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The secondary school experimentation of SUPERCOMET in Italy

R.Viola [1], ***M.Michelini*** [1], ***L.Santi*** [1], ***F.Corni*** [2]
[1] *Research Unit in Physics Education, University of Udine, Italy*
[2] *Physics Department, University of Modena and Reggio Emilia, Italy*
Corresponding author's e-mail: rossviola@yahoo.it

1. Introduction: the Supercomet Project

SUPERCOMET is a biannual project within the program Leonardo da Vinci of the European Union and is of what will be the final product of this project: a multimedia tool for teaching superconductivity addressed in particular to secondary school students.

The objectives of the project are to producing the multimedia tool and to create an international community at an European level able to revitalize the teaching of physics in order to open new international collaborations.

Through a highly interactive tools on CD which comprises animation, films of demonstrative experiments, and uses modern pedagogical methods such as collaborative learning and problem solving, the project aims to introduce superconductivity to European high school curricula.

During the first year of the project the following were produced a CD-ROM with didactic material and 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 It was translated the material into the languages of countries participating in the project and experimented in high school classes in various parts of Europe.

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

Further integrated proposals have been included with the revised material.

2. The Italian contribution to the project

In the first year Italy, represented by the University of Udine (led by Marisa Michelini), translated and adapted all material for the experimentation, and collaborated to the definition of didactic proposals included in the teacher's guide. Adaptations were made to the curricula of various types of Italian schools.

During the second year and an extension period the Italian group conducted 3 typologies of experimentation in 22 classes of 12 different schools of 12 cities from North to the South of Italy:

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 paths in teaching.

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

A1) As apprenticeship of a perspective teacher in collaboration with an expert teacher of 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, [1]). 6

different monitoring tools relative to this research experimentation were used to analyze the experimentation.

Type B) Action research by a web network of schools (Drago Web). Drago Project is a web online collaboration between 3 teachers (expert in using ICT) from 3 schools (from Sicily and Calabria which are areas in the south of the country with a strong need for innovation and the support required by this). 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 by national projects of support to scientific vocations (PLS – Physics). The prize-giving was held at a conference where 500 students participated and exhibited the experimentation Supercomet (around 60 students).

Type C) experimentation in experimental low level of secondary school (no.3) and in traditional classes of the last years of secondary school (15) following the suggested path foreseen by the project, with meetings for comparison and discussion during the experimentation, between teachers who chose between 2 main strands: electrical properties and magnetic properties.

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 10 different seats distributed in all Country.

3. Training courses for teachers

For the training courses lasting 1-2 days the teachers made use of the Guide for teachers and the CD-Rom with 6 modules. These took place in Bolzano (2), Udine (2), in the National Congress of the Association for Teaching Physics (AIF), in Latina (1) and in Catania (1).

Six experiments were carried out during the training activities (Fig. 1) of which 4 are assembled with self-made materials and 2 with commercial materials.

1. Electrical and magnetic properties of different materials:
Classification of various everyday materials (conductors, magnets, insulators, diamagnetic and paramagnetic material) in terms of their interaction with a magnet. Characteristics of magnetic attraction. Construction of field lines of a cylindrical magnet using a compass. Relations between field lines and flux.
2. A falling magnet:
Comparison between the falling of a small magnet and a piece of steel of the same dimensions in a tube of copper.
3. A jumping ring:
Three rings of different materials (copper, aluminum and plastic), at room temperature or previously heated/cooled, are subject to a sudden variation in intensity of magnetic flow. The height of their jump is analyzed in terms of material and temperature.
4. Piled magnet rings:
Four magnet rings are piled onto a wooden bar, facing each other the same polarity. Measure of their relative distance and behavior reacting to an external force along axis.
5. Magnetic levitation:
Observation and discussion of the characteristics of the levitation of a magnet on a superconductor.
6. Measure of the resistance-temperature curve of a superconductor:
A superconductor material is cooled and its resistance is measured in temperature and time by means of a data logger system. The graphs obtained are compared with the data obtained by the previous experiment levitation.

Fig. 1 The six experiments for teachers training course.

4. Instruments and methods

Two types of worksheet of the didactic activities and experimentations were developed:

- traditional detailed worksheets that helps students to analyze each experiment, seen as an auto-consistent module, to recognize the relevant physical quantities, to take measurements, analyze data and look for an explanation of phenomena observed using the experiment results.
- Sequence of stimulus-questions, realized according to strategy PEC (Prevision-Experiment-Comparison [2]) and the inquiring physics methodology [3]: the entire course is organized as a sequence of activities based on PEC cycles with student worksheets.

Six monitoring worksheets were prepared, according to standards of evaluation of innovation developed in previous research [1] :

1. Class presentation (previously experimentation carried out, physics arguments familiar to the students, laboratory and computer use, methods of teaching, attitude of the class)
2. Departure point for each student (ability, interests, attention, socializing, school performance)
3. Board diary of various activities carried out
4. Final report (text in free form containing: evaluation of materials, difficulties met with modules contained on the CD, interdisciplinary arguments, reactions of the students, evaluation of the experiment, suggestions)
5. Final students evaluation (attention, school performance during the experimentation)
6. Student interview according with a grid (one interview per student group performance where they are asked what they believe they have learned, if they liked the activities, how they learned and, finally, they are asked to review a particular argument among those dealt with)

5. The didactic path

The groups of teachers from Pordenone and Udine proposed 3 paths that may be adapted both for experimental low level of secondary school and for traditional classes of the last years of secondary school, using the Supercomet materials.

P1_Magnetic field path. “Faraday’s way to the magnetic properties of the superconductor, or rather the path of field lines” is characterized by the following steps:

– Analysis of the electric field lines due to a dipole and of the field lines in the case of a magnetic dipole (mapping and characterization in both cases)
– Analysis of the situations of suspension associated with field lines and situations of equilibrium (stable and not stable): they use the two experiences of ring-shaped magnets and not ring-shaped magnets.
– Slowing down of the magnet and the superconductor thanks to induced currents; analogy with the Fountain Effect
– Possibility to surround the superconductor with field lines: experience of magnetic levitation; introduction of the hypothesis of diamagnetism; possibility of correction of the position of instable equilibrium.

P2. Resistivity behavior. " The master way of the properties of the superconductor, or the course of resistivity" follows these steps:

– Analysis of temperature dependence of resistivity, with particular attention the below 0 degree Celsius temperatures.
– Falling of resistivity and different properties of conduction of superconductors
– Effects of superconduction.
– Analysis of electrical circuits with elements of virtual superconductors.

P3. "Transformations of energy" for second classes of PNI course, put in the curriculum after the study of energy transformations and electric field. The proposal contains a new path in that it departs from the conservation of mechanical energy and its transformation into other forms and in particular into an electrical form; it looks at electric field and electrical conduction (module 4 of CD-Rom) and then analyzes the magnetic behavior of currents (Module 1 and 2), electromagnetic induction (Module 3), superconductivity (Module 5). It is constituted by a combined use of laboratory experience, modules of the project Supercomet and interactive applets. It was favored group work for the laboratory experiences, some of which were conducted in qualitative form, others quantitative, guided by the worksheets. The strategy of inter-group discussions with the aim of sharing conclusions is implemented as the way to discuss experimental results.

6. Approaches and strategies

The prevailing strategies utilized in the experimentation are those proposed in the research experimentation (A1), where the stimulus-questions lead the student to reason about situations of the cycle Prevision-Experiment-Comparison (PEC). The main strategy carried out is the conceptual exploration [4] 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 active role of the students with multimedia material was at a minimum of 30% and the same occurred with experiments. The project thus contributed to the didactic improvement not only from the point of view of content, but also in methods.

The approaches utilized were 4-5: A1) problematic – explorative (15%), A2) multimedia (20%), A3) applied (5%), A4) experimental (15%), A5) mixed (45%).

In 4/12 cases teachers filled in the described worksheets for the monitoring of the experimentation. Analyzing them we can see that, on a total time of 84 hours spent in the experimentation, most time (48%) was utilized for doing experiments, 22% was dedicated to the interaction with CD modules, 16% to the discussion after these activities and only 14% to a presentation of contents at the beginning of the lesson.

Between the approaches, the most utilized was the experimental one (3 schools in an integral manner) and, next, a mixed typology which followed a combination of an experimental approach and a multimedia approach. In 2 cases an applied approach was utilized and the course P2 was developed focusing on technical applications of superconductive materials. All courses made use of the multimedia tools of Supercomet Project (CD modules), 4 schools utilized the experiments prepared by the

group from Udine and, finally, 4 schools also inserted other experiments in their courses, different from those mentioned:

- of particular value the sequence of 10 experiments (Fig. 2) proposed in the experimentation done by DRAGO Project,
- the experiments to determine the Ohm's law,
- experiments on the conservation and transformation of energy as angle of attack for the path,
- a series of experiments on magnetic interactions for the study of the intensity of magnetic fields produced by magnets and currents, and the analysis of the magnetization of other materials.

Positive results emerged from the monitoring of learning and from the students' progress tests. Most students have improved their profit and care especially in experimental-multimedia experimentations. Results show that there is an improvement of 40% for lowest bands of profit and of 30% for average bands.

1) Oersted's experiment,
2) Field lines of a rectilinear line of current,
3) Field lines produced by a broken and whole magnet,
4) Motion of an iron sphere in proximity to a magnetic field produced by a rectangular magnet,
5) Pohl's experiment,
6) qualitative analysis of Lenz-Faraday-Neumann's law,
7) the transformer,
8) production of a variable tension from a variable magnetic field (alternator),
9) analysis of the equilibrium between two ring magnets which are piled on a vertical axis,
10) analysis of the characteristic (V,I) of ohmic and not-ohmic materials.

Fig. 2 Experiments proposed in Drago Project

7. Concluding remarks

The experimentation done in the two years of the Supercomet Project has been significant for several aspects: paths developed according to scholar level, type of school, social and territorial conditions, methodologies, strategies, used and developed tools.

The paths differ in angle of attack for objectives, in contents, in attention to different disciplinary base aspects and in technological application.

The utilized strategies and methodologies have been characterized not only for scholar level and type of school, but for the way of integrating experiments and multimedia tools too.

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

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