development and achievements.

The PGEC programme served to increase the pool of qualified learners and trainees locally, which in turn strengthened the national educational and training infrastructure.

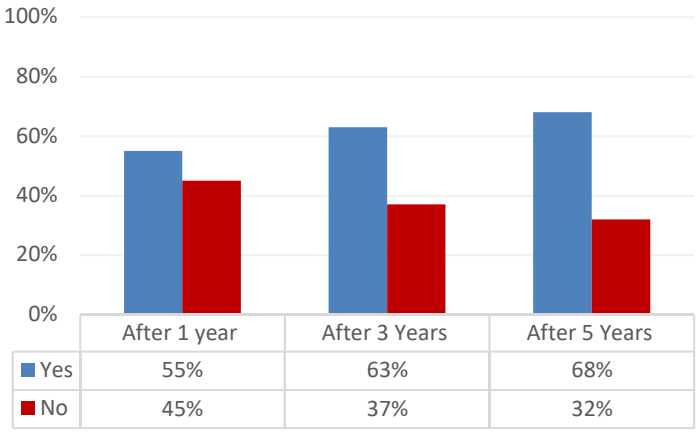

FIG. 29. Participants sharing knowledge and skills gained in the PGEC by organizing or holding training events after completion of the course: after one year, T (total respondents) = 44; after three years, T = 29; and after five years, T = 19.

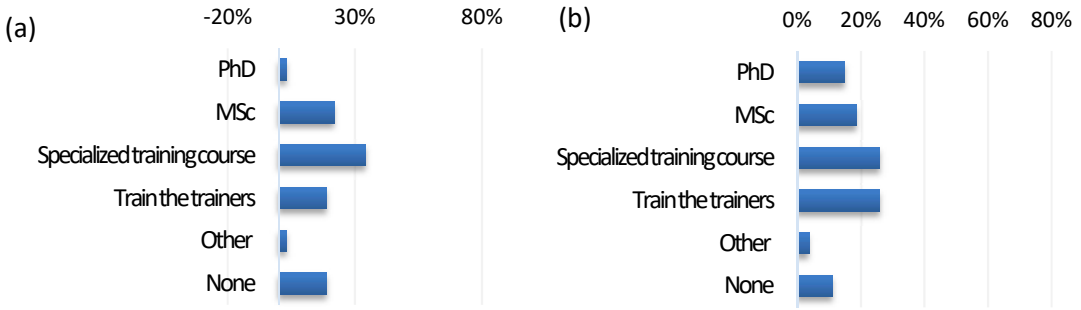

FIG. 30. Percentage of affirmative answers for the contribution of the PGEC towards specific professional and academic development: (a) three years after completion of the course, T (total respondents) = 27; (b) five years after completion of the course, T = 19. Note that giving more than one answer was possible.

6.5.4. Recommending the PGEC: ongoing success of the PGEC

Regardless of the time that had passed since their participation in the course, about 90% or more of the respondents had recommended the course to their colleagues or employees. These results seemed to hold in the longer term, with the highest of all recommendation rates being from the respondents in the historical evaluation. Such a high level of recommendation reflected the esteem in which the PGEC is held in the Region (see Fig. 31).

6.5.5. Final comments and suggestions of participants

The answers to the ultimate questions of the questionnaires also bear out the findings mentioned previously. Participants were asked whether they wished to make any additional comments (after three years, after five years and in the historical evaluation). They were also asked for suggestions on how to improve the course to make it more applicable to their duties (after one year). Participants generally praised the course but also identified areas for improvement.

Some testimonials on the benefits of the PGEC are listed in the following:

- "The PGEC course was very helpful in delivering knowledge in the field of radiation protection. It covered almost all the fields of radiation protection. The impact of this course is spread over all of our careers. This course will help us in providing guidance during our whole service while working in the field of radiation safety." (PGEC in Malaysia, 2013.)
- "I would like to say thank you to IAEA for providing this very useful training programme. Wish that the PGEC programme will continue supporting developing countries." (PGEC in Malaysia, 2013.)
- "The PGEC was a great experience and I have learned a lot in many fields, especially in the medical field." (PGEC in Malaysia, 2009.)
- "The PGEC training programme is necessary for promoting the organizational and national radiation safety infrastructures of all countries." (PGEC in Malaysia, 2007.)
- "The PGEC provided me with more knowledge and enhanced my existing knowledge on radiation protection and safe use of radiation sources. This made me more competent in performing my job as an evaluator of applications for licences for radioactive material and for facilities, and made me more confident as a trainer on radiation safety courses and regulations." (PGEC in Malaysia, 2004.)
- "IAEA should continue the PGEC programme to develop staff in support of Member States." (PGEC in Malaysia, 2004.)

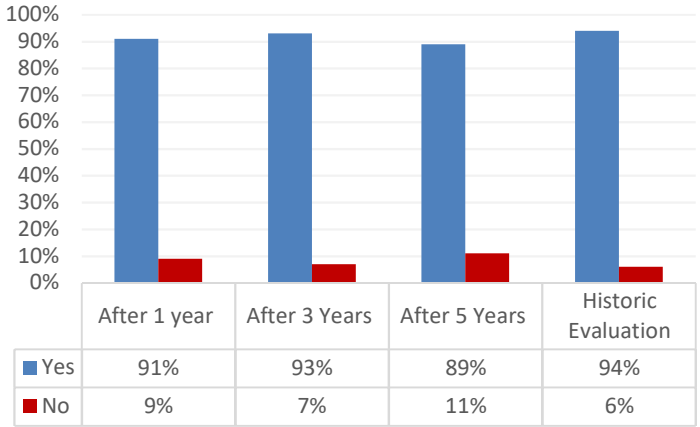

FIG. 31. Percentage of participants who had recommended the PGEC to their colleagues or employees in the Asia and the Pacific Region for all time periods of the impact evaluation: after one year, after three years, after five years and in the historical evaluation: total respondents (T) = 44; T = 29; T = 19; T = 134.

Besides the praise, margins for improvement were identified — more so after one year given that the questionnaire specifically asked for suggestions for improvements.

Participants consistently suggested that the part of the training dedicated to practical exercises be increased and that some kind of follow-up refresher courses for the training be considered. They suggested better accommodating the workload to the time available (either by increasing the duration of the course or by focusing the workload). They also desired more involvement of past participants in the programme.

The possibility for the course to acquire some kind of certification or (academic) recognition was often stressed. Generally, the possibility of adapting the methods used to optimize retention of knowledge and including actions for better assimilation (spaced learning, cases studies) was also suggested.

Some suggestions made on potential improvements to the PGEC:

- "Time provided for the session and content was compressed." (PGEC in the Syrian Arab Republic, 2010.)
- "1. An alumni grouping of PGEC participants should be established as soon as possible. This would provide an effective platform to the graduates to share their experience and establish a pool or network of experts. 2. There must be a regular meeting of PGEC alumni for discussion on issues regarding radiation protection worldwide and their solutions as well as improvements in the course." (PGEC in Malaysia, 2004.)
- "In the lecture class, some related video clips could be added for better understanding. Include more technical visits and practical classes at relevant laboratories. Could arrange some lectures by previous participants from abroad." (PGEC in Malaysia, 2011.)
- "After following the PGEC, give a chance to students to apply their knowledge, to participate and solve problems relating to safety that occur in a country that is developing a safety culture. Or give them a case study to solve the problem." (PGEC in Malaysia, 2013.)
- "Increase practical exercises, increase the time because the course material is too long." (PGEC in Malaysia, 2014.)

7. RESULTS OF THE IMPACT EVALUATION FOR THE PGEC: EUROPE REGION

7.1. CONDUCT OF THE PGEC

The PGEC has been conducted regularly at two IAEA Regional Training Centres in the Europe Region: in Belarus (since 2001) in Russian and in Greece (since 2013) in English.

The impact evaluation for the Europe Region was based on answers from 118 participants in 12 PGEC courses (see Table 6)[8].

7.2. PROFESSIONAL BACKGROUND OF PARTICIPANTS

Regardless of the time passed since participation in the course, and even for the historical evaluation of courses going back 16 years, the participants in the PGEC were working primarily for the regulatory body.

Since the working category 'regulator' comprises most of the course's participants, this is an expected result.

Although significant at first sight, the variation between the ratio of regulators after one year (23%) and after three years (67%) is from only one course offering. For the much greater number of responses

[8] A pilot survey (after three years) for the PGEC held in Greece in 2011–2012 was conducted in 2015 with a slightly different questionnaire. The results of that survey are not included in this report.

collected in the historical evaluation, the percentage of participants who were working for the regulatory body lies somewhere in between (40%).

It is not possible to distinguish meaningful variation for other working categories (see Fig. 32).

7.3. IMPACT OF THE PGEC ON PARTICIPANTS

7.3.1. Pre-PGEC versus post-PGEC professional levels

Monitoring the professional progress of PGEC participants helps in understanding the influence of the programme over time. For the Europe Region, a general and progressive increase in the number of PGEC participants moving over time from a staff position to a managerial position can be observed (see Fig. 33).

To some extent, this reflects a typical career progression: as staff who were PGEC participants gained experience, they were promoted to higher positions. However, other reasons discussed in the following might play a part in furthering the careers of PGEC participants.

7.3.2. Effects of the PGEC on the professional development of participants

Regardless of the time passed since participation in the course, the majority of respondents stated that the PGEC had had a significant impact on their professional development, with an increasing trend over time.

Altogether, 69% after one year, 84% after three years and 94% for the historical evaluation recognized that the PGEC had had a 'high or medium' impact on their professional development (see Fig. 34).

Such results could suggest a lapse of time before the impact of the PGEC becomes apparent.

In addition to evaluating the professional development of participants, increases in work performance and gaining of additional responsibilities were also considered.

Figure 35 (a) and (b) show that one year after completion of the PGEC, more than half the participants had gained additional responsibilities and that their work performance had generally improved[9].

TABLE 6. IMPACT EVALUATION CONDUCTED ONE YEAR, THREE YEARS AND FIVE YEARS AFTER COMPLETION OF THE PGEC COURSE PLUS HISTORICAL EVALUATION, UP TO 2015: IAEA REGIONAL TRAINING CENTRES IN BELARUS (BYE) AND GREECE (GRE)

1 YEAR			3 YEARS			5 YEARS			HISTORIC EVALUATION		
RTC	No. of participants	Response rate	RTC	No. of participants	Response rate	RTC	No. of participants	Response rate	RTC	No. of participants	Response rate
GRE	13	100%	BYE	13	92%	*			BYE	142	38%
									GRE	57	69%
Total Respondents		13			12						93
						* No courses available					
YEAR WHEN THE PGEC WAS CONCLUDED AT EACH REGIONAL TRAINING CENTRE (RTC)											
GRE 2015			BYE 2013						BYE (7 courses) 2001 2002 2005 2006 2007 2008 2010 GRE (3 courses) 2003 2006 2008		

[9] Examples provided by participants of additional responsibilities included: performing activities in the field of alpha spectroscopy; training radiation protection officers; assessing radiation protection programmes; responding to illicit trafficking incidents; and becoming head of the division of radiation emergency management and training.

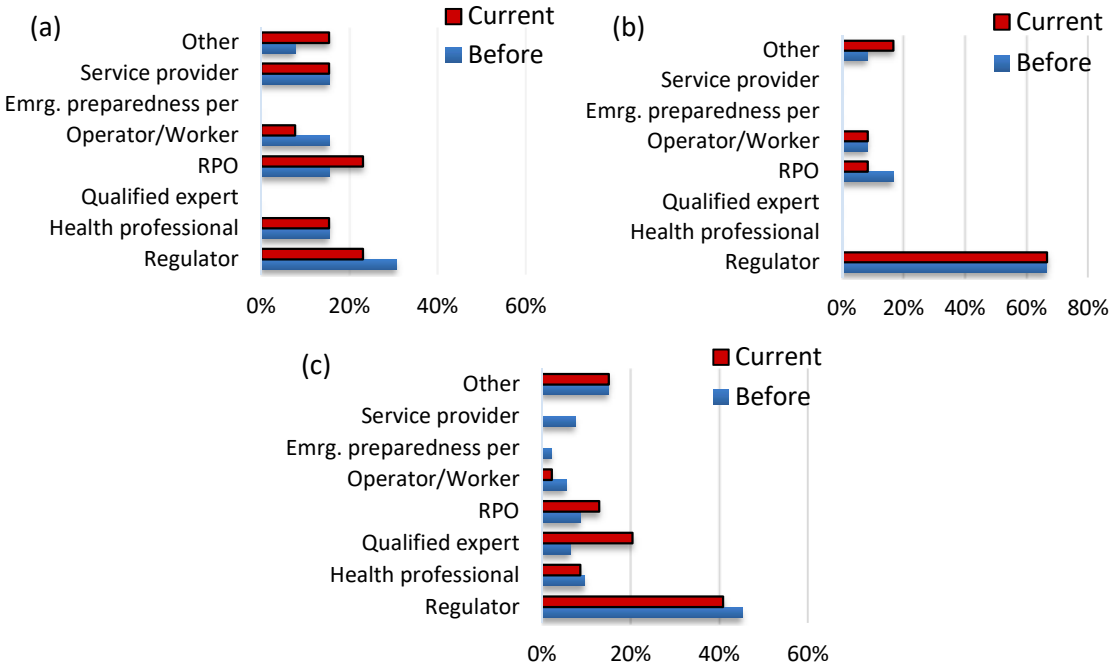

FIG. 32. Percentage of working categories for participants, before attending the course and after completion of the course: (a) after one year, T (total respondents) = 13; (b) after three years, T = 12; (c) historical evaluation, T = 93.

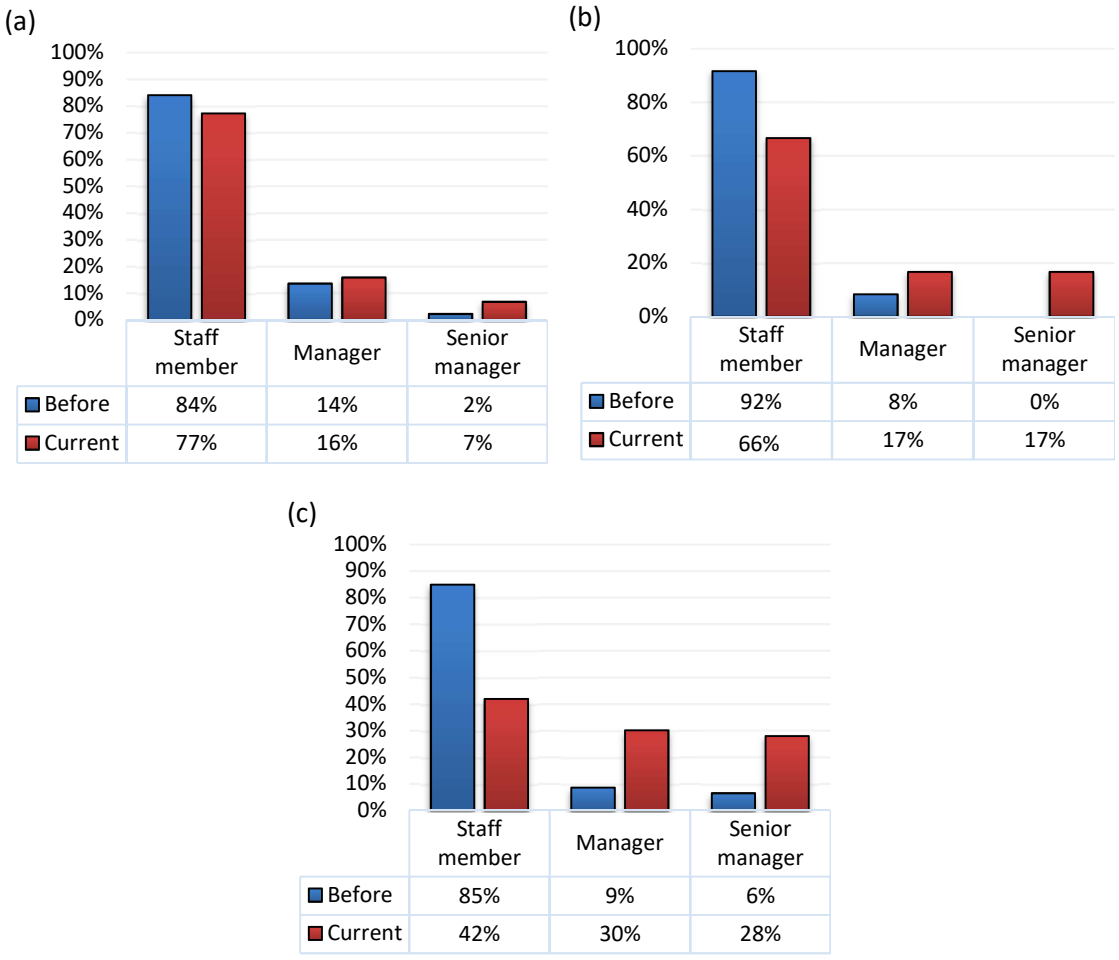

FIG. 33. Participants by professional level before attending the course and after completion of the course: (a) after one year after, T (total respondents) = 13; (b) after three years, T = 12; (c) historical evaluation, T = 93.

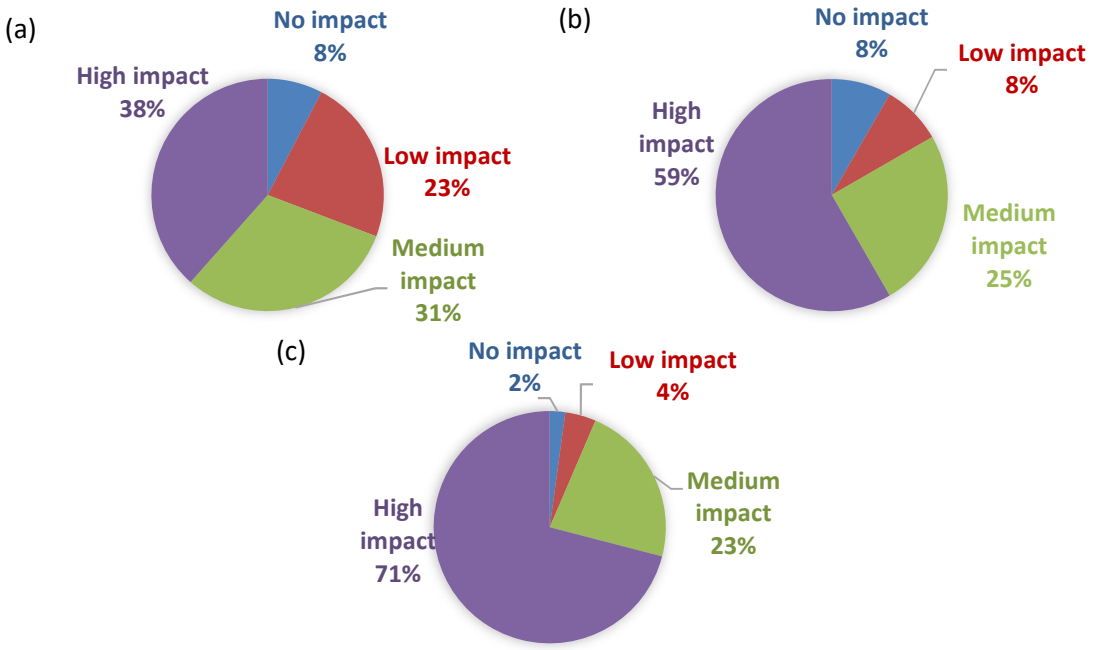

FIG. 34. Participants stating that the PGEC had had a positive impact on their professional development after completion of the course (a) after one year, T (total respondents) = 13; (b) after three years, T= 12; (c) historical evaluation, T = 93.

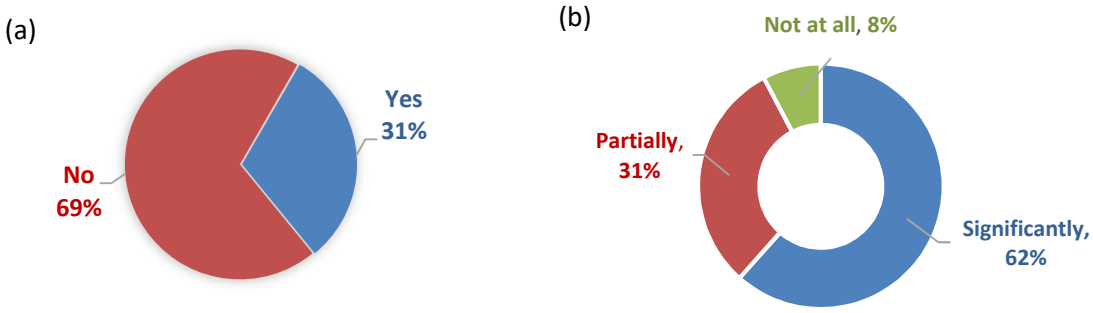

FIG. 35. Participants stating one year after completion of the course that the PGEC had had an impact on: (a) acquiring additional responsibilities; (b) their work performance; T (total respondents) = 13.

These findings support the inference that attending the PGEC had benefited the careers of the participants and had furthered upward mobility in the organization.

Among the many responses specifying their progression since participation, participants generally considered the PGEC to have been a fundamental experience and emphasized that the skills that they had gained had contributed substantially to their professional advancement:

- "Before the PGEC, I was working for the regulator (environmental board) as a radiation safety specialist. In 2011 the diploma from the training course gave me an opportunity to apply for a senior officer's position in the higher government institution (ministry of the environment) which required a corresponding qualification, and since 2015 I have been working as an adviser on radiation safety." (PGEC in Belarus, 2011.)
- "Head of sector inspection, NRSA. Completing the PGEC in Belarus helped me in organizing the inspection activities in radiation safety and the safe use of ionizing radiation sources." (PGEC in Belarus, 2007.)

– "My position is the deputy director of the national centre. The course gave me a huge impact: was very helpful. I was able to view radiation safety from all sides. Gained new knowledge and got acquainted with this unique field of human knowledge. I became acquainted with the leading experts of different areas. I met great new friends with whom I still have a great relationship. I recommend the continuation of such courses." (PGEC in Belarus, 2006.)

– "Head of diagnostic radiology and nuclear medicine physics in department of medical physics and radiation safety. As a result of attending the PGEC, I became a radiation protection expert; one of few in my country." (PGEC in Greece, 2006.)

– "Technical manager of an accredited laboratory for dosimetry of ionizing radiation. The impact of PGEC: knowledge and skills that I obtained during the course helped me to work in dosimetry of ionizing radiation (training of those professionally exposed, dosimetry measurements, shielding design, patient and fetal dosimetry)." (PGEC in Greece, 2003.)

7.4. IMPACT OF THE PGEC ON RADIATION SAFETY INFRASTRUCTURE

Examining the impact that PGEC participants had had on the local radiation safety infrastructure helped to show how the knowledge and skills learned from the PGEC had been translated into concrete outcomes.

Although PGEC participants were from a range of working categories, this part focuses on participants from the regulatory body, who formed the largest category.

7.4.1. Findings after one year and after three years

The impact that participation in the PGEC had had on the local radiation safety infrastructure was evaluated. Participants were requested to indicate the extent to which they had affected key aspects of radiation safety in the seven thematic safety areas (TSAs) mentioned earlier (see Section 3.1).

The results showed that in the Europe Region respondents had applied the knowledge and skills acquired from the PGEC in their daily practice to strengthen the radiation safety infrastructure in the Member States.

Fig. 36 shows, most participants who were from regulatory bodies declared that the PGEC had a significant impact in helping them to enhance radiation safety in most of the TSAs, but mainly on a longer term.

Participants who were employed as regulators provided the following feedback:

– "Development of legal and regulatory requirements on transport of radioactive material, development of legal and regulatory requirements on education and training in radiation protection, assessment of compliance with national and international transport regulations, planning and conduct of inspections of transport operations: for all activities described above, in those that I participated the impact I think was that organizational and national radiation safety infrastructures changed in a better way." (PGEC in Greece, 2015.)

– "Prepared and managed the EduTA [Education and Training Appraisal] mission, participated at the table top exercise 'Management and termination of a radiological accident caused by a vehicle transporting an ionizing radiation source', where I presented an actual corresponding situation that occurred the same year in Bosnia Herzegovina; participated at the ESOC [Emergency Operations Centre] tabletop exercise, whose purpose was to assess the actions of the ESOC [Emergency Operations Centre] group, and when information was received about the stolen source to present an analysis of the actual corresponding situation." (PGEC in Greece, 2015.)

– "Directly involved in updating the national rules in the field of radiation safety and participated indirectly in the development of other documents relating to radioactive materials. The knowledge obtained during the PGEC helped me to evaluate these documents professionally and to make some improvements." (PGEC in Belarus, 2013.)

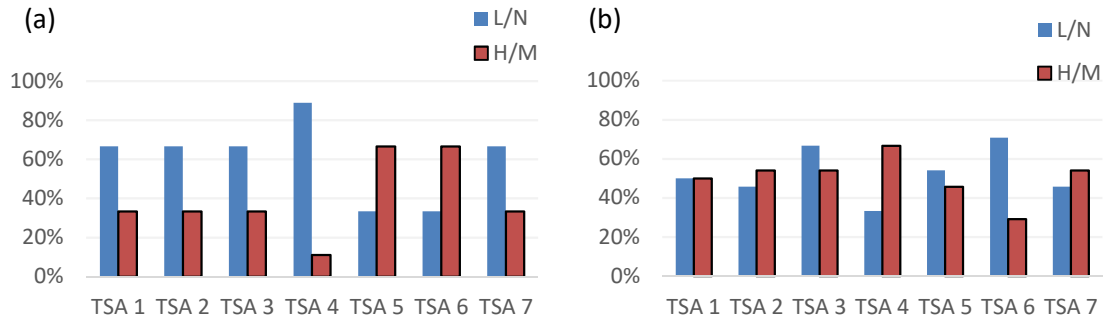

FIG. 36. Responses from participants who were from a regulatory body stating that after completion of the course, the knowledge and skills gained in the PGEC had had a high to medium (HM) or low or no (LN) impact on each TSA: (a) after one year, T (total respondents) = 13; (b) after three years, T = 17.

- "Knowledge I gained in the PGEC I use in daily work for preparing legal acts or training stakeholder institutions." (PGEC in Belarus, 2013.)
- "Based on the study of course materials from the PGEC, I prepared a monitoring plan for the unit in which I work, for radiological monitoring of the perimeter of the unit. Studying the course materials pushed me to create new methods of personnel protection for ionizing radiation sources, on the basis of norms and IAEA recommendations." (PGEC in Belarus, 2013.)
- "Participation in the development of normative legal acts and methodological documentation on prediction, early detection, mitigation and response to radiological accidents and incidents." (PGEC in Belarus, 2013.)

Some respondents identified the inertia of systems as being the main impediment both to applying the lessons from the course and to having lasting effects in their workplaces.

7.4.2. Findings of the historical evaluation

The historical evaluation covered 10 PGECs held in the Europe Region prior to 2011.

Simpler than that used for the evaluations after one year, after three years and after five years, the historical evaluation questionnaire (see Annex III, Part 3) asked only whether or not there had been impacts in each of the seven TSAs.

For the 10 courses concerned, all the respondents indicated having had an impact in at least one of the TSAs.

As Fig. 37 shows, every TSA had had impacts through participants applying the knowledge, skills and attitudes acquired in the PGEC. The course's impacts were relatively evenly distributed across the seven TSAs — unlike for the other regions, for which some TSAs stood out as having had particular impacts.

Participants' specific comments provided further insights:

- "The training course gave me a comprehensive overview of different aspects and areas of radiation safety. This has turned out to be very beneficial in my current position as a counsellor, as I am responsible for developing radiation safety regulations which cover all aspects related to this. It is easier for me to interact with the interested parties as I can relate to their positions and reasoning. Therefore, I believe that I can make more balanced and neutral decisions and ensure that all aspects are covered. Knowledge from the training course has also turned out to be very useful while participating in the working groups of the European Council and Commission." (PGEC in Belarus, 2010.)
- "The experience from the PGEC helped me to successfully prepare the new regulations in the field of radiation and nuclear safety and security and to be in line with the IAEA documents and recommendations." (PGEC in Greece, 2008.)

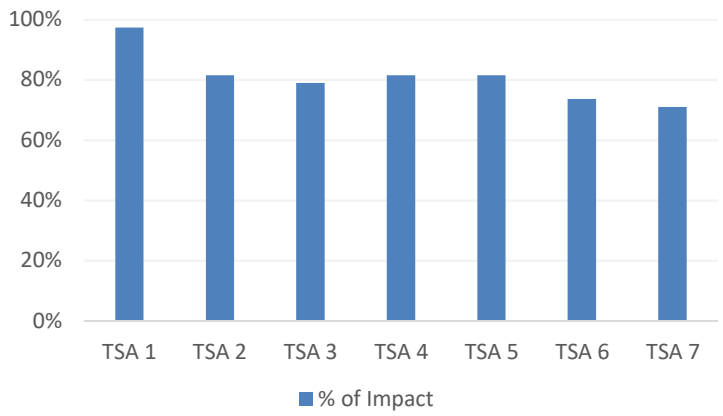

FIG. 37. Percentage of participants who were from a regulatory body stating for each specific TSA that the PGEC had had positive impacts: Total respondents = 38.

- "The knowledge acquired in the PGEC allowed us to participate in the development of legal documents, such as the procedure for verification of economic entities by the regulatory body, and the regulations on radiation safety." (PGEC in Belarus, 2007.)
- "The PGEC facilitated my later activities. After taking the course, I participated in the development of some legal requirements, most importantly the new framework for updated dose limits, published in 2008. My current position requires that I either propose or analyse proposals for legal documents." (PGEC in Greece, 2006.)
- "My general and basic knowledge (obtained during the PGEC) helped me to develop the 'law on the use of atomic energy' in line with the development of radiation safety in medicine (diagnostics and therapy), radioactive sources and radioactive waste, and requirements for staff training in working with radioactive sources, and other areas." (PGEC in Belarus, 2005.)

7.5. SUSTAINABILITY AND EFFECTIVENESS OF THE PGEC

'Sustainability and effectiveness' together refer to the ability of the projects developed and of the competences acquired during the PGEC to be transferred via different channels to the radiation safety infrastructure in Member States.

This transfer is monitored by means of four indicators to assess the beneficial impact of the course: follow-up of work projects (7.5.1); the sharing and dissemination of the knowledge and skills acquired (7.5.2); the PGEC's contribution to development of competence and academic development (7.5.3); and the readiness of participants to recommend the PGEC to their peers (7.5.4).

7.5.1. Continuation of the PGEC work projects

PGEC work projects were aimed at helping participants to solve specific radiation protection problems in their Member States. In practice, each participant conducted the work project during the course on a topic that was initially identified and was then further refined together with their direct supervisors. Participants were then expected to follow through on the work when they returned home.

Most participants (69%) confirmed one year after completion of the course that they had performed follow-up activities on their work projects (see Fig. 38).

The work projects, which were started during the course and were intended to be finished when the PGEC participants returned home, served to link the training itself, the professional life of the participants and ultimately the radiation safety infrastructure in the Member States.

Respondents provided specific examples illustrating how and on what subject they had done their work projects and had contributed to strengthening the national radiation safety infrastructure:

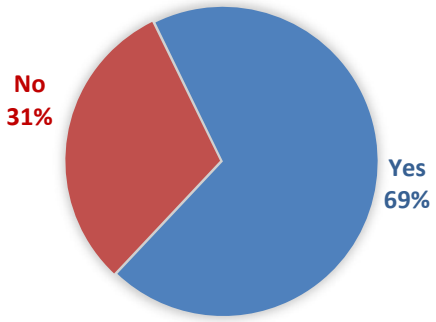

FIG. 38. Percentage of participants who had conducted follow-up activities for their PGEC work project one year after completion of the course; total respondents = 13.

- "I have managed to learn the use of PENELOPE Monte Carlo code, which I am utilizing for my studies." (PGEC in Greece, 2015.)
- "Prepared and managed the EduTA [Education and Training Appraisal] mission (project work of the PGEC was 'Design of a training programme for first responders in the framework of the national strategy for education and training in radiation, transport and waste safety')." (PGEC in Greece, 2015.) "I continued to work in the field of alpha spectroscopy which was the theme of my project work in the PGEC." (PGEC in Greece, 2015.)
- "Developed setup for waste characterization." (PGEC in Greece, 2015.)

7.5.2. Sharing knowledge and skills

In addition to the work projects, the extent to which participants shared or disseminated their new knowledge and skills testified to the sustainability and the effectiveness of the course.

An integral element of the PGEC is therefore devoted to 'training the trainers'. PGEC participants equipped with the necessary basic skills and tools to become trainers trained other personnel locally in radiation protection in line with international standards. Within a reasonable time-frame, this promulgation of the impacts enhanced the pool of trained personnel locally both quantitatively and qualitatively.

Regardless of the time passed since participation in the course, a little under half the respondents declared that they had organized or held a training event in radiation protection and the safe use of radiation sources (see Fig. 39). Although this is a somewhat less significant percentage than for other regions, the limited amount of data gathered so far for the Europe Region prevents drawing many conclusions.

The training delivered by former PGEC participants included a course on radiation protection for training national border officers, aimed at police officers; a course on dosimetry in diagnostic radiology; training for radiation protection officers and health professionals; and training for first responders and others in law enforcement institutions about nuclear safety. The diversity of the training highlights the broad spectrum of topics covered by the PGEC.

7.5.3. Contribution of the PGEC to development of competence

The contribution of the PGEC to specific professional or academic development was recorded three years after completion of the course (see Fig. 40). A significant number of participants did not report any contribution of the PGEC towards achieving academic or professional development. However, most respondents affirmed that the knowledge and skills acquired in the PGEC had enabled them to attend specific training courses and to further enhance their competences.

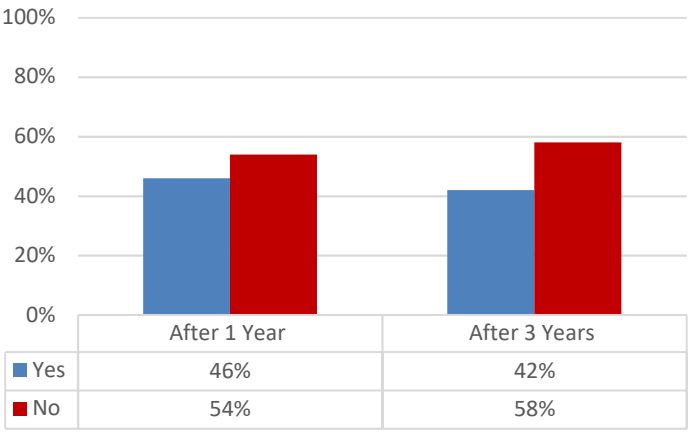

FIG. 39. Participants sharing knowledge and skills gained in the PGEC by organizing or implementing training events after completion of the course: one year after, T (total respondents) = 13; three years after, T = 12.

These training courses were mostly specialized courses and 'train the trainers' events. However, the competences acquired in the PGEC had enabled some participants to undertake academic degrees such as master's degrees or doctorates. Some respondents stressed the part that the work projects had played in their later academic development and achievements.

The PGEC programme served to increase the pool of qualified learners and trainees locally, which in turn strengthened the national educational and training infrastructure.

7.5.4. Recommending the PGEC: ongoing success of the PGEC

Regardless of the time that had passed since their participation in the course, about 90% or more of the respondents had recommended the course to their colleagues or employees. These results seemed to hold in the longer term, with the highest of all recommendation rates being from the respondents in the historical evaluation. Such a high level of recommendation reflected the esteem in which the PGEC is held in the Region (see Fig. 41).

7.5.5. Final comments and suggestions of participants

The answers to the ultimate questions of the questionnaires also bear out the findings mentioned previously. Participants were asked whether they wished to make any additional comments (after three years, after five years and in the historical evaluation). They were also asked for suggestions on how to improve the course to make it more applicable to their duties (after one year). Participants generally praised the course but also identified areas for improvement.

Some testimonials on the benefits of the PGEC are listed in the following:

- "The PGEC is one of the most important courses organized by the Agency; the only one that gives you complete oversight on radiation protection matters. It is crucial that these courses continue to be organized. PGEC provides knowledge that cannot be obtained in smaller countries, or in countries with limited funding in the field of radiation protection." (PGEC in Greece, 2006.)
- "The course was very useful for acquiring knowledge and skills. I want this course to continue for the new generation." (PGEC in Belarus, 2013.)
- "I found that the PGEC was very important for my professional development, especially as I attended the training at the beginning of my career. Because the programme of the course covered all the fields in radiation protection and safety, I go very often to the literature from the PGEC if there is a problem that is not related to my current work but still is about radiation protection and safety." (PGEC in Greece, 2008.)

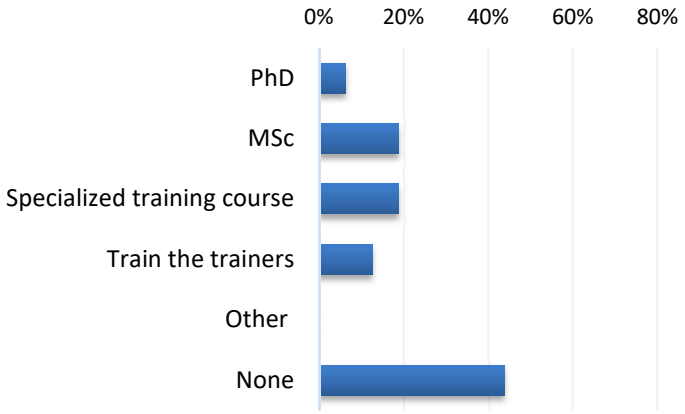

FIG. 40. Percentage of affirmative answers for the contribution of the PGEC towards specific professional or academic development three years after completion of the course: T (total respondents) = 12. Note that giving more than one answer was possible.

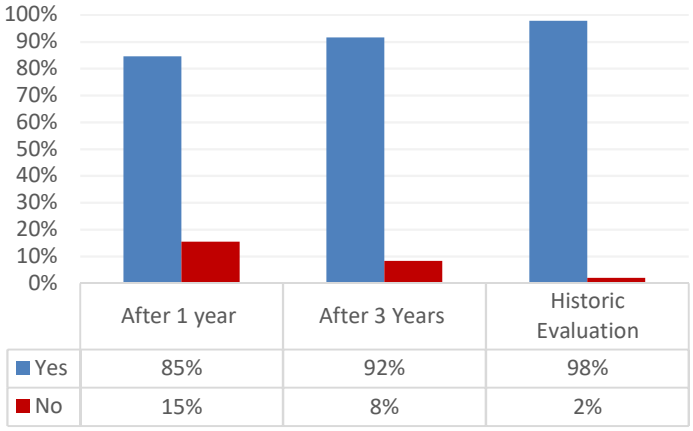

FIG. 41. Percentage of participants who had recommended the PGEC to their colleagues or employees in all IAEA Regional Training Centres in the Europe Region and for all time periods; one year after, three years after and in the historical evaluation. Total respondents (T) = 13; T = 12; T = 93.

- "Thank you to all the organizers of this magnificent course in Belarus! To date, this course has given me a lot in my professional life! I hope there will still be a continuation of these courses, such as were organized for the past participants in Belarus! Thank you!" (PGEC in Belarus, 2005.)
- "Very useful and important course on nuclear and radiation safety." (PGEC in Belarus, 2005.)

Besides the praise, margins for improvement were identified — more so after one year given that the questionnaire specifically asked for suggestions for improvements.

Participants consistently suggested that the part of the training dedicated to practical exercises be increased and that some kind of follow-up refresher courses for the training be considered.

The possibility for the course to acquire some kind of certification or (academic) recognition was also mentioned.

Some suggestions on potential improvements to the PGEC:

- "It would be nice if short term refresher courses were carried out to update knowledge obtained in these courses (refresher training)." (PGEC in Belarus, 2013.)
- "During the PGEC, the technical and practical visits to various facilities and entities were very useful. If it would be possible, it would be great to include more visits of this kind, which help a lot for the training process." (PGEC in Greece, 2015.)

– "About the course, in my personal opinion the course can be changed in order to be more applicable by revising all the training materials (presentations: some of them contain quite old information, references to old publications, etc.)." (PGEC in Greece, 2015.)

– "I recommend this course to younger colleagues. I hope this course might be recognized by local authorities as a sound basis for recognition of a qualification as radiation protection expert." (PGEC in Belarus, 2004.)

8. RESULTS OF THE IMPACT EVALUATION FOR THE PGEC: LATIN AMERICA AND THE CARIBBEAN REGION

8.1. CONDUCT OF THE PGEC

The PGEC has been conducted regularly at one IAEA Regional Training Centre in the Latin America and the Caribbean Region: in Argentina (since 1981) in Spanish.[10]

The impact evaluation for the Latin America and the Caribbean Region was based on answers from 166 participants in 12 PGECs (see Table 7)[11].

8.2. PROFESSIONAL BACKGROUND OF PARTICIPANTS

Regardless of the time passed since participation in the course, and even for the historical evaluation of courses going back 16 years, the participants in the PGEC were working primarily for the regulatory body.

Since the working category 'regulator' comprises most of the course's participants, this is an expected result.

Whereas for one year after participation the number of regulators remained the same as on joining the course, this number had increased by 12 percentage points for five years after completion of the course. This could indicate the influence of the PGEC in orienting its participants towards working for the regulatory body.

More may be known once a single PGEC has been evaluated across the entire impact evaluation cycle (after one year, after three years and after five years).

It is not possible to distinguish meaningful variations for other working categories (see Fig. 42).

TABLE 7. IMPACT EVALUATION CONDUCTED ONE YEAR, THREE YEARS AND FIVE YEARS AFTER COMPLETION OF THE COURSE, PLUS HISTORICAL EVALUATION, UP TO 2015: IAEA REGIONAL TRAINING CENTRE IN ARGENTINA (ARG)

1 YEAR			3 YEARS			5 YEARS			HISTORIC EVALUATION		
RTC	No. of participants	Response rate	RTC	No. of participants	Response rate	RTC	No. of participants	Response rate	RTC	No. of participants	Response rate
ARG	12	92%	*			ARG	11	82%	ARG	482	33%
Total Respondents		11					9				146
			* No course available								
YEAR WHEN THE PGEC WAS CONCLUDED AT THE REGIONAL TRAINING CENTRE (RTC)											
ARG 2015						ARG 2011			ARG (29 courses, yearly basis) - 1981-1991 - 1993 -2010		

[10] The first year in which a PGEC course was implemented in any Region was 1981.

[11] Two pilot surveys were conducted in 2015, one year after and three years after the PGECs held in Argentina in 2013 and 2012, respectively, with slightly different questionnaires. The results of those surveys are not included in this report.

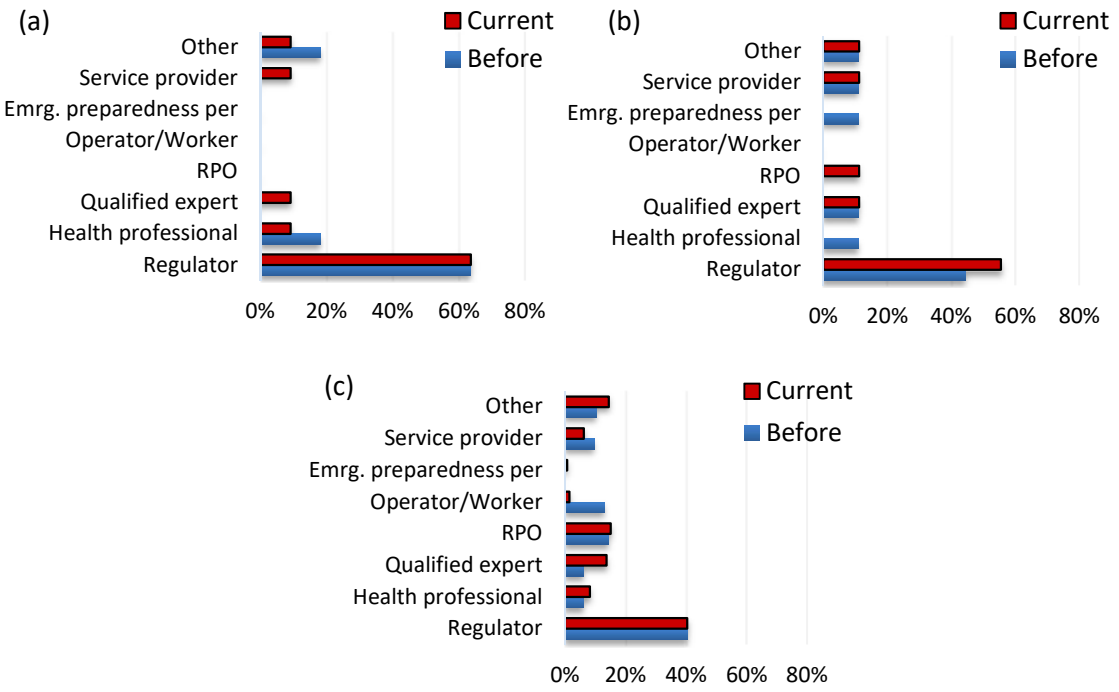

FIG. 42. Percentages of working categories for participants, before attending the course and after completion of the course: (a) after one year, T (total respondents) = 11; (b) after five years, T = 9; (c) historical evaluation, T = 146.

8.3. IMPACT OF THE PGEC ON PARTICIPANTS

8.3.1. Pre-PGEC versus post-PGEC professional levels

Monitoring the professional progress of PGEC participants helps in understanding the influence of the programme over time. For the Latin America and the Caribbean Region, an increase in the number of PGEC participants moving over time from a staff position to a managerial position can be observed (see Fig. 43). This is especially true after five years (+22%) and in the historical evaluation (+25%), as shown in Fig. 43.

To some extent, this reflects a typical career progression: as staff who were PGEC participants gained experience, they were promoted to higher positions. However, other reasons discussed in the following might play a part in furthering the careers of PGEC participants.

8.3.2. Effects of the PGEC on the professional development of participants

Regardless of the time passed since participation in the course, the large majority of respondents stated that the PGEC had had a significant impact on their professional development, with an increasing trend over time.

Altogether, 82% after one year, 100% after five years and 97% for the historical evaluation recognized that the PGEC had had a ‘high or medium’ impact on their professional development (see Fig. 44).

Such results could suggest a lapse of time before the impact of the PGEC becomes apparent.

In addition to evaluating the professional development of participants, increases in work performance and gaining of additional responsibilities were also considered.

Figure 45 (a) and (b) show that one year after completion of the PGEC course, nearly half the participants had gained additional responsibilities and that their work performance had generally improved.

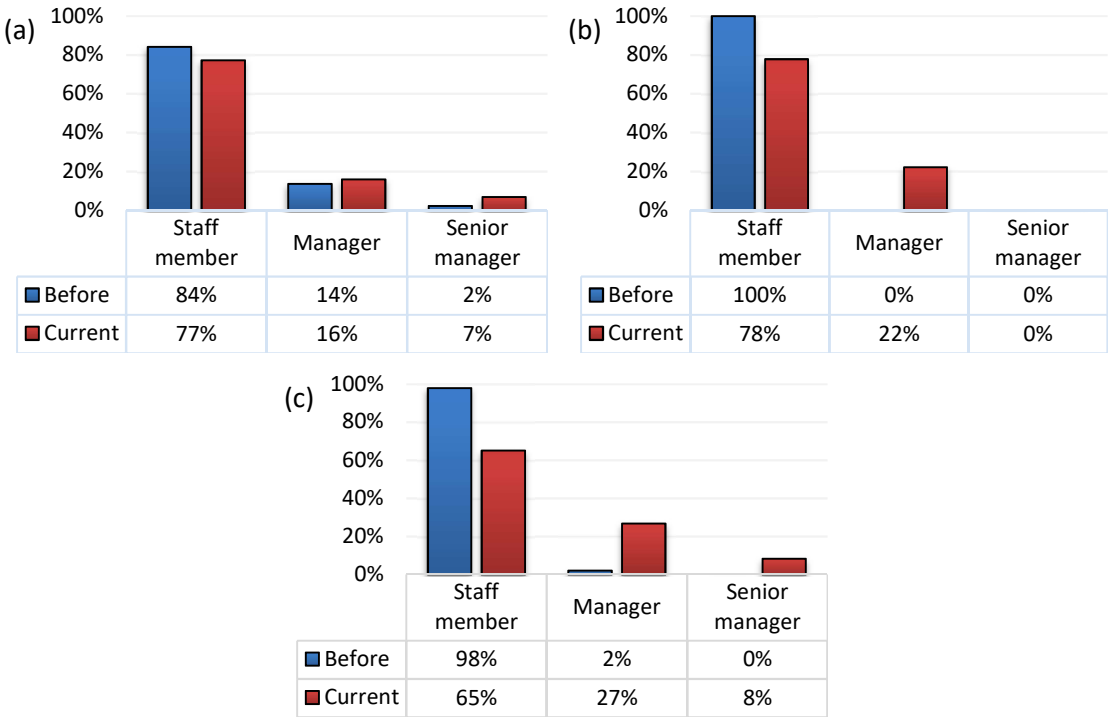

FIG. 43. Participants per professional level before attending the course and after completion of the course: (a) after one year, T (total respondents) = 11; (b) after five years, T = 9; (c) historical evaluation, T = 146.

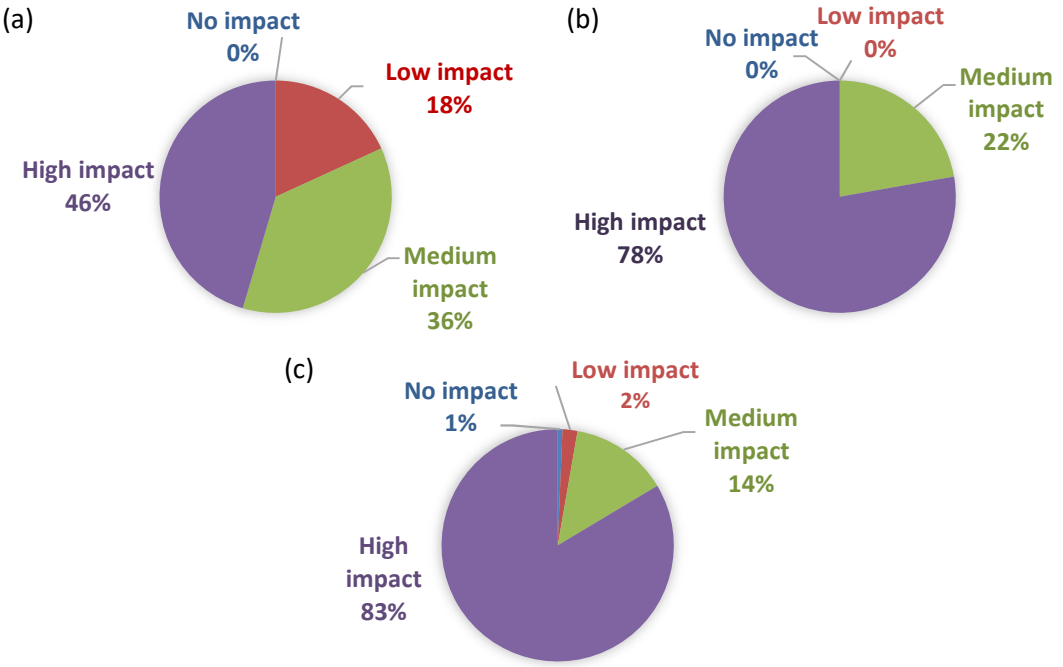

FIG. 44. Participants stating that the PGEC had had a positive impact on their professional development after completion of the course: (a) one year after, T (total respondents) = 11; (b) five years after, T = 9; (c) historical evaluation, T = 146.

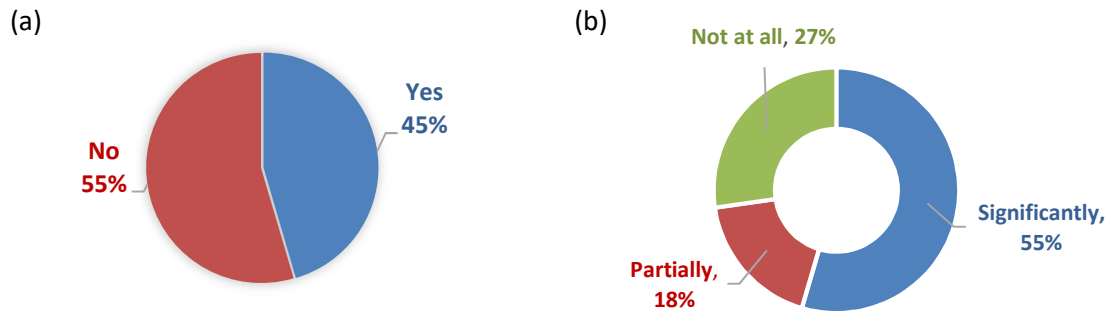

FIG. 45. Participants stating that, one year after completion of the course, the PGEC had had an impact on: (a) acquiring additional tasks; (b) their work performance; total respondents = 11.

These findings support the inference that attending the PGEC had benefited the careers of the participants and had furthered upward mobility in the organization.

Among the many responses specifying their progression since participation, several participants emphasized that the programme had provided them with a sound technical basis in radiation protection.

- "Specialist licensing and radiation protection. Increased knowledge in radiation protection has allowed for better job performance as a regulator." (PGEC in Argentina, 2011.)
- "The PGEC has enriched my cultural heritage in terms of radiological protection, allowing me to do my job much better, for which I am very grateful. Thank you." (PGEC in Argentina, 2012.)
- "Thanks to the course I did, I now work as a supervisor for radiological protection areas, transport of radioactive materials and radioactive waste." (PGEC in Argentina, 2008.)
- "Head of evaluation and control of nuclear and radioactive facilities. The PGEC allowed me to acquire the necessary basic training to assume the leadership of teams at the regulatory body." (PGEC in Argentina, 2002.)
- "Director of radiation safety measurements division. The knowledge gained from the PGEC is highly relevant, not only to respond appropriately to questions from users and to encourage their safety culture, given the permanent treatment of the service, but also to maintain my current position." (PGEC in Argentina, 2001.)
- "In charge of the department of physical security of radioactive sources in the regulatory body. The knowledge gained at that time laid the foundation for my developing professionally." (PGEC in Argentina, 2000.)
- "I am currently an inspector and evaluator for the licensing and control group of the geological service. I am also a university professor and I teach the subjects of radiation protection physics and industrial X-ray imaging in a programme of radiology and diagnostic imaging. The knowledge acquired in the PGEC allowed me to learn all the basic, intermediate and advanced fundamentals of radiation protection. This has given me the daily work of assessing documentation and execution of inspections conducted by the regulatory authority…. Thanks to the knowledge acquired in this course, it has helped me professionally to gain a foothold in the area of radiation protection in my country." (PGEC in Argentina, 1997.)
- "Head of personnel dosimetry laboratory, national atomic energy commission. Highly positive impact because since my return after the PGEC, I have incorporated the use of the operational quantities for the assessment of occupational dosimetry control." (PGEC in Argentina, 1994.)
- "Currently working as the director of technology transfer of the institute of nuclear energy. The PGEC course gave me the technical basis for the issue of radiation protection in different practices which allowed for working directly with end users to improve radiation protection in the country." (PGEC in Argentina, 1981.)

8.4. IMPACT OF THE PGEC ON RADIATION SAFETY INFRASTRUCTURE

Examining the impact that PGEC participants had had on the local radiation safety infrastructure helped to show how the knowledge and skills learned from the PGEC had been translated into concrete outcomes.

Although PGEC participants were from a range of working categories, this part focuses on participants from the regulatory body, who formed the largest category.

8.4.1. Findings after one year and after five years

The impact that participation in the PGEC course had had on the local radiation safety infrastructure was evaluated. Participants were requested to indicate the extent to which they had affected key aspects of radiation safety in the seven thematic safety areas (TSAs) mentioned earlier (see Section 3.1).

The results showed that in the Latin America and the Caribbean Region respondents had applied the knowledge and skills acquired from the PGEC in their daily practice to strengthen the radiation safety infrastructure in the Member States.

As Fig. 46 shows, most participants who were from regulatory bodies declared that the PGEC course had a significant impact in helping them to enhance radiation safety in most of the TSAs areas, more significantly on the longer term. The limited number of respondents precludes meaningful elaboration on these figures.

Participants who were employed as regulators provided the following feedback:

- “I am participating in the review of Mexican official standards, in particular monitoring occupationally exposed personnel. In addition, I am in charge of coordinating the internal course on fundamentals of radiation protection in my institution, where I teach the subject of biological effects following exposure to ionizing radiation.” (PGEC in Argentina, 2015.)
- “What has been learned has been applied in the evaluation and control of radiation facilities nationwide in the organs evaluated by the national nuclear energy commission.” (PGEC in Argentina, 2015.)
- “[There have been] improvements in the processes of authorization and regulatory control, and in proposals for new research projects.” (PGEC in Argentina, 2015.)
- “[There have been] upgrades of security requirements for category 2 installations and [upgrades in] safe handling of radioactive material; and new licensing requirements for facilities in accordance with new international requirements. With respect to radiological surveillance, we have not been able to update due to lack of necessary equipment for radiation monitoring and dose estimation for intakes of radionuclides.” (PGEC in Argentina, 2015.)
- “The impact has been positive from the administrative point of view; and in inspections, evaluations and measurements for decision making purposes from the regulatory point of view.” (PGEC in Argentina, 2015.)

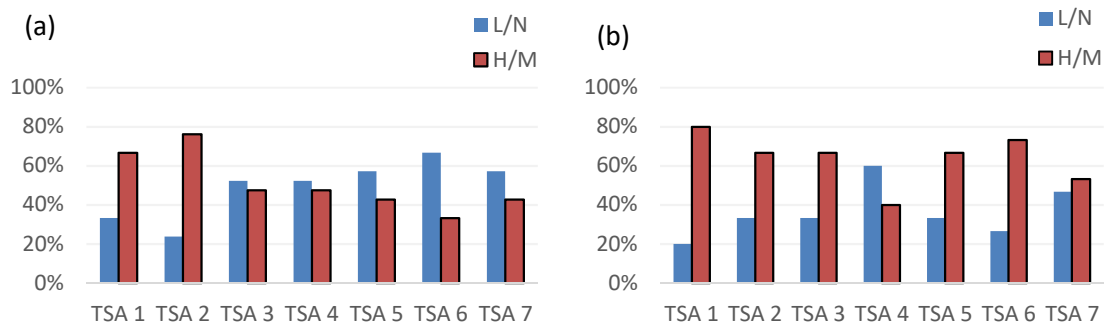

FIG. 46. Responses from participants who were from a regulatory body stating that after completion of the course, the knowledge and skills gained in the PGEC had had a high to medium (HM) or low or no (LN) impact on each TSA: (a) after one year, T (total respondents) = 7; (b) after five years, T = 5.

- "I worked as an evaluator and inspector in the department of regulatory control of the regulatory authority, specifically in the industry group. The learning achieved in the PGEC has allowed me to complete a comprehensive training in radiation safety and protection and nuclear safety. This has contributed to improving the scientific and technical capabilities of the national regulatory authority and the strengthening of regulatory control. I am currently participating in the process of preparing the draft amendment to the regulations for the safe transport of radioactive material, with a view to updating according to the new recommendations of the IAEA. I am responsible for the authorization process for occupationally exposed personnel, under the management system of the regulatory authority, and I have participated in tasks to establish a national training strategy for security training and radiation protection." (PGEC in Argentina, 2011.)
- "The knowledge and experience acquired in the aforementioned year and its application in my professional work has contributed to strengthening security assessments and audits carried out by the national nuclear energy commission. Additionally, it enabled technical criteria to be provided for regulating uses of radiation for safety in various industrial and medical practices." (PGEC in Argentina, 2011.)
- "The national regulatory authority is updating its regulations with the fundamental contribution of those who completed the PGEC. It has improved and optimized resources for regulatory control." (PGEC in Argentina, 2011.)
- "To answer this question, one should consider the levels the participants in the training are at, because many questions asked depend on the level of decisions and the legal framework, and on the impetus and support that is rendered for this. In my case I have worked with particular contributions on the preparation of draft documents to serve in the legal and regulatory framework in the future." (PGEC in Argentina, 2011.)
- "Participated in improvement projects of the official national standards." (PGEC in Argentina, 2011.)

Lastly, an explanation that was given by those stating that they had had a limited (low or no) impact pointed to the absence of equipment.

Of those regulators who had applied the knowledge and skills gained during the course barely or not at all (i.e. low to no impact), the lack of institutional support from decision makers for enhancing radiation protection at the national level was stressed as a limiting factor. Some mentioned the difficulty in assessing the course after so many years, while others stated that they would have needed further training to have made a significant impact.

8.4.2. Findings of the historical evaluation

The historical evaluation covered 29 PGECs that were held in the Latin America and the Caribbean Region prior to 2011.

Simpler than that used for the evaluations after one year, after three years and after five years, the historical evaluation questionnaire (see Annex III, Part 3) asked only whether or not there had been impacts on each of the seven TSAs.

For the 29 courses concerned, all the respondents indicated having had an impact in at least one of the TSAs.

As Fig. 47 shows, every TSA had had impacts through participants applying the knowledge, skills and attitudes acquired in the PGEC. TSA 2 and TSA 6 stood out as having had greater impacts than the others.

The knowledge and skills acquired by participants had been applied to strengthening the radiation safety infrastructure in the Member States in several areas:

– "What has been learned in the PGEC and experiences shared during it served to provide elements for consideration in the development of standards and [elements] leading to the granting of authorizing technical reports." (PGEC in Argentina, 2008.)

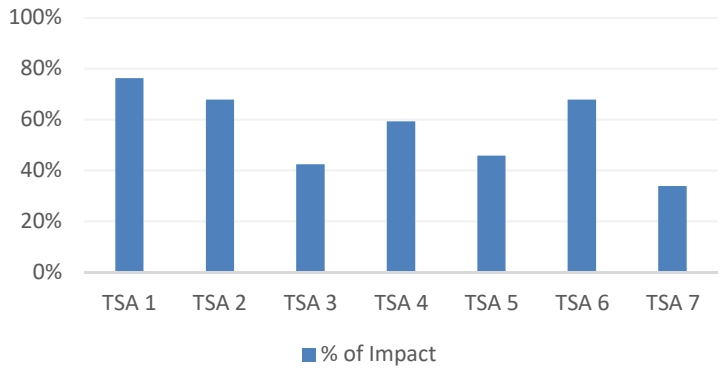

FIG. 47. Percentage of participants who were from a regulatory body stating that the PGEC had had positive impacts for each specific TSA: Total respondents = 59.

– "[Applied] to write a guide for users, a radiation protection manual." (PGEC in Argentina, 2007.)

– "Participated in the initial activities of the regulatory agency: development of inventory act for radiation sources, establishment of safety guidelines for highly radioactive sources (department of energy programme). I participated in the development of the national law for nuclear activities." (PGEC in Argentina, 2005.)

– "My work on the regulations has been enriched by participating in regulatory inspections and technical analysis in which knowledge and skills acquired in the course have been applied." (PGEC in Argentina, 2004.)

– "Knowledge acquired has enabled me to deal with all fields of the application of radiation and this has also enabled my assistance in the preparation of standards and procedures for the control and regulation of radiation use in the country." (PGEC in Argentina, 2003.)

– "Whether for importing or exporting radioactive sources, only the ministry has the authority for authorization. We have an inventory of radioactive sources in the country. Before the course there was none." (PGEC in Argentina, 2002.)

– "Working on the draft national response plan for radiological emergencies." (PGEC in Argentina, 2001.)

– "I have had a moderate impact in terms of regulatory requirements. The PGEC was the starter for developing new guidelines and procedures as well as for improvements in the implementation of activities and processes. The impact was not as significant in terms of the legal aspects." (PGEC in Argentina, 2000.)

- “On my returning from the course, the national regulatory framework was developed, and a system of authorizations and [a system of] inspections were implemented.” (PGEC in Argentina, 1998.)
- “I am also a professor at a university, where I teach the subjects of radiation protection, physics and industrial X-ray images in a programme of radiology and diagnostic imaging. The knowledge acquired in the PGEC allowed me to learn all the basic, intermediate and advanced fundamentals of radiation protection, which has guided my daily work in assessing documentation and in execution of inspections conducted by the regulatory authority.” (PGEC in Argentina, 1997.)
- “The course was excellent, providing me with a good level of preparation for the tasks I performed and still do.” (PGEC in Argentina, 1989.)
- “It allowed me to prepare the regulations of the Law on Protection and Radiological Safety, in addition to various licensing procedures as well as all necessary materials, forms and checklists for inspections.” (PGEC Argentina, 1986.)

8.5. SUSTAINABILITY AND EFFECTIVENESS OF THE PGEC

‘Sustainability and effectiveness’ together refer to the ability of the projects developed and of the competences acquired during the PGEC to be transferred via different channels to the radiation safety infrastructure in Member States.

This transfer is monitored by means of four indicators to assess the beneficial impact of the course: follow-up of work projects (Section 8.5.1); the sharing and dissemination of the knowledge acquired (Section 8.5.2); the contribution of the PGEC to academic development (Section 8.5.3); and the readiness of participants to recommend the PGEC to their peers (Section 8.5.4).

8.5.1. Continuation of the PGEC work projects

PGEC work projects were aimed at helping participants to solve specific radiation protection problems in their Member States. In practice, each participant conducted the work project during the course on a topic that was initially identified and was then further refined together with their direct supervisors. Participants were then expected to follow through on the work when they returned home.

A little under half the respondents (45%) confirmed one year after completion of the course that they had performed follow-up activities on their work projects (see Fig. 48).

The work projects, which were started during the courses and were intended to be finished when the PGEC participants returned home, provided the opportunity to apply the knowledge and skills gained in the courses in the professional activities of participants. This contributed eventually to strengthening organizational and national radiation safety infrastructure.

Respondents provided specific examples illustrating how and on what subject they had done their work projects and had contributed to strengthening the national radiation safety infrastructure:

- “Application and development of internal dosimetry for nuclear medicine workers.” (PGEC in Argentina, 2015.)
- “My job was on risk assessment and every five years facilities in my country delivered such assessments, which are reviewed and approved or not by the regulatory authority, and my work served as the basis for this.” (PGEC in Argentina, 2015.)
- “Developing a strategy for providing quality control services to internal and external users to the national university.” (PGEC in Argentina, 2015.)
- “Radiation protection in nuclear power plants.” (PGEC in Argentina, 2015.)
- “Creating an inspection sheet for positron emission tomography/computed tomography (PET/CT) practice and strengthening of practical actions for regulatory control.” (PGEC in Argentina, 2015.)

More than in other regions, participants indicated not having conducted follow-up activities to their work projects.

Specific reasons given by respondents for not conducting follow-up activities included: the fact that the subject of the work project did not apply to their current occupation; a lack of national support for training health professionals on-line; and a lack of regulation and of a legal framework for radiation safety for steelmakers.

8.5.2. Sharing knowledge and skills

In addition to the work projects, the extent to which participants shared or disseminated their new knowledge and skills testified to the sustainability and the effectiveness of the course.

An integral element of the PGEC is therefore devoted to 'training the trainers'. PGEC participants equipped with the necessary basic skills and tools to become trainers trained other personnel locally in radiation protection in line with international standards. Within a reasonable time-frame, this promulgation of the impacts enhanced the pool of trained personnel locally both quantitatively and qualitatively.

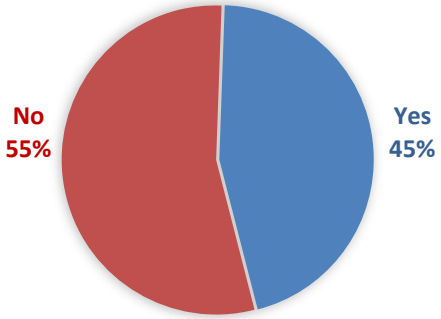

FIG. 48. Percentage of participants who had conducted follow-up activities to their PGEC work project one year after completion of the course; total respondents = 11.

A total of 64% of respondents confirmed having organized or held one or more training events in radiation protection and the safe use of radiation sources after one year, and this increased to 73% for subsequent years (see Fig. 49).

The training delivered by former PGEC participants included, among other things: university lectures and assistance in the medical field; training such as with simulated radiological emergencies; workshops in radiation protection for radiation protection officers; talks at hospitals on radiological protection; and training of new users.

8.5.3. Contribution of the PGEC to development of competence

The contribution of the PGEC to specific professional or academic development was recorded five years after completion of the course (see Fig. 50). Most respondents affirmed that the knowledge and skills acquired in the PGEC had enabled them to attend specific training courses and to further enhance their competences.

These training courses were mostly specialized courses and 'train the trainers' events. However, the competences acquired in the PGEC had enabled some participants to undertake academic degrees such as master's degrees.

The PGEC programme served to increase the pool of qualified learners and trainees locally, which in turn strengthened the national educational and training infrastructure.

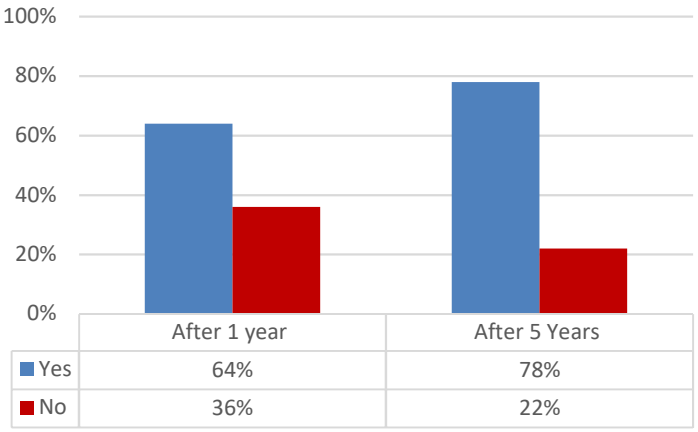

FIG. 49. Participants sharing knowledge and skills gained in the PGEC by organizing or implementing training events after completion of the course: after one year, T (total respondents) = 11; after five years, T = 9.

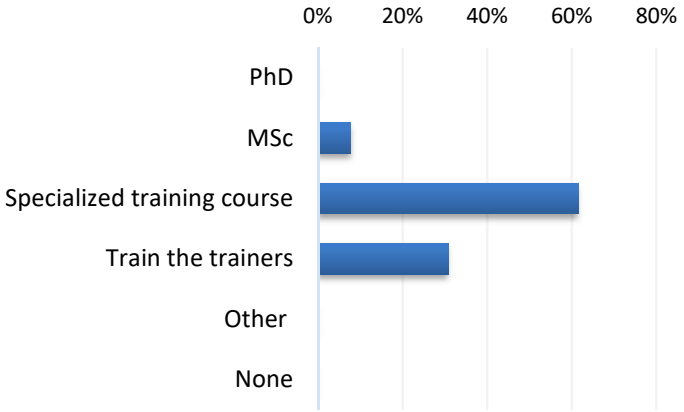

FIG. 50. Percentage of affirmative answers for the contribution of the PGEC towards specific professional or academic development five years after completion of the course; T (total respondents) = 9. Note that giving more than one answer was possible.

8.5.4. Recommending the PGEC: ongoing success of the PGEC

Regardless of the time passed since their participation in the course, about 90% or more of the respondents had recommended the course to their colleagues or employees. These results seemed to hold in the longer term, with the highest of all recommendation rates being from the respondents in the historical evaluation. Such a high level of recommendation reflected the esteem in which the PGEC is held in the Region (see Fig. 51).

8.5.5. Final comments and suggestions of participants

The answers to the ultimate questions of the questionnaires also bear out the findings mentioned previously. Participants were asked whether they wished to make any additional comments (after three years, after five years and in the historical evaluation). They were also asked for suggestions on how to improve the course to make it more applicable to their duties (after one year). Participants generally praised the course but also identified areas for improvement.

Some testimonials on benefits of the PGEC are listed in the following:

– "I thank the IAEA and the [Argentine] authorities for the opportunity that was given to me in attending this training, as it gave me the experience of sharing and learning much more about other ways of improving as a professional in my area; and of being able to bring what they taught to my work, thus contributing to radiation safety. Also, in the framework of this international association, of sharing experiences that occurred in our country, learning from

colleagues and working for the safety of people and [for the] environment." (PGEC in Argentina, 2011.)

- "The course is of great help to everyone who works in radiation and gives appropriate knowledge which may be applied in our field of work." (PGEC in Argentina, 2008.)
- "In my case, despite already having prior knowledge of the majority of the course material, due to research activities, it has served to reinforce the knowledge received and to obtain a certificate guaranteeing it. Also, it provides a network of colleagues in Latin America with whom we have a similar language and that we can use in case of any questions, especially with the PGEC teachers. This course is very useful for those of us who are regulators, and also to correct concepts and functions from the role of student." (PGEC in Argentina, 2002.)
- "This course allowed me to meet a large group of professionals from Argentina and from other countries, as well as professionals involved as teachers, whom I admire and will not forget. Also, the group of colleagues from the region who were present were very good and we still maintain contact. The course meant a qualitative leap in our work as radiation safety professionals." (PGEC in Argentina, 2000.)

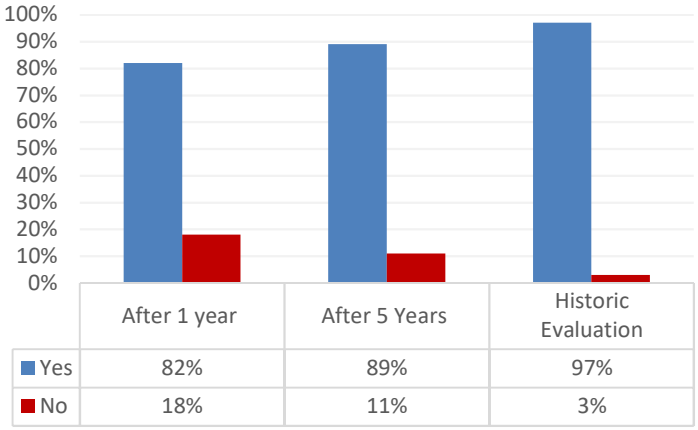

FIG. 51. Percentage of participants who had recommended the PGEC to their colleagues or employees in the Latin America and the Caribbean Region for all time periods; after one year, after five years and in the historical evaluation. T (total respondents) = 11; T = 9; T = 146.

- "The PGEC was my great start in the area of radiological protection. I obtained the necessary basis for the work I do at the University, where I teach courses in radiation protection for the areas of medicine and industry responsible for radiation protection as well as my participation in the only service provider that exists in the country. I personally thank the IAEA and my teachers I had in the PGEC for having been trained." (PGEC in Argentina, 1996.)
- "The PGEC course has been an important achievement for the development of and capabilities in security and radiation protection. An added value given is interpersonal ties that strengthen the exchange of experience, encouraging growth in the Region." (PGEC in Argentina, 1994.)
- "I thank the IAEA for giving me the opportunity to take the course because the knowledge acquired in the course opened doors for me at the university, and I ask for continuous teaching of the course for many young people without financial resources to be able to take the training." (PGEC in Argentina, 1989.)
- "The course in which I participated from 8 June to 31 July 1981 changed my life. Since then radiation protection was and is my passion. In this course I met Dr. Beninson and the great Argentine masters of radiation protection, such as Dr. Touzet, who even after so many years has maintained professional contact. Thank you, thank you and the IAEA!" (PGEC in Argentina, 1981.)

Besides the praise, margins for improvement were identified — more so after one year given that the questionnaire specifically asked for suggestions for improvements.

Participants consistently suggested that the part of the training dedicated to practical exercises be increased and that some kind of follow-up refresher courses for the training be considered. They also suggested that the course material be updated.

The possibility for the course to acquire some kind of certification or (academic) recognition was also mentioned.

Some suggestions made on potential improvements to the PGEC:

- "I recommend that some issues should be updated according to the state of the art, especially in the introduction of software that has been developed for the safety assessment of practices with ionizing radiation." (PGEC in Argentina, 2009.)
- "The PGEC, which has been very important for professional development in my institution, has a drawback as it has not been recognized by the national secretariat of higher education, science and technology, the body responsible for recognizing courses, specializations, etc., completed in another country. The PGEC course is therefore not recognized for merit and competition as a specialization course or graduate course by human resources [in the institution]." (PGEC in Argentina, 2007.)
- "Thank you for the opportunity to participate in this training, which gave me knowledge in the area of work; it would have been good as a contribution to the curriculum vitae if this course could be recognized in my country as a graduate course and could be promoted to a higher level in our working institution." (PGEC in Argentina, 2006.)
- "The course helped me in my professional development and improved my performance in my work at the nuclear power station. However, it would be very good to revisit some aspects that might have been forgotten with time. Thank you." (PGEC in Argentina, 2006.)
- "As I learned, the PGEC emerged in Argentina as an initiative to share knowledge between [radiation] workers. When I took the course, it had become highly theoretical; the application was extremely restricted, to the point that even the practical work had become data management. If this continues, I think the possibilities are underused by the atomic centre." (PGEC in Argentina, 2011.)
- "Increase practical exercises: the volume of participants is determined on the cost of the practical exercises. Change the format of the assessment with the practical component. Professors change in the phase of the FIUBA [Faculty of Engineering of the University of Buenos Aires], with different teaching methodologies. Pre-training subjects (mathematics and physics) for professionals, because with lack of preparation in the same specialty it is a bit complex at the start of the course. A week of adaptation in the new city prior to the start of the course for logistics reasons and housing." (PGEC in Argentina, 2015.)

9. CONCLUSIONS

9.1. GENERAL

The success of any training programme relies on the alignment of the delivery with the identified needs, on the effective and lasting acquisition of the targeted competences, on the application of those competences and ultimately on it all to provide the desired outcomes and meet the actual needs of the individual, organization or Member State [10].

The impact evaluation for the PGEC covered 35 years of activities. As suggested throughout the report, the course benefits both the participants as well as the radiation safety infrastructure in the Member States. The benefits of the course, noticeable in the short term, become even more apparent in the long term. With very high approval rates from the participants, the results of the historical evaluation testify to the enduring influence of the PGEC.

At the same time, as pointed out in Section 4, room for improving the PGEC courses has been identified, by means of the following:

- Fostering the PGEC's (formal) recognition;
- Enhancing the work projects;
- Envisioning refresher courses;
- Involving former course participants in the programme and establishing an alumni.

9.2. PROFESSIONAL DEVELOPMENT

The impact evaluation confirmed that, regardless of the time passed since participation in the course and regardless of the region, the PGEC played an important role in the professional development of participants and in advancing their careers, i.e. promotion from staff member to manager, or from managerial to senior positions.

Even when participants did not reach higher hierarchical positions, they usually gained additional responsibilities, and a large majority reported significant improvements in their daily job performance.

Finally, the qualitative answers that were collected demonstrated the PGEC to be an altogether enhancing and highly valued course that increased the confidence of participants, improved their competences in radiation protection and opened the door to new professional opportunities.

9.3. STRENGTHENED RADIATION SAFETY INFRASTRUCTURE

The PGEC contributed significantly to strengthening radiation safety infrastructure through its participants turning their learning into actions that had a direct and positive impact.

With regulators constituting the largest group of PGEC participants, the course had the highest impact on regulatory related activities. The responses of regulators who attended the PGEC revealed that it was notably instrumental in helping them to: develop and improve legal requirements and standards at the national level; review and revise existing procedures; perform evaluation and inspection activities; and develop monitoring programmes.

It is important to emphasize that the impact of the PGEC courses depends greatly on the areas of responsibility of its participants. Throughout the report, the concrete examples given by the respondents illustrate how their application of what they had learned from the PGEC courses helped to strengthen the radiation safety infrastructure, both at the organizational level and at the national level.

9.4. LONG TERM SUSTAINABILITY OF THE PGEC PROGRAMME

The impact evaluation confirmed that the outcomes of the PGEC are sustained over time in numerous ways, such as in the continuation of activities relating to work projects beyond completion of the courses.

The sustainable transfer of learning occurs systematically through the many training events organized by PGEC participants once they are back in the field.

Many participants confirmed the contribution of the PGEC to their academic development. The course enabled some participants to attain higher academic degrees such as master's degrees or doctorates.

The very high number of PGEC participants recommending the course to their colleagues is a tribute to the quality of the course and is an incentive to improve the course even further.

Altogether, this report confirms that the competences acquired in the PGEC were transferred to the field, promoting the professional development of its participants and strengthening radiation safety infrastructure in the Member States.

The evaluation of the PGEC is a continuing process. With time, further data and comments will be fed back and will help in refining the analysis.

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ANNEX I: PGEC FOLLOW-UP QUESTIONNAIRE AFTER ONE YEAR

Part I: Personal background

1. Name (as in passport).
2. Date of birth.
3. Your nationality.
4. Institute name (current employer).
5. Contact e-mail (if you do not wish to be contacted on the e-mail where this survey was sent).

Part II: Professional development

6. Indicate your field of work immediately **before** attending the PGEC, and your **current** field of work.

	Industrial (radiography, irradiator facilities, well logging, NORM)	Medical	Nuclear (NPP, research reactor, fuel cycle facility, waste management, isotope production, uranium mining)	Research/ academic	Regulatory authority	Service provision (training, dosimetry, calibration)	Agriculture	Other (explain under Question 7)
Field of work before PGEC								
Current field of work								

7. If your answer to Question 6 is ‘Other’, please specify.

8. Indicate your working category immediately **before** attending the PGEC and your **current** working category.

	Regulator	Health professional	Qualified expert	Radiation protection officer	Operator/ worker	Emergency preparedness personnel	Service provider	Other (explain under Question 9)
Working category before PGEC								
Current working category								

9. If your answer to Question 8 is 'Other', please specify.

10. Indicate your professional level immediately **before** attending the PGEC and your **current** professional level.

	Staff member	Manager	Senior manager
Professional level before PGEC			
Current professional level			

11. As a result of attending the PGEC, were you assigned additional tasks or responsibilities?

Yes, please specify

No

12. To what extent has the PGEC played a role in your professional development? Rate the impact using the scale provided.

No impact	Low impact	Medium impact	High impact

Part III: Using and sharing what you learned

13. By applying what you learned during the PGEC, please indicate to what extent you have impacted the described activities (select all that apply). For areas not applicable to your profession, please check N/A.

Regulatory Infrastructure for the Safety and Control of Radiation Sources

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on the safe use of ionizing radiations and radiation sources (about notification, authorization, review and assessment, inspection and/or enforcement; promoting compliance with the Code of Conduct)					
Establishment/development of the national register of radiation sources (maintained by the regulatory body)					
Establishment/development of procedures for notification, authorization, review and assessment, inspection and/or enforcement					

Radiological Protection in Occupational Exposure

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on occupational exposure (about responsibilities of employers, registrants and licensees; implementation of radiation protection programmes; criteria for service providers)					
Development of a radiation protection programme (including individual and workplace monitoring programmes) at the level of the end users and/or facility					
Assessment of external and internal dose to occupationally exposed personnel (at the level of the facility or in the framework of service providers)					

Radiological Protection in Medical Exposure

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on the control of medical exposure (about authorization process; radiation protection training of medical personnel; design considerations of facilities; equipment performance; installation, commissioning and maintenance)					
Application of principles of justification and optimization in diagnostic and interventional radiology, radiotherapy and nuclear medicine					
Establishment of quality assurance (QA) programmes for radiation protection in medicine					

Public and Environmental Radiological Protection

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on the control of public exposure (about control of discharges, foodstuffs and selected commodities, chronic exposures (radon, NORM and past practices) and/or radioactivity in materials for recycling; environmental monitoring)					
Development of a national policy and strategy for radioactive waste management (legal and regulatory requirements on decommissioning and radioactive waste management)					
Development of procedures to control and safely manage radioactive waste, to monitor levels of radioactivity in foodstuffs and selected commodities; to monitor radiation levels in the environment (i.e. in air, soil and water)					

Emergency Preparedness and Response

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on emergency exposure situations (for example establishment of an emergency management system; development and optimization of protection strategies; criteria and operational intervention levels for decision making purposes)					
Development of procedures for the protection of the public and of workers (for mitigation of consequences of a nuclear or radiological emergency; protective actions during radiological emergencies; protection of emergency workers and helpers)					
Development of procedures for environmental monitoring in emergencies (e.g. field radiation and contamination monitoring methods; field sampling and sample measurements; public monitoring; dose projections; dose assessment; decontamination actions)					

Education and Training in Radiation Protection and Safety

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on education and training in radiation protection (e.g. for qualified experts, radiation protection officers, workers, health professionals, regulatory staff)					
Development of a national policy and/or strategies on education and training in radiation, transport and waste safety					
Establishment and/or enhancement of a national education and training programme in radiation protection and safety					

Transport Safety

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on transport of radioactive material (for identification of national competent authorities; consignor's and carrier's responsibilities; activity limits and material restrictions; package limits and typical contents; labels)					
Assessment of compliance with transport regulations, including investigation of non-compliances, transport incidents and appropriate enforcement actions					
Planning and conduction of inspections to transport operations and issuing of approvals					

14. Based on your rating, describe how you have impacted organizational and/or national radiation safety infrastructures. If you have not been able to apply what you learned in any of the listed areas, please explain why.

15. Since you attended the PGEC, have you organized and/or implemented a training event or lecture in radiation protection and the safe use of radiation sources?

Yes, please specify

No

16. Have you had the opportunity to follow-up or continue to develop any activities concerning your work project from the PGEC?

Yes, please specify
No, please specify

17. As a result of attending the PGEC, has your on the job performance improved? Please use the rating scale below, where 1=Significantly and 5=Not at all.

1=Significantly ⊙	⊙	⊙	⊙	5=Not at all ⊙

18. Please select which of the following topics you have shared from the PGEC **within your organization:**

(a) Principles related to quantities and measurements (calculations, detectors, measurement techniques)
(b) Types of biological effects following exposure to ionizing radiation
(c) International recommendations on radiation protection and safe use of radiation sources
(d) Elements of a regulatory infrastructure for radiation protection (legal framework, regulatory system, effectiveness assessment of regulatory programmes)
(e) Estimation of doses arising from external and internal exposure
(f) Concepts related to a radiation protection programme against occupational exposure (any practice)
(g) Radiation protection principles related to medical exposure (radiology, radiotherapy, nuclear medicine)
(h) Information related to exposure of the public due to practices (sources, responsibilities, safe transport)
(i) Principles for intervention in situations of chronic and emergency exposure (response, preparedness, assessment)
(j) Training needs analysis; organization, implementation and evaluation of a training course
(k) Other, please specify

(l) None

19. Have you shared knowledge, skills and material obtained from the PGEC with colleagues **outside your organization** (through training, supervision, collaboration etc.)?

(a) Yes, please specify

(b) No

20. Have you recommended the PGEC to your employees and/or colleagues etc.?

(a) Yes
(b) No

21. One year after attending the course, please provide any suggestions for improvement on how the course could have been made more applicable to your duties (for example course material, instructional approach, practical exercises, work-project etc.)?

ANNEX II: PGEC FOLLOW-UP QUESTIONNAIRE AFTER THREE OR FIVE YEARS

Part I: Personal background

1. Name (as in passport)
2. Date of birth
3. Your nationality
4. Institute name (Current employer)
5. Contact e-mail (if you do not wish to be contacted on the e-mail where this survey was sent).

Part II: Professional development

6. Indicate your field of work immediately before attending the PGEC and your current field of work.

Field of work	Industrial (radiography, irradiator facilities, well logging, NORM)	Medical	Nuclear (NPP, research reactor, fuel cycle facility, waste management, isotope production, uranium mining)	Research/ academic	Regulatory authority	Service provision (training, dosimetry, calibration)	Agriculture	Other (explain under Question 7)
Field of work before PGEC								
Current field of work								

7. If your answer to Question 6 is ‘Other’, please specify

8. Indicate your working category immediately before attending the PGEC and your current working category.

	Regulator	Health professional	Qualified expert	Radiation protection officer	Operator/ worker	Emergency preparedness personnel	Service provider	Other (explain under Question 9)
Working category before PGEC								
Current working category								

9. If your answer to Question 8 is 'Other', please specify.

10. Indicate your professional level immediately before attending the PGEC and your current professional level.

	Staff member	Manager	Senior manager
Professional level before PGEC			
Current professional level			

11. Please provide your current job title and describe any impact to your current position as a result of attending the PGEC.

12. Please indicate if the PGEC has contributed to any of the following academic and/or professional development.

(a) Ph.D.
(b) M.Sc.
(c) Specialized Training Course
(d) Train the Trainers
(e) Other
(f) None

13. To what extent has the PGEC played a role in your professional development? Rate the impact using the scale provided.

No impact	Low impact	Medium impact	High impact

Part III: Using and sharing what you learned

14. By applying what you learned during the PGEC, please indicate to what extent you have impacted the described activities (select all that apply). For areas not relevant to your profession, please check N/A.

Regulatory Infrastructure for the Safety and Control of Radiation Sources

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on the safe use of ionizing radiations and radiation sources (about notification, authorization, review and assessment, inspection and/or enforcement; promoting compliance with the Code of Conduct)					
Establishment/development of the national register of radiation sources (maintained by the regulatory body)					
Establishment/development of procedures for notification, authorization, review and assessment, inspection and/or enforcement					

Radiological Protection in Occupational Exposure

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on occupational exposure (about responsibilities of employers, registrants and licensees; implementation of radiation protection programmes; criteria for service providers)					
Development of a radiation protection programme (including individual and workplace monitoring programmes) at the level of the end users and/or facility					
Assessment of external dose and internal dose to occupationally exposed personnel (at the level of the facility or in the framework of service providers)					

Radiological Protection in Medical Exposure

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on the control of medical exposure (about authorization process; radiation protection training of medical personnel; design considerations of facilities; equipment performance; installation, commissioning and maintenance)					
Application of principles of justification and optimization in diagnostic and interventional radiology, radiotherapy and nuclear medicine					
Establishment of quality assurance (QA) programmes for radiation protection in medicine					

Public and Environmental Radiological Protection

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on the control of public exposure (about control of discharges, foodstuffs and selected commodities, chronic exposures (radon, NORM and past practices) and/or radioactivity in materials for recycling; environmental monitoring)					
Development of a national policy and strategy for radioactive waste management (legal and regulatory requirements on decommissioning and radioactive waste management)					
Development of procedures to control and safely manage radioactive waste, to monitor levels of radioactivity in foodstuffs and selected commodities and/or to monitor radiation levels in the environment (i.e. in air, soil and water)					

Emergency Preparedness and Response

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on emergency exposure situations (for example establishment of an emergency management system; development and optimization of protection strategies; criteria and operational intervention levels for decision making purposes)					
Development of procedures for the protection of the public and workers (for mitigation of consequences of a nuclear or radiological emergency; protective actions during radiological emergencies; protection of emergency workers and helpers)					
Development of procedures for environmental monitoring in emergencies (for example field radiation and contamination monitoring methods; field sampling and sample measurements; public monitoring; dose projections; dose assessment; decontamination actions)					

Education and Training in Radiation Protection and Safety

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on education and training in radiation protection (for qualified experts, radiation protection officers, workers, health professionals, regulatory staff)					
Development of a national policy and/or strategies on education and training in radiation, transport and waste safety					
Establishment or enhancement of a national education and training programme in radiation protection and safety					

Transport Safety

	No impact	Low impact	Medium impact	High impact	N/A
Development of legal and regulatory requirements on transport of radioactive material (for identification of national competent authorities; consignor's and carrier's responsibilities; activity limits and material restrictions; package limits and typical contents; labels)					
Assessment of compliance with transport regulations, including investigation of non-compliances, transport incidents and appropriate enforcement actions					
Planning and conduct of inspections of transport operations and issuing of approvals					

15. Based on your rating, describe how you have impacted organizational and/or national radiation safety infrastructures. If you have not been able to apply what you learned in any of the listed areas, please explain why.

16. Since you attended the PGEC, have you organized and/or implemented a training event or lecture in radiation protection and the safe use of radiation?

    (a) Yes, please specify

    (b) No

17. Have you recommended the PGEC to your employees and/or colleagues?

    (a) Yes
    (b) No

18. Are you currently participating in any national or international project (with the IAEA, or with other organizations at the national or international level) in support of the radiation safety infrastructure in your organization and/or country?

    (a) Yes, please specify

    (b) No

19. Additional comments

ANNEX III: PGEC FOLLOW-UP QUESTIONNAIRE FOR THE HISTORICAL EVALUATION

Part I: Personal background

1. Name (as in passport)
2. Date of birth
3. Your nationality
4. Institute name (current employer)
5. Contact e-mail (if you do not wish to be contacted on the e-mail where this survey was sent).

Part II: Professional development

6. Indicate your field of work immediately before attending the PGEC and your current field of work.

Field of work	Industrial (radiography, irradiator facilities, well logging, NORM)	Medical	Nuclear (NPP, research reactor, fuel cycle facility, waste management, isotope production, uranium mining)	Research/ academic	Regulatory authority	Service provision (training, dosimetry, calibration)	Agriculture	Other (explain under Question 7)
Field of work before PGEC								
Current field of work								

7. If your answer to Question 6 is ‘Other’, please specify.

8. Indicate your working category immediately before attending the PGEC and your current working category.

	Regulator	Health professional	Qualified expert	Radiation protection officer	Operator/ worker	Emergency preparedness personnel	Service provider	Other (explain under Question 9)
Working category before PGEC								
Current working category								

9. If your answer to Question 8 is 'Other', please specify.

10. Indicate your professional level immediately before attending the PGEC and your current professional level.

	Staff member	Manager	Senior manager
Professional level before PGEC			
Current professional level			

11. Please provide your current job title and describe any impact to your current position as a result of attending the PGEC.

12. To what extent has the PGEC played a role in your professional development? Rate the impact using the scale provided.

No impact	Low impact	Medium impact	High impact

Part III: Using and sharing what you learned

13. By applying what you learned during the PGEC, please indicate if you have impacted any of the following areas and provide a brief description in the next question.
    Regulatory infrastructure for the safety and control of radiation sources
    Radiological protection in occupational exposure
    Radiological protection in medical exposure
    Public and environmental radiological protection
    Emergency preparedness and response
    Education and training in radiation protection and safety
    Transport safety
    Other, please specify

    None

14. As a result of applying what you learned during the PGEC, please describe if you have made any impact on development of legal and regulatory requirements, guides or procedures and/or implementation of activities and processes in order to strengthen organizational and/or national radiation safety infrastructures.

15. Have you recommended the PGEC to your colleagues and/or employees?
    (a) Yes
    (b) No

16. Are you currently participating in any national or international project (with the IAEA, or other organizations at national or international level) in support of the radiation safety infrastructure in your organization and/or country?
    (a) Yes, please specify
    (b) No

17. Additional comments

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International Atomic Energy Agency
Vienna
ISBN 978–92–0–159319–1
ISSN 1011–4289