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

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ABSTRACT

The MOSEM^2 project (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 – NO/08/LLP-LdV/TOI/131013) 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. During the talk the project and its deliverables will be described in detail pointing up possible contribution/improvement to formal/informal development of physics curricula. Examples of MOSEM^2 outcomes, including Teacher Guide, will be illustrated with a special attention paid to computer based learning approaches as well as areas for further research topics and subjects will be discussed.

KEYWORDS

Modelling, data acquisition, vocational training, upper secondary school, physics teachers, superconductivity, electromagnetism, minds-on approach.

INTRODUCTION

The lack of proficient physics teachers in Europe 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 and has been documented by several studies and papers as well as pronounced at conferences held in recent years.

The MOSEM^2 project aims to contribute to process of changing the situation by promoting lifelong learning in physics and pedagogy for science teachers at the upper secondary level through offering a range of modelling, simulations and data acquisition tools based on existing commercial and non-profit solutions. Also the outcomes of previous Leonardo da Vinci related projects will be offered and improved.

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.

This paper shows some examples of the project outcomes which are only a small portion of the material under development. The authors want to draw readers' attention not only to the content but mostly to the widely understood philosophy of teacher training, lifelong learning process of competences building and minds-on approach to teaching. The subject used as an illustration – motion of an object (metal or magnet) in a copper tube – has been chosen to present differences in approaches to the same phenomena and indicate advantages and disadvantages of methods/tools (animation, modelling and data acquisition).

In the framework of evaluation it is considered to perform specific research based actions such as classroom trial of materials, interviews with teachers and questionnaires for student on these trials. Results will be used to enhance both content and strategies – deliverables of MOSEM^2 project.

ANIMATIONS

There is a number of publications discussing different aspects of animations as a tool in computer based learning and highlighting their advantages in teaching and learning processes. 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.

Besides many entirely described attributes of an animation made for the educational purposes the content should be correct and the animation - easy to run. Students begin their work with watching such an animation – the teacher encourages the 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 have used a SUPERCOMET flash animations or especially shot videos, where a first visualization helps to introduce a topic or arise students' interest in it. The collection of such animations is available at website: http://online.supercomet.no/.

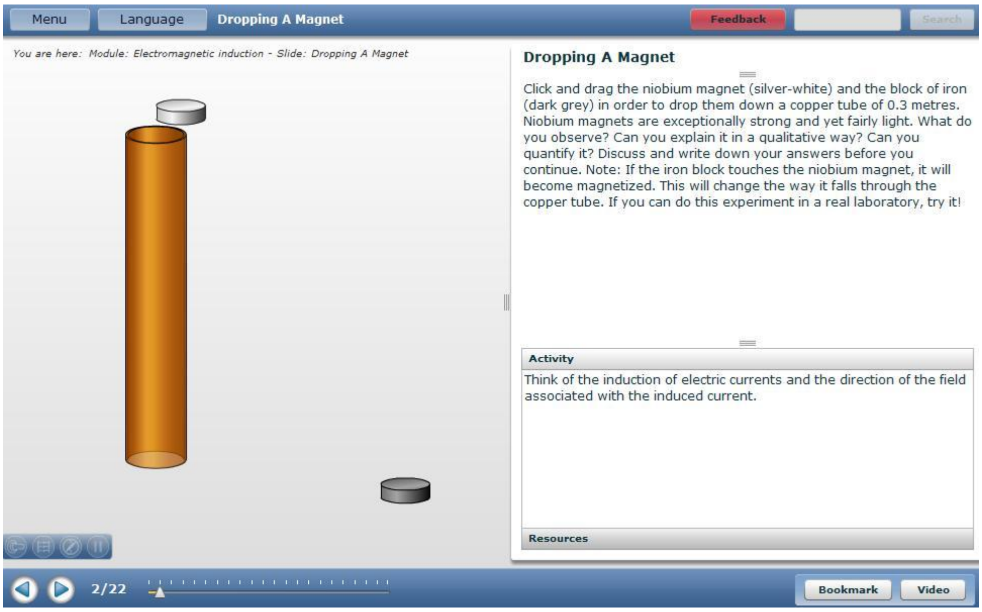

Figure 1. Screen shot from on-line modules application showing the animation of a magnet falling down the copper tube

Figure 1 presents an animation of a magnet or a piece of metal falling down copper tube. The user may virtually drop the objects and observe their behaviour on a screen. The text window consists of minds-on approach questions and gives more information about the activity. To formulate minds-on type of questions we recommend one of the work strategies – formats, given in Table 1.

Table 1. Minds-on approaches to activities

Format 1	Format 2
• Set up the experiment according to the recipe • Do not start the experiment or any experimental observations (data, processes) at the moment!!! • Let students predict what will happen (phenomenon, numbers, behaviour,… depending on the experiment), preferably written (short key words) • Perform the activity, the experiment • Let students observe what is happening, let them speak out loud, or write it down (Everybody!!) • Confront the observation with the prediction: the self evaluation/the peer evaluation • Go to the theoretical background (conceptual or quantitative and numerical) • Look for misconceptions, erroneous reasoning • Applications • Reflections	• Set up the experiment according to the recipe • Perform the activity, the experiment • Let students observe what is happening, let them speak out loud, or write it down (Everybody!!) • Do NOT start giving the theory, nor any solutions, WAIT!!! • Let students discuss/write down what the real physics behind the experiment is (partially, what phenomenon, laws, processes, formula are optional, …) • Go to the theoretical background (conceptual or in depth and numerical) • Confront the good theory with the predicted explanation • Look for thinking errors • Applications • Reflections

The formats are written for an activity with an experiment but the same recipe easily applies to activities with simulations or models developed by project partners.

MODELLING

By modelling in MOSEM^2 project we have understood a computer-based activity where the user creates or modifies an existing model – building or introducing changes to a computer algorithm that produces data or a simulation of a phenomenon.

Recently, it has been extensively investigated and reported by many authors that different aspects of modelling as a tool in computer based learning are enriching teaching and learning practices. 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. Therefore we use Easy Java Simulation (EJS) and Coach 6 (the educational environment) tools that demand low programming skills but involve profound knowledge of physics including advanced equations.

Figure 2 presents a model of magnet falling down inside a copper tube, implemented in EJS 3D. The user may rotate a set-up looking at it from different perspectives. An induced current in a copper tube is visualized in the form of the red dots when the 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 – some of them directly in the model window (see bottom bar) and equations.

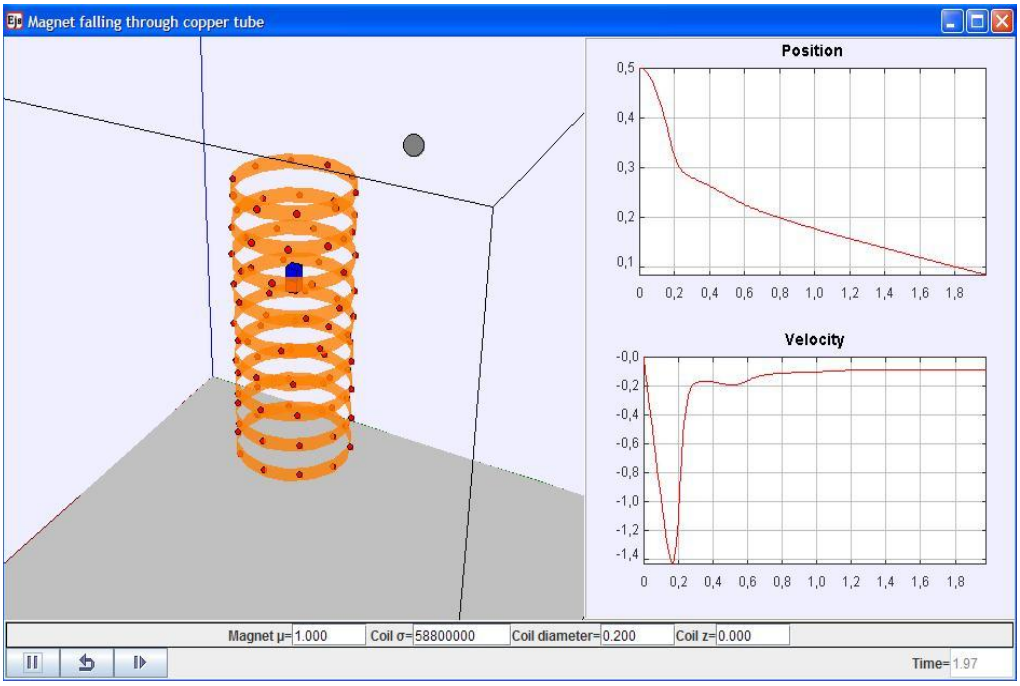

Figure 2. Screen shot from EJS 3D showing a simulation of magnet falling through copper tube

DATA ACQUSITION

It is well known that professionally prepared data-acquisition activities for students allow stimulating development of their knowledge and skill. Therefore $MOSEM^2$ data-acquisition activities are created to encourage student to control and measure real physical phenomena by collecting data from the equipment connected to the computer or from the analysis of the real movie showing a physical situation. To gather and elaborate data students use Coach 6 environment, an interface and sensors.

In such a way the 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.

Figure 3 shows a real, easy to perform experiment in which a neodymium magnet or magnets are falling inside a copper tube of a known diameter. The time of covering a certain distance – tube length – can be measured with Data Video tools or light gates connected to a computer. Moreover the set-up can be enriched by placing coils along the tube and registering the induced voltage as a function of time via computer aided procedure. Therefore the results of the measurements can be compared with the results of modelling or, in other words, predictions from the modelling procedure can be verified. Teachers may also propose some changes to the design of the experiment or its set-up to improve the quality of proposed student activity.

Figure 3. Real time experiment with magnet falling through copper tube

SUPPORT MATERIALS

Support materials developed 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 the 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 the Teacher Seminar and is a central part of a project support materials. 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 planed to develop two types of seminars:

- the first one, during 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. Such a seminar is prepared to follow up evaluated strategy to "motivate" teachers for using the materials and presents usability and value of educational materials.
- the second one, during which teachers are considered as managers and builders of their professionalism, 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 the 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.

CONCLUSIONS

The authors want to explore and support various didactic scenarios in which data acquisition, modelling, and simulation are combined in an integrated approach to teaching and learning of electromagnetism and superconductivity. The activities are supported by ICT, data video and data logging, and directly coupled with simulation, modelling and data analysis.

Within the MOSEM^2 project we advocate the participation in a teacher seminar prior to using animations, simulations, modelling and data-acquisition. The seminar will serve to shaping 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 presenter.

The results of such actions will be checked during the evaluation process. Methodology wildly used to measure the influence of a multimedia (simulation, modeling and data analysis) on the development of scientific knowledge and key competences of teachers and students are planed to be applied. Further publications dealing with the problem more deeply are considered to be proposed in the last state of project realization.

The authors expect the results of MOSEM^2 project will spread like rings in water across borders, based on the international collaboration within 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 allow building language skills and cultural understanding.

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