PROCEEDINGS

of the Union of Scientists - Ruse

Book 5

Mathematics, Informatics and Physics

Volume 8, 2011

RUSE

ISSN 1311-9974

The Ruse Branch of the Union of Scientists in Bulgaria was founded in 1956. Its first Chairman was Prof. Stoyan Petrov. He was followed by Prof. Trifon Georgiev, Prof. Kolyo Vasilev, Prof. Georgi Popov, Prof. Mityo Kanev, Assoc. Prof. Boris Borisov, Prof. Emil Marinov. The individual members number nearly 300 recognized scientists from Ruse, organized in 13 scientific sections. There are several collective members too – organizations and companies from Ruse, known for their success in the field of science and higher education, or their applied research activities. The activities of the Union of Scientists – Ruse are numerous: scientific, educational and other humanitarian events directly related to hot issues in the development of Ruse region, including its infrastructure, environment, history and future development; commitment to the development of the scientific organizations in Ruse, the professional development and growth of the scientists and the protection of their individual rights.

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BOOK 5

"MATHEMATICS, INFORMATICS AND PHYSICS"

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MOSEM 2 PROJECT - LEARNING ELECTROMAGNETIC PHENOMENA AND SUPERCONDUCTIVITY BY INTEGRATION OF DATA ACQUISITION, DATA VIDEO, MODELLING, SIMULATION AND ANIMATION

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Abstract: *The MOSEM 2 project aims to promote lifelong learning in physics and pedagogy for science teachers at the upper secondary level through offering a range of modelling tools based on existing commercial and non-profit solutions, as well as the outcomes of previous Leonardo related projects. It seeks to extend the minds-on experiments and materials from the twin project MOSEM by adding a set of computer aided activities covering a series of topics in Electromagnetism and Superconductivity. The new activities will integrate different ICT technologies: data acquisition, data video, modelling, simulation and animation.*

Keywords: *Data acquisition, data video, modelling, simulation and animation, vocational training, upper secondary school, physics teachers, superconductivity, electromagnetism*

INTRODUCTION

Europe lacks competent physics teachers what is driving a negative feedback loop that hinders recruitment of good candidates – students learning to become teachers – that could possibly turn the trend. This situation is ongoing at both national and European levels, as has been documented by several studies and conferences in recent years. The MOSEM 2 project, funded by European Commission, aims to contribute to changing this situation in a positive way by promoting lifelong learning in physics and pedagogy for science teachers at the upper secondary level through offering a range of modelling tools based on existing commercial and non-profit solutions, as well as the outcomes of previous related projects. Development in 2009 - 2010 is followed by testing and revisions in 2010 - 2011, and finished versions will be ready by the end of the project.

The MOSEM 2 project builds on the foundations of several collaborations in national and/or European projects, most recently the MOSEM and SUPERCOMET 2 projects, which are the direct sources of the ideas for the MOSEM 2 consortium. The partnership behind the project proposal consists of leading European physics educators with a proven track record of collaboration in previous projects, as well as being frequent contributors at international conferences for physics education. The project has 30 partners in 11 countries (Austria, Belgium, **Bulgaria**, Czech Republic, France, Italy, Netherlands, Norway, Poland, Spain, UK), 9 universities, 2 foundations and Simplicatus AS will develop the project deliverables. Testing and dissemination is carried out with 13 upper secondary schools and 8 valorisation partners. **University of Ruse** and **English Language School "Geo Milev"** present Bulgaria in the project. The MOSEM 2 project aims to improve physics teaching through use of data-logging, models and simulations combined with online learning modules containing animations, textual descriptions and media files (videos, photos, etc.) and will contribute to innovation in scientific curricula of the European schools, in particular by offering educational paths that show how it is possible to reconstruct classical physics in a modern perspective, developing new teaching/learning strategies and methodologies and using materials, tools based on multimedia and ICT.

The tangible results of the MOSEM 2 project include new contents for the existing and internationally used electronic learning environment offered to participating schools and teachers. The new materials combine mathematical models, simulations and video analyses of simple thought-provoking tabletop experiments, supported by electronic and printed materials comprising additional videos, animations and text. Specially developed teacher seminars allow the participants to experience these resources and pedagogical methods to facilitate active learning, building on the outcomes of SUPERCOMET 2 and MOSEM. Additionally, MOSEM 2 will improve the previous outcomes of SUPERCOMET 2 and MOSEM by adding a quantum-mechanical explanation of the physics behind superconductivity, by courtesy of leading researchers in this exciting field of physics. The MOSEM 2 project will augment the experiments and materials from the twin project MOSEM by developing a set of models and simulations covering a series of topics in electromagnetism and superconductivity, and creating a collection of real-life data in the form of pictures, videos, and data-acquisition activities. This is supported by a teacher seminar and a printed teacher guide for lifelong learning.

This paper shows some examples of the project outcomes which are only a small portion of the material under development. The subject used as an illustration – **magnetic field in Helmholtz coils** - has been chosen to present differences in approaches to the same phenomena and indicate advantages and disadvantages of methods/tools (modelling, simulation and data acquisition).

ICT TOOLS USED IN THE PROJECT

MOSEM 2 project focuses on `constructional`category ICT tool [4] for constructing new information and understanding. The strands relevant to science within this category are: Data acquisition, Video analysis, Modelling, Animations/Simulations and Data processing. All these ICT tools should be integrated to enhance student understanding. Different ICT methods can be combined to give complementary insights.

1. Data acquisition

MOSEM 2 data-acquisition activities are created to encourage student to control and measure real physical phenomena by collecting data from equipment connected to the computer or from analyzing real movie showing a physics situation. To gather and elaborate data students use Coach 6 educational environment [7], interface and sensors. In such a way connection between real computer aided experiments, simulation and modelling of the same phenomena is realized. This creates a consistent way of learning/teaching from a constructivism point of view.

The main learning benefits of data-acquisition activities are:

- Computer equipped with interface and sensors becomes an universal measurement instrument
- The rate of data collection is available over a wide range of time and sampling frequencies
- Presenting data while being collected allows making immediate observation of the data
- Encourages critical thinking skills (more time for exploration/analysing results)
- Promotes active learning (student investigations).

Figs. 1 and 2 show screen shots of real, easy to perform experiments, created with Coach 6 program. The program is widely used throughout Europe as a comprehensive system which integrates tools for computer measurement and control, video-measurement and modelling. The program provides an environment allowing simultaneous use of a variety of tools: explanatory text, images, videos, graphs, tables, displays, models and programs. It is an authoring system that enables creating multimedia activities [3]. Two experiments are presented as an example: **Experimental verification of Ohm`s law** (Fig.1) and **Magnetic field inside/around solenoid** (Fig.2). Students are asked to complete the experimental equipment with Coach 6. In the first experiment a current-voltage characteristic of different resistors is studied [6]. Students use voltage and current sensors to measure a voltage across the resistor and a current carried through the resistor. From processing the measurement data they determine the resistance R. During the measurement the power is gradually varied from 0 to 12 V.

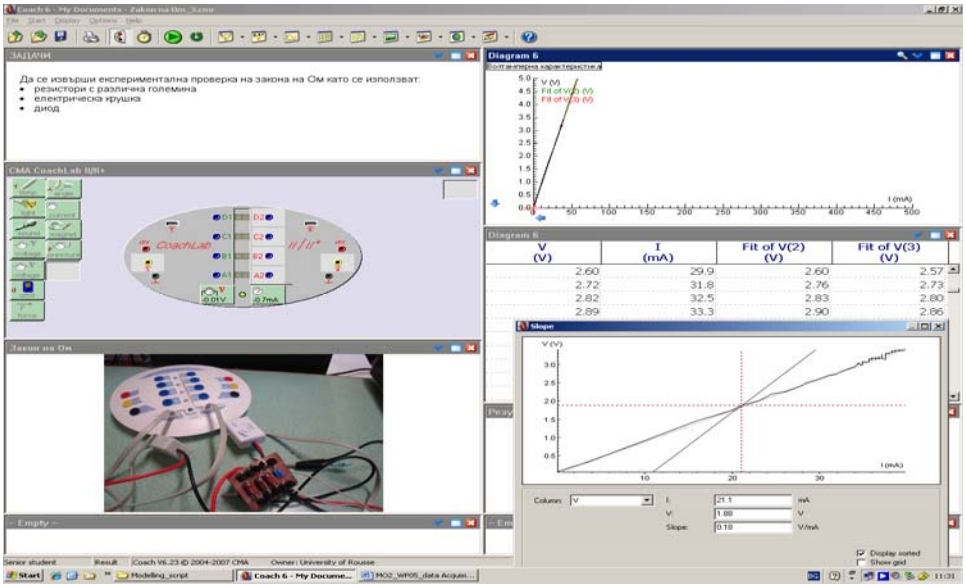

Fig.1. Screen shot showing experiment “Experimental verification of Ohm`s law”

In the second experiment a magnetic field inside/around solenoid is studied [5]. Magnetic sensor connected with Coach 6 system is situated in solenoid with current. During the measurement the power is gradually varied from 0 to 6 V. From processing the measurement data the relation between magnetic induction and current is obtained. Students will be able to change the magnitude of electrical current in the loop and the position of magnetic sensor inside and outside the solenoid. The result did not depend on the precise placement of the sensor inside the solenoid, indicating that the magnetic field is constant inside the solenoid. Inside the coil the field is very uniform, and the field from a solenoid is essentially identical to the field from a bar magnet.

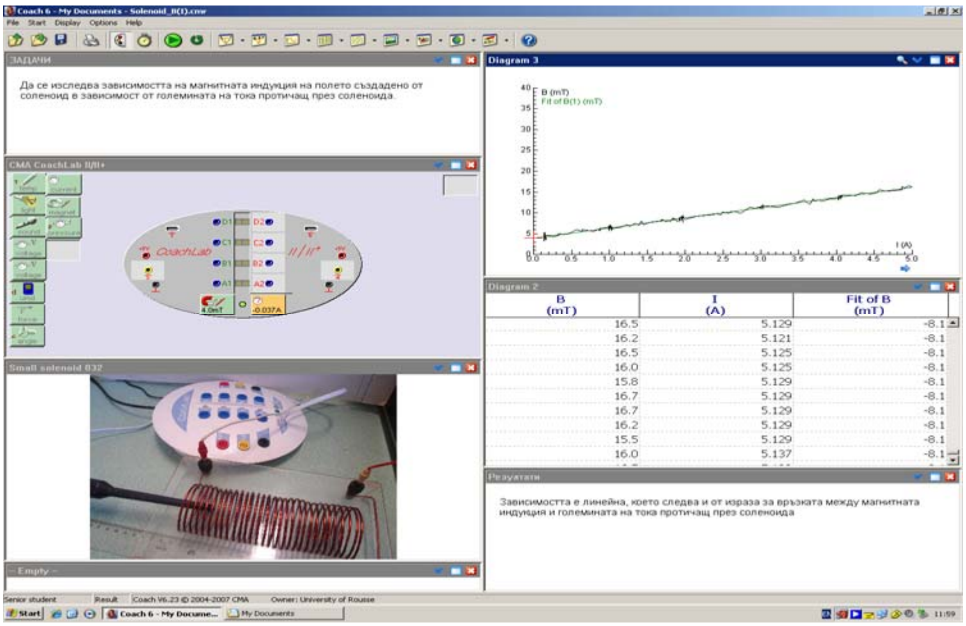

Fig.2. Screen shot showing experiment “Magnetic field inside/around solenoid”

The magnetic field generated in the centre, or core, of a current carrying solenoid is essentially uniform, and is directed along the axis of the solenoid. Outside the solenoid, the magnetic field is far weaker.

2. Data video experiments

Data-video experiments allow making measurements of position and time of moving objects on digital video clips or images. During the measurements the data are collected in the form of points (manually, or automatically by point tracking). The possibility of synchronizing graphs with the video frames help students to bridge the concrete visual display of a motion event and its abstract graphical representation. Students can make their own video of an experiment. In case the video recording is difficult to arrange then student can perform an experiment and then analyse video of already recorded experiment in Coach Activity.

Fig. 3 shows screen shot of real experiments **"Measurement of the magnetic field with a compass needle".** The learning objectives in this experiment are:

- To measure the magnetic field of a magnet B_M in the units of horizontal component of the Earth's magnetic field B_E
- To understand that a magnitude of a magnetic field of a magnet varies with distance from the magnet
- To determine empirically the relation between the magnetic field of a magnet and the distance from the magnet

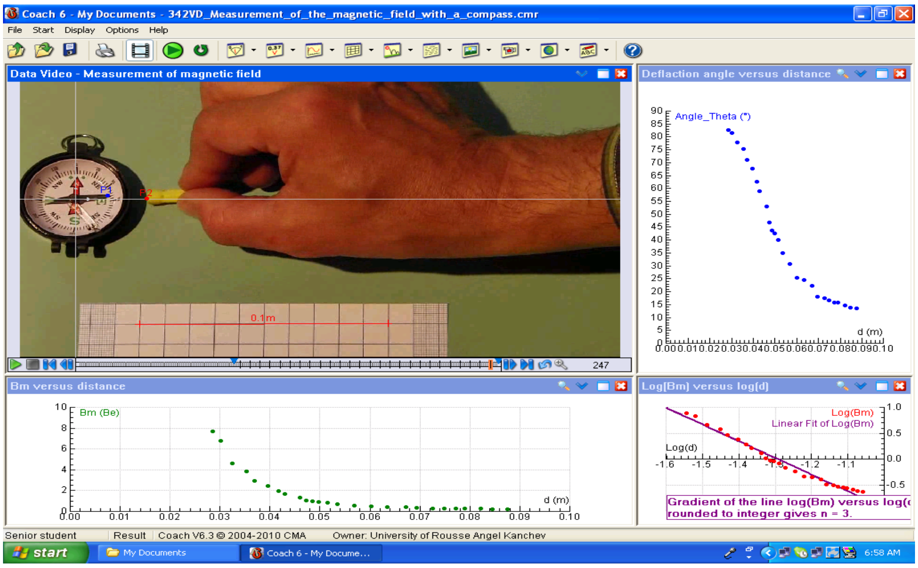

Fig.3. Screen shot showing experiment "Magnetic field of compas needle"

3. Modelling

In Modelling experiments students can create, explore or use computer models of dynamical changing systems.The main learning benefits of modelling are:

- Allows to solve complex and realistic problems, not just limited to ideal situations
- Helps to enhance student's theory building abilities (model visible to students)
- Model structure is easy to modified allowing trying different modeling ideas
- Allows to compare the theoretical models with experimental results (data acquisition, video measurement)

A key feature of modelling activity is the process of editing and altering a model to study the change of behaviour. Students can use the model to test their theories and knowledge about a phenomenon. MOSEM 2 modelling activities are assigned to make students understand how things work by having them actually work with the model, combining physics, math, and technology. To achieve the goals we favour modelling whenever the complexity of the model can be reasonably understood by average high school students. Coach 6 tools demand low programming skills but involve profound knowledge of physics including advanced equations.

As an example of modelling the experiment **"Magnetic field in Helmholtz coils"** is presented (Fig.4). A Helmholtz pair consists of two identical circular magnetic coils that are placed symmetrically one on each side of the experimental area along a common axis, and separated by a distance d equal to the radius R of the coil. Each coil carries an equal electrical current flowing in the same direction. The learning objectives are:

- To analyse magnetic field B generated by a pair
- To use the given model for simulation

The experiment with Helmholtz coils is a good example for integrating of different ICT tool – data acquisition and modelling.

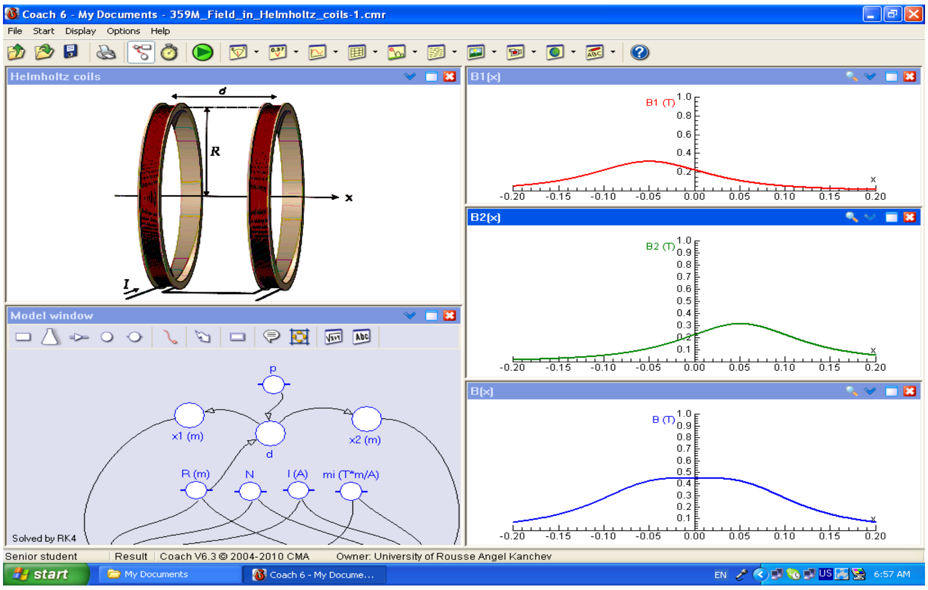

Fig. 4 .Screen shot showing modelling of magnetic field in Helmholtz coils

4. Simulation

A simulation is called a computer program that uses an internal model to produce data and visualization, as accurate as possible, of a simulated phenomenon. In addition to a number of important attributes of a simulation the one intended for educational purposes should be quantitatively right, interactive and allows changing parameters. Student primarily work with a simulation – this way teacher makes the student explore a phenomenon by running the computer program with different parameters and/or initial conditions, and analyze/visualize the quantitative outcomes of the program. For preparing MOSEM 2 simulation activities Easy Java Simulation (EJS) has been used [1, 2]. The ESJ is a free, Java modelling and authoring tool designed for creation of interactive computer simulations of scientific phenomena. These simulations can be used in computer laboratories with students to explain better difficult concepts, to let students work with the simulations or (for more advanced students) even create their own simulations. EJS has been created by Francisco Esquembre and is a part of the Open Source Physics project [2]. EJS has been designed to help a person who wants to create a simulation to concentrate most of his/her time in writing and refining the algorithms of the underlying scientific model, and to dedicate the minimum possible amount of time to the programming techniques [1].

The program EJS allows creating simulations which requires a model of a high complexity (considered to be too difficult to be understood by a student therefore not suitable for modelling activity). EJS has been used because it leverages the creation and inspection of programs as compared to pure programming. In the project a collection of ready-to-use interactive EJS experiments will be developed.

Fig.5 presents screen shot from EJS 3D showing a simulation of experiment **"Magnet falling through copper tube"**. The user may rotate a set-up looking at from different perspectives. An induced current in a copper tube is visualized in the form of red dots when a magnet is falling down the tube. There is also a metal ball falling nearby the setting to show the difference in the behaviour of these two objects. As the variables of the model are calculated in a real time the appropriate graph are presented along. Using EJS tools one can see and modify a model behind the simulation introducing changes to its variables. Teachers and teacher trainers will be able to use EJS experiments developed in the project directly or, by using EJS program, to modify them according to their own needs.

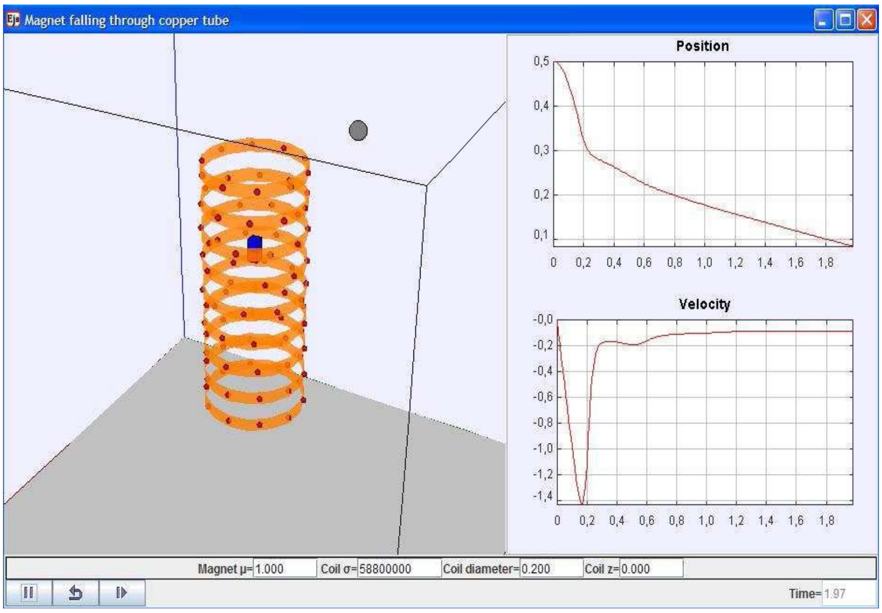

Fig.5. Screen shot from EJS 3D showing a simulation of magnet falling through copper tube.

5. Animation

There is a number of publications discussing different aspects of animations as a tool in computer based learning. In the MOSEM 2 project an animation is called a computer visualization or video (broadly moving images created with the use of computers) that displays a phenomenon without a real computation behind it. The main learning benefits of animation are:

- Comparing representations in order to get a better understanding of the more abstract ones
- Getting a better understanding of the relation between variables
- Better mechanism for self correction (debugging tool)
- Easier to use for poor-skilled students

The heart of an animation is a model, program or sensor data – the 'engine' which contains all the rules and formulas. Besides many entirely described attributes of an animation made for the educational purposes the content should be correct and animation easy to run. Students begin their work with watching such an animation – in that case teacher encourages learners by asking them to sit down and watch a nice, qualitative visualization, which explains by itself, thanks to visual clues 'how things work'. Educational activities associated with the animation are limited however. Creating MOSEM 2 animation based activities we use SUPERCOMET flash animations or especially shot videos, where a first visualization helps to introduce a topic or increase students' interest in it. The collection of such animations is available at website: http://online.supercomet.no. Animations can be created with the Coach 6 system too.

SUPPORT MATERIALS

Support materials developing in the project consist of ready-to-use electronic and printed resources for the different outcomes of the entire project – models, simulations, videos, date acquisition exercises, etc. – and various teacher seminar oriented documents – how-to-explanations, descriptions of different types of exercises, subject related booklets etc. All types of support materials will be freely available on the project resources and majority of them will be published in a form of Teacher Guide. Its main intension is to outline the pedagogical rationalism for using MOSEM 2 outcomes and suggest effective ways of using them in the classroom, as a part of everyday teaching, in stand-alone mode and in combination with experimental kits and multimedia tools. The Teacher Guide is an integral part of Teacher Seminar and is a central part of a project support materials. Moreover it consists of basic information about the physics of electromagnetism and superconductivity as well as shows possibilities for evaluation of the work.

TEACHER SEMINAR

In general a teacher seminar does not only transfer knowledge to teachers but can aim at different goals and at different levels of teachers' professionalism. For MOSEM 2 it is planned to develop two types of seminars:

- the first one, in which teachers are considered as learners very much like students are considered in a traditional classroom, so they follow guidelines strictly and therefore remain intellectually passive in the sense that they only absorb ideas. This is assigned to follow up evaluated strategy to "motivate" teachers for using the materials and presents usability and value of educational materials.
- the second one, in which teachers are considered as managers and builders of their professionalism and is based on equality between all participants including the teacher trainer. Crucial for this type of seminar is interaction and discussion, along with good preparations by both – the participants and the teacher trainers – therefore project materials are good bases on which the process is initialized.

The responsibility to choose the exact format of a seminar to attend will be left to participants. The implementation – approach, activities, teaching style, learning materials for students, assessment and evaluation – will be presented, but final decision when and how to use them will be left to the individual participating teacher.

CONCLUSION

Within the MOSEM 2 project we advocate the attendance at a teacher seminar prior to using animations, simulations, modelling and data-acquisition. The seminar will address both subject knowledge and alternative conceptions and in addition will offer pedagogic approaches to the material in electromagnetism and superconductivity. All of this takes place in a supportive environment with an emphasis on developing both the participants and the presenter. The authors expect the results of MOSEM 2 project to spread like rings in water across borders, based on the international collaboration of the project and a planned online community connecting teachers in different countries. Different type of meetings including conferences will be used to share experience, teaching materials and methods. This will not only help to improve physics teaching in certain organizations but also will allow building language skills and cultural understanding. The part of materials and texts in Bulgarian has been prepared by the author of this paper and has been presented during teacher` seminars organized in Ruse and Shumen, following by teachers' and students` evaluation [5], organized in the English Language School in Ruse. All materials developed by participants in the projects SUPERCOMET 2, MOSEM and MOSEM 2 can be seen on sites: http://online.supercomet.no and http://mosem.eu free.

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The MOSEM^2 (MOdelling and data acquisition for continuing vocational training of upper secondary school physics teachers in pupil-active learning of Superconductivity and ElectroMagnetism based on Minds-On Simple ExperiMents) project is supported by the European Commission under the Leonardo da Vinci, Transfer of Innovation programme, project number: NO/08/LLP-LdV/TOI/131.013.

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ПРОЕКТ MOSEM 2 - ИНТЕГРИРАНЕ НА РЕАЛНИ ЕКСПЕРИМЕНТИ, ВИДЕОАНАЛИЗ, МОДЕЛИРАНЕ, СИМУЛАЦИИ И АНИМАЦИИ ПРИ ИЗУЧАВАНЕ НА ЕЛЕКТРОМАГНИТНИТЕ ЯВЛЕНИЯ И СВРЪХПРОВОДИМОСТТА

Надежда Нанчева
Русенски университет „Ангел Кънчев"

Резюме: Предлаганата работа представя проекта MOSEM 2 и малка част от материалите, разработени в рамките на проекта. Представените примери демонстрират различни педагогически подходи – реален експеримент, видеоанализ, моделиране, симулации - при изследване на електромагнитни явления и свръхпроводимост.

Ключови думи: *Реални експерименти, видеоанализ, моделиране,симулации и анимации, повишаване квалификацията на учители по физика, обучение по физика, електромагнетизъм, свръхпроводимост.*

* The experiments presented in Fig.3 and Fig.4 have been developed by team from Amstel Institute – Netherlands.

ISSN 1311-9974