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EMERALD and *EMIT*—worldwide computer aided education and training packages in medical physics

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Abstract

This paper describes the development of two web based education and training packages *EMERALD* and *EMIT* designed to meet the training needs of professional medical physicists. The program has been developed over a number of years by collaboration between hospitals and universities across Europe. The program concentrates on assisting competence development in five initial areas: diagnostic radiology; nuclear medicine; magnetic resonance tomography; ultrasound; and radiotherapy. Each of the topic areas includes around 50 training tasks in five hypertext workbooks, supplemented by a topical image database. The training materials have been extensively refereed during the development phase and are now in use in 65 countries across the globe. Initial evaluation has shown that the material enhances the training experience and produces a more consistent output.

Introduction

The two projects *European MEdical RAdiation Learning Development* (*EMERALD*) and *European Medical Imaging Technology Training* (*EMIT*) have been developed under the EC Leonardo da Vinci program (for vocational education and training). The training program was developed over a number of years by collaboration between medical physicists across Europe (EMERALD/EMIT Consortium) with the aim of meeting training needs of professional medical physicists (Dendy 1997; Tabakov, Roberts, Jönsson, Ljungberg, Lewis, Wirestam, Strand, Lamm, Milano, Simmons, Deane, Goss, Aitken, Noel, Graud, Sherriff, Smith, Clarke, Almquist and Jansson 2005). It was also intended to promote consistency and assist with the mobility of trainees between centres and also between countries. The projects have been supported by the *European Federation of Organisations for Medical Physics*, EFOMP (www.efomp.org). In December 2004 in Maastricht, Holland, the project *EMIT* was awarded the first ever Leonardo da Vinci Award.

EMERALD contains three modules covering the Physics of Diagnostic Radiology, the Physics of Nuclear Medicine, and the Physics of Radiation Therapy and within *EMIT,* two modules cover the Physics of Ultrasound and the Physics of Magnetic Resonance Imaging. The training module concept is designed to develop goals, skills and competencies through carrying out specific tasks which are typical for the medical physicist. Each of the modules has a training curriculum incorporating a number of pre-described tasks based on a set of competencies (in accord with the UK's IPEM Training scheme and the EFOMP recommendations), a structured time table, a student workbook with practical training tasks, and an image database illustrating these tasks. Each task is allotted an estimated completion time within the 80 day module.

Learning and teaching online

Online learning is developing from an instructional paradigm to a learning paradigm, a distinction made in pedagogical theory (Barr and Tagg 1995). In an *instructional paradigm*, a specific methodology and a specific body of knowledge largely determine the teacher's actions, including planning, content, lessons and the assigned tasks. On the contrary, the teacher with a *learning perspective* provides student support, the students themselves actively discovering knowledge and constructing it. Thus, in the learning paradigm it is a student's own learning and success which sets the boundaries and defines the tasks. This is brought into sharp focus in online learning. For online learning to be successful, a complex system must be developed; one that provides sufficient planning while incorporating a great deal of flexibility which allows the student to manage much of what is done (Alexander 2001; Stephenson 2001).

In developing the training packages we tried to move away from using the purely instructional paradigm, preferring a mixture of revelatory and conjectural approaches. With an awareness of the lack of resources across Europe, and indeed the rest of the world, it was also clear from the outset that our approach to learning had to be student-centred rather than teacher or trainer centred. In addition, interaction between trainees is important and the trainer's role is expected to be more as a coach who provides focussed feedback. While from the outset we recognised that in some situations trainee-trainee interaction might be limited, we took the view that these interactions would develop in due course. The importance of this interaction was confirmed in the pilot evaluation of the *EMERALD* material.

Basic concepts of the training scheme

Training in the medical physics disciplines varies widely from country to country. While many countries provide specific educational programs leading to a MSc, very few provide formal practical training (Roberts, Tabakov and Lewis 1995). Despite well-established educational programs in medical engineering and medical physics, a natural tension between the elements of education and training nonetheless exists (Barnes and Johnson 1999); structured training is thus a very recent development. The *EMERALD* and *EMIT* programs build on training programs from the UK following prospectives from the UK Institute of Physics, Engineering and Medicine, IPEM (IPEM 2002) and the European Federation of Organisations for Medical Physics, EFOMP (Jessen 1999; Lamm 2001). These documents list competencies required by medical physicists in a variety of specialist areas. The lists were expanded into structured training timetables and protocols (tasks) defining practical work which would enable the student to achieve the relevant level of competence.

These modules were designed so that the trainee will acquire necessary professional skills within the allocated 80 days. This 'condensed' training phase can be carried out in most countries after which the trainee can spend up to two months in his own country/state to study the local regulations and professional requirements. This scheme also allows the individual modules to be taken separately.

The training material

The training program is intended for use throughout Europe. Separate Course Guides for *EMERALD* and *EMIT* primarily provide recommendations for implementing the program, and on monitoring and assessing the progress of the trainee. The Course Guides also present radiation protection principles and safety in the five subject areas. Training Timetables should be used together with the Course Guides, and are available together with the Training Workbooks (e-Workbooks) and the digital Image Database.

Image databases (CD-ROM)

Radiological equipment is intensively used for diagnostic and treatment purposes and the time available for training is very limited. Due to their costs equipment cannot be purchased only for training purposes. Thus, young medical physicists have extremely limited time for practical training in the hospitals. The solution to this problem is to encourage the use of modern educational technology.

In order to provide possibilities for effective training with off-site (distance) studying of contemporary radiological equipment, the *EMERALD*/*EMIT* Consortium has developed a database of digital images (IDB). The Image Database is in five volumes (Diagnostic Radiology, Nuclear Medicine, Radiotherapy, MRI and Ultrasound). Each IDB contains 500-1000 images of radiological equipment and its components, block diagrams and performance parameters, graphs, waveforms, Quality Assurance procedures and measuring equipment, test objects and image quality examples, typical images and artefacts, etc. The images are organised to correspond to the Training Workbook and curricula. The structure of the image collection facilitates the use of the database by hyper linking of images and text in the workbooks.

ThumbsPlus by Cerious Software Ltd., is used for quick and easy searching through the IDB. The browser presents each image as a thumbnail image which can be enlarged. A keyword search of the IDB can be performed as well (Figure 1).

Workbooks

The structure of each training module is based on the tasks in the Workbook. Each task, there are around 50 in each book, is described using a standard format. It contains explanations and protocols to be followed and requires answers to specific questions and problems. The proper performance of each task should be verified by the trainer (in accordance with the Course Guide) before the trainee is allowed to continue with other tasks. Trainees are encouraged to work together especially on tasks which arise from a learning perspective, i.e., real-life problem solving rather than instructional tasks are promoted.

Skills are acquired by observing real activities and taking notes, using existing regulations, protocols, software, using various types of measuring equipment, understanding the basic characteristics and parameters of various radiological equipment, performing measurements, radiation dosimetry, collecting results, calculating parameters and other activities most often related to quality control, and full assessment of various types of equipment.

Initially the *EMERALD* materials were printed. However in order to enhance the presentation of the training material and to make future cost-effective updates possible, we now present the materials as e-books. After some consideration the consortium developed a simple interface based on a web-browser, rather than using more complicated multimedia author tools. In order to facilitate the use of these e-books through the Internet we decided to depart from a fully

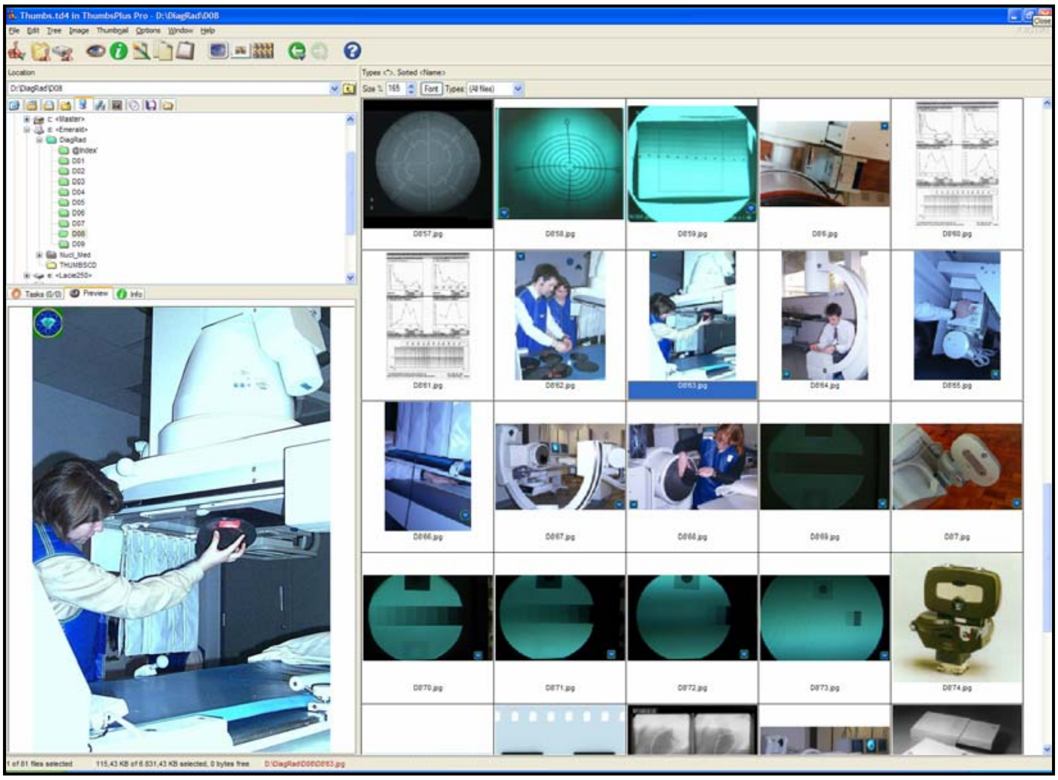

Figure 1. Graphical interface of the image database CD-ROM with *ThumbPlus* (Cerious Software Ltd browser) for easy viewing on a PC. Sample is from the Student Workbook – The Physics of Diagnostic Radiology, Chapter 8. *Basics of fluoroscopic X-ray equipment quality control*.

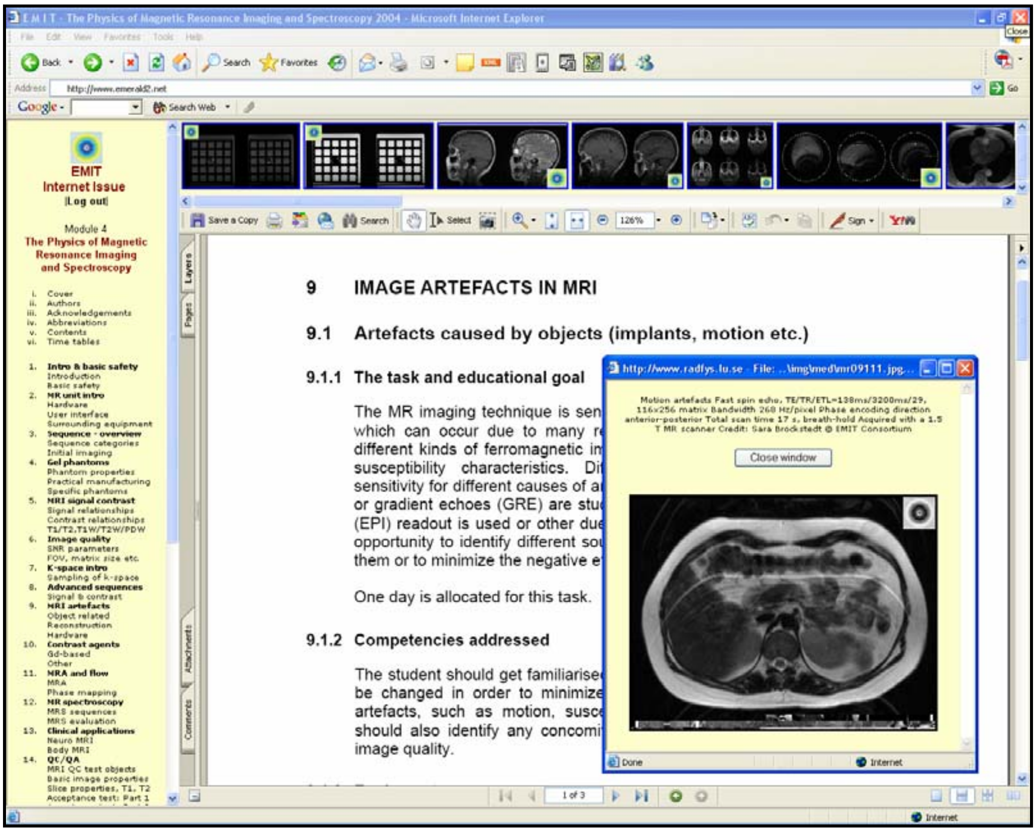

Figure 2. The user interface used for the Workbooks combined with the image database. Sample is from the MRI e-book of *EMIT*. The left frame holds the Table of Contents (hyperlinks) for the chapters in the present module, as well as links to the other 4 modules. The main frame contains the e-workbook chapters (1 PDF file for each chapter) with the different tasks and instructions etc. Relevant words in the text are hyperlinked to images in the database and cross-referenced to other chapters. The upper frame contains thumbnail images which are hyperlinked to make a window pop up to view an enlarged image and its caption. The interface looks the same for all modules.

integrated PDF-based e-Workbook. Thus the text and the images were separated to allow reasonable download times. This required a structure to keep all information together, and a user-friendly and simple HTML-interface with three frames was developed (Figure 2).

The e-Workbooks and Course Guides are in *Adobe Acrobat* PDF files. The text of each training task is hyperlinked with digital images. The Workbook is read with any web browser and the *Acrobat Reader*®, but can also printed and used as a normal book. The development of the e-books started with a classification of tasks and a corresponding division into separate PDF files. The structure of all tasks is based on hyperlinks through the training timetables to hold all training entries together. In this structure the tasks in each module are grouped into chapters, according to a logical build-up of knowledge during the training.

A general front-end interface was developed allowing access to all 5 training modules and the respective Course Guides. This 'Training-on-Line' web site is hosted by Lund University (it is available through the *EMERALD*/*EMIT* web site (www.EMERALD2.net). The access to the site is password protected and allows entry to modules, which have been purchased. All five e-books can be used either through the Internet, or directly from CD-ROMs. For a more detailed description of the development and structure of the *EMERALD* and *EMIT* training e-workbooks, the reader is referred to the paper by Tabakov et al. (2005).

Digital Medical Physics Dictionary

It was suggested after a medical physics training conference and following training seminars that a multilingual dictionary of terms used in Medical Physics would be very valuable. The use of the *EMERALD* training materials in above 60 countries around the world further confirmed this need. Thus, a digital dictionary (e-Dictionary) was developed under the project *EMIT* (Tabakov et al. 2005). In the pilot version it is based on seven languages (English, French, German, Italian, Swedish, Portuguese, and Spanish) reflecting the partnership of *EMERALD* and *EMIT* projects.

The first phase of the project included development of a software interface and a collection of terms in English, covering the fields of Diagnostic Radiology, Nuclear Medicine, Radiotherapy, MRI and Ultrasound Imaging. The collection of terms was translated by selected specialists and updated by the entire Consortium. The interface of the e-Dictionary was created together with the Inter-University Medical Physics Centre in Plovdiv, Bulgaria. The digital dictionary translates between any two of the above languages. Additionally, the software is designed for potential translation into other languages. The total volume of the dictionary is about 3600 terms per language (Figure 3).

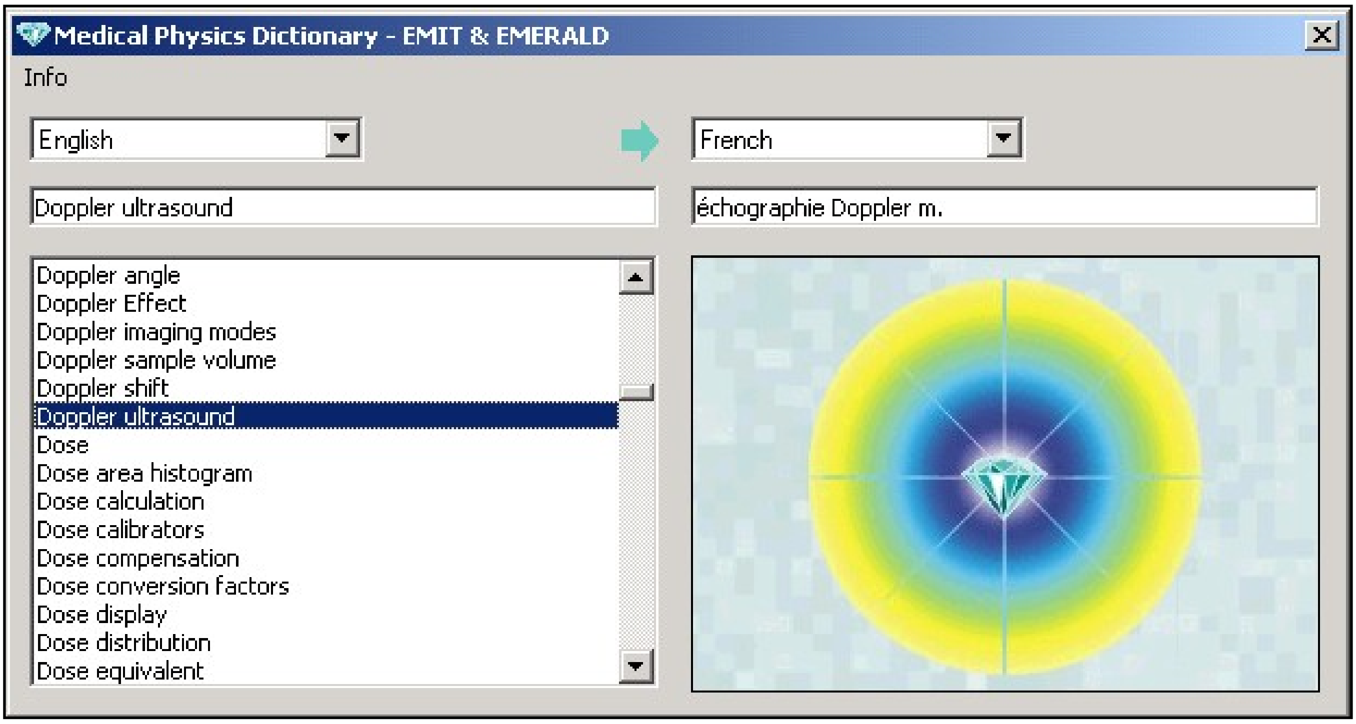

Figure 3. The Medical Physics Dictionary that is complementary to the Work books and Image Database. The dictionary that was requested by the EC Leonardo da Vinci program is based on 7 European languages (English, French, German, Italian, Swedish, Portuguese, and Spanish) reflects the initial partnership of *EMERALD* and *EMIT* projects.

Discussion

In order to evaluate the content, materials, timetable etc. of each module, the Consortium has held a number of workshops in Europe where experts were invited to join. The initial feedback covered the education and training aspects of the program. All lecturers approved the intensive use of image material and the educational IDB. The International Atomic Energy Agency included *EMERALD* images in its lecturing material (IAEA 2003). Some lecturers include selections of the training tasks as practical laboratory tasks in their university courses, in addition to a number of PC simulations for the assessment of image quality.

The effectiveness and effortlessness use of the package was another point of interest brought up by experts. The intuitive interfaces of *EMERALD* and *EMIT* e-books and images allow immediate use of the materials with no requirements on computer literacy. Some e-learning specialists see this approach as a good example, whereas others suggest that the lack of interactivity makes the material less innovative. However, our goal was to put effective learning in the forefront; input from trainers and trainees confirms that this goal was clearly reached.

Regarding e-learning materials on the Internet, trainees find them easy to use and of high educational value, although many prefer to use the material from the CD-ROM rather than from Internet. This is clearly linked to the demand for access to information without being dependent on the quality of the Internet link. This feedback supports to some extent learning in blended mode (Garrison and Kanuka 2004), i.e., e-learning mixed with face-to-face meetings. The training use of *EMERALD* showed enthusiastic support from the trainees. The initial reservations from the supervisors were also noted (Tabakov et al 2005). The latest however, appeared to be based on the fact that many supervisors regarded the training package as a rigid training structure. In reality though, this structured training is highly flexible. Within the pedagogical structure, every task is designed to allow its replacement with a similar and existing local task and methodology in the specific training centre. In this case the replaced original *EMERALD*/*EMIT* task functions as a good *practice guide*. In addition, the time for completion of the different tasks is only indicative. The built-in flexibility of our training packages makes them e-learning materials which could support any existing training program, without conflicting with its requirements. This, combined with the structured innovative contents of the training material made *EMERALD* and *EMIT* training materials for e-learning the most widely used training packages in Medical Physics.

Conclusion

Multimedia materials in the education and training of medical physics, medical engineering and radiology are not new. Up until now however, software packages have mainly been developed to meet local requirements. The training programs *EMERALD* and *EMIT* are the first multimedia training packages based on extensive academic curricula and competencies for medical physicists. Nor has anyone in this field addressed the development of computer-aided training materials whose use extends over months rather than days. The first image database (*EMERALD* 2001) was launched already in 1999 and after a very short period of time proved to be a valuable resource for education and training.

The material includes:

- five sets of curricula;
- delivery through the internet or from two CD-ROMs;
- e-workbooks with training tasks, supporting image databases;
- course guides (in 5 languages);
- a digital dictionary (cross translation in 7 languages); and
- one promotional web site with demo, one for online learning.

The pedagogical structure allows the training tasks to be modified in the country of use, according to existing national protocols/ regulations.

The *EMERALD* and *EMIT* programs were developed to facilitate consistency in medical physicist training across Europe and to meet much of the requirements of countries where education needs to be integrated with in-house training (Barnes 1999; Oliver, Fitchew and Drew 2001). It is intended to assist with the mobility of trainees between different universities and countries. The built-in flexibility creates a multi-faceted structure, which greatly increases the applicability of the training materials not only in various countries, but also within different medical professions. Whether we have succeeded in that direction has yet to be seen, but it is notable that the training materials are now being used in more than 60 countries. Finally, that the Consortium members were awarded the first ever Leonardo da Vinci Award in December 2004, encourages further development of this unique training material.

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