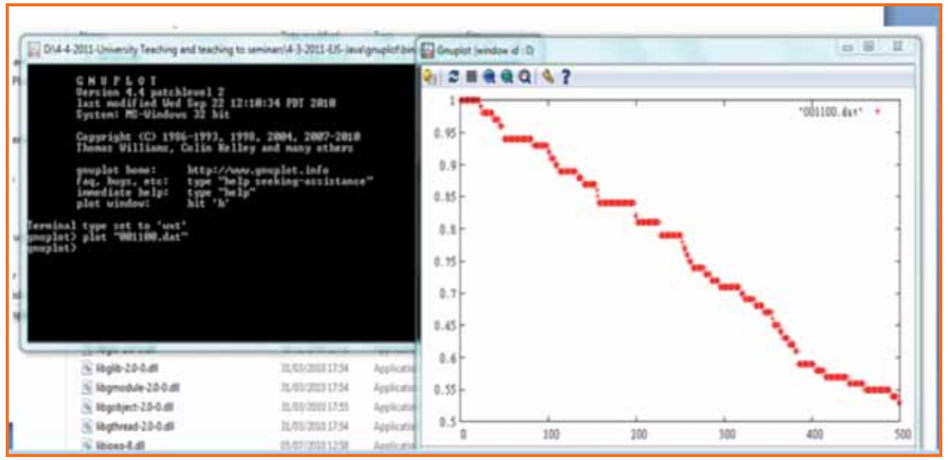
Computational Experiment and its relation to Inquiry Based Science Education and Pedagogical Content Knowledge



Summary:

The scenario implemented –initially- the principles of the Computational Experiment (CE) combined with Inquiry Based Science Education during a training course of Natural Science teacher trainees for the exploitation of the use of ICT in Didactics and Pedagogy. The scenario will be tested by the teacher trainees as they will train teachers-acting as multiplier agents- of Natural Sciences for the study of the influence of the CE principles to the algorithmic approach, the use of Modeling Indicators and to affective issues of teachers like motives and metacognitive –reflection characteristics.

Aims:

1. To explore the views of in-service teacher trainees on various components of their training in the use of ICT based Scenario, which integrate the Computational Science-CE- approach with IBSE.
2. To enhance teachers' ability to improve students' high order thinking skills and meaningful learning, through self-reflection and metacognitive knowledge
3. To follow-up discussions of trainees' attitudes, for the impact of the Computational Experiment process in subject teaching and the motives for IBSE

Main activities:

The development of scenario based on the principles of the Computational Experiment(CE) with emphasis on Modelling, Simulation, Numerical Methods and Algorithms

Narrative:

A scenario will be implemented at teacher training centers by experienced teachers already trained in the use of the Computational Experiment.
Scenario will develop including a)The modeling phase b) The simulation phase and c) The computational phase. Features of IBSE will be included in a) The hypotheses space b) The experiments space and c) The predictions space
In our BP we developed an application based in Java simulation writing the model, the simulation and the algorithm for the decay of nuclei. Teachers realized that the laws of physics as they are presented in the textbooks lack of certain discussion, as for example the change of the decay parameter (probability) results to a stochastic process not presented in the textbook.

End user:
In service teachers

Involved actors:
Teacher trainees

Location:
Teachers training centres

Languages available:
English

Where to find the application:
e.g. web based www.spsycharis.gr at a module dedicated to Pathway

Evaluation parameters:
In service teachers have already been trained about the principles of the CE during a training program using particular scenario based on the use of stochastic Monte Carlo techniques and results indicate a strong shift to the consideration of the added value of the Computational Experiments. Computational experiment will be implemented by them through a teacher training program for the exploitation of ICT in the Didactics to in-service teachers.

Duration:
5 hours

Optimum number of participants: 20

Additional information or resources:
www.oracle.com/us/sun/index.htm
www.opensourcephysics.org/

Landau, R. H. Paez, J. & Bordeianu, C. (2008). A Survey of Computational Physics Introductory Computational Science, Princeton University Press, Princeton and Oxford.
Sloot, P. (1994). Lecture on Parallel Scientific Computing and Simulations. In CERN school on computing, Sopron, Hongary August.
Tobochnik, J. & Gould, H. (2008). Teaching statistical physics by thinking about models and algorithms. Am. J. Phys. 76,(4&5).
Yasar, O. & Landau, R. (2003). Elements of Computational Science and Engineering Education. SIAM Review, 45(4), 787-805.

Teachers' Competencies

1	subject matter/content knowledge	x
2	nature of science	x
3	Multidisciplinary	x
4	knowledge of contemporary science	x
5	variety of (especially student-centred) instructional strategies	
6	lifelong learning	x
7	self-reflection	x
8	teaching/ learning processes within the domain	x
9	using laboratories, experiments, projects	x
10	common sense knowledge and learning difficulties	
11	use of ICTs	x
12	knowledge, planning and use of curricular materials	x
13	Information and Communication Technologies with Technological Pedagogical Content Knowledge	x

Mapping best practices with main principles

3. 3. Develop multiple goals:

- **understanding big ideas in science including ideas of science, and ideas about science**
- **scientific capabilities concerned with gathering and using evidence**
- **scientific attitudes**

Teacher trainees realized that the principles of the Computational Experiment involve different spaces that fit well with the essential features of Inquiry.
During the training the hypothesis space, the experimental space and the prediction space were used while teachers realize that even at the school textbooks there are processes that they need to be understood in more scientific way. For example they realized that the exponential decay does not always obey the law described in the text book but is rather a stochastic process.

4. Understanding students' concepts and learning style about of science phenomena:

There have been few systematic studies in Science Education that focus on the relationship between psychological and cognitive factors in learning, while learning is considered as a generative process involving human cognitive, metacognitive and motivational processes. Computer-based learning environments impose challenges to learners by leaving the locus of control mainly in the hands of the learners and are strongly related to motives, regulation of learning and learning performance. The aim of the training is to investigate the impact of the computational experiment to use of modelling construction indicators namely systemic structure, geometric structure, temporal structure and interaction structure and the shift to certain psychological structures, i.e. locus of control, self esteem, motives and metacognition. From the experiment the learning styles of students could be investigated and classified.

8. Doing science: experimenting, analyzing, interpreting, redefining explanations:

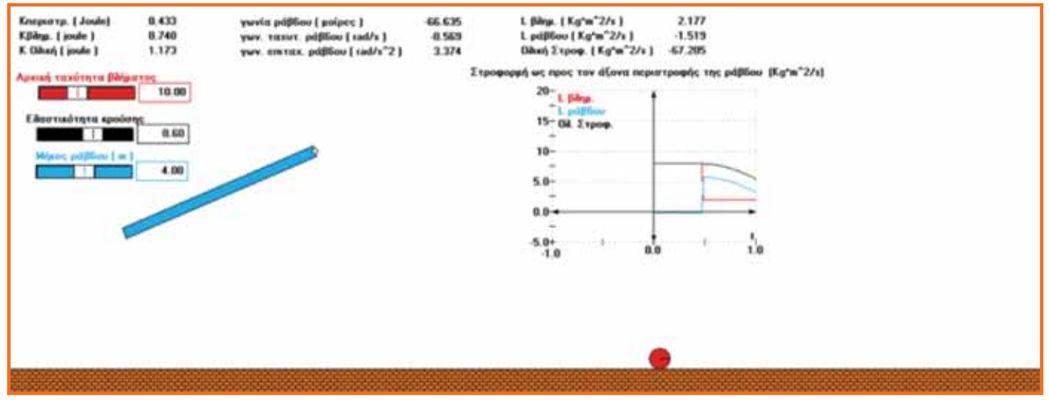
During the training, teacher trainees realized that the computational experiment (CE) involves Modelling and Simulation and Experimentation that reflect the nature of science and they considered that as strongly connected to learning concepts and processes. For example by analyzing, data produced by the real time simulation, teachers were able to redefine their explanations, to determine how ideas are related to one another, and the limitations of the theory. Modelling included the cognitive processes of differentiating, organizing, and attributing.
Computational Sciences(CSE) are generally considered to be a – if not the – key technology of the future (e.g Benioff & Lazowksa, 2005) and so should be incorporated in physics teaching at levels of Education. The core of CSE may be thought of as its collection of computational tools and methods and its problem-solving mindset, which uses knowledge in one discipline to solve problems in another. This CSE core is now being incorporated into computational science courses and books that combine scientific problem solving with computation and into curricula at various levels of education.

9. Assessment: formative ~ of students' learning and the summative ~ of their progress:

A preliminary evaluation was implemented during a teachers training program for the exploitation of the use of ICT in the Didactics for the formation of scenario using the Computational Experiment. The Evaluation concerned the use of modeling indicators and teachers trainees shift for motives in science education. Results were presented at a conference (Psycharis,S.& Botsari,E. (2011). The impact of the Computational Experiment to Inquiry Based Science Education and Pedagogical Content Knowledge. GUIDE INTERNATIONAL CONFERENCE 2011. "E-learning innovative models for the integration of education, technology and research" . Università degli Studi "Guglielmo Marconi" .Rome, 18 – 19 November 2011

10. Cooperation among teachers and with experts:

During the training period, teachers triggered a discussion about CE , the connection between the phases of CE with a didactic scenario based in IBSE. Cooperation was implemented through the step by step writing of the algorithm and the source code of the application. Scaffolding was implemented among teachers and between teachers trainees and the expert. We observed that scaffolding fade out at the end of the process.



Scenario: Conservation of Angular Momentum- Interactive Physics-Grade 12