LIFE-LONG LEARNING OF SECONDARY SCHOOL SCIENCE TEACHERS ENHANCED BY THE USE OF ICT

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Introduction

The information and communication technologies (ICT) have played a key role in promoting social and cultural changes and have brought many opportunities for citizens to have limitless access to information, which makes it possible for them to be able to face some of the present challenges for professional updating and lifelong learning. In-service teachers' training in the use of ICT has become key, not only to facilitate the processes of lifelong learning, but also to introduce innovation in classrooms and in the teaching-learning process (Kikas, 2004). This brings new educational answers to the challenges of this new cultural and economic context.

In this presentation, "Interactive Science", a teacher development model focused on secondary school Sciences teachers, is introduced. It incorporates several actions intended to promote teachers' updating in their particular Science area of knowledge and abilities, and the competence to build and use multimedia learning materials and ICT as tools for stimulating innovation in their classrooms (Hirning, 2002).The model also encourages students' cooperative learning by including strategies for them to participate in discussions through communities of practice.

Contextualised training experiences and case studies carried out in Portugal and Spain with secondary school Science teachers have revealed that there are some particular training needs to be addressed (see http://www.ucv.mct.pt/home/; http://www10.uniovi.es/cienciainteractiva227). Among them are the following:

(1) Sciences teachers need to continuously incorporate new discoveries in their particular specialization field in order to enrich their Science teaching curricula;

(2) teachers are seldom involved in co-operative work experiences with other scientific professionals and researchers who may help them to update their knowledge;

(3) they know little about how to incorporate the information and communication technologies (ICT) and multimedia learning materials in their teaching-learning process. In this particular area: a) secondary school teachers may be using some multimedia learning materials which come from the market as teaching resources, but most of them are not familiar with the processes involved in building them, so that they cannot create their own teaching multimedia resources; b) they have little experience in introducing pedagogic innovations in the classrooms by incorporating multimedia learning materials; some of them even show negative attitudes towards these resources;

(4) secondary school pupils need to be taught about the latest scientific discoveries with the aid of learning resources that help them to better understand and enjoy Science.

"Interactive Science" model for promoting in-service training for secondary school Science teachers

Science teachers need to be involved in a continuous professional development process to be able to properly carry out their teaching responsibilities. Fortunately this process can be based on a constructivist and meaningful approach to learning and can be performed in contexts where scientific experiences are carried out to generate new knowledge in a particular field. This perspective suggests that, it would be useful to set up meetings and communities of practice among Science researchers and professionals, education specialists, educators, teachers and even pupils to discuss Science and new discoveries. These meetings would allow interaction, exchange of ideas, experiences and research results; they would also allow the creation of new strategies and resources for the learning of Science, as well as stimulate students' interest in the study of Science. It is important to take into account, among other things, the incorporation of the already existing networks of Science professionals and teachers, the Internet facilities, the information and communication technologies and the multimedia materials. All these resources would encourage Science professionals to promote generated, shared and acquired knowledge. This knowledge, in turn, should be found in classrooms, where it could encourage young people to renew their interest for Science and to enjoy learning it.

The "Interactive Science" model for training in-service secondary school Science teachers addresses these issues through promoting close interaction between institutions where knowledge is produced and others in charge of promoting in-service teachers training for lifelong learning; that is, between universities and research centres and teachers' support centres. The main aim of this model is to narrow the gap that currently exists among various institutions and to promote their coordination so as to reach better quality of education for children, teenagers and professional adults.

Objectives of the "Interactive Science" model

The objectives of the model are:

(1) To promote training strategies for in-service teachers' scientific updating based on a constructivist and meaningful approach to learning. These strategies would help them to update their knowledge in Science by playing a leading role in their own learning process. Secondary school teachers would be invited to visit scientific laboratories where knowledge is generated and where they would be in close contact with scientific researchers. Interaction between them would encourage their respective professional developments.

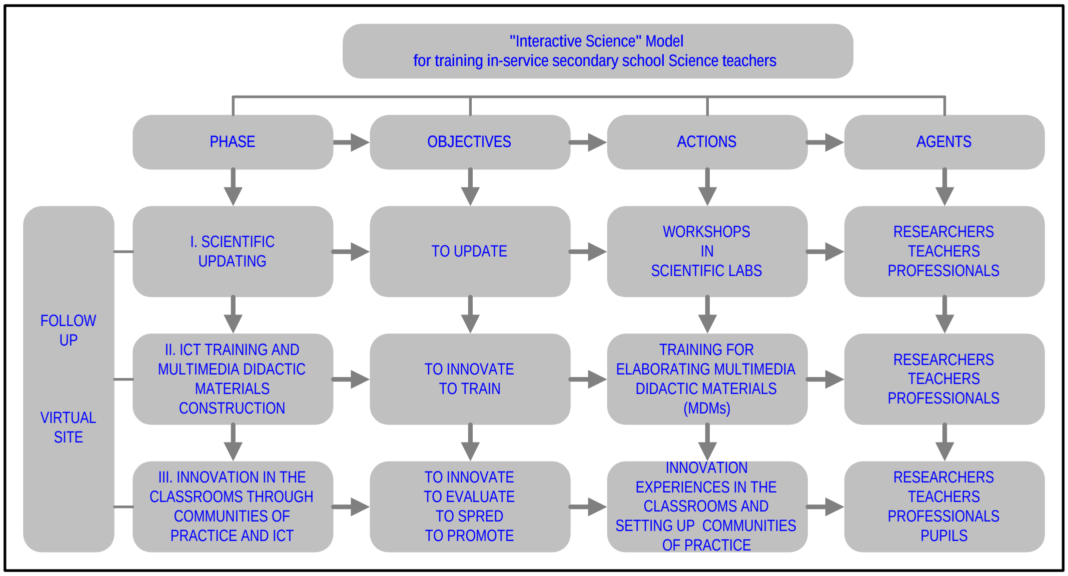
(2) To promote in-service teacher training in the use of information and communication technologies and in the elaboration of their own Science multimedia teaching materials as useful tools to innovate teaching-learning processes in their classrooms. Teachers could also learn how to create these materials by being actively involved in the activities performed by a multidisciplinary team who might help them to understand how to use these resources to teach Science in their classrooms later on. These multimedia materials would be based on a constructivist and student-centred approach to learning which will offer teachers a new perspective on teaching Science.

(3) To promote innovation in the teaching-learning process by incorporating in the classrooms ICT, multimedia learning materials and new approaches to learning and teaching Science, using a communities of practice model. This would involve pupils into the model and bring teachers the opportunity to organize innovative action-research processes in their classrooms to experiment with the efficiency of these technological resources and teaching approaches in learning. In addition, pupils may enjoy learning Science by using these interactive resources in a way which fulfils their own particular learning needs and complement the information provided by teachers. Both teachers and pupils would be stimulated and motivated by discovering and experiencing these new approaches to learning.

4) To promote continuous communication between researchers and teachers through their participation in virtual learning communities (VLCs). These communities could help researchers, teachers and pupils to interact and discuss the activities available throughout this model and their effects. VLCs would also act as motivator to maintain teachers', pupils' and researchers' engagement in the activities the model proposes. These communities could also stimulate teachers'

and researchers' lifelong learning, the social construction of knowledge with regard to how to teach Science and would permit the dissemination of Science information among other citizens.

These objectives and training strategies have been classified into three main phases in the "Interactive Science" model, whose objectives, actions and agents are shown in graphic 1:



Graphic 1. "Interactive Science" Model: Phases, objectives, actions and agents

Phases and specific actions involved in the "Interactive Science" model

Some specific actions could be carried out in each of its phases to facilitate the achievement of the "Interactive Science" training objectives mentioned before,.

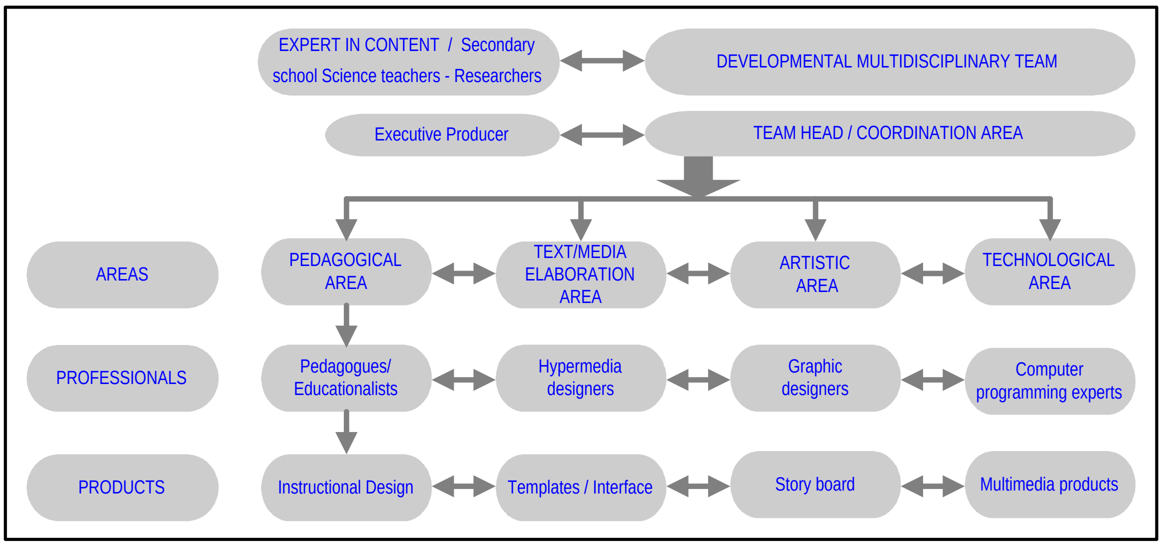
Phase I: Scientific updating

Two main actions were included in this first phase: teachers' visits to scientific research laboratories and Science updating workshops led by researchers. The information and useful materials produced in this phase as presentations, images and papers were incorporated in the follow-up virtual site (FVS), which also gathered the dialogue between teachers and researchers through the forum of the site. The comments and opinions of the participants were collected in the forum and provided valuable information as a formative ongoing evaluation of the training experiences undertaken.

Phase II. Teachers' training in the use of information and communication technologies and in the construction of their own scientific multimedia didactic materials

The model promotes active involvement of secondary school Science teachers in the development of their own multimedia teaching materials. The objective was to provide them with significant information about both the complexity of the processes involved in their construction and the possibilities they bring to promote innovative experiences in the classrooms in both face-to-face lessons and self-learning processes.

These didactic resources are built by a multidisciplinary team of professionals (pedagogues and educationalists, hypermedia-graphic designers and computer programming experts) according to an instructional design based on the constructivist and student-centred approach to learning. Constructivism claims that learners construct their own reality based upon their perceptions or experiences, thus emphasise the role of the learners, who take on increasing responsibility for their learning. Secondary school Science teachers would be working cooperatively with the multidisciplinary team to elaborate these resources in their condition of experts in the Science subject each multimedia material is addressing (Bodker, 1991).The structure of this team is represented in graphic 2.

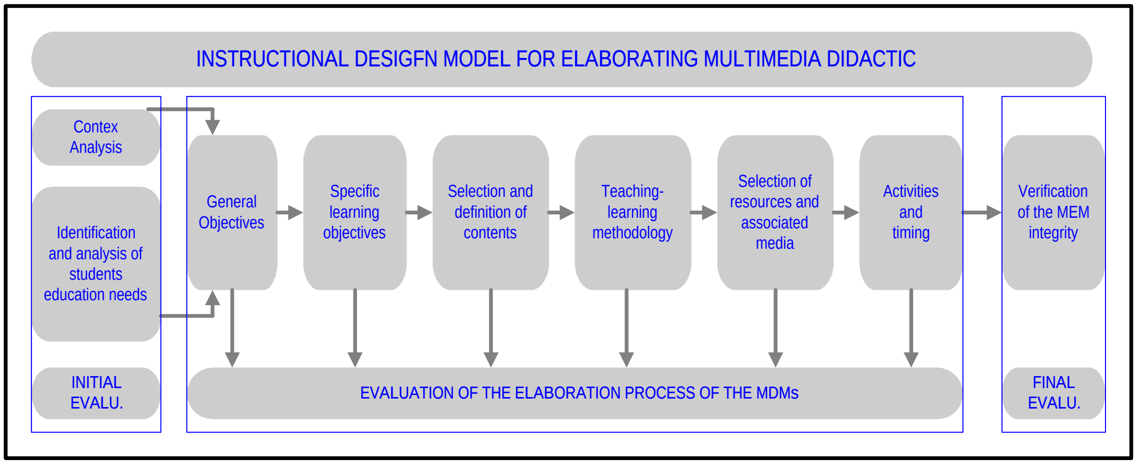


Graphic 2. Structure of the multidisciplinary team

Processes involved in the construction of Science multimedia didactic materials

After completing the first phase of the model, secondary school Science teachers were informed about the aims of the second phase and its objectives. In a meeting, teachers were introduced to the professionals of the developmental multidisciplinary team, who showed them multimedia teaching materials (MDMs) and also explained their own function in the process of elaborating these materials. This information was needed to help the teachers to understand their role within this team.

The processes involved in the construction of Science multimedia teaching materials and the actions teachers were expected to take are: (1) elaborate an instructional design for the multimedia didactic resources according to a constructivist and student-centred approach to learning, graphic3 (2) design the interface of the multimedia teaching material, figure1 3) elaborate the hypermedia design, (4) perform the graphic design, and (5) elaborate the computer programmes. Some of the tasks these processes require are described below:



Graphic 3. Structure of the Instructional Design of the multimedia didactic materials (MDMs)

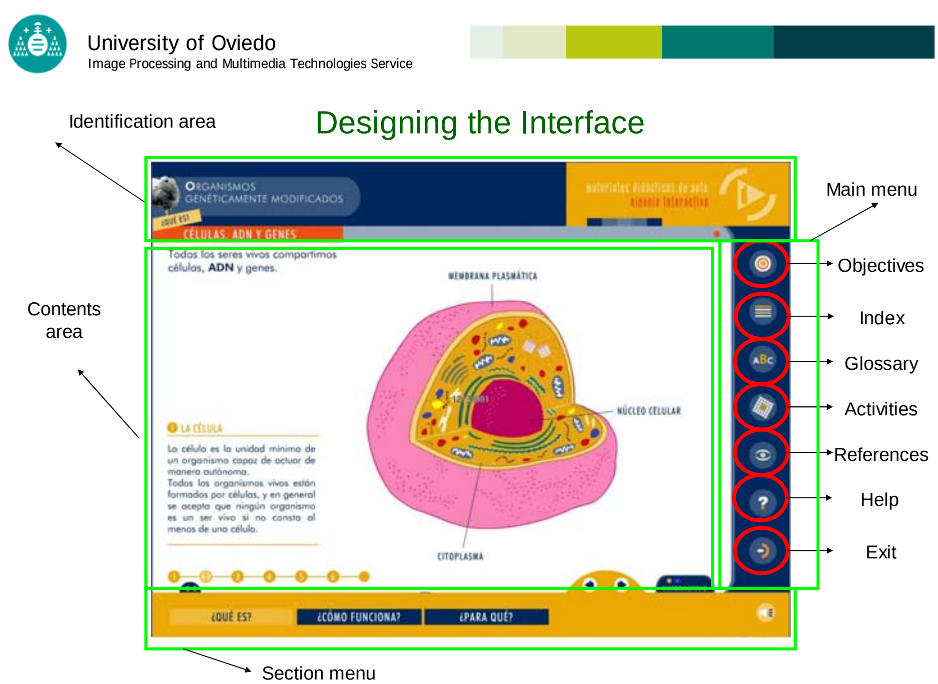


Figure 1. General scheme of the Interface of the multimedia didactic materials

Actions to be taken by the teachers in the multidisciplinary team

In phase II teachers worked closely with the professionals of the multidisciplinary team. From the start, teachers discussed the procedures in order to work cooperatively. The educationalists of this team worked closely with the teachers; these professionals helped them to realize the importance and the need of considering the various components of the instructional design when elaborating the multimedia teaching materials. Together with the educationalists, the teachers reflected on:

(a) The context of the Science learning subject addressed by the multimedia teaching materials: which scientific content he/she wants to teach, why this content is useful (its social implications) and who is going to use the multimedia resources to learn that content (information about pupils' characteristics and educational level). All this information is needed to achieve the principles of necessity and meaningfulness of good quality multimedia didactic materials (MDMs).

(b) The contextual frame in which the MDMs are going to be used: face-to-face teaching or combined with virtual environments.

(c) The students' diversity according to different factors, such as their previous knowledge of the subject, intellectual, attitudinal and other competence factors. This information addresses the principle of necessity of MDMs.

(d) The aim and learning objectives the MDMs would help the students to achieve.

(e) The specific scientific contents to be included in the MDMs and their structure. This information is related to the principle of coherence of MDMs.

(f) The possible media resources to be included in the MDMs: text, images, sound, simulations, video, links, etc. This information is needed to reach the principles of vitality, interconnection and interactivity of the MDMs.

(g) The activities to be included in the material to help the students to apply their learning and to check their progress towards reaching the learning objectives. In order to select useful activities for all students, teachers were invited to grade them.

(h) The evaluation criteria to be applied to assess the students' learning progress.

All this information was written by the teachers in an instructional design planning form the educationalists gave them; they were helped by the educationalists. The information included in this plan was discussed later on with the professionals of the multidisciplinary team: educationalists, hypermedia-graphic designers and computer programmers, in order to reach the principle of coherence of the MDMs. When the teachers structured the contents of the Science learning subject with the help of the educationalists and selected the media to be included in the multimedia teaching materials (text, sound, images, etc.), the other professionals of the team started working on their designs: the interface, the navigation menu, the simulations, the interactive buttons, the links, etc. Teachers and educationalists closely monitored the work of these professionals to suggest changes in the design of the materials they considered more appropriate for learning purposes. This cooperative working procedure allowed the performance of an ongoing evaluation of the quality of the materials before completing them, which is needed to achieve the principle of integrality of the MDMs. Once the materials were finished, the team met again to evaluate the final product and to discuss how it could be used for innovation in the classroom.

Interaction among all these professionals combined both synchronous and asynchronous communication via e-mail and the follow-up virtual site. To be effective, cooperative work among professionals in the multidisciplinary team needed a great amount of communication, empathy, mutual support, encouragement and frequent and positive feedback. No doubt, teachers would appreciate a nice cooperative working atmosphere where they can easily learn the difficult task of creating their own multimedia learning resources.

Phase III. Innovation in the classrooms through communities of practice and ICT

ICT are nowadays present in all spheres of social life, and schools cannot close their doors to them and forget their social implications. Educational systems need to provide teachers and students with the necessary literacy training in the use of ICT in order to help them to cope with the new social expectations in relation to their ability to use them properly (Pilv, 2004). Many parents and families are still unaware of the new social challenges their children will be confronted with as regards the use of ICT, and because of that they are not always able to help and encourage their children to be adequately trained in the use of this technology (Martínez, Pérez, Jimeno and Cantero, 2003). Computers and internet connections at home, on the other hand, might be expensive for some families, which leads us to consider the convenience of having schools collaborate with other social institutions to guarantee that children and teenagers within all population sectors have access to opportunities to learn how to use this new technology.

These circumstances makes us think about the need for in-service training for teachers so that they get used to this new technology -as commented in phase II- before introducing these resources to the classrooms as learning tools, and invite them to analyse their effectiveness in learning through action-research. This would encourage pedagogical innovation. Pedagogical innovation through the introduction of ICT in the different curriculum subjects could contribute to helping to discover their positive potential influence on children's learning and to generate teachers' positive attitudes towards their use.

One possible and effective way of incorporating ICT for innovation in the classrooms is by organizing training workshops in ICT and "communities of practice" (CoPs) with students, where they have to work cooperatively in groups to analyse and do research on a particular area of knowledge. The concept of "communities of practice" is rooted in the human value of sharing ideas, strategies and especially knowledge on practice.The social construction of knowledge which takes place through this sharing behaviour or "communities of practice" (Lave and Wenger, 1991; Wenger, 1998) involves participation, responsibility, interaction and communication, and is associated with the ideas of lifelong learning, meaningful learning, and the student-centred approach to learning. Lave and Wenger (1991, p.98) have described a Community of Practice as "… a set of relations among persons activity and world over time and in relation with other tangential and overlapping CoPs". They understand a community of practice as "an intrinsic condition for the existence of knowledge" (1991, p.98). From this perspective, it can be understood that students would improve their knowledge and practice skills by contrasting their own experiences with one another.

This reasoning guides the third phase of the "Interactive Science" model, where the Science multimedia teaching materials built in phase II, together with ICT, would be put into practice in the classrooms when organizing communities of practice with students. In order to do that, instructional design should include opportunity to develop communities of practice with students, and promote engagement with the specific tasks to be done with ICT and the multimedia resources in accordance with the learning objectives to be achieved.

Instructional design

When developing innovative experiences in the classrooms through the establishment of students in communities of practice using ICT, teachers could act as facilitators of the students' learning process, and could introduce clearly and precisely the learning objectives, the cooperative methodology to follow, the activities to be performed and the proposed use of ICT (Smith and Ragan, 1999; Martínez, Miláns del Bosch, Granda, Lupiáñez, Pérez, Martínez and Sampedro, 2003).The main tasks and actions teachers could consider when organizing and developing this instructional design are summarised in table 1.

Tasks	Actions
To perform an initial evaluation of the students' learning needs in a particular Science subject and their ICT abilities so as to identify students' training diversity	Checking students': ▪ previous knowledge in the subject to be learnt ▪ previous abilities in using ICT ▪ intellectual capacity ▪ learning attitudes and expectations
To plan the instructional design according to the students' educational level and learning needs	Formulate: ▪ learning objectives, including: knowledge, skills and attitudes ▪ contents ▪ teaching-learning methodology, including student-centred approach to learning and communities of practice ▪ activities, including cooperative work and discussions through ICT ▪ resources, including ICT and multimedia didactic materials ▪ timing ▪ ongoing evaluation procedures, including techniques to gather information such as participative observation, students' self-reports, task analysis, interviews with students, debates and group discussions.
To put into practice the instructional design and to perform an ongoing formative evaluation of the teaching-learning process through action-research To write an on-going report with the description of the main issues identified along the development of the action-research	Analysing: ▪ the adjustment of each element of the instructional design to the current teaching-learning process and to adjust them if limitations are encountered ▪ the students' involvement in their learning activities ▪ the contribution of the communities of practice, the multimedia didactic materials and ICT to increase students' motivation for learning Writing: ▪ An ongoing report containing the description and interpretation of the main issues identified through the formative evaluation and the action-research.
To perform a final evaluation of the teaching-learning	Identifying:

process and the students' learning To write a final report with the main results obtained from the action-research performed	▪ the strong and weak areas in the teaching-learning process, as well as the possible causes for them ▪ quality indicators and guidelines for improving the teaching-learning process incorporating communities of practice and ICT Writing: ▪ A final report containing the issues commented above.

Table 1. Tasks and actions to be considered when organizing and developing the instructional design

The follow-up virtual site (FVS) would show in this third phase of the model, information and pictures of the innovative experiences the teachers are performing in their schools through action-research.Among others, values such as discipline, responsibility, punctuality, respect for others, sharing, caring, assertiveness, and communication and social skills (to listen, to talk to others, to take turns, to take decisions, to accept consequences…) as well as self-esteem would be encouraged.

As indicated in table 1, action-research using procedures to gather information such as participative observation, students' self-reports, task analysis, interviews with students, debates and group discussions would help teachers to assess the effects of the innovative experiences of incorporating communities of practice and ICT in their classrooms. Through an ongoing evaluation process, teachers could analyse: (1) the adjustment of each element of the instructional design to the current teaching-learning process and adjust them if limitations are encountered, (2) the students' involvement in their learning activities, and (3) the contribution of the community of practice, the Science multimedia teaching materials and ICT to increase students' motivation for learning.

Also, after the innovative experience in the classrooms has concluded, teachers could conduct a final evaluation of the teaching-learning process and the students' learning results identifying: (1) the strong and weak areas in the teaching-learning process, as well as the possible causes for them, and (2) quality indicators and guidelines for improving the teaching-learning process incorporating communities of practice and ICT. A final report containing the description and interpretation of the main issues identified through the formative and final evaluation, as well as indicators for good practice could then be written to let other teachers and education administrators know about the benefits and limitations of these innovation didactic experiences.

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