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Educational Aspects in Radiography, Physics, and Technology

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Introduction

Diagnostic and interventional radiology professionals (radiologists, radiographers, medical physicists, engineers, etc.) need to be up to date with the required knowledge, skills, and competences (KSC) to ensure the safety and health of patients undergoing a diagnostic or an interventional radiology procedure. To practice their profession, in most countries they need to meet these as a legal requirement.

It is therefore important for these professionals to engage in a continuing professional development (CPD) program in order to maintain their license to practice. These requirements are transposed in all the relevant national legislation.

In most cases, the national legislation includes specific requirements in relation to the education, training, and CPD for the healthcare professionals. It is therefore recommended that all healthcare professionals study their relevant national legislation in order to identify their legal obligations and make sure that they conform to them.

Legal Obligations

The use of ionizing radiation sources is regulated at the national level, and professionals using such sources need to be licensed to do so. The national regulations are based on the International Basic Safety Standards (IAEA 2014) and, for the European Union Member States, are also based on the European Basic Safety Standards (EC 2013).

Both of these recommendations imply that professionals using ionizing radiation sources must be engaged in CPD programs in order to maintain their license to practice. These requirements are transposed in all the relevant national legislation.

Throughout one’s working life, it is essential to acquire new knowledge, skills, and competence to cope with the rate of change of healthcare technology, techniques, and procedures.

When this is done in a planned manner, it is termed continuing professional development, or CPD.

As one’s professional career progresses and the responsibilities increase, it is necessary to adapt the KSCs to cope with the new demands, and hence the need for CPD will increase rather than decrease. Therefore, all professionals, after completing their basic education and training, should be involved in CPD.

CPD can be viewed as vital for the individual professional, their employer, and the profession; it enables maintenance of competence and provides protection from competitor threats and challenges as well as any possible legal action against them. Essentially, the professional benefits in terms of motivation and job satisfaction, and increases their possibilities for promotion. The profession increases its reputation and prestige, while the employer appreciates staff with high self-confidence and an encouraging approach in the introduction of new services. The patient, and therefore the public, benefits from
high-quality medical procedures and the introduction of new ones to routine practice that are scientifically and technically supported.

CPD covers all the activities that increase KCSs and the personal talents that are necessary to deliver services. Such activities include:

- Participation and/or contribution to scientific meetings, conferences, and so on, as well as seminars, training courses, and workshops.
- Research, publication, and self-study (e.g., reading publications such as scientific journals, standards, textbooks, and legislation and contributing to them).
- Improvement of services and providing education and training to related professionals (e.g., creating or adapting protocols and procedures, introducing new services, presenting lectures, etc.).

Each individual professional should plan in advance, for each calendar year, their professional development plan for the coming year, using as a guide the personal CPD cycle presented in graphical form in Figure 67.1 (EFOMP 2015).

The personal CPD cycle consists of eight steps:

1. **Reflect on your role, subject specialism, and priorities:** Conduct a critical self-evaluation in order to identify weaknesses, gaps in competence in your present role, and gaps in KSCs required for priorities to be met in the coming year. Future career ambitions should also be reflected upon.

2. **Analyze your professional goals and needs using your reflections, reviews, and appraisals:** Using your reflections, yearly reviews, and appraisals, analyze your present situation with respect to your professional goals, needs, and ambitions and identify gaps in KSCs that need to be bridged.

3. **Using this analysis, create a professional development plan for the coming year:** Create a realistic professional development plan for the coming year, taking into account the required resources to realize it.

4. **Carry out your planned activities, log outcomes, and reflect on progress:** Identify and attend courses, seminars, conferences that can provide the required knowledge, and if necessary, plan and realize self-learning. Plan and visit other departments to acquire the needed skills and competence. It is very important to log the outcomes and reflect on progress after each event is completed.

5. **Create a professional development record from the evidence in your log:** List the events you have attended and your self-learning activities indicating, where appropriate, the CPD point you were awarded and the KSCs achieved.

6. **Reflect on the impact of what you have achieved in your professional development record:** Conclude your professional development record with a reflection on the impact of what you have achieved.

7. **Submit personal development record to national CPD scheme for evaluation and recording:** The final professional development record should be submitted to the
national CPD scheme for evaluation and recording in the individual professional’s CPD record.

8. Obtain feedback from national CPD scheme: The feedback received from the national CPD scheme should be considered as an input to step one for the next year’s cycle.

The integrity and prestige of a profession is raised by formal standardized CPD schemes. Also, the individual professional benefits from CPD by increasing their competence and competitiveness and by stimulating their job satisfaction and increasing their career expectations.

67.4 Education and Training Resources

67.4.1 Introduction

There is a vast amount of education and training resources available, aside from university studies, that a professional can identify and use to meet his/her CPD needs. Today’s trend is to use self-learning resources in one’s own time and pace, although it should be emphasized that face-to-face events still have their value in offering personal interaction with peers and the opportunity to develop networks of collaboration in areas of common interest.

The main categories of these are discussed in some detail in this sub-section.

67.4.2 Conferences

Conferences offer the opportunity to compare views or take advice about a topic of interest.

They are usually very large events over several days and cover a lot of topics under one or more professional activities that are centered on a specific theme. In order to cover all the topics, large conferences run a number of parallel tracks such that a participant cannot possibly follow all of them. It is therefore important to plan well in advance which sessions of which tracks of interest would be possible to attend so that the maximum benefit will be gained.

Large conferences usually include a technical exhibition that can offer the conference participants the chance to find out about new and upcoming technologies. Participants also have the chance to interact with the personnel of the technology manufacturers and solve queries they may have with their own equipment.

It is advisable that all professionals attend such a conference at least once per year so that they can keep abreast of new and upcoming technologies.

67.4.3 Educational Events

Educational events include short courses, seminars, and workshops that are usually concentrated on a specific topic. The educational events that are followed by an examination are of extra value. This can serve mainly as an evaluation of the knowledge gained from the event, although in some cases, depending on the structure of the event, testing of skills and competences are included. It is pointed out that an examination can be more than a written examination. It could well include the practical testing of skills and competences as well as an oral examination to test the ability of the examinee to communicate verbally. It could also be a combination of all three methods of examination, which is of more value as it offers a complete evaluation of the KSCs gained by the examinee.

Educational events for professionals are usually organized by the relevant professional societies and are advertised on their websites.

67.4.4 Electronic Learning (e-Learning)

It should be recognized that many of today’s students are different from students of the past. They are information technology confident, digitally smart, and accustomed to accessing information from the Internet when and where they need it. They prefer an interactive learning environment to the classical lecture theatre learning. The same applies to today’s healthcare professionals seeking learning material to fill the gaps of their KSCs.

The majority of the international, regional, and even national professional organizations have already developed, are developing, or planning to develop e-learning platforms for their members.

The reader is advised to search the websites for the relevant international, regional, and national professional organizations to identify their efforts in providing e-learning platforms for their members. Here, two examples will be used as references:

1. The Radiology Integrated Training Initiative (R-ITI)
2. The European Training and Education for Medical Physics Experts in Radiology (EUTEMPE-RX)

67.4.4.1 The Radiology Integrated Training Initiative (R-ITI)

The Royal College of Radiologists of the United Kingdom, with support from the National Health Service (NHS) of the United Kingdom, have developed the Radiology Integrated Training Initiative (R-ITI). This educational initiative covers most aspects of radiology, including physics and general science, through the availability of a very large archive of validated patient studies, along with around 1000 e-learning sessions that are self-learning, divided in eight main modules. A module is dedicated to physics concepts with 90 sessions. Another module is dedicated to basic science with 10 sessions. Both of these modules include their clinical relevance. Each session requires 20–40 minutes and follows a standard format of (a) delivery of information, (b) demonstration of concepts, (c) a self-assessment test, and (d) links to additional educational resources.

To aid navigation, the Curriculum Guide provides, with color coding of the main module groups, an overview of the entire database. It can be downloaded from: http://www.e-lfh.org.uk/programmes/radiology/r-iti-downloads/.

There is also a Tutorial Template, which is available for download, that helps trainers to integrate planned presentations, seminars, and workshops with appropriate sessions from the e-Learning database. Once the template is completed, it can be distributed to all the involved trainers, well in advance of the training event, to assist them to prepare themselves accordingly.
67.4.4.2 The European Training and Education for Medical Physics Experts in Radiology (EUTEMPE-RX)

The EUTEMPE-RX project was a three-year, European Commission funded project that started in August 2013 (http://www.eutempe-rx.eu/). Its objective was to develop a course consisting of a number of modules (short courses) to cover the KSCs for Medical Physics Experts, as detailed in the European Commission’s Radiation Protection Report 174 (RP 174) (EC 2014a) in the area of Diagnostic and Interventional Radiology.

Twelve course modules have been developed, each covering a series of KSCs as listed in RP 174. They have been designed using a blended learning scheme that combines online with face-to-face learning. Each module ends with an assessment of the achieved KSCs. A quality control system ensures the quality of each course module content, design, and organization.

Important preparatory parts and new theoretical material are provided to the participants during the e-learning phase of each course module. The educational part of the course modules, which is quality monitored through the e-learning platform, offers a group experience to the participants through their active contribution in the learning process. This allows for a shorter face-to-face phase that concentrates more on the practical acquisition of skills and competence through interactions between the faculty and the participants. The participants of each course module are expected to devote some 40 hours of active learning during the e-learning phase spanning over several weeks and another four to six days during the face-to-face phase of each course module.

The EUTEMPE-RX is currently operational under the umbrella of EUTEMPE-Net. For more information visit www.eutempe-net.eu.

67.4.5 Self-Directed Learning

Self-Directed Learning (SDL), as defined by Malcolm Knowles, is:

In its broadest meaning, self-directed learning describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. (Knowles, 1975, p. 18)

The important aspect of this definition of SDL is that the learner takes firstly the initiative to follow a learning experience and secondly the responsibility for its completion. Once the learner takes the initiative, he/she takes full responsibility for defining the learning experience and following it through to its completion. Input from others is not excluded, as the learner has the final decision. Also, self-direction does not mean the learner learns alone or in isolation. This may be the case for any given learning task, but the main factor is that the learner is running the learning experience, starting from acknowledging the need to learn.

Resources for SDL include all the resources mentioned in the previous sub-sections as well as many others, such as:

1. Training after the installation of new equipment
2. Equipment manuals
3. Manufacturers websites
4. Quality control tools and accessory manufacturer’s websites
5. National, regional and international organization’s websites
6. Books and journals

1. Training after the installation of new equipment: It is a usual practice that, after the installation of new equipment and before this is put to clinical use, short training of all the professionals involved is undertaken by the equipment providers. This is usually one to two days long and offers the basic training required for the professionals involved to start using the newly acquired equipment.

It is assumed that this training, together with the previous experience of the professionals involved, is enough to optimally run the equipment. This is not always achievable, as there is not always enough time for the trainees to digest all the information and solve all their queries. This leads to under and non-optimal usage of the equipment. It is advisable that the training on new equipment takes place over several periods after the installation of the equipment. The periods, duration, type, and level of these training activities, to be effective and provided at a reasonable cost, must be specified in the tender documentation and agreed with the equipment provided before the signing of the final purchase agreement. An example of a request for such training activities could be in the following form:

The contractor will provide training at the installation site to the Engineers, Radiographers and Medical Physicists for all stages of maintenance (preventive and corrective), operation, and fault diagnosis. The training will be done within the normal working hours of public service.

All costs, other than the costs of travelling, living, and salary of trainees, will be borne by the Contractor, for example, instructor costs, educational materials, samples, and equipment, manuals, etc. The numbers of trainees will be:

a. Engineers: two persons per modality. The duration of the training will not be less than seven hours.

b. Radiographers: four persons per modality. The duration of the training will not be less than 21 hours.

c. Medical Physicists: two persons per modality. The duration of the training will not be less than 14 hours.

In the middle and at the end of the training the contractor will submit a report to the employer for the quality and level of trainees as well as for their response to the education and training, and a certificate will be issued to each trainee individually.

Enhanced training for a total duration of five (5) working days will be carried out after six (6) months from the functioning of the systems. This training will be scheduled in consultation and cooperation with the employer.
In the above example, the aim of the enhanced training, six months after installation, is to give all the involved professionals the opportunity to solve all the queries that have accumulated during their initial experience in using the equipment and also to acquire additional training to advance the utilization of the capabilities of the equipment.

2. Equipment manuals: All newly purchased equipment is accompanied by at least one set of user's, operation, and technical manuals. These can be in hard copy form or in electronic form. If requested in the tendering documents, these can also be provided in the language of the professionals using the equipment. They offer information for all the professionals involved on the optimal use of the equipment as well as advice on the correct preventive maintenance and routine testing of the equipment.

Experience says that these manuals are hardly used. Usually, one refers to them when a problem arises. This is a bad practice. It is advisable that all professionals involved study these manuals during the first few months that the equipment is put to clinical use and use them continuously thereafter as reference documents in their efforts to optimize the use of the equipment, taking advantage of all the equipment's capabilities.

3. Manufacturer websites: Manufacturer websites offer a vast amount of additional information on all their products, as well as education and training activities. These may include white papers on a particular technology, webinars on the practical use of specific products, manual updates, hazard notices as well as announcements for technical seminars and courses. Some manufacturers may provide a section for frequently asked questions and the possibility of answering individual queries. Some of them may also provide discussion forums through their websites. It is therefore advisable that all professionals make a habit of visiting their equipment manufacturer's websites regularly in order to identify events and material that may be of interest to them in advancing their KSCs on the usage of their specific technologies.

4. Quality control tools and accessory manufacturer websites: In a similar manner to the equipment manufacturers, the manufacturers of the quality control tools and accessories used with the equipment provide similar educational and training material on their websites.

It is therefore advisable that all professionals make a habit of visiting their quality control tools and accessory manufacturer websites regularly in order to identify events and material that may be of interest to them in advancing their KSCs on the usage of their specific technologies.

5. National, regional, and international organization websites: Organizations relevant to professional activities are divided into governmental and non-governmental and exist at the national, regional, and international level. Governmental organizations are responsible for the legalities of a subject, while non-governmental organizations usually deal with specific professions. All of these organizations produce, and have available on their websites, material that can be used by professionals for their education and training.

On the national level, for example, the American Association of Physicists in Medicine (AAPM), a non-governmental organization, has a vast repository of information and didactic material, created through many years of dedicated voluntary efforts by its members. Most of this material is collected in the AAPM Virtual Library (Pipman and Bloch 2015) which is accessible through its website at http://www.aapm.org/.

An example of a regional non-governmental organization is the European Federation of Organisations for Medical Physics (EFOMP), which provides courses, policy statements, and guidelines for medical physicists (http://www.efomp.org/). Internationally, for medical physicists, there is the International Organisation of Medical Physics (IOMP) that provides guidance for medical physicists at the international level (http://www.iomp.org).

Similarly there are national, regional, and international non-governmental organizations for all the other professions.

With respect to the governmental organizations, relevant to diagnostic radiography physics and technology and, more precisely, for radiation protection, are the websites of all the national competent authorities at the national level, for example the Health Protection Agency (HPA) of the United Kingdom, which is an integral part of Public Health England (https://www.gov.uk/government/organisations/public-health-england).

On the regional level, an example is the European Commission websites that provide studies and reports on a vast number of issues. A more specific and relevant example is the Radiation Protection website that provides a large number of freely downloadable reports (http://ec.europa.eu/energy/en/topics/nuclear-energy/radiation-protection). An example of such a report would be the Radiation Protection Report No. 175 “Guidelines on Radiation Protection Education and Training of Medical Professionals in the European Union” (EC 2014b).

The most relevant international governmental organization for radiography physics and technology would be the International Atomic Energy Agency (IAEA). Two of its divisions, the Human Health (http://nucleus.iaea.org/HHW/Home/index.html) and the Radiation Protection (https://rpop.iaea.org/RPOP/RPoP/Content/index.htm) divisions, produce a vast number of reports, books, guidelines, and standards that are freely downloadable. They also organize conferences, workshops, seminars, and other educational and training events. Of special interest is the IAEA Cyber Learning Platform for Nuclear Education and Training (CLP4NET) at http://clp4net-nkm.iaea.org/index.html. This is an online platform that allows the easy identification of
educational resources; it includes a learning environment that supports courses led by instructors and can distribute e-learning resources to a broader audience.

Under the governmental organizations, it is important to mention the national, regional, and international standardization bodies that produce standards that are essential to the provision of professional services.

As specified by the British Standards Institute (BSI), a standard is a “document, established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. Standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits” (BSI 2011).

According to BSI (BSI 2011), there are six main types of standards:

**Specification:** It gives a coherent set of absolute requirements, each objectively verifiable. The result is a non-negotiable set of criteria for products, services or systems. It is particularly suited to giving the performance criteria demanded of a product, or the fundamental elements of a service or management system.

**Code of practice:** It contains recommendations and guidance, where the recommendations relevant to a given user have to be met in order to support a claim of compliance. Users may also justify substitution of any of the recommendations in a code of practice with practices of equivalent or better outcome. Depending on the context and field of application, a code of practice usually reflects current good practice as employed by competent and conscientious professionals.

**Guide:** which primarily contains information and guidance. It may also include recommendations where appropriate but these are generally of a nature that would not support reliable claims of compliance.

**Method:** A document specifying detailed instructions for carrying out one or more procedures for measurement, testing, sampling, evaluating or specifying performance. Note that a method only gives the procedure. It does not specify performance requirements or the outcome.

**Vocabulary:** A compendium of terms and definitions, which helps to harmonise the use of language within a given sector, field or discipline.

**Classification:** An ordering of items or grading system for use across a given sector, field or discipline.

Each nation has its own national standardization body that adopts regional or international standards or creates its own national standards. Professionals should be aware of the national standards that cover their own profession. Usually, national standards are provided in the national language and are therefore more easily implemented.

Perhaps the most important regional standardization bodies are those of the European Union, for which more information on the functioning and type of standards produced can be found from their respective websites. The most relevant of these for diagnostic radiography professionals are:

- **CEN—Comité Européen de Normalisation** (https://www.cen.eu/Pages/default.aspx)
- **CENELEC—Comité Européen de Normalisation Électrotechnique** (http://www.cenelec.eu/)

   Respectively, the most relevant international standardization organizations are:

- **IEC—International Electrotechnical Commission** (http://www.iec.ch/)
- **ISO—International Organization for Standardization** (http://www.iso.org/iso/home.html)

6. Books and journals: A book contains the experience, knowledge, understanding, and skills that can be used to perform a task or solve a problem. A relevant book, or a set of books, on a profession can serve as reference material and as a refreshing tool to a professional at times that one needs to remember standard knowledge or refresh one’s mind of a standard procedure. Books contain the past and, on some occasions, the current knowledge about a profession. As such, it must always be remembered that some aspects of a book may no longer be valid or be outdated (writing, editing, printing, and publishing delays) with the rapid advance of today’s science and technology.

   Scientific peer reviewed journals contain original articles that have been written by scientists/professionals and evaluated for technical and scientific quality and correctness by other experts in the same field and, as such, offer a professional the latest scientific news in a particular field. Reading such journals keeps the professional up to date with his/her profession.

Since the late nineties, books and journals have also been made available in electronic (soft) form or exclusively electronically, called e-books and e-journals, respectively. These are easier to review and update and cheaper to produce and maintain. They are also easier to store as they do not require a physical library to store them. They can be carried and accompany professionals everywhere and anywhere as long as they have with them their personal computer, smart phone, or tablet. In some cases, e-books and e-journals are accessible free of charge.

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