ECP-2008-EDU-428037

LiLa

Annual Report

15 May 2009 – 14 May 2010

www.lila-project.org

Deliverable number/name	*D1.1 - 2*
Dissemination level	*Public*
Delivery date	*8 September 2010*
Status	*Final*
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e*Content*plus

This project is funded under the *e*Content*plus* programme[1],
a multiannual Community programme to make digital content in Europe more accessible, usable and exploitable.

[1] OJ L 79, 24.3.2005, p. 1.

1 Table of content

2 What is LiLa all about?

Project Objectives

LiLa, the Library of Labs, is an EC funded project that aims to foster and enhance the learning of the natural sciences and engineering. The interest of young people to study these subjects is steadily decreasing in all European countries, although these sciences are crucial for the economic future. Assuming that the study of the natural sciences and engineering is considered as too demanding and theoretical, universities have developed simulations ("virtual laboratories") to make abstract concepts more graphic and concrete. And they made laboratory equipment remotely accessible ("remote laboratories") in order to provide practical experience in a more flexible way. LiLa will make all these online and remote laboratories centrally accessible.

For understanding the added value the LiLa project provides for teachers and students, it is important to recognise the advantages of virtual and remote laboratories. Universities have developed virtual laboratories for a couple of reasons. First of all virtual labs illustrate abstract algorithms and mathematical descriptions of nature, thus making them understandable in a more vivid way. But they also allow to change parameters and students can observe the resulting changes. Some environments even allow the modelling of new simulations. Virtual experiments are especially suited for teaching in cases where real experiments are too complex, too expensive, or too dangerous. The experiments can be designed especially for student's needs and setups are more variable than in real circumstances. Virtual experiments also allow mistakes that would lead to severe and expensive damages. Simulations provide experiments that are not observable in reality. Last, but not least these experiments can be performed by many students concurrently and they are easily reproducible any time.

Remote experiments have other advantages. Most often they are set up in circumstances where equipment for hands-on experiments or laboratory capacity is limited. They allow greater flexibility concerning time and location. Students get access to more experimental setups. It is important to note that remote experiments are not designed to substitute real laboratories. They cannot replace the hands-on lab experience. But they are well suited to complement the real labs, they offer an alternative if these are not available, and in some cases they are also a pedagogic alternative. Remote experiments can prepare students for industrial processes they will find in later their later professional life. Processes found in today's industry are usually operated remotely from control rooms using computers communicating in networks, or require running times too long to be operated by individuals. In some cases remote experiments are to be preferred for security reasons (like in experiments with radioactive substances). The sharing of equipment is especially important if the equipment is very expensive, cannot be afforded by every university, and still, once purchased, is used only part time.

The latter argument, i.e. the sharing of resources, leads to the idea of Lila. Right now the number of experiments of a single institution can provide is very limited. No single university can afford the development of all the virtual laboratories and remote experiments necessary to cover their whole curriculum. This goal can only be attained on European level. Remote experiments are quite cost-intensive, yet seldom used to full capacity. Virtual experiments on the other hand were expensive in development and are easily shareable. The value of the content is obvious, and the technical possibility for sharing exists. Still, sharing of this content occurs only scarcely for a couple of reasons. The existence of the content is often not known and cannot be retrieved easily, since there is neither a central record nor an appropriate indexing. Lecturers work isolated and are unaware of colleagues at other universities. Even if found, the material can often not be used because a scheduling system is missing (important for remote labs) and authentication mechanisms for students of other institutions don't exist. Last, but not least, cooperative work is not supported by most online laboratories, but wanted by students and university teachers. The infrastructure for this would have to be developed by each institution independently. It is the core objective of LiLa to build this infrastructure only once and as service for the institutions.

The measures of Lila to change the situation described above are

- to create a technical and organizational framework for the mutual exchange of experiments across Europe (and beyond),
- to build a repository of experiments on a central server where experiments can be retrieved,
- to equip the experiments with describing data (metadata) and integrate them into library catalogs, thus making them retrievable in library systems,
- to make the experiments accessible via an access control and a booking system that allows reservation of experiments by lecturers and booking of experiments by students,
- to facilitate the creation of courses and allow users to supplement and change courses,
- to integrate the LiLa experiments into a framework that fosters collaboration between students and discussion on experiments,
- to provide the necessary technical framework to download and embed the experiments into learning management systems of any university interested in their use, and
- to disseminate the LiLa network across Europe.

3 Who is participating in the Library of Labs?

Consortium

The LiLa consortium consists of eleven partners from higher education and industry, who perform different tasks in the project: some provide the experiments that are made available through the Library of Labs ("content providers"), some cater for the technology that is used for making content available on the internet ("technology providers"), and last but not least there are scientific advisors that provide valuable information about how to design the LiLa service.

The content can be of different types: The Technical University Berlin provides its RemoteFarm, an online laboratory of remotely controlled physics experiments used in undergraduate education. Similarly, the University of Cambridge brings in a collection of experiments in chemistry, called Weblabs, that is aimed at graduate students. The Aristotle University of Thessaloniki contributes the Nanotechnology Remote Lab (NRL). Other content providers have developed virtual experiments or simulations that often give access to experiments which cannot easily be performed in reality. Among them are the Universities of Stuttgart and Basel, the Cambridge-based company CMCL innovations, or the University of Linköping with its OpenModelica simulation language.

The second group of partners is formed by the technology providers. Experts in their respective fields, they develop the technical infrastructure needed for the LiLa environment. The backbone of the technical infrastructure is set up and run by the Computing Centre of the

University of Stuttgart. The Telematic Systems Engineering Department of the Technical University Madrid has great expertise in designing and implementing access control and scheduling systems. The Technical University Berlin is providing search functionalities and a metadata structure by which experiments and supporting materials can be easily found. Oracle Germany has acquired SUN Microsystems Germany, who was the provider of the "Wonderland" 3D software environment used for modelling some of the experiments. Oracle is committed to continue SUN's contribution to the project and provides valuable know-how for the technical implementation of the LiLa portal.

The scientific advisors perform research in different fields: The Technical University Delft is an experienced creator of online courses and materials and adds pedagogical expertise to the consortium, in order to give students the best learning experience possible. Evaluation tasks are mainly carried out by the University of Thessaloniki and the TU Berlin, while the Library of the University of Stuttgart provides knowledge on metadata and e-publishing of traditional media.

	Partner	*Participation Type*	*Contribution*
	Universität Stuttgart	Coordinator Content Provider	VideoEasel Simulation Environment
	Technische Universität Berlin	Content Provider	RemoteFarm Remote Experiments
	Oracle Germany B.V.	Technology Partner	Wonderland 3D Environment
	Technische Universiteit Delft	Scientific Advisor	Didactics, Evaluation
	Linkopings Universitet	Content Provider	OpenModelica Simulation Language
	Universität Basel	Content Provider	NanoLab
	Universidad Politecnica de Madrid	Technology Partner	Access Control
	Aristoteleio Panepistimo Thessalonikis	Content Provider Quality Management	Remote Labs, Evaluation
	University of Cambridge	Content Provider	WebLabs
	CMCL Innovations	Content Provider	SRM Websuite
	MathCore Engineering AB	Technology Partner	3D Modelling

4 What has been achieved during the first project year?

Project Results/Achievements

In its first year, the LiLa project was busy with researching the needs of its prospective users and designing its technical infrastructure accordingly. Interviews with current users of the LiLa content all over Europe exposed the requirements for the LiLa system. While the didactic specialists worked on the functional design of the LiLa portal, the technology partners decided on the basic architecture of the system. In order to make LiLa as openly available as possible, we decided to follow a two-directional track: LiLa content will be accessible not only at a dedicated internet portal, but can also be downloaded and used in every Learning Management System that supports the widely used SCORM standard (moodle or ILIAS, for instance). Thus LiLa content can be used in familiar learning environments as well as independently.

First parts of the LiLa infrastructure have been implemented, and significant parts of the experiments and laboratories have been prepared for publication on the website.

In specific, the project achievements of the first year are as follows:

- A standard packaging format for experiments within the LiLa portal has been defined, and the experiments available at the partners have been packaged in this format (“LiLa Learning Objects” or LLOs).
- A first prototype of the LiLa web portal has been setup on the basis of the LifeRay portal technology. It provides basic functionalities for the LiLa target user groups: Experiments in the form of LLOs can be uploaded and will then appear within the portal. Wikis, ratings of content and other Web 2.0 functionalities are provided by the LifeRay portal software and need not to be rewritten by the LiLa partners. That is, many portal functionalities that foster community building and cooperation are already available in the prototype.
- An access control system has been defined and implemented. This technology, based on the Shibboleth protocol, allows users - students or lecturers - from any university to log into the portal, using the account and password of their home institution. This simplifies both the maintenance of the portal, and simplifies its use for the target audience.
- In order to be found, the content on the LiLa portal has to be indexed and tagged with suitable “metadata”, that is description data about the content itself, like title, subject, etc. For this reason, the LiLa project defined a metadata model for remote experiments and virtual laboratories. This model not only established a common language within the project, it also defines the technical means by which experiments, course modules on experiments and complete lectures can be searched for - one of the functionalities the LiLa portal provides.
  The LiLa project decided on a subset of the widely used Dublin core metadata set, extended by some additional elements that are not available in the Dublin core set. The design goal of this set is to enable the portal to fill in as many data elements as possible by an automatic procedure, and avoid manual data entry whenever possible.
- The LiLa project made its activities known worldwide, see section 7, and integrated experiments from external partners from Sydney and Cambridge

(Mass.). Remote experiments hosted by the University of Technology, Sydney, are already available inLiLa; prototypical access to experiments designed at the MIT in Cambridge, built on the iLabs architecture, is available as well.

- First steps towards the integration of LiLa content into curricula have been started. It should be noted that this is an ongoing and long-term process that will be not completed by the end of the project, but first results can be reported already.

The University of Stuttgart provides a first example for the use of LiLa content in a university course. Here the lecturer of "physics for engineers", attended by 1300 first year students, faced a new situation. Triggered by the change of the university program from the diploma model to the two-tier Bachelor/Master model no time is left in this course for additional exercises or access to practical laboratory hands-on courses, the latter only being included in the second semester. To offer additional online exercises was a good idea to handle this situation. Chosen experiments were the virtual laboratory of the University of Stuttgart, remote experiments of the TU Berlin and some external virtual experiments.

The interest of the students in exercises with online experiments was high. 87.4 % of 812 asked students said that they are interested in such kind of exercises (see figure 1).

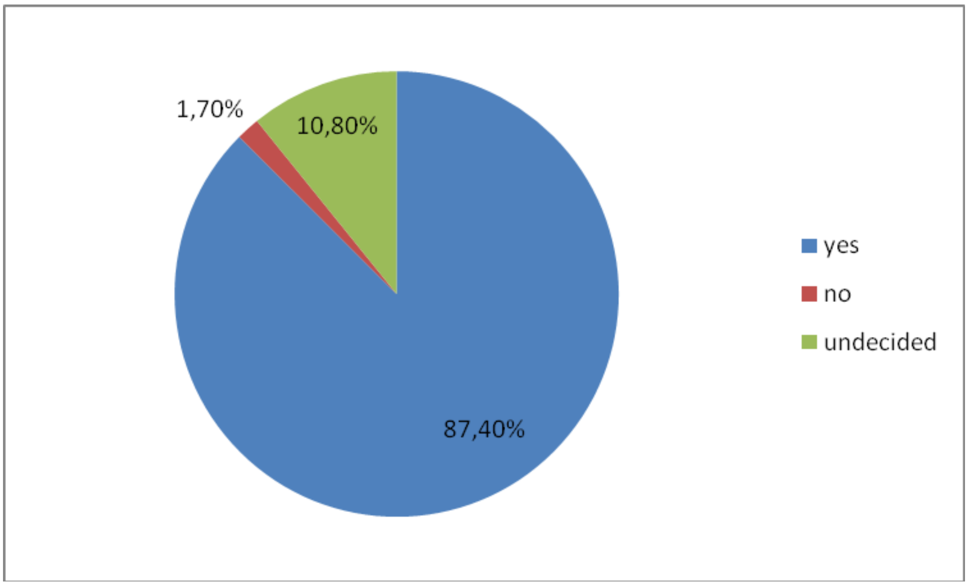


figure 1: student's motivation to attend online experiments (n=812)

Online questionnaires showed some results of the pilot phase in the winter term 2009/2010. One result is for example that the exercises with online experiments increase the motivation of the students to deal with the content of the lecture. 88.9 % said that they agree or totally agree that the exercises with online experiments increased their motivation. Only 11.1 % said that this was not the case (see figure 2). This shows that online experiments are an appropriate measure to raise the student's attention and motivation for physics which is seen as a difficult subject by many of them.

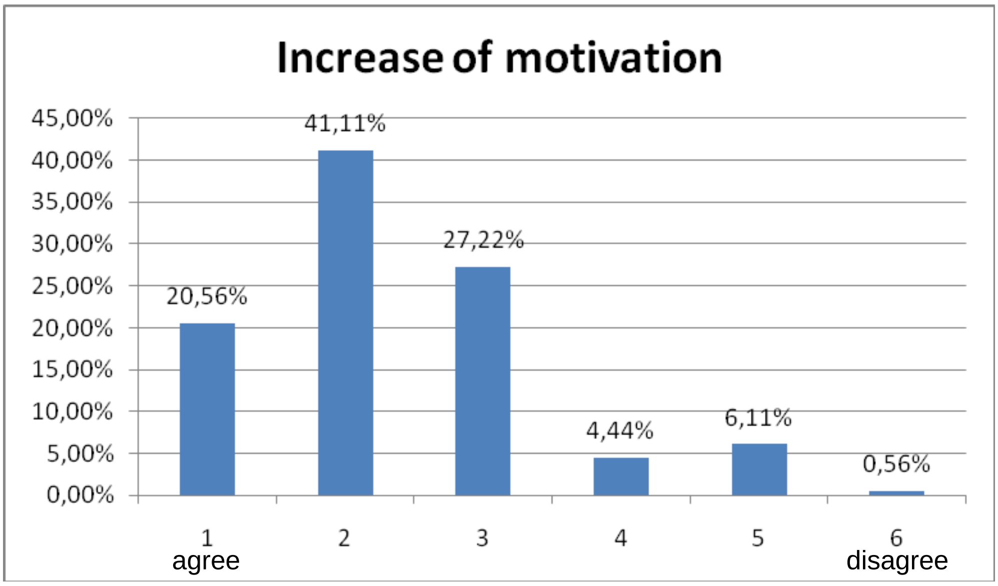


figure 2: Increase of motivation to deal with the subject caused by online experimenting

5 Who can profit from the Library of Labs?

Target Users & their Needs

Interest in key scientific disciplines like physics or chemistry is constantly decreasing among young people all over Europe, according to the Rocard report on science education in Europe of 2007 [High Level Group on Science Education: Science Education Now: A Renewed Pedagogy for the Future of Europe, European Commission 2007]. As a means to reverse this trend, the Rocard commission, among other measures, recommends to privilege an inquiry-based method of teaching science knowledge over deductive methods used in the past.

With this general background the LiLa portal has three target groups: students, university teachers and content providers.

Hands-on experience increases motivation among students and leads to a better learning. On the other hand, real laboratory space and supervision resources are scarce at many universities, and not all students can profit from a practical training in a physics or chemistry lab. Remote laboratories can ease that situation by providing experiments that can be done at any time during the day and often without supervision. Additionally, if an industry standard control software is used, students can experience a process control that is similar to what they will be confronted with in their professional life. LiLa aims to develop an attractive means to find and use remote and virtual experiments for students in engineering and natural science studies, to connect them and give them the possibility to interact with fellow students using the same laboratories.

However, most students will be confronted with laboratory work during their university courses. Hence, for reaching the target group of students, it is vital to assist teachers in designing and performing remote or virtual laboratory experience within their courses. LiLa therefore will provide teachers with accompanying materials and, most important, two different ways to access experiments and simulations: Not only can they be used on the LiLa portal, but also by downloading and integrating them into any Learning Management System (LMS) that supports the SCORM standard, like ILIAS or moodle. In this way, teachers can easily integrate LiLa content into new and existing courses on their preferred platform. From our experience, what prevents teachers from using new methods and technologies in their teaching is the lack of time. LiLa will therefore provide example assignments and courses with accompanying materials that can be used in class.

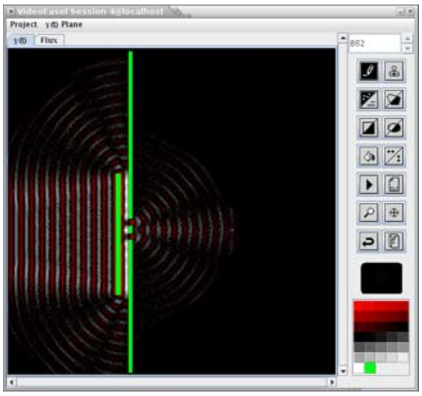
A third target group are “content providers”: Universities or companies with remote or virtual experiments which they like to share and distribute all over Europe or even world-wide. Developing and maintaining remote or virtual labs often is time-consuming and expensive, and attracting more users helps in using the labs to full capacity. LiLa may even enable the sharing of labs in the first place as it will provide a booking system that is necessary for a true distributed use of the lab. Moreover, by offering their own labs to the LiLa community, service providers gain access to a great choice of additional labs within the LiLa network. LiLa supports service providers by supplying a packaging service for wrapping the experiments into “LiLa Learning Objects” (LLOs) suitable for using them on the LiLa portal as well as any SCORM compliant Learning Management System.

6 Which experiments and simulations are offered in LiLa?

Underlying Content

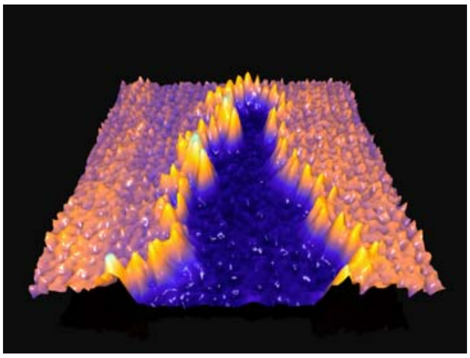
LiLa content brought into the project is of two kinds: On the one hand, interactive media such as remotely controlled experiments, laboratory setups, virtual experiments, simulations and interactive courses, and on the other hand traditional media accompanying these experiments, i.e. instructions, lecture notes, tutorials, and guidelines.

Video Easel (University of Stuttgart)



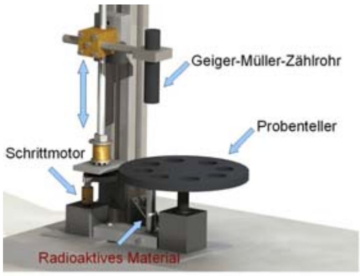
Virtual Laboratories are learning and research environments allowing users to design and execute experiments on the computer. Virtual laboratories use the metaphor of a physical lab. Similar to its real counterparts, virtual laboratories consist of a physical simulation and measurement devices. The Virtual Laboratory of the University of Stuttgart (Germany), called "VideoEasel", focuses on simulations from the fields of many-body systems, statistical mechanics, image processing and other related topics. Over 50 virtual experiments are available. Virtual laboratories support education and research by making phenomena accessible that were only formulated as abstract concepts. They provide additional experiments for students in class or at home, and extend the laboratory capacity by setups that are either hard or impossible to perform in reality.

Nanoworld (University of Basel)



Within the "Nanoworld" project of the University of Basel (Switzerland) students are provided with a virtual laboratory containing experiments from different disciplines in nano technology such as Tomlinson simulation, Confocal Microscopy, Scanning Microscopy, etc. The computer is introduced as supplementing educational instrument for more diversity in education. The aim is a dynamic, interactive and realistic visualisation of natural scientific problems. Apart from factual knowledge students impart procedural and applied knowledge. Approximately 40 experiments are available.

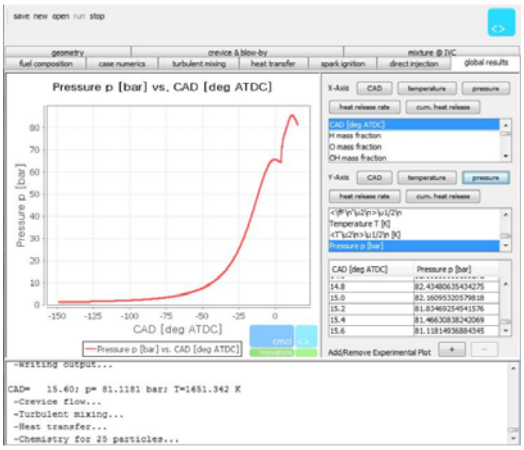
Remote Farm (TU Berlin)



In Berlin, remotely controlled experiments are used in undergraduate engineering courses. In our online practical courses with remote experiments the participants study the fundamentals of physical phenomena with live experiments. The picture shows a schematic view of the radioactivity setup. This setup enables persons not able to deal with real radioactive sources to perform the experiment from any web browser in the world.

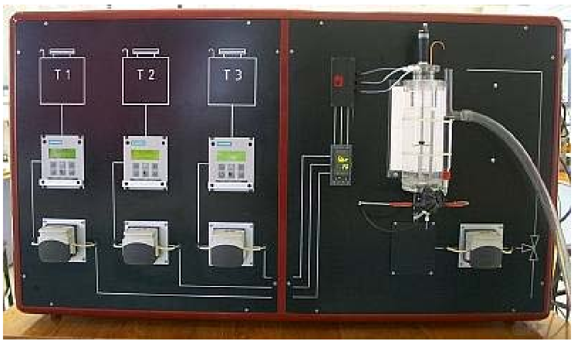
SRM web-suite (CMCL)

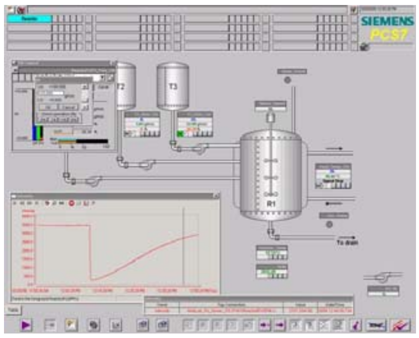
The "SRM web-suite" from cmcl innovations (Cambridge, United Kingdom) offers students authentic experiences with state-of-the-art engine design tools that simulate fuels, combustion, and emissions in conventional and advanced internal combustion engines. CMLS allows simulations to be carried out in a timeframe that is suitable for an educational environment. The SRM web-suite can be accessed from anywhere and supports a wide range of educational goals and pedagogical methods. Currently, CMCL offers two instructional modules using the SRM web-suite. "Influence of engine speed, load, and compression ratio on combustion in engines" provides fundamental instruction on the effect of various engine parameters on combustion and ultimately performance and regulated emissions. "Homogenous reactor modelling for advanced combustion engines" is the second module, which teaches students about advanced combustion modes and the impact of fuel characteristics on performance and emissions. Students can learn through exploration by adjusting parameters, running simulations, and seeing the effects; guided exercises are also provided to reinforce the relationships that students observe in their own experimentation.



Weblabs (University of Cambridge)

The 'Weblabs' e-learning project of the University of Cambridge (United Kingdom) is an online learning resource based around remote operation of real experimental apparatus. Two different Weblabs experiments have been developed for use in Chemical Engineering education; one on chemical reaction engineering and another on process control.



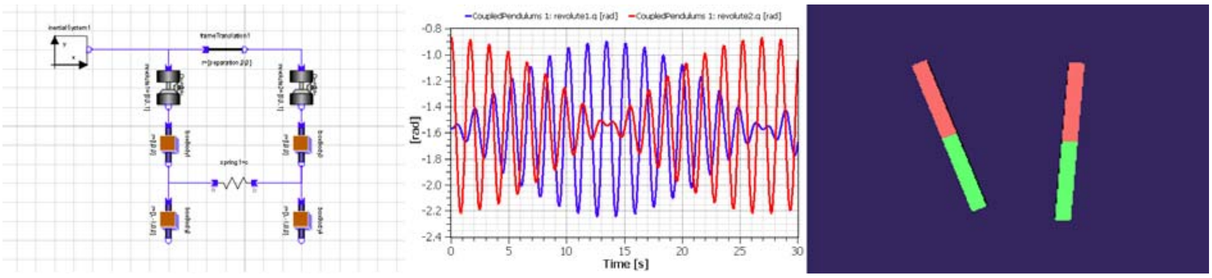


chemical reactor device... *...and control unit.*

Each experiment can be operated on the same piece of apparatus from almost any location in the world via a remote internet connection. Students can view the process from the perspective of the practicing Chemical Engineer.

MathModelica (MathCore)

Based on the Modelica language, MathModelica is a platform of MathCore (Linköping, Sweden) suitable for modelling and simulation of dynamic multi-engineering and life science systems. It comes with a customisable set of Modelica component libraries and provides an environment for modelling, simulation, analysis, and documentation. With MathModelica it is possible not only to optimise your tests and experiments, but also to study phenomena that would otherwise be hard to understand.

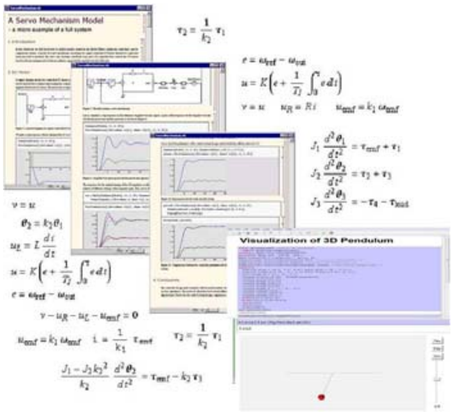


Two coupled pendulums as a MathModelica model

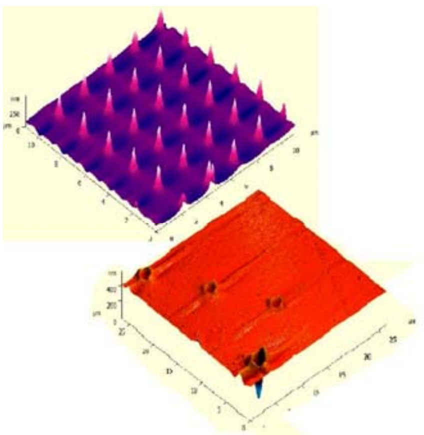
MathModelica is useful in a variety of areas, such as modelling and simulation in the automotive and aircraft industries, robotics, complex machinery, and life science.

OpenModelica Notebook

OMNotebook from the University of Linköping (Sweden) is an interactive notebook and is part of the open source platform OpenModelica. DrModelica is the course material in teaching the Modelica language based on the notebook. The OMNotebook can easily be adapted to other programming languages, which is done in OMScheme for teaching the Scheme language. The notebook can also be adapted to other areas, such as physics, chemistry, biology, biomechanics etc., where phenomena can be illustrated by dynamic simulations within the notebook.



Nanotechnology Remote Lab (Aristotle University Thessaloniki)



The Nanotechnology Remote Lab (NRL) of the Physics Department, Aristotle University of Thessaloniki consists of Scanning Probe Microscopy remote experiments based on the NanoEducator platform (NT-MDT Co.). The NRL aims to introduce undergraduate and postgraduate students coming from different disciplines, such as physics, chemistry, engineering, biology and medicine, to Nanoscience and Nanotechnology experimental methods, tools & phenomena via special Atomic Force Microscopy, Scanning Tunneling Microscopy and Force Nanolithography course materials & experiments.

7 What has been done during the first project year?

Summary of Activities

The activities of the project's first year were focussed on building a web portal for housing the experiments, working on the metadata necessary for finding the content, dissemination in the world wide community of providers of online laboratories, and the use of the material in university teaching.

The web portal constitutes the core of the LiLa infrastructure. Here students and teachers alike will find experiments and accompanying materials, and owners of remotely controlled experiments and simulations can upload their content to LiLa. The web portal is the place to index the experiments, to search for them, to gain access to them, to share experiences and connected material like assignments, to rate them, and, to a certain degree, to perform the experiments collaboratively. The great challenge building such a portal is to make it powerful in its functionalities, but still as easy to use as possible. Most experiments need access control and booking facilities: Either they can be operated only by one user at a time, or they need regular maintenance or supervision. Therefore, we focused on developing authentication functionalities (we use the software "Shibboleth" for this), and the design and implementation of a booking/scheduling system for the organisation of the access to remote labs and virtual labs with limited resources. The booking system is an important added value for the providers of remote labs. They often have to rely on non-technical arrangements when the labs can be used, but double bookings can hardly be avoided.

A lot of work has also been done on the didactical design of the portal. The portal is to be used by students, teachers, tutors, and content providers likewise. We want to provide a number of commenting and collaboration functionalities without making the portal another learning management system. While only the main functionalities were implemented in the first year, future work on the portal will concentrate on the didactical design and on usability.

Metadata are the key to the retrieval and exchange of experiments. Only by metadata is it possible to find content on a website like the LiLa portal. Defining a good metadata framework is therefore of the utmost importance for the project. The metadata scheme we developed includes the description of the "rig" (i.e. the physical set-up of an experiment), the experimental package (i.e. the control software for operating the rig), the media package (i.e. the content that accompanies an experiment) and the module/lesson which contains all the material (experiments, instructions, assignments etc.) in a learning unit. While the work on the metadata is mostly finished, the didactical description of the module/lesson which we will use in the portal has still to be defined.

The portal becomes all the more interesting the more content it includes. Therefore a great deal of dissemination activities have been done to find and attract other content providers. All content providers were very interested in the goals and concepts of LiLa. Some of them already have their own infrastructures while others have avidly waited for something like the LiLa portal. Important contacts have been established with Australia (University of Technology Sydney), the US (MIT), and Austria (Carinthian University of Applied Sciences in Villach). With these (and some other) institutions LiLa is becoming part of the evolving Global Online Laboratory Consortium (GOLC). The different institutions in GOLC bring their own infrastructure and one of the goals of GOLC is to connect these. We have already made some progress in connecting the infrastructures of the MIT (called "iLabs") and of the

Australian universities (“Sahara”) to LiLa. Also the discussion about metadata is continuing and a first draft for GOLC metadata is expected by the end of June 2010. Since the metadata model is very close to the one of LiLa, the LiLa portal will be the first to implement it.

Integration in university teaching is the last main activity of the project to be mentioned here. Not only is the preparation of online learning modules that use online experiments quite time consuming, it is also a challenging task to convince teachers to use these materials. Education is often quite old fashioned and the usage of the LiLa materials implies a change of teaching and learning cultures of the lecturers and students involved. We are on a good way in disseminating the content in our universities beyond the content that originates from our own institutions, but dissemination is sometimes indirect and relying on tactics rather than ration arguments. This is something our media departments are used to in the field of eLearning, though. A lot of teachers react very positively to the content once they get to know it and its possibilities more closely.

As becomes clear from the mentioned topics, activities of the second year of the project will focus on the didactical functionalities of the portal, content integration of third parties, and integration of the content into university courses.

8 What does it need to keep LiLa up & running?

Impact & Sustainability

The sustainability of the infrastructure built by LiLa largely depends on the interest of the participating universities to sustain it. This, on the other hand, depends on the international attention, the usefulness and use of the distributed content, and the added value of the portal services. Nevertheless, the portal must be maintainable with small effort and be equipped with self service functionalities. Some money could be raised by commission fees for chargeable content. For this business models are in the course of development right now and still discussed by the participants of the project. Results will be presented with the next annual report. The sustainability of the content itself is an issue as well, but not too problematic since the content comes from established teaching scenarios that are used and maintained by the creators of the content themselves.

International attention and reputation is an important motivation for universities to engage in projects and initiatives. Accordingly international networking is an important part of the project's dissemination. Most important right now is the participation of LiLa members in the "Global Online Laboratory Consortium" (GOLC). GOLC (for details see section 7) has a couple of objectives in common with LiLa and provides an excellent platform to make LiLa content known to the scientific community and to connect the content of other consortia to the LiLa portal. Another important activity is the presentation of LiLa content and the Lila infrastructure at conferences. Many contacts, especially to other content providers, are initiated here and lead to the integration of further content in the portal. A different approach is the distribution of Lila content in larger portals for educational content like OpenCourseWare or Merlot. These portals will lead many users to the Lila content. Last, but not least it is important to integrate LiLa into educational initiatives of universities like SEFI (the European Society for Engineering Education). Here many experts for university education meet and exchange experiences. These experts are multipliers for innovations of LiLa in their respective universities.

The usefulness and use of the portal depends on the number of offered experiments, assisting material (like assignments for experiments, teaching guidelines and experience statements) and the possibility to communicate with peers. All these factors are important for the intensity of use of the portal. The number of offered experiments is raised by the attractiveness of services for content providers: SCORM packaging of online experiments, the provision of authentication and booking as well as the possibility of standardized description of the material, which makes it retrievable worldwide are strong motivations which already attract many content providers. Assisting material is very helpful for teachers, but it causes great effort to produce it; hence the sharing of this material besides the online experiments themselves is an important issue. For the sharing of this content concepts were developed and have to be integrated into the portal in the second year. Connected with this issue is the possibility to contact peers and communicate with them. For this, motivating users to get involved is essential and remains the most challenging issue for LiLa. Users do like searching for material, but will they contribute as well?

Up to now the LiLa portal has had a great increase of offered experiments and their use. This makes us confident that the portal will be sustainable after the end of the project.

9 Where can I learn more?

Further Information

For further information, please visit the LiLa project website: http://www.lila-project.org. There you can watch or download our presentation “15 questions & answers about LiLa”, or subscribe to the LiLa newsletter. You are also welcome to visit the LiLa conference in Cambridge, 11 and 12 April 2011.