THE PROJECT OF THE SPANISH NUCLEAR INDUSTRY FORUM TO ELABORATE A DIDACTIC INTERACTIVE MATERIAL ON RADIOLOGICAL PROTECTION

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Abstract

The Education & Training Department of the Spanish Nuclear Industry Forum, has a wide experience in preparing educational material on issues related to energy, including nuclear energy. At the beginning of 2011, this Department launched a new project to develop an interactive educational material on Radiological Protection. This material is, initially, in Spanish and is freely available in www.rinconeducativo.org.

The Project aimed to develop an attractive, comprehensive and interactive material, to facilitate students and teachers to become familiar with ionising radiations and radiological protection. The novelty of the project, intended for Elementary, Middle and High schools, is that is based on the European framework of "key competencies for lifelong learning". These key competencies, as defined by the European Commission, are *"a set of knowledge, skills and attitudes that all individuals need for personal fulfilment and development, inclusion and employment"*.

To facilitate the acquisition of competencies, it is essential to define appropriate tasks, which must make sense inside and outside the classroom, be useful and interesting, contextually pertinent, varied and proper for the objectives to be achieved. The ultimate goal is to create an integrated structure of tasks, activities and exercises that facilitate the acquisition of as many key competencies as possible.

The didactic material presented in this paper follows this integrated structure of tasks, activities and exercises. Besides, it also includes reference texts, links to pertinent websites and videos on basic aspects related to radiological protection.

Students, through the development of a specific task, and the related activities and exercises, will learn the differences between ionizing and non ionising radiation, the origin, characteristics and different types of ionising radiation, the methods available to detect and measure them, the potential detrimental health effects, the existing protection actions to minimize the risks and the wide variety of beneficial applications that can have for man.

Key Words: Didactic material; Key competencies for lifelong learning; radiological protection.

Introduction

Technologies that use ionizing radiation, including energy production, quite often generate distrust and fear in the general public, due in most cases to lack of information, or because the information is transmitted with such a technical language that is very difficult to understand.

Therefore, the challenge is to provide information on these issues using a language accessible to the general public. The importance of training people from an early age has led to invest great efforts to prepare didactic materials for schools and colleges.

In Spain several documents on different aspects related to ionising radiation have been published in the past. In 2009-2010, the Spanish Regulatory Body (Consejo de Seguridad Nuclear, CSN) published two complete Didactic Guides on Radiation and Radiological Protection, one for Elementary School students (CSN 2009) and another for Middle and High School students (CSN 2010). These Guides, besides providing valuable information on different topics related with radiation and radiological protection, include specific information for teachers (Objective of the unit, minimum time required to do the unit, didactic suggestions and questions (and their answers) on the topic of the Unit). These Guides (in Spanish) are freely available in CSN webpage.

In this paper we present the project launched in 2011 by the Spanish Nuclear Industry Forum. The objective of the project is to develop a didactic material attractive, understandable and interactive, to help students and teachers to become familiar with the radiological protection and in general with ionizing radiation, a physical agent that is part of everyday life.

The novelty of this project is that has been developed based on the European framework of key competencies for lifelong learning (European Commission 2007; Otten and Ohana 2009). Key competencies are considered the set of knowledge, skills and attitudes that all individuals need for personal fulfilment and development, inclusion and employment. These competencies, although must be developed during the period of compulsory education, are the basis for further learning throughout life.

The reference European framework, which in general is followed in Spain, has eight key competencies for lifelong learning:

1. Communication in the mother tongue.
2. Communication in foreign languages.
3. Mathematical competence and basic competences in science and technology.
4. Digital competence.
5. Learning to learn.
6. Social and civic competence.
7. Sense of initiative and entrepreneurship.
8. Cultural awareness and expression.

In order to acquire the key competencies, is essential to define and select appropriate tasks to learn the elements making up the competence. These tasks have to make sense inside and outside the classroom, must be useful and interesting, contextually appropriate, varied, must encourage the acquisition of as many key competencies as possible, and must be appropriate to the objectives to be achieved. Ultimately, the goal is to create an integrated structure of tasks, activities and exercises that would facilitate the achievement of the key competencies.

It is important to note the differences between task, activity and exercise:

- A **task** pursues the attainment of a competition. The tasks set situations (or problems) that every student should try to solve by making good use of all his/her personal resources. An example of task would be to analyze the electricity bill of their home.

- An **activity** seeks to achieve a certain behaviour. Within the task of analyzing the energy bill, an activity would be to collect the bills of the last 6 months and compare costs.
- An **exercise** aims to achieve a certain behaviour. In the example mentioned above, an exercise would be to review the rates and differences in the monthly bills.

The project presented in this paper pursue that through a specific task, and associated activities and exercises, students expand their knowledge on ionizing radiation, its origin, characteristics, adverse health effects, the radiation protection system and that they are aware of the role played by ionizing radiation in our daily lives due to its many beneficial applications in a wide range of fields as medicine, industry, agro-alimentation, environment or preservation of the historic and artistic heritage.

Based on the proposal of a real task to be developed, the students will have to do a wide variety of activities and exercises to be able to achieve the final objective of the task proposed. Throughout the process, the students will have to develop research activities, solve reflection problems, mental activities, mechanic exercises, work planning, interdisciplinary, inter alia, to be able to complete the task proposed. We intend that students carry out cognitive processes of knowledge, comprehension, analysis, synthesis and that they apply previously acquired knowledge in solving problems and self-evaluation. By performing a set of exercises that motivate them, the task proposed will be solved while they have fun.

In addition to the tasks, activities and exercises, the didactic material developed in this project includes texts on various aspects related with ionizing radiation, to help students in their research and learning. The content of the texts is adapted to the age of the students (Elementary, Middle and High Schools). It also provides "links" to relevant websites where they can find additional information that will help them to resolve doubts that may arise during the implementation of the proposed task. Finally, a set of video tutorials to facilitate understanding of the subject is also provided.

Material and methods

The programme eXe learning has been used to elaborate the didactic material (Figure 1). The eXe learning programme is a freely available application (http://exelearning.org/wiki), created to assist teachers and academics in the publishing of web content without the need to become proficient in HTML or XML markup.

eXe project grew out of the New Zealand Government Tertiary Education Commission's eCollaboration Fund and was led by the University of Auckland, The Auckland University of Technology, and Tairawhiti Polytechnic. It was later supported by CORE Education, a New Zealand-based not-for-profit educational research and development organisation. It has also been greatly assisted by a global group of participants and contributors.

eXe was named a finalist in the New Zealand round of the IMS Global Learning Impact Awards 2008 and went on to claim a Leadership Award at the international judging. (eXe was rated Best in Show for "Content Authoring", and also one of the top 3 participant rated projects!). There are now several projects inspired by eXe around the world.

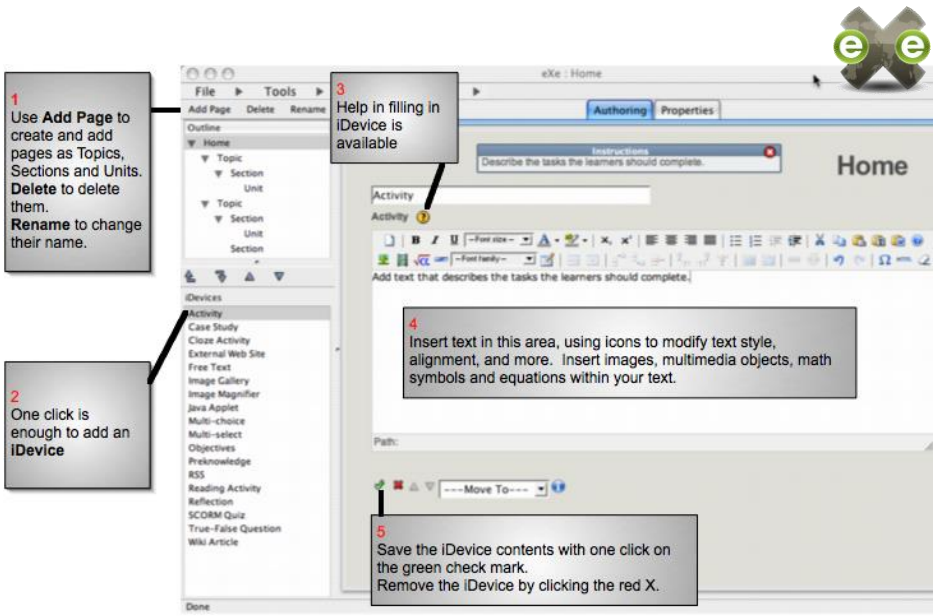
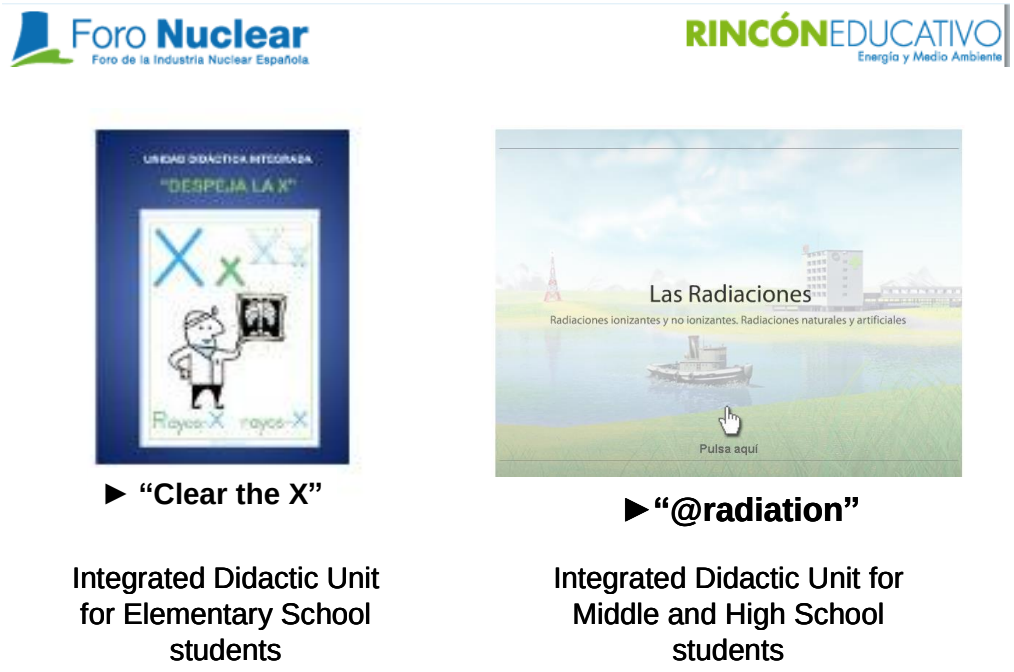


Figure 1. Screen of the eXe learning programme, showing some of the utilities it has.

Didactic material on radiological protection, based in the framework of key competences for lifelong learning

The didactic material presented in this paper has been structured in two separate parts: one for Elementary School students and the other one for Middle and High School students, since there are substantial differences in curricula between these educational levels (Figure 2).



► "Clear the X"

Integrated Didactic Unit for Elementary School students

►"@radiation"

Integrated Didactic Unit for Middle and High School students

Figure 2. Didactic material on radiological protection. Left: Integrated Didactic Unit for Elementary School student. Right: Integrated Didactic Unit for Middle and High School students. Available in www.rinconeducativo.org.

Didactic material for Elementary School students

The Integrated Didactic Unit (IDU) has been called "Clear the X" (Figure 2). The task proposed in the IDU for Elementary School students is to "Organize a formal visit to the radiology department of the nearest hospital". To perform this task, students have to create working groups and distribute the research work to be done to acquire information on different aspects related to ionizing radiation, mainly on X-rays. Besides providing material to help students to understand the basic aspects of ionizing radiation, activities for four working groups are suggested, each of which aimed that students will learn more about a specific aspect of ionizing radiations.

The proposed topics for the four working groups are:

i) Ionizing radiation. With activities that will allow them to know the differences between ionizing and non ionizing radiation, cosmic radiation and other sources of natural radiation and radiological protection concepts.
ii) Applications in research. With activities related with the use of X-rays in art, archaeology, conservation of old books and photography.
iii) Applications in industry. The activities proposed for this topic include videos and movies of children's TV series in which they talk about X-rays. It also includes activities related with food irradiation, the quality control of materials used in industry, or the use of X-ray to control the passenger access in airports.
iv) Medical applications. With activities centred on the use of X-rays for diagnosis and treatment of diseases.

Each working group has to perform a set of three-four activities (An example can be seen in Figure 3). The activities are based on press news, videos or pictures, and through different practical exercises (multiple choice questions, or choice of appropriate response, interpretation of data or searches for information), pose challenges that students must solved, helping them to acquire the knowledge required to carry out the task.

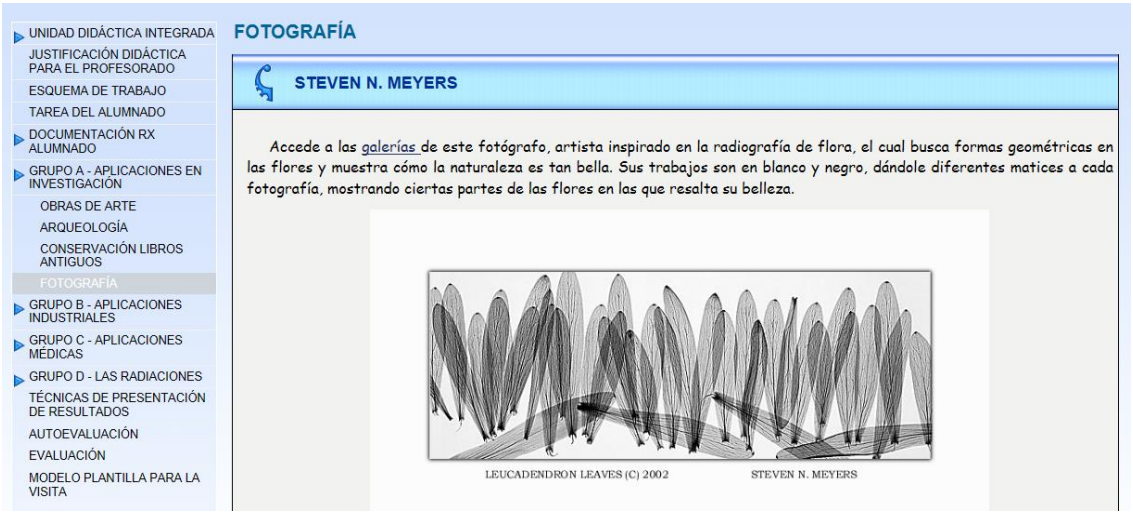


Figure 3. Example of one activity proposed to Elementary School Students. This activity is just one of the set proposed for Working Group ii, "Applications in research". The students can see how X rays can be use to see inside objects or living organisms and to make artistic photographs.

Once each working group has completed the activities, they will have to make an oral presentation to their classmates to share the acquired knowledge. Within the didactic material,

they can find information on techniques for presenting the results, to help them with their oral presentation.

The next step is to complete the task, i.e. to organize and carry out a formal visit to the radiology department of the nearest hospital. To do so, they will have to prepare everything they need for the visit, from arranging a bus to arrive to the hospital, to prepare the questions for the experts they are going to meet at the hospital. In the IDU, the students can find guidance on those aspects that have to be taken into account before and during the visit.

Figure 4. Links at the end of each activity. The Dictionary of the Royal Academy of the Spanish language (left) and a link to Google (right).

Ones the task is finished, the aim is that the Elementary School students will know the differences between ionizing and non ionizing radiation, understand that ionizing radiation is a physical agent that is found in nature and to which all of us are exposed, and roughly know the various beneficial applications that the use of ionizing radiation have for humans, being aware that the misuse of ionising radiation can also cause harmful health effects.

Within the didactic unit, there is also information for teachers including an explanatory text on the key competencies for lifelong learning, a work scheme to use the IDU or the didactic justification of the IDU. At the end of each activity, there is a table giving detailed information to the teachers on the aspects worked in each specific activity (competence, context, type of activity/exercise, and evaluation criteria).

Didactic material for Middle and High School students

The Integrated Didactic Unit for Middle and High School is called "@radiation" (Figure 2). The task that has been raised to the students is to "Build a radioactivity measurer". The students will have to create working group to go through the different activities proposed within the IDU, which will enable them to acquire the skills necessary to perform the task successfully. Six working groups are proposed, with their associated activities and exercises:

i) Cosmic radiation. With activities that will allow them to know the differences between natural and artificial ionizing radiation, sources of natural radiation, basic concepts on dosimetry and radiological protection.
ii) Applications in agro-alimentation. With activities related with the use of ionising radiation to increase the production of food, to better preserve it or to eradicate insect pests.
iii) Ionising radiation in Archaeology. With activities to learn on how ionising radiation can be used to do research in archaeology, for example to find out the origin of some very old objects like the Antiquitera machine.
iv) Nuclear power. The activities proposed for this topic include videos and movies explaining how nuclear energy is produced (fission and fusion processes), the type and number of nuclear reactors existing in Spain, the radioactive wastes produced and their management, what is a epidemiological studies and their purpose.
v) Ionising radiation in art. With activities centred on the use of ionising radiations in art research and its conservation (paintings, sculptures, etc.) (Figure 5).

vi) Other applications of ionising radiation. With activities focused on the use of ionising radiation in medicine or to control passengers at the airport (scanners).

Figure 5. Example of one of the activities of The Working Group v: "Ionising radiation in art". Students can discover how ionising radiation is used to see "inside" the artwork.

As in the IDU for Elementary school, the activities proposed to Middle and High School students are based on press news and videos of real life events, what will increase their interest on the topic. Each activity includes different types of exercises (questions, data interpretation, information retrieval, etc.), to help them to acquire the knowledge required to carry out the proposed task.

Taking into account that this IDU is for Middle and High School students, a big effort has been done to include in the didactic material, texts with all the basic knowledge on different aspects related with radiological protection that students have to acquire. Thus, students have a section within the IDU where they can find information on:

- What is radiation?
- Ionising and non-ionising.
- Natural and artificial ionising radiation.
- Detection and measurement of ionising radiation.
- Biological effects of ionising radiation.
- Radiological protection. Emergencies.
- Nuclear power. Radioactive wastes.
- Other applications of ionising radiation: Medicine; agro-alimentation; environment; industry; preservation of historic and artistic heritage.

In each activity, there are links to these texts, so that students can easily access the information they need while they are doing the activity.

Finally, they will have to complete the task of building a radioactivity measurer. In the IDU, they will find instructions on how to build a Geiger meter (components, circuit, etc.). Additionally, in each working group, an activity directly related with the task has been included, so that students become familiar with the measurer.

The objective is that once the task has been completed, the students have acquired enough knowledge to distinguish between ionizing and non ionizing, know the types and main characteristics of ionizing radiation, the methods used to detect and measure radiation, the detrimental effects that can produce on human health, the radiation protection system developed to minimize these risks and the main fields of beneficial applications of ionising radiation.

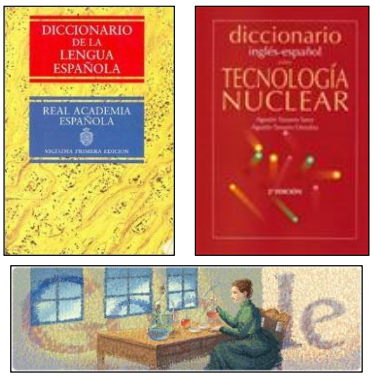


Figure 6. Links at the end of each activity. The Dictionary of the Royal Academy of the Spanish language (top, left), a dictionary of nuclear terms (top, right) and the link to Google (bottom).

The Integrated Didactic Unit also includes information for teachers on the key competencies for lifelong learning framework, the work scheme they can follow to use the IDU, the didactic justification of the IDU, and the key competencies addressed in each of the activities proposed.

Once the didactic material has been completed, the effort is currently focused in the promulgation of the units among Elementary, Middle and High Schools in Spain.

Both Integrated Didactic Units are freely available in the webpage www.rinconeducativo.org.

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