THE INITIAL KNOWLEDGE LEVEL OF THE PARTICIPANTS TO RADIATION PROTECTION COURSES

Gabriel STANESCU

"Horia Hulubei" National Institute of Physics and Nuclear Engineering – IFIN-HH, Nuclear Training Centre, 30 Reactorului, P.O.Box MG-6, RO-077125 Bucharest-Magurele, Romania,
e-mail: stanescu@nipne.ro

ABSTRACT

The design of radiation protection training programmes involves significant efforts due to the different participants' knowledge levels and often to their various practices. Nuclear Training Centre (CPSDN) within "Horia Hulubei" National Institute of Physics and Nuclear Engineering IFIN-HH develops, over four decades, radiation protection training courses for all practices (excepting NPP ones) involving ionising radiation applications. Currently, CPSDN organises more than 20 training programmes yearly for 400 – 500 participants from different institutions, including IFIN-HH. Most of these courses involves training on radiation protection and radiological safety in medical, industrial and research practices and are approved by the national regulatory body (National Commission for Nuclear Activities Control – CNCAN).

This paper presents our results of the analysis on the initial knowledge of participants in radiation protection training courses with a view to support the programmes design and to ensure their efficiency. In this purpose we developed multiple-choice short tests for CPSDN trainees in order to be taken at the beginning of each training programme. The results of these tests are recorded and computer processed. Detailed analysis of these results was performed both for the initial radiation protection training programme (for beginners) and for the refresher radiation protection training programme.

As a result of these analysis the lacks of the trainees' knowledge were identified, as well as their misunderstandings or confusions. These results would be used in the design of CPSDN training programmes in order to improve training quality and to adapt it to participants' knowledge level.

1. Introduction

In the case of the radiation protection courses, the information about trainees' level of knowledge is difficult to be obtained because participants often come from different practices and have different educational background [1]. Of course, it is desirable the homogenization of the group, but this is not always feasible.

Within "Horia Hulubei" National Institute of Physics and Nuclear Engineering IFIN-HH, Nuclear Training Centre (CPSDN) is developing, since 1970, post-secondary and post-graduate trainings for the personnel involved in practices with ionising radiation sources or advanced physical techniques. The Training Centre offers mainly training programmes in radiation protection and radiation safety in all fields involving the use of radiation, excluding nuclear energy. CPSDN organises more than 20 training programmes yearly for 400 – 500 participants from different institutions, including IFIN-HH. These courses are approved by the national regulatory body (National Commission for Nuclear Activities Control – CNCAN).

In Romania, the system for the recognition of the competencies in radiation protection consists in obtaining the practice permit granted by the regulatory body (CNCAN). The

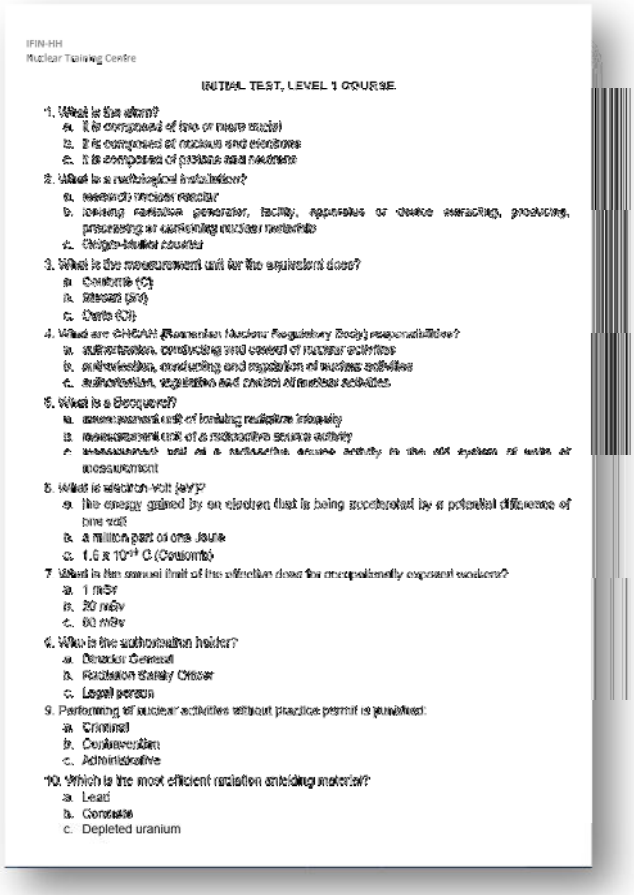
practice permits are classified into three levels: level 1 for radiation workers, level 2 for radiation protection officers and level 3 for radiation protection experts. The training requirements for personnel are specified in the national regulations [2] and are in compliance with the provisions of the Council Directive 2013/59/EURATOM [3]. Radiation protection training programmes shall be correlated with the specific level of practice permit and with domains of applications: x-ray generators, particle accelerators, sealed sources, unsealed sources, nuclear installations, transport of radioactive materials, practices with low radiological risk.

In order to design the radiation protection training programmes, the acquiring of information on participants' knowledge level is essential for improving the course quality and to fill the gaps [4, 5].

The aim of this paper is to present some of the efforts made by CPSDN in order to evaluate the initial knowledge of participants to radiation protection training programmes.

2. Material and methods

By its quality management system, CPSDN has implemented a procedure to assess trainees' knowledge at the beginning of each training programme. For this purpose we developed multiple-choice short tests with 10 questions and 3-5 answer options each. The tests (Fig. 1) are anonymous and include questions from various fields appropriate for the topic and level of the course (basic physics, legislation, applied radiation protection).



IFIN-HH
Nuclear Training Centre

INITIAL TEST, LEVEL 1 COURSE

1. What is the atom?
   a. It is composed of two or more nuclei
   b. It is composed of nucleus and electrons
   c. It is composed of protons and neutrons
2. What is a radiological installation?
   a. research nuclear reactor
   b. ionizing radiation generator, facility, apparatus or device extracting, producing, processing or containing nuclear materials
   c. Geiger-Muller counter
3. What is the measurement unit for the equivalent dose?
   a. Coulomb (C)
   b. Sievert (Sv)
   c. Curie (Ci)
4. What are CNCAN (Romanian Nuclear Regulatory Body) responsibilities?
   a. authorization, conducting and control of nuclear activities
   b. authorization, conducting and regulation of nuclear activities
   c. authorization, regulation and control all nuclear activities
5. What is a Becquerel?
   a. measurement unit of ionizing radiation intensity
   b. measurement unit of a radioactive source activity
   c. measurement unit of a radioactive source activity in the old system of units of measurement
6. What is electron-volt (eV)?
   a. the energy gained by an electron that is being accelerated by a potential difference of one volt
   b. a million part of one Joule
   c. 1.6×10^{-19} C (Coulomb)
7. What is the annual limit of the effective dose for occupationally exposed workers?
   a. 1 mSv
   b. 20 mSv
   c. 50 mSv
8. Who is the authorization holder?
   a. Director General
   b. Radiation Safety Officer
   c. Legal person
9. Performing of nuclear activities without practice permit is punished:
   a. Criminal
   b. Contravention
   c. Administrative
10. Which is the most efficient radiation shielding material?
   a. Lead
   b. Concrete
   c. Depleted uranium

Fig. 1. The initial test form for the level 1 training programme

Such specific tests were developed and implemented both for the initial radiation protection training programme (level 1) and for the refresher radiation protection training programme (level 2). In the latter case, the test has a higher degree of difficulty because the participants to the refresher course have relevant experience in the nuclear field (at least 5 years).
Data from 230 tests were collected and processed for the level 1 training programme. The results of these tests are recorded and computer processed using a spreadsheet software.
Only personnel who worked in the nuclear field at least 5 years and who have previously graduated an initial level 2 training programme could participate at the refresher radiation protection training programme (level 2). Therefore, in this case, the test is more difficult and includes more questions on applied radiation protection. Data from 79 tests were collected and processed for this type of training programme.

3. Results

We will present data and their analysis for the two types of courses mentioned above: level 1 (initial training) and level 2 (refresher training).
The data are processed automatically after entering the answers into a spreadsheet software. For the level 1 course, the data processed from 230 tests showed a mean score of 5.66 points (of maximum 10) with the distribution shown in figure 2.

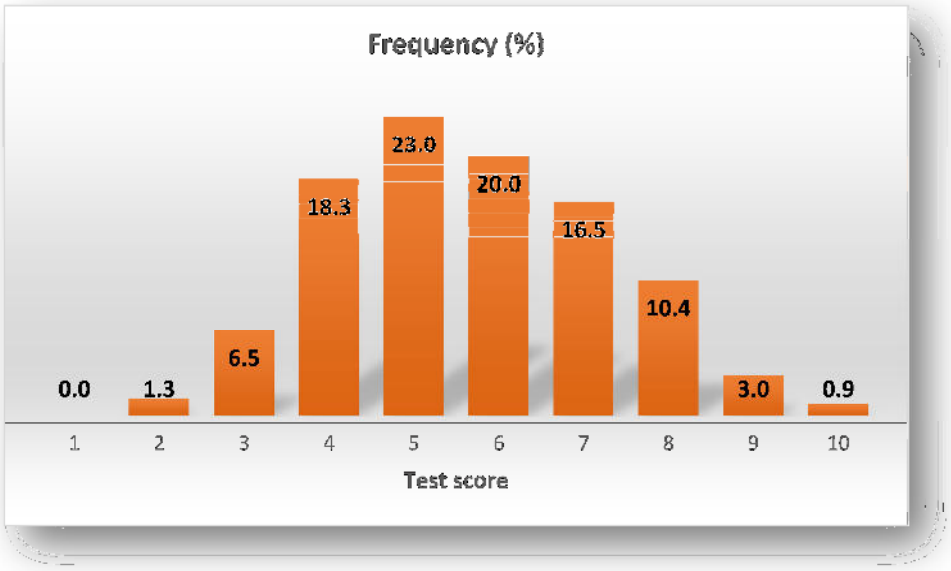


Fig. 2. Distribution of the test scores of the participants to level 1 course

A useful analysis is related to the correctness of answers given for each question (Fig. 3).

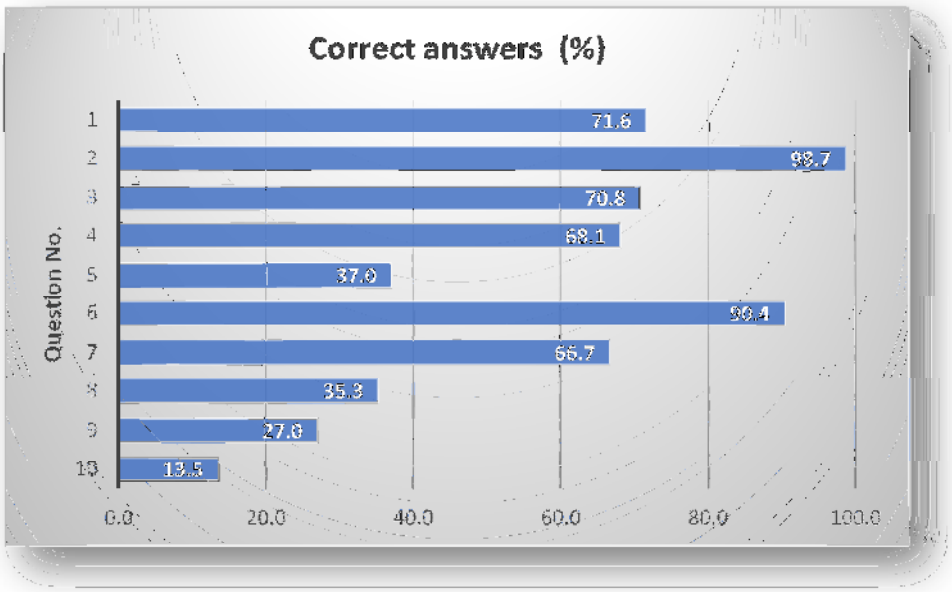


Fig. 3. Percentage values of correct answers for each question of the test (level 1 course)

In the electronic format there is recorded not only the correctness of the answer (correct / incorrect) given by trainee, but also the choice indicated for each question (the letter *a*, *b* or *c* that represents the given answer). Therefore it is possible to evaluate not only the correct answers but also the incorrect ones (Table 1) and hence it can be assessed deeper the initial knowledge of participants on various issues related to radiological protection.

Choice	Question No.									
	1	2	3	4	5	6	7	8	9	10
	%	%	%	%	%	%	%	%	%	%
a	2.2	0.4	11.9	17.9	31.7	90.4	21.6	14.3	69.9	83.4
b	71.6	98.7	70.8	14.0	37.0	0.9	66.7	50.4	27.0	3.1
c	26.2	0.9	17.3	68.1	31.3	8.7	11.7	35.3	3.1	13.5

Tab 1: The choices given for each question (percentage);
the correct answers are pointed in green (level 1 course)

Analysis of the answers given for each question (Fig. 3) shows that for two questions the correctness is more than 90%, for four questions is 60% - 90% and for four questions is less than 50%. The questions that have been answered correctly less than 50% are the Questions No. 5, 8, 9 and 10 (Fig. 4).

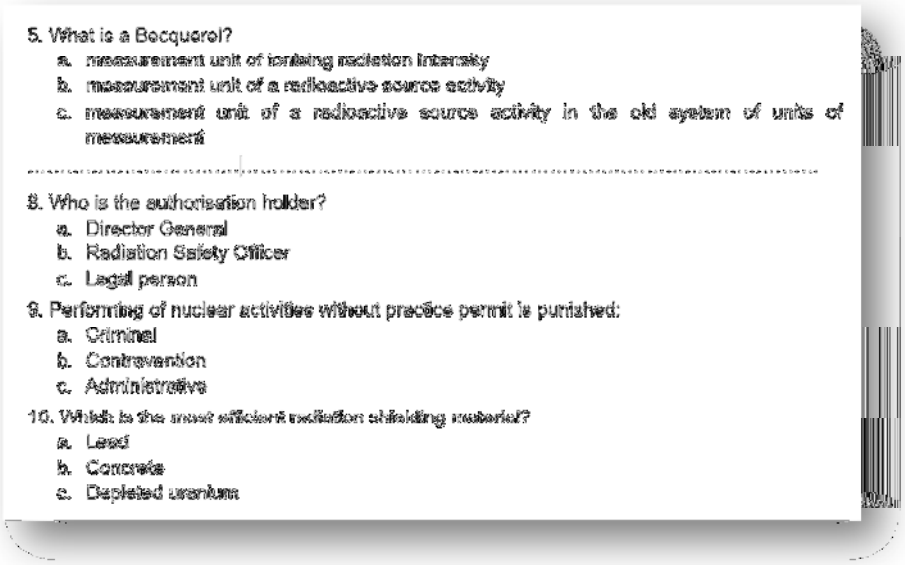


Fig. 4. The questions that have been answered correctly less than 50% (level 1 course)

It can be noted here that one of the questions is from basic physics, two are related to legislation and one is related to applied radiation protection. The analysis of the choices (a, b or c) shows that, regarding the Question No. 5, there is a confusion between the radioactive source activity and the intensity of radiation. Also, the using in practice of another unit (Curie) probably leads to significant choices of the option (c). On legislation, at Question No. 9, the selection rate of 69.9% for the incorrect answer (a) shows a perception even more restrictive than requires the nuclear law in force. The use of lead for shielding of ionizing radiation in many nuclear applications leads to the opinion that it would be the most effective shielding material and therefore the overwhelming wrong answers to the last question. Analysing these results, correlated with the results to the questions with correct answers more than 50%, some of the topics and sub-topics included in the syllabus of this type of course (basics of nuclear physics, some aspects of the legislation, the interaction of radiation with matter, etc.) can be adjusted.

For the refresher radiation protection training programme (level 2), the data processed from 79 tests showed a mean score of 5.47 points (of maximum 10) with the distribution shown in Figure 5.

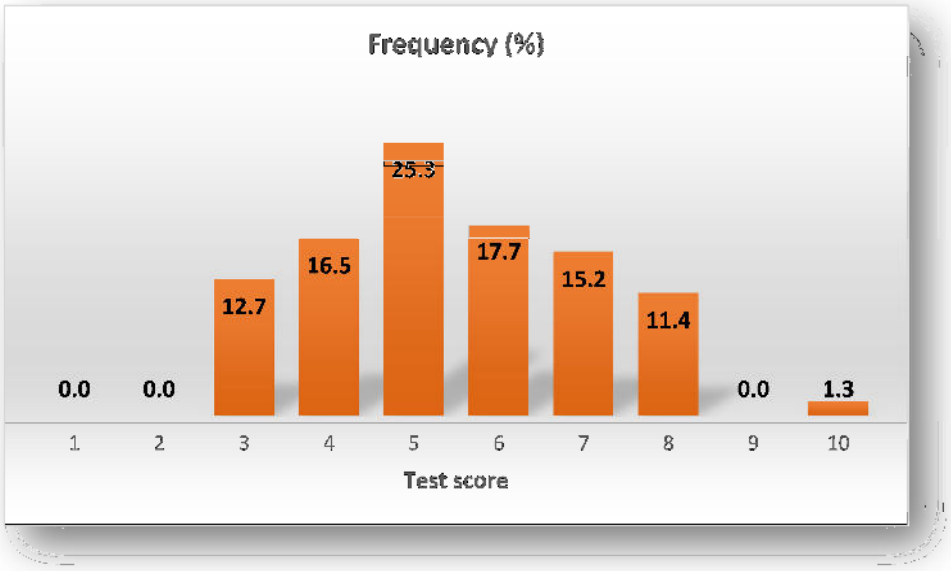


Fig. 5. Distribution of the test scores of the participants to level 2 course

Here it can be noticed the absence of the very low scores (1 and 2), and also of the higher scores (9, 10), probably due to the higher degree of difficulty of the test.
The analysis of the correctness of the answers (Fig. 6) in this case indicates that for one question has been answered correctly more than 90% participants, for two questions the correctness is 60% - 90%, for two questions is 50% - 60% and for five questions is less than 50%.

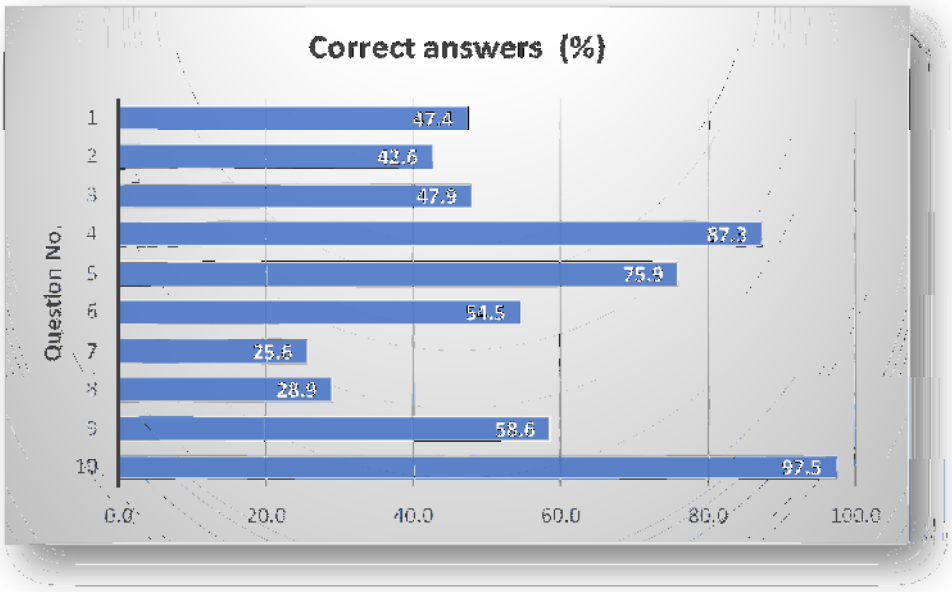


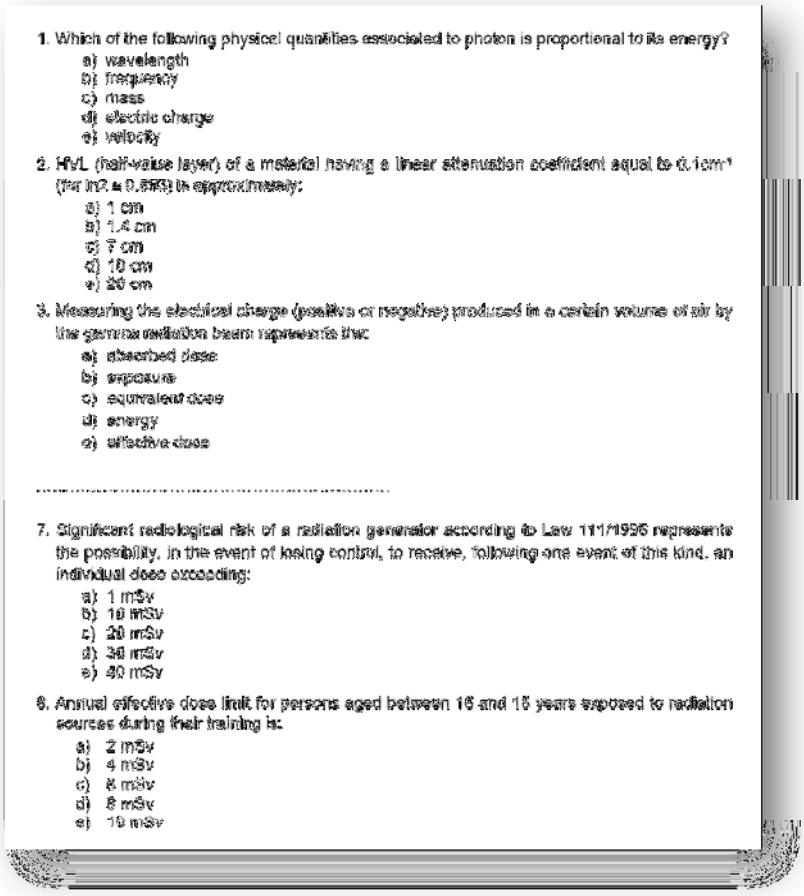
Fig. 6. Percentage values of correct answers for each question of the test (level 2 course)

The analysis of the choices selected by participants (5 options in this case) will allow to evaluate the knowledge of the trainees at the beginning of the training programme in order to improve the quality of this type of programme (Table 2).

Choice	Question No.									
	1	2	3	4	5	6	7	8	9	10
	%	%	%	%	%	%	%	%	%	%
a	29.5	20.6	19.2	2.5	17.7	7.8	25.6	50.0	1.4	2.5
b	47.4	36.8	47.9	87.3	0.0	5.2	21.8	3.9	58.6	0.0
c	5.1	42.6	16.4	1.3	2.5	13.0	50.0	28.9	28.6	0.0
d	1.3	0.0	12.3	7.6	3.8	54.5	1.3	1.3	10.0	97.5
e	16.7	0.0	4.1	1.3	75.9	19.5	1.3	15.8	1.4	0.0

Tab 2: The choices given for each question (percentage);
the correct answers are pointed in green (level 2 course)

The questions that have been answered correctly less than 50% are the Questions No. 1, 2, 3, 7 and 8 (Fig. 7).


1. Which of the following physical quantities associated to photon is proportional to its energy?
a) wavelength
b) frequency
c) mass
d) electric charge
e) velocity

2. HVL (half-value layer) of a material having a linear attenuation coefficient equal to 0.1 cm^{-1} (for ln2 ≈ 0.693) is approximately:
a) 1 cm
b) 1.4 cm
c) 7 cm
d) 10 cm
e) 20 cm

3. Measuring the electrical charge (positive or negative) produced in a certain volume of air by the gamma radiation beam represents the:
a) absorbed dose
b) exposure
c) equivalent dose
d) energy
e) effective dose

7. Significant radiological risk of a radiation generator according to Law 111/1996 represents the possibility, in the event of losing control, to receive, following one event of this kind, an individual dose exceeding:
a) 1 mSv
b) 10 mSv
c) 20 mSv
d) 30 mSv
e) 40 mSv

8. Annual effective dose limit for persons aged between 16 and 18 years exposed to radiation sources during their training is:
a) 2 mSv
b) 4 mSv
c) 6 mSv
d) 8 mSv
e) 10 mSv

Fig. 7. The questions that have been answered correctly less than 50% (level 2 course)

Two of these questions are from basic and specific physics (Questions No. 1 and 3), the Question No. 2 is a practical exercise in applied radiation protection field and the Questions No. 7 and 8 are from basic legislation with little practical application. The analysis of the

choices in this case shows confusing answers to the questions of physics and practical exercise, and the answers to the questions on legislation were completely erroneous. It was a confusion with dose limits for occupationally exposed workers to the Question No. 7 and answers with no basis to the Question No. 8. Correlation with the questions that have correct answers in a greater extent, allows the experts of the Nuclear Training Centre to establish the didactic strategy for this type of training: emphasis on applied exercises in the field of radiation protection and on the advanced concepts of radiation physics and legislation.

4. Conclusions

The results of the analysis on the initial knowledge of participants in radiation protection training courses will support Nuclear Training Centre to identify the lacks in the trainees' knowledge, as well as their misunderstandings or confusions. This will allow trainers to determine teaching approach for each type of course.
The analysis will lead to continuous improvement of the contents of the radiation protection training programmes by adjusting some of the topics and sub-topics contained in the programme and emphasizing on the applied exercises on radiation protection.
Finding out as much as possible regarding the initial knowledge level of the participants is an important milestone in the success of a course. The results presented would be used in the design of CPSDN training programmes in order to improve training quality and to adapt it to the participants' knowledge level.

5. Acknowledgements

This work was partially supported by the Romanian Ministry of Research and Innovation through "Nucleu" Programme – Project PN 16 42 03 03.

6. References

[1] Matjaž Koželj, Where is the border between professional and radiation protection education and training, ETRAP 2013 5th International Conference on Education and Training in Radiological Protection, 13 - 15 March 2013 Vienna, Austria (2013)
[2] National Commission for Nuclear Activities Control, "Norms on issuing of practice permits for developing nuclear activities and designation of radiation protection qualified experts", Bucharest (2002) (in Romanian).
[3] European Commission, Council Directive 2013/59/ Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation. Official Journal of the European Communities L 13 (2014)
[4] P. M. Sadler, The Initial Knowledge State of High School Astronomy Students, unpublished doctoral dissertation, Harvard University, Cambridge, MA (1992)
[5] I.A. Halloun, D. Hestenes, The initial knowledge state of college physics students, American journal of Physics 53.11, 1043-1055 (1985)