Friulian Journal of Science **11**. 2009, 41-50

SUPERCOMET Projects in Udine

LORENZO MARCOLINI, MARISA MICHELINI,
ALBERTO STEFANEL, ROSSANA VIOLA*

Abstract. SUPERCOMET 2 (SUPERCOnductivity Multimedia Educational Tool phase 2) is a Project within the Program Leonardo da Vinci phase II of the European Union, involving Universities and Secondary Schools of 15 European countries. The objectives of this Project are the production of a multimedia tool for teaching superconductivity and the creation of an international community at a European level, able to revitalize the teaching of physics in order to open up new international collaborations. Several materials have been developed in this framework: interactive animations, text, videos, hands-on materials for demonstrating and measuring phenomena related to superconductivity, electromagnetism, with an accompanying teacher guide and a teacher seminar. These materials have been used both in teacher seminars and training and in classroom experimentation in the partner schools.
In Italy the University of Udine led and coordinated the experimentation[1] that involved students from several schools and from several Italian regions. The planning of the pathways points out various curricular proposals concerning approaches, methods and contents. Some schools and teachers from Udine have been actively involved in the project: here the paths of the experimentations proposed and carried out by teachers in Udine are presented and analyzed.

Key words. Multimedia tool, interactive tools, superconductivity, interactive materials, information and comunication technologies (ICT), action-research, mechanical energy transformation, current magnetic effects, transformer, magnet levitation, Cooper pairs, electromagnetic induction, Meissner effect.

---

* Research Unit in Physics Education of the University of Udine, Italy.
E-mail: cird@amm.uniud.it

[1] The head of the projet is prof. Marisa Michelini of the to Physics Department and Research Unit in Physics Education of Udine University.

1. SUPERCOMET Projects. The project aims to introduce superconductivity into European high school curricula with experiments, didactic materials and interactive tools on CD which comprise animation, films of demonstrative experiments, using modern pedagogical methods such as collaborative learning and problem solving.

During the first year, school year (s.y.) 2004/05 of the project, the following were produced:

– a CD-ROM with didactic material;
– a teacher's guide to clarify characteristics and roles of support material (texts, worksheets and computer presentations) and preview didactic courses.

During the second year of the project:

– the material was translated into the languages of countries taking part in the project;
– several didactic proposals were tried out in high school classes in various parts of Europe;
– the training course model and the teacher guide were tested on a group of teachers.

At the end of the first period of experimentation and dissemination materials were revised and new ones were integrated in order to produce a final version at the end of the project.

Further integrated proposals were included with the revised material. Didactic and research paths were developed too.

2. The Italian contribution to the project. The University of Udine in the first phase translated and adapted all the material for the experimentation and collaborated to the definition of didactic proposals included in the teacher's guide.

During the SUPERCOMET2 Project and the extension period (s.y. 2006/07) the Italian group developed research pathways, experiments and carried out 3 typologies of trials involving five Italian regions.

3. Training courses for teachers. SUPERCOMET2 developed a specific teachers training course, perfected materials to be used in experiments and specific activities with teachers. In Italy 4 different types of teachers' seminars were held in 4 different cities (Udine, Bolzano, Matera and Catania). The total number of schools involved is 13, with 51 teachers. There were 2 sessions in Udine and 1 for each of the other cities, the final meeting was in Catania.

Details of the workshops are in Table 1.

One of the contributions of the

Table 1. The teachers workshops.

Type	Seat	No. of involved schools	No. of teachers	Female	Male	No. of sessions	Length of the sessions (h)
1°	Udine	5	13 - 15	3 - 5	10 - 10	2	5 - 5
2°	Bolzano	2	10	4	6	1	8
3°	Matera	3	5 *	3	2	1	5
4°	Catania	3	8 **	4	4	1	8

workshops was to develop proposals on using ICT and new methodologies.

Types of i schools nvolved: in Udine Ordinary, Technological and PNI Scentific High School, IPSIA and ITI Cst; ITIP and Classic High School in the others too. 120 (*) and 140 (**) students took part to the seminars in Matera and Catania too. In Table 2 content of teacher workshops are summarized.

4. Class experimentations. Trials in Italy started in s.y. 2005/06 and continued in s.y. 2006/07.

The total number of students involved in the experimentation was 348, with a total of 110 students from the ages 14-16 and 238 from the ages 17-18, from 22 classes in 12 schools in different parts of the Country (Udine, Gemona, Pordenone, Bolzano, Ragusa, Vibo Valentia, Palermo).

The total number of sessions was 71 for a total of 138 hours of lessons with the students. Fourteen teachers were involved.

During the second year (s.y. 2005/06) and an extension period (2006/07), the Italian group led 3 typologies of experimentations (using the adaption of SUPERCOMET materials to the curricula of the different Italian schools and the didactic proposals – teacher guide too):

Type A) Research experimentation with setting up of didactic tools for analyzing didactic innovation produced during class activities and the efficiency of learning processes, with the relative tools of partial and global evaluation with respect to pathways in teaching.

This was carried out in 2 contexts with 2 very different modalities:

A1) As apprenticeship of a per-

Table 2.

20 june 2005 – 5 hours (13 attending teachers)
Introduction to the SUPERCOMET project
The CD-Rom and the teacher guide
ICT and Physics education
The history of superconductivity
What is superconductivity
Superconducting materials
The BCS theory
How to introduce superconductivity
Introduction to the experiments and the videos
Discussion with teachers and task assignment (produce didactical pathwayss)

2 February 2006 – 5 hours (15 attending teachers)
Illustration of the experiments
Execution of the experiments (in series)
Discussion with teachers and task assignment (produce experimental forms)
After these meetings, the group met every 2 months (5 hours each time) to discuss methods of work, problems, approaches, proposals for new pathways addressed to the different types of schools and age of students.

spective teacher in collaboration with an expert teacher from a secondary school and the Research Unit in Physics Education of the University of Udine.

A2) as research experimentation conducted by a researcher/teacher following a protocol of didactic innovation individuated in previous research (PRIN, Ref M.L. Aiello Nicosia et al, Teaching Mechanical oscillations using and integrated curriculum, International Journal in Research on Science Education 19,8,1997). Six different monitoring tools were used to analyze the experimentation.

Type B) Action research by a web network of schools (DRAGO Web), by a group of teachers and teachers who had collaborated in an online web, involving 2 Italian regions (Sicily and Calabria) areas in the south of the Country with a strong need for innovation and support. The 3 levels of study: that of students; the teachers who lead and follow these with blended modalities; the researchers, who in different environments carried out the task of analyzing the work of students and the activity of the teachers. The project received an award from the national projects to support scientific vocations (PLS – Physics). The prize-giving was held at a conference where 500 students took part and exhibited the experimentation SUPERCOMET (around 60 students).

Type C) experimentation in experimental low level secondary schools (3) and in traditional classes of the last years of secondary school (15) following the suggested pathways of the project, with meetings for comparison and discussion during the experimentation, between teachers who chose one of the 2 main branches: electrical properties and magnetic properties.

The prevailing strategies used are those proposed in the research experimentation (A1), where the stimulus-questions lead the student to reason out situations of the cycle Prevision-Experiment-Comparison (PEC). The main strategy carried out is the conceptual exploration even when the activity is conducted without worksheets.

The teachers of the schools involved in the project followed different methodologies:

A) used only multimedia material,

B) carried out the main experiments combining use of multimedia materials,

C) based their course mainly upon experiments.

The Project contributed to didactic improvement from both the content and method viewpoint.

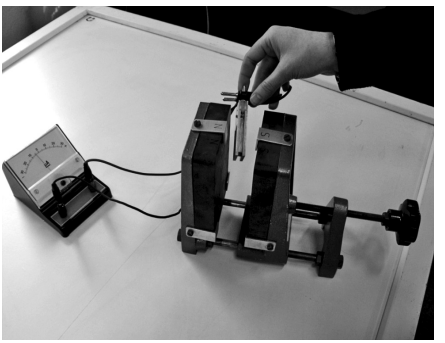
The approaches used were 4-5: A1) problematic – explorative, A2) multimedia, A3) applied, A4) experimental, A5) mixed.

5. The pathways of the experimentations proposed and carried out in Udine. Udine made original proposals on how to teach superconductivity in secondary schools. Methods in primary and secondary schools are different. The approaches differ depending on whether magnetic properties, electric properties and ener-

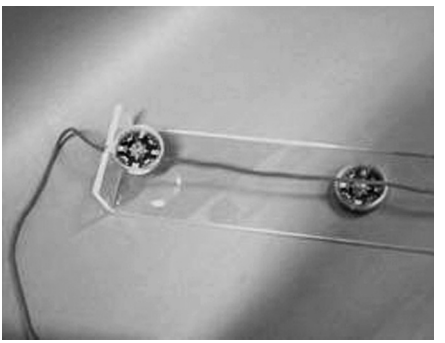
getic aspects are taught. There are elements of innovation on the methodological level too. The experimentation was based on research carried out in the University of Udine and it included experiments, monitoring tools, reasoning tools and learning pathways, tested by a SISS experienced teacher in the technical High School ITI Malignani of Udine.

5.1 The energy transformations and superconductivity. The pathway was planned by the teacher Vilma Capocchiani and she and Riccardo Sangoi tested itin two second year classes (aged 15-16 years) of the Liceo scientifico "Marinelli" in Udine for a total of 32 hours, more than half of the time was dedicated to experimental activities. It differs from the previous approaches in that it employs energy transformations AC 3 as the basis for a mostly experimental approach (ME-1), integrated with the SC-CD modules and the active partecipation of the students (SL-1). It fits the argument of mechanical energy transformations, usually considered in second year curricula. The detailed pathway of the steps is the following (E1-E5).

E1) In the context of mechanical energy transformation into different forms, electric transformations in particular are analyzed. It is recognized that there are different ways, static and dynamical, to produce electric energy. The electrostatic and magneto-static fields are explored and compared. The experimental exploration of a DC circuit, using traditional instruments and on-line sensors, is integrated with the discussion of the SC-CD 4th module. The phenomenology is described through the first and the second Ohm laws and their limits are discussed considering the I-V characteristic of a bicycle lamp, exploring the energetic processes (Joule effect).

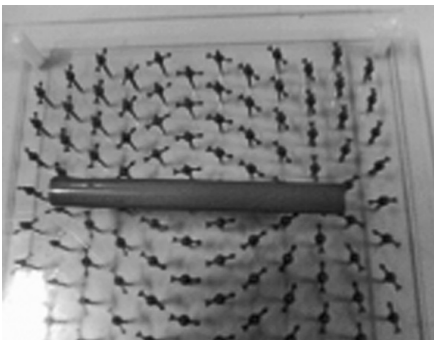


E1. mechanical energy trasformation.



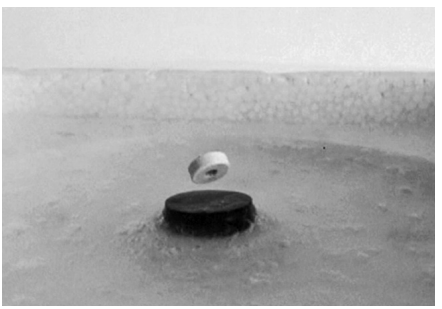
E2. The Oersted experiment.

E2) The electric current magnetic effects are introduced with qualitative experiments and the module 1 of SC-CD, integrated with an activity of formalization. The magnetic fields generated by magnets are visualized by constructing the field lines with iron filings and compasses. The Oersted



E3. Magnetic field of a magnet.

E5-1. magnetic suspensions (piled magnets).



E5-2. levitation supeconductor.

experiment is completed with the Biot-Savart law for a straight wire. The magnetic fields produced by currents are thoroughly analysed in terms of formalization and description with the experimental and simulated exploration of the Ampère and the Pohl experiments.

E3) The description of the magnetic effects of currents is completed analyzing the field produced by coils and magnets at first experimentally explored in the laboratory, then considered using the module 2 simulations of SC-CD.

E4) The students, in groups, explore the way to produce induced voltage. The concept of flux is introduced and clarified. The transformer and the dynamo alternators working behaviours are analised to reinforce the concepts of induction and alternate currents. The energetic processes involved in the transformers are analyzed.

E5) In groups, the students explore the interaction between piled magnets and various situations of levitation of a magnet on a superconductor. With the same strategy previously adopted, in this module too the experimental exploration and the superconductivity interpretation are integrated, discussing in particular the formation of the Cooper pairs. A short discussion about the application of superconductivity completes the pathway.

5.2 "Introduction to superconductivity" – approach through the magnetic properties. The didactic pathways were developed by the research

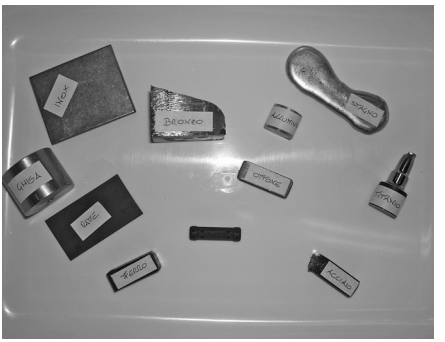
group of he URDF of Udine and tested in the technical High School ITI Malignani of Udine, in the framework of a collaboration between the University of Udine and this school, by the school teacher who led an expert teacher (M. Braida) during the 2005/06 s.y. in a final year following an approach to the magnetic properties of superconductors (AC-1), with active partecipation of the students (ME-1) and activity performed in groups (SL1).

The experimentation took, in all, 10 hours, 2 hours for the pre-test and the post-test and 8 hours of experimental and simulation activities. The integrating and qualifying part of the project are the didactical instruments prepared and used in the experimentation:

– 8 working forms, one per lesson, projected to stimulate a problematic attitude and collect elements on the learning processes
– 1 test on the main complications, employed as a pre-test and post-test
– 1 brief document on the superconductivity to support individual study of the students.

The thread of the contents are presented with its segments (M1-M8), indicating in brackets the progressive number of experiments effectively done by the students.

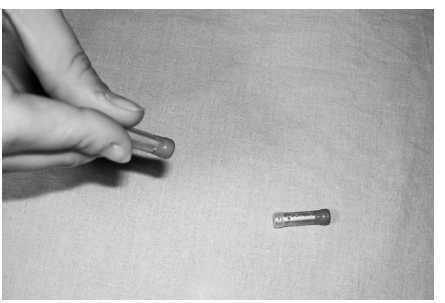
M1 – The interaction of a magnet with various objects made of different materials is explored. The behaviour classes are: 1) iron, or steel, or nickel (ferromagnetic), 2) non metals and many metallic objects (copper, bronze, aluminum). It is recognised



M1. Interaction of a magnet with various objects made of different materials.

that not all metals exhibit ferromagnetic properties. The exploration of the interaction is completed with the recognition of the reciprocity and of the dependence on distance. The ability of the magnet to modify the space properties introduces the magnetic field, which is represented by means of field lines constructed using small compasses, iron filings, single compasses. Such representation gains formal meaning when it is observed that the different superficial density of lines can be correlated to the field intensity.

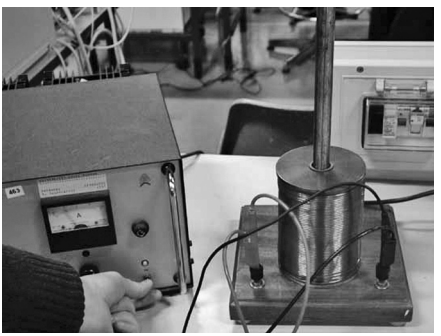
M2 – The interaction between two magnets is explored: ring-shaped



M2. Interaction between two magnets.

magnets are piled, by means of a wooden bar and magnet bar-shaped are faced, being free to rotate. By progressive degrees of exploration, the following steps are taken: recognition of the bipolar nature of the magnetic field sources, construction of the relation force-distance between poles of magnetic rods in one direction and role of the pair of forces in the interaction.

M3. Calamite in colade libare intun tubo di ram.



M4. Jumping ring experiment.

M3 – While rod magnets (or button shaped) in a vertical (or inclined) plastic pipe (or on a guide) fall with an accelerated motion, when they are put into a copper pipe (or guide) they move very slowly. The recognition of the role played by the induction voltage and then the induced currents in the copper pipe-guide leads to the interpretation of the phenomenon. The field produced by these induced currents, in this case has the opposite effect of the inducing field and then is responsible for the evident slowing down of the falling magnet. The experiment, first carried out with an integer pipe, then with a pipe with longitudinal cuts, can effectively lead to a quantitative analysis with traditional apparatus.

M4 – The phenomena of electromagnetic induction and of magnetic suspension are reconsidered by studying the experiment of the Thompson ring, proposed to show the influence of temperature and resistivity. The experiment, repeated with rings of different materials demonstrate that there is an analogous behaviour due to the strong field produced by the induced currents, which are as intense as the ring temperature is low. The evident decrease of resistivity is associated with the decrease of temperature of the material of the ring.

M5 – By analogy with the Thomson ring, the behaviour of a magnet on a frozen superconductor is explored. The levitation of the magnets is compared with the analogous situations observed before: the experiment of the floating magnets suggests

that the magnet must be subjected to an opposite field; the experiment of the falling magnet in the copper pipe indicates that the effect tends to autoregulation, i.e. it is produced by an induced field. The fact that the magnet levitates but does not fall, as the case of the magnet into the copper pipe, indicates that the induced field must be equal to the inducing field, or that the superconductor behaves as a perfect diamagnet (Meissner effect). The effect of induction produced by the presence of the magnet does not stop when the magnet is still, (as happens with an ordinary conductor) then in the superconductor the dissipative effects must be absent, or $\rho \sim 0$.

M6 – The experimental exploration of the Meissner effect introduces the main events leading to the discovery of superconductivity, characterizing the type I and II superconductor phenomenology, describing the anomalous behavior of the three quantities which exhibit critical values in superconductors: magnetic field, current and temperature.

M7 – A short review of the technological applications of superconductors offers the opportunity of interdisciplinary connections of various types, given the relevance of the use of superconductors in the electronics and sensors fields (cryoelectronics and superconductor sensors), medical diagnostic (NMR), and in advanced physics research (superconductor magnets).

M8 – The explorations in segments 6 and 7 lead to the discussion of the basic elements of the BCS theory, the only one that accounts for I type superconductors. This theory can lead to the role played by the lattice in the production of neat attractive effects between electrons, i.e. in the formation of the Cooper pairs, and the effect of condensation of such pairs, not subjected to the exclusion principle.

6. Conclusions. The value of the SUPERCOMET Project is to join theoretical and epistemological aspects, with experimental (and the suggested experiments in the simulations of the CD-Rom are never artificial or misleading), with technological and then technical aspects.

The experimentation carried out in the two years of the SUPERCOMET Project was significant for several reasonbs: pathways developed according to pupil level, type of school, social and territorial conditions, methodologies, strategies, tools used and developed.

The angle of attack differed depending on the objectives, in contents, attention to different disciplinary based aspects and in the technological application.

The strategies and methodologies used are distinguished not only for pupil level and type of school, but also for the way of integrating experiments and multimedia tools.

Three different modalities of research experimentations have enabled a data analysis which is a source in studying learning processes.

Bibliografie/ References

Viola R., Michelini M., Santi L., Corni F. (2008). The secondary school experimentation of Supercomet in Italy. In Jurdana-Sepic R. (Ed) *Frontiers of Physics Education.* Rijeka: Girep-Epec, pp. 392-398 [ISBN 978-953-55066-1-4] pp.190-196.

Michelini M., Santi L., Viola R., Corni F. (2008). Superconductivity in Italian Secondary Schools: the experimentation carried out by Udine University with Supercomet 2 (SC2) materials. In Sidharth B.G., Honsell F., Mansutti O., Sreenivasan K., De Angelis A. (Eds) *Frontiers of Fundamental and Computational Physics.* New York: Melville [ISBN 978-0-7354-0539-4; ISSN 0094-243X], pp. 225-226.

Michelini M., Viola R., Engstrom V. (2008). Superconduttività: esperimenti e modelli. Il laboratorio reale e il laboratorio virtuale nel progetto Supercomet 2. In Andronico A. (Ed) *Didamatica 2008 - Informatica per la didattica*. Bari-Roma Laterza [ISBN 978-88-8231-456-9], pp. 110-114.

Michelini M., Viola R. (2008). Gli strumenti multimediali della sperimentazione Supercomet. In Andronico A. (Ed) *Didamatica 2008 - Informatica per la didattica.* Bari-Roma Laterza [ISBN 978-88-8231-456-9], p. 97.