SUPERCOMET2:
Superconductivity to motivate students to learn electromagnetism

José M. Zamarro (*), Luisa Mª. Fernández (**), Lucía Amorós (**), Francisco Esquembre (***)
(*) Dpto. de Física. Facultad de Química.
(**) Dpto. Didáctica y Organización Escolar. Facultad de Educación.
(***) Dpto. Matemáticas. Facultad de Matemáticas
Universidad de Murcia. Campus de Espinardo. 30 071 Murcia. Spain

Abstract. *Superconductivity is used in the SUPERCOMET European project as a topic to motivate the interest about magnetism, current, electromagnetic induction. SUPERCOMET has been designed as a computer application combining graphics, animations, text and navigation to make selected parts of the physics curriculum in upper secondary school more interesting and accessible. A teachers guide is also available that is intended to outline the pedagogical rationale for using SUPERCOMET and suggest effective ways of using it in the classroom, as part of everyday teaching, in stand-alone mode and in combination with practical demonstrations, and other Information and Communications Technologies. In this communication we will show shortly the contents of the application, some conclusions of our participation within a "Student Fair" and the results of the teachers seminar.*

Keywords. Multimedia for teaching Physics, suerconductivity.

1. Introduction

SUPERCOMET is an acronym for "SUPERCOnductivity Multimedia Educational Tool" [2], and the project utilizes a multimedia presentation of superconductivity developed by a company with its roots at NTNU as a basis for the development of a new computer application designed for use in physics teaching at the upper secondary school level. This application belongs in a concept where the project also develops printed teaching material and training courses for physics teachers. Through promoting a modern, constructivist way of learning physics, the aim of the project is to enhance teaching methods in physics, including the use of ICT tools in the classroom. SUPERCOMET was a project with eight partners in four European countries Italy, Norway, Slovenia and UK, funded by the EU Leonardo da Vinci programme, started on December 2001, ending June 2004. Within this programme SUPERCOMET2 [3] continue further develop, translate, test, adapt and disseminate the training materials (computer application, teacher guide and teacher seminar) from the SUPERCOMET project in order to improve the quality of the continuing vocational training of upper secondary school physics teachers throughout Europe, this project has 35 partners in 13 countries.

In this work we will describe the SUPERCOMET CD multimedia and the result of the teacher's seminar, a test has been made with students in a secondary school but the analysis of the results is not yet ready. We participated in a "Student Fair" where people could experiment with superconducting levitation, and play with the multimedia material, a presentation of SUPERCOMET with an audio description of the project was running continuously.

2. Teaching-learning with animations

Whilst the SUPERCOMET CD includes a wide set of textual reference materials, links, glossaries, images, video clips of demonstrations and quizzes which together all contribute to providing an excellent superconductivity teaching resource, the most important feature of SUPERCOMET is the large number of interactive animations of physical processes that it provides.

Animation can help learning in different ways:

• Virtual labs can provide pupils with access to a number of experiments that would otherwise be impossible for them to experience in a normal

classroom, for reasons of safety, or because the effects are too fast, slow or small.
• By interacting with animations, easily altering factors and examining the effects of these changes, pupils can gain insights that might otherwise be hidden by noise and the difficulties of practical experimentation.
• If used in combination with experiments in the real world, animations can help students understand the relationship between models and reality, and thus come to an understanding of how science is done.
• Animations make learning science more enjoyable and appealing to pupils.
• Animations have been shown to be effective at illustrating the complex functional and procedural relationships so often found in physics learning.
• By adding conceptual interpretation to simulations of what is a strippeddown version of reality, animations can help students link conceptual models with real-life phenomena.
• Animations provide learners with images and motions, both of which are essential to understanding and memorizing scientific concepts.
• Animations remove the noise found in live experiments, thus allowing students to construct models of physical phenomena more easily.
• Interactive animations of physical concepts can allow students to test and refine their own models of new phenomena.
• Appropriate animations can help learners decode text.
• Animations allow the students to be more active in their learning, thus relying less on their teacher as the main source of knowledge

3. SUPERCOMET multimedia

SUPERCOMET has been designed as a computer application combining graphics, animations, text and navigation to make selected parts of the physics curriculum in upper secondary school more interesting and accessible. The main part of the application are interactive animations, text is provided mainly to promote inquiry learning among students.

SUPERCOMET contains six self-contained modules and a set of other useful navigational, teaching and information resources:

Module 1. Magnetism of wires and magnets
Module 2. Magnetism of coils and materials
Module 3. Electromagnetic induction
Module 4. Electrical conduction
Module 5. Introduction to superconductivity
Module 6. History of superconductivity

3.1 Module 1. Magnetism of wires and magnets

This module connects naturally occurring and easily observable magnetic forces with the concept of a magnetic field. Some materials are naturally magnetic, others are not. Magnetic materials are sometimes called magnets, and magnets are surrounded by magnetic fields.

Oersted, Pohl experiments and tasks with magnets are the main subjects of this module.

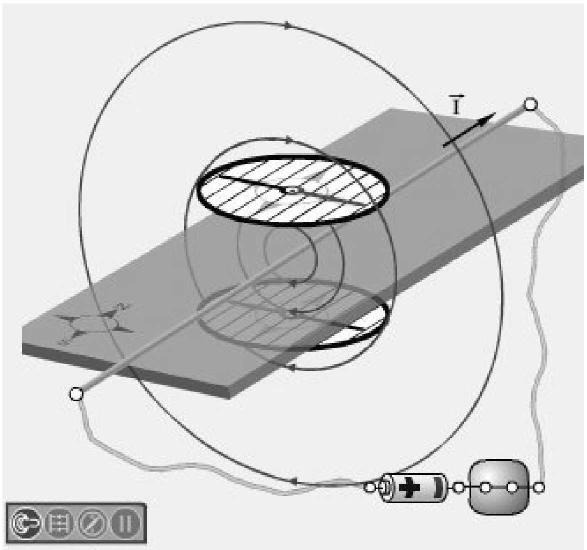

Figure 1. Interactive animation about the Oersted experiment

Using magnetic compass a variety of experiences can be performed to study the interaction between them and the electric current going through a straight wire, students is conducted to the concept of magnetic field due to electric currents, the “Right Hand Rule” is introduce to help finding the direction of the magnetic field generated by an electric current. Seven different tasks are propose to match magnets with magnetic field lines plots. The force between a magnetic field and an electric current is checked with animations about the Pohl experiment.

3.2 Module 2. Magnetism of coils and materials

In this module the equivalence between coils and magnets and the magnetism of material are analyzed, the behaviour of ferromagnetic, paramagnetic and diamagnetic materials are shown; Weiss domain and Curie temperature are introduced using animations.

Based on work with the SUPERCOMET material, the pupils shall be able to

• recognise that electricity and magnetism are two faces of the same phenomenon.

• recognise that the magnetic field around a solenoid is similar to the field of a bar magnet

• recognise the different properties of paramagnetic, diamagnetic and ferromagnetic materials.

• recognise that a ferromagnetic material can be magnetized by an external magnetic field.

• recognise that a ferromagnetic material can lose its magnetization if it is heated up sufficiently.

3.3 Module 3. Electromagnetic induction

One of the most important discoveries of the science for the technical and science development is introduced in this module, the electromagnetic induction. Electric induction using a magnet and a solenoid is shown with an animation, the Faraday and Lenz laws are also introduced studding the vector character of the flux definition.

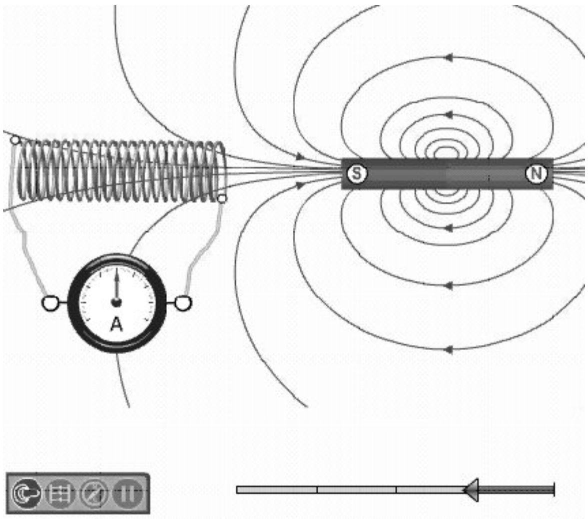

Figure 2. Interactive animation to experience with Electromagnetic induction

Different experiences can be performed to study the dependence of the electromotive force with the variation of magnetic flux, all these experiments drives to the alternator, the device responsible for the production of the alternating electric current, the base of the technical and scientific present development.

Based on work with the SUPERCOMET material, the pupils shall be able to

• use the terms induction, coil, circuit, current, magnetic flux, generator, rotor, stator, dynamo recognize that an AC motor in principle is an AC generator «running backwards»

• identify some applications of induction coils in everyday technology (e.g. transformers, electrical motors and generators, loudspeakers, microphones)

3.4 Module 4. Electric conduction

This module uses animations to visualize the phenomenon of electric conduction. Some materials conduct electricity, others are insulators, some are semiconductors, and some are superconductors.

Based on work with the SUPERCOMET material, the pupils shall be able to

• use the terms: conductor, semiconductor, resistor, insulator, cross-section, resistivity, conductivity, temperature coefficient, mean free distance, lattice, charge carrier, electrons, holes, ions, power loss

• recognize electrons, holes and ions as charge carriers

• identify some well-known conductors, insulators and semi-conductors

and to describe

• the relationship between the kinetic energy of the lattice (temperature of the material) and resistance

• the differences between AC and DC in terms of charge carriers and electric field.

• the relationship between voltage, current and resistance (Ohm’s first law)

• the relationships between resistance, cross-section, length and resistivity of the material (resistance law or Ohm’s second law)

3.5 Module 5. Introduction of superconductivity

This module introduces readers to the concept of superconductivity and how it relates to – and extends – electricity and magnetism. It runs through the main phenomena of superconductivity, the properties of different forms of superconductors and the theoretical explanations which underpin them.

The module shows at the beginning the behaviour of magnets and conductors that have interest to contrast them with the behaviour of superconductors, the ability for levitation and the variation of conductivity with temperature. Especially interesting is the explanation of superconductivity in terms of Cooper pairs in a qualitative but a proper way.

By the end of this module students should be:

- able to recognize the theoretical puzzles which superconductivity presented (and still presents) to scientists;
- able to use existing knowledge of electricity and electromagnetism, and of lattice vibrations and internal energy, to understand some of the explanations;
- able to recognize that the rules of quantum mechanics dictate behaviour at low temperatures – and that some explanations of superconductivity cannot be accounted for in simple terms ;
- aware that the following terms are used in explanations of superconductivity: drift velocity of electrons; eddy currents; penetration depth of magnetic field; Cooper pairs; phonons; vortices; fermions; bosons.

3.6 Module 6. History of superconductivity

This module contains a chronological overview of the experimental discoveries, theoretical breakthroughs and applications related to superconductivity. Who were the scientists behind the Nobel prizes that have been awarded for superconductivity research throughout history? What are the most recent developments?

The relation between technical progress and a new and transcendental discovery is well established introducing the history of superconductivity, the history began with professor Heike Kamerlingh Onnes, in his laboratory at the University of Leiden, on July 1908 he managed to cool down the noble gas helium to the temperature where it condenses to a liquid. He was the first scientist in history to create liquid helium. On 1911 Onnes discover superconductivity studying the resistance of mercury at the temperature of liquid helium.

A special attention is dedicated to the superconductors of high temperature, the race towards superconductors over the liquid Nitrogen temperature at the end of the eighty's decade was an exciting scientific fact. It is emphasize the present challenge for science to find a theory to describe this kind of superconductivity.

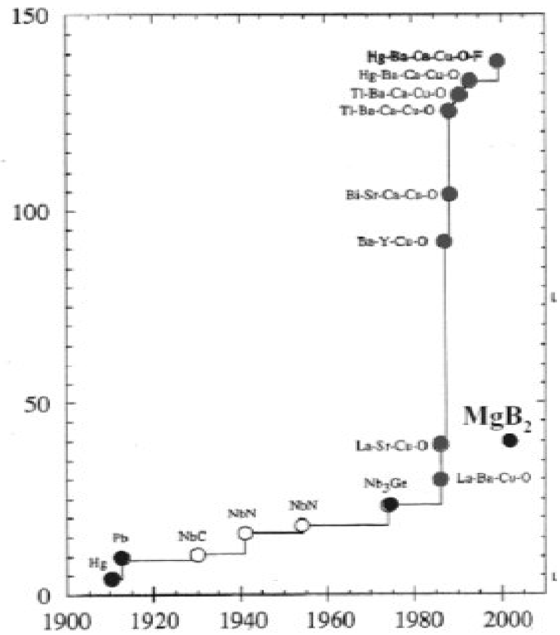

Figure 3. The history of the critical temperature for superconductors

4. Slides set up

Modules are formed by slides, in Figure 4 we see a typical slide. The main part of the window is occupied by the animation with which you can interact clicking on some parts of it or interacting with some icons located in the left bottom corner, a text explaining the subject and proposing activities is shown on the right, below this text a "Tip" could be found for some experience.

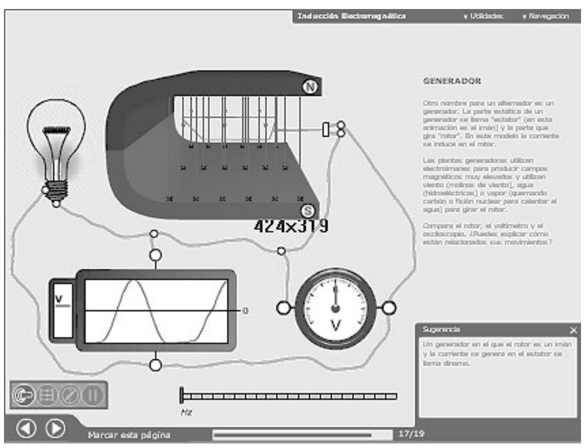

Figure 4. Screenshot of SUPERCOMET screen

At the upper corner you can see the title of the current module, the Utilities menu where you can find Help, a Glossary, FAQs, Resources, the Teacher Guide, and info about SUPERCOMET, a menu with facilities for navigation is always available.

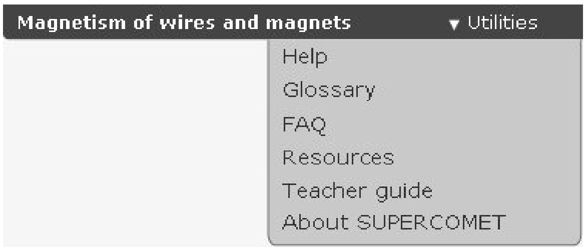

Figure 5. Utilities menu

At the bottom of the window we found two arrows to move sequentially forward and backward through the module, on the right of these arrows, you can click to bookmark a page that you would later like to come back to. It is not possible to bookmark multiple pages. In the middle, a longitudinal index allows you to navigate to the page you selected within the module.

5. Teacher Seminar

A seminar with teachers of secondary schools was held at the University of Murcia. The seminar began with a presentation of the project, a description of the content of the CD and, using the SUPERCOMET CD material, an introduction to superconductivity; most of the teachers did not know the principles of superconductivity.

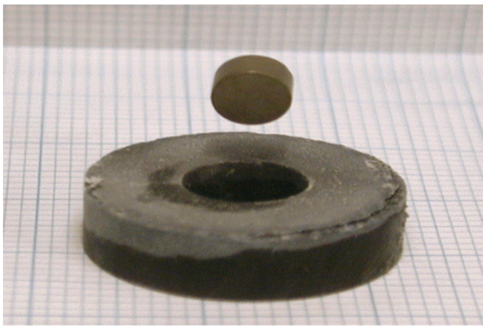

Figure 5 Levitation of a magnet over a superconductor.

Experiences about, how to handle liquid Nitrogen, forces between magnets, electromagnetic induction and levitation of a magnet by a superconductor was performed.

Teachers were gathering in groups of five people with similar teaching activities, they were invited to work with the SUPERCOMET CD in order to check the usefulness of these materials in their teaching activities. They assign the content of the multimedia to the different concepts to be learnt at each educational level.

A test was used to evaluate the level of satisfaction of teachers with seven items following a Likert scale. The more important conclusions were:

- For the main part of the teachers, the seminar has shown a different way to teach Physics.
- Half of them declare that the seminar has promoted their motivation to teach physics and to transmit this motivation to their students.
- Also half of them declare that the seminar has been very useful to go deeper in the superconducting phenomena and to explore it in a passionate way.

6. Acknowledgements

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7. References

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