On-Lab: A web environment for On-line Labs development

Marco Alfano, Biagio Lenzitti , Rocco Versace

Abstract: *Traditional education, mainly based on theoretical teaching, is not sufficient anymore to provide students with complete expertise. Theoretical knowledge must be paired with practical experience in order to attain complete and aware learning. To this end, a laboratory seems the ideal place where to gain such a practical experience. When education goes on-line, exploiting Internet and all the related networks technologies, also the laboratory must become on-line allowing students to interact with real or virtual apparatuses from anywhere and at anytime. A few tools exist for the remote control of real or virtual apparatuses and many more tools exist for the creation of on-line exercises, but no tool allows to combine both functions. This paper presents a web environment, On-Lab, that allows teachers to easily interface to real and virtual apparatuses (workstations, routers, robots, ….) and create exercises on those apparatuses. At the same time, students can remotely access the on-line labs and practice on the lab machines through the pre-created exercises.*

Key words: *On-line Education, e-Learning, Laboratory, Lab Interface, Internet, Computer Networks.*

INTRODUCTION

Internet is more and more present in various social and professional environments and it is therefore natural to begin thinking about didactic and formative methodologies that can take advantage of this technology as well as the new teaching and learning paradigms that such technology suggests and makes feasible. At the same time, traditional education, mainly based on theoretical teaching, is not sufficient any more to provide students with complete expertise and satisfy all their learning needs.

A significant enhancement is obtained by placing traditional education along with more modern methods of learning (laboratorial didactics) to make the teaching/learning forms close to the learning paradigms and rhythms of the students, especially in this moment in which the core of the educational and didactic action is moved from teaching to learning, from knowledge to know how, and the learning process is more and more an inseparable continuum of theory and practice [1].

A laboratory can therefore be considered as a "place", a physical or virtual space (in the case of an on-line laboratory), where students can touch, manipulate, try and retry and can compare and confer among themselves. A real and concrete experience is thus lived. A laboratory must also consider, among its main objectives, the increase of student sensibility towards self-evaluation of competences and actions and of self-verification of the attainment of the established formative objectives.

Many Internet sites offer on-line courses. Some of these courses are supervised by a tutor who interacts with the trainees creating, in practice, a "virtual classroom". Some other sites allow to interact with instruments and apparatuses such as, for example, oscilloscopes, robots and computers. When these apparatuses are entirely controllable from a remote computer, the site becomes an "on-line laboratory".

Various kinds of on-line laboratories available in Internet have been analysed. Some of them offer an on-line interface to physical instruments in order to remotely perform both generic management of the instruments and one or more guided exercises [2]. It is nevertheless more common to find virtual laboratories that simulate existing instruments with the purpose of showing their functionalities. The majority of these laboratories are developed in java (usually through servlets) to be easily used through the net [3]. Finally, Internet offers a great number of laboratorial exercises that take the form of on-line of questionnaires [4], [5], [6].

Some tools for the creation of on-line laboratories and on-line exercises have been analyzed. The main characteristics of these tools together with their advantages and disadvantages are shown in Table 1.

Table 1. Tools for creation of on-line labs and exercises.

PRODUCT	FEATURES	ADVANTAGES	DISADVANTAGES
LabView [7]	• Off line • Simple interface • Possibility to expand the product with functions and additional components	• Customization of the created tools • No programming competence required • Fast and satisfactory results	• Mainly useful to electrical engineers • No possibility to create quizzes and exercises • High costs • Available only in English
GO-TEST [8]	• On Line • User management • Customizable questions • Own server in lease (upon request)	• Questions customization • Good system of statistics for the answers • User management	• More suitable for surveys than questionnaires • Little intuitive • No multimedia • High costs • No possibility to interact with physical apparatuses
tecchio.net [9]	• On Line • Customizable questions • Hierarchical user management • Remote and real-time maintenance	• Questions customization • Good system of statistics for the answers • Two questionnaire types	• Terms of use not clear • No multimedia • Tied to Microsoft server • No possibility to interact with physical apparatuses
WebQuiz [10]	• Off line • Web interface • Customizable questions layout	• Simple and intuitive • Wizard for on line questionnaire publication • Free Web site for questionnaire publication	• Little customization • No multimedia • No possibility to interact with physical apparatuses
WinAsk 2000 [10]	• Off line • Windows application • Customizable questions layout.	• Free • Very simple	• Little customization • No multimedia • No possibility to interact with physical apparatuses

With regards to the creation tools of on-line laboratories, it is possible to find in the net some products that allow to create virtual instruments. However, no tool for creation of simple interfaces to physical instruments has been found. In any case, the software that allows creation of virtual instruments does not provide the teacher with the possibility to create some exercises based on that instruments, and vice versa, the software that allows creation of questionnaires and exercises doesn't offer the possibility to interact with physical or virtual instruments.

ON-LAB SOLUTION

On-Lab has been created to offer a single solution to the two requirements previously analysed. It is a web environment that allows simple and quick development of interfaces to physical or virtual lab instruments and creation and on-line publication of exercises based on those instruments (that usually are not accessible because expensive and delicate).

The learner interacts with an instrument through an exercise and experiments what really happens to the instrument. The interaction between the instrument and the exercise is filtered by an interface created by the administrator who simply establishes the nature of the interface (physical or virtual) and specifies the list of the commands accepted by the instrument. The application has three levels of authorization: *Administrator* that creates the new interface; *Teacher* that creates exercises on the existing interfaces; *Student* that can only execute the exercises.

The objectives of On-Lab can then be summarized as follows:
– an easy environment to be used;
– possibility for the administrator to create in a simple way interfaces to any lab instrument;

- possibility for the teacher to create on line exercises and automatic interaction with the instruments through an interface created by the administrator;
- possibility for the student to experiment and test commands on the chosen instruments.

Development and implementation of On-Lab
On-Lab has been designed considering three key points:
- *Modularity*: different modules can have a whole set of agents with a defined set of tasks. Such modules can be easily replaced, updated and increased;
- *Reusability*: possibility to reuse the definitions of objects in the system in different ways: heredity, aggregation etc.;
- *Management of common interface*: definitions of common interfaces that can virtually manage every type of shared resources.

On-Lab has been developed in java and thus respects all the points described above and it is independent from the operating system. Moreover, for the safety of the whole application, a filter on the performed commands has been added and authentication (to avoid unwanted accesses from the outside) has been implemented.

Architecture
The architecture of On-Lab (Fig. 1) consists of three main components: The *Instrument Interface* (IS), the *Distribution Level* (DL) and the *Client* (CL). The instrument interface task is to send commands to the instrument, wait for the command output and return it to the DL. The Distribution Level is a http proxy server that receives the commands from a user, transmits them to the IS, waits for the answer and transforms it in HTML code that transmits to the CL. The Client is a normal web browser that connects a user with On-Lab through Internet.
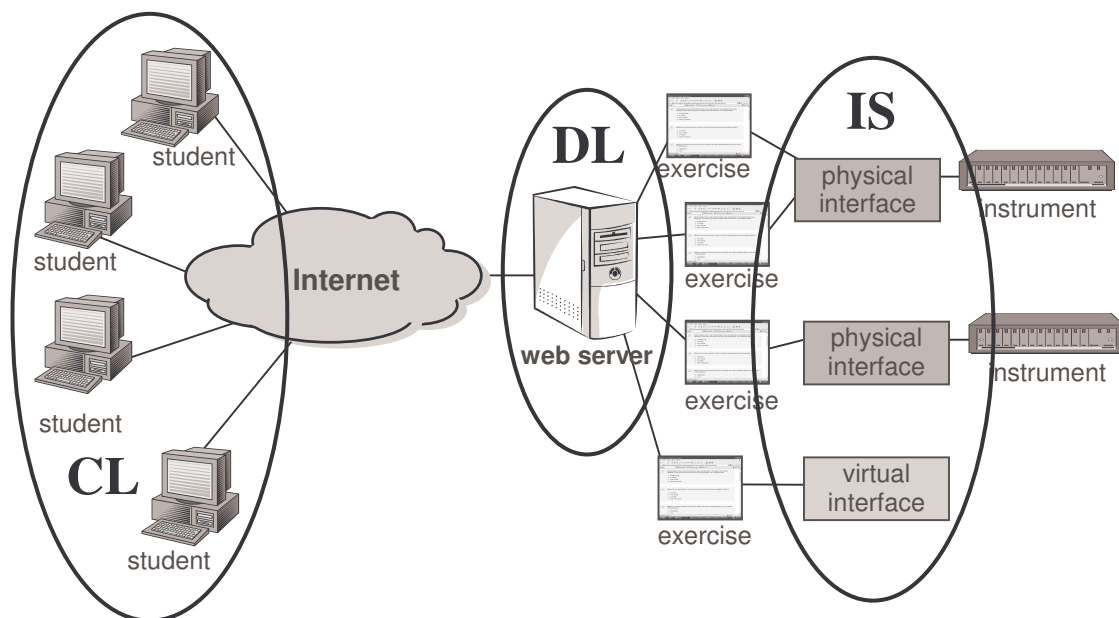

Fig. 1. On-Lab Architecture

ON-LAB USAGE
The use of On-Lab is very simple and friendly. As a first step, the administrator defines the interfaces that will be used for the creation of the exercises. To allow greater flexibility, two types of interfaces can be created:

– _Virtual interface_, in which the administrator specifies the commands to perform, inserts a brief description and defines the output textually or graphically. In practice, the administrator implements a virtual instrument by describing the input that can be accepted by the instrument and the output that will be produced.

– _Physical interface_ to a real apparatus, in which the administrator only specifies the commands that can be performed in the instrument (Fig. 2).
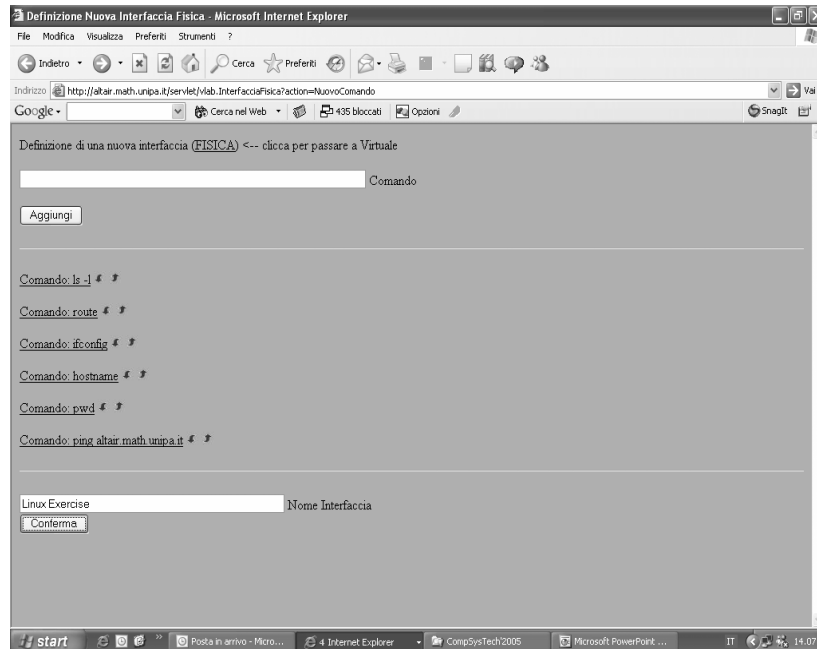

Fig. 2 – Physical interface creation.

When a student performs an exercise on a real instrument and gives the correct answer, the command will be really performed on the instrument and the real output of the instrument will be shown in the web page of the exercise.

The commands specified in the interface will be the only ones that can be performed. Moreover, it will not be possible for a student to perform a command with a parameter, if this parameter is not added by the teacher during the creation of the exercise.

A teacher can create exercises based on the defined interfaces. The creation of an exercise corresponds to the creation of a questionnaire and it is very simple and intuitive. The teacher must only specify the questions, the possible parameters, the help activation and the points to assign (for right/wrong answers and help requests). Finally, it is possible to choose the questionnaire layout and decide whether the questionnaire will be used for "self-evaluation" or as an exam (Fig. 3).

When connecting to On-Lab, a student will see all the available exercises in his/her own homepage. When taking an exercise, the student will answer each question by writing the answer in the proper input window and confirming it with the OK button. If the answer is correct (or wrong but the command is in the list of the allowed commands) the instrument output will be directly shown in the output window of the web page. It is also possible to test a command writing it down in the special test window without interfering with the exercise (Fig.4).

When a student writes a command (as an answer to a question or in the test window), On-lab reads the exercise files and validates the command through the interface. If the command can be performed, On-Lab sends the command to the instrument for execution and then creates a simple script to redirect the output and the error of the command from the _stdout_ and _stderr_ to a text file. Once the procedure is done, On-Lab

takes the text file which contains the output of the command, puts it in html format and sends the (web) response page to the client.
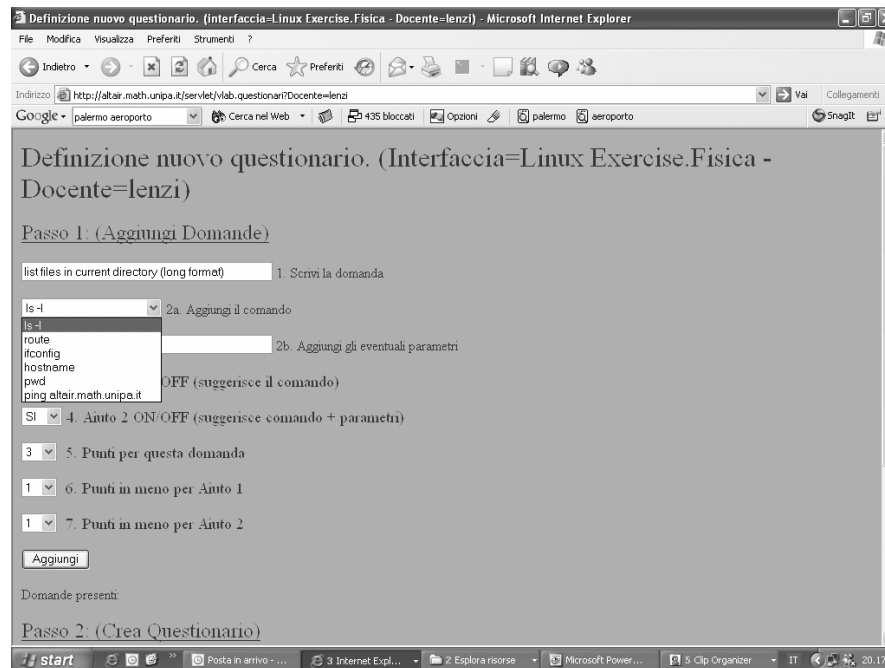

Fig. 3 – Questionnaire creation.

CONCLUSIONS AND FUTURE WORK

The analysis of the lab solutions present in the Internet has shown two standard approaches:

– the first one takes the form of questionnaires for evaluation or self-evaluation that verify the student preparation through questions and quizzes;

– the second one consists on the implementation of virtual instruments or the creation of interfaces that allow interaction with physical instruments.

In the first case the student verifies his/her own learning level through a sort of on-line exam that does not provide any further motivation beside checking what he/she knows. In the second case, instead, the student feels undoubtedly more involved since he/she has the possibility to interact with the instruments, test the commands and visualize the effects in real time. On the other hand, the management and creation of an interface or a virtual tool does not result simple and immediate; a teacher often does not have the technical competences to deal with a software and, therefore, he/she has to be satisfied with the existing tools which are little, if not at all, modifiable.

In order to solve these problems and merge the two solutions, that deal with very important aspects and are somehow complementary, the On-Lab solution has been developed. The development of the On-Lab solution has been carried out taking into account some key points:

• modularity
• safety of the system
• simplicity of use
• flexibility
• customization of the exercises

Some preliminary experiments have been performed on On-Lab. They have shown that the first prototype results very stable and functional, even though some aspects can be improved in the following versions. For instance, it should be possible to improve the graphical part of the exercitation by giving the possibility to insert images and graphics to

the questions. Another improvement could result in adding a parser that analyzes the commands provided by the user so to make the control on the commands less rigid without, however, decreasing the system safety. Finally, statistics pages could be added. A student could check the results of his/her own exercitations and a teacher could check the results and trends of all his/her students.

On-Lab can be found at the address http://altair.math.unipa.it/vlab.
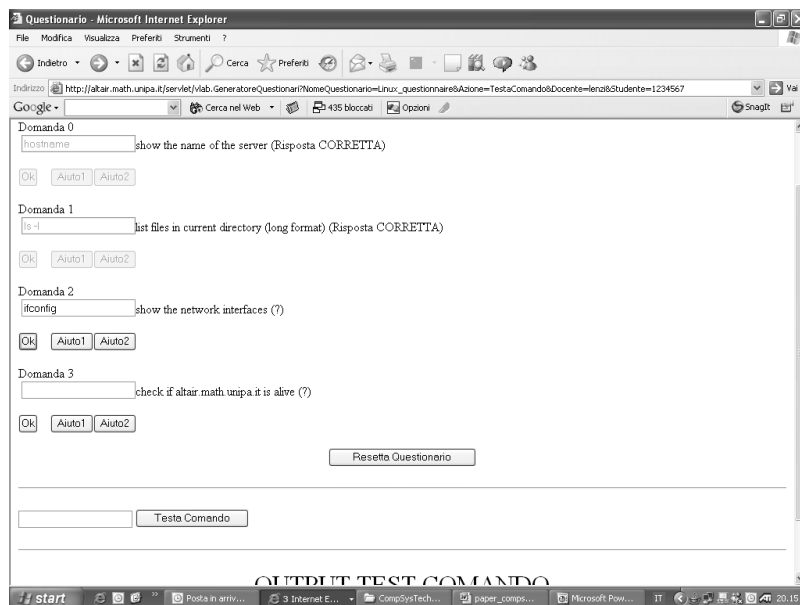

Fig. 4 – Answering a questionnaire.

REFERENCES

[1]   Dewey, J., Experience & Education. Collier Books, 1963.

[2]   NUS Internet Remote Experimentation Vlab (http://vlab.ee.nus.edu.sg/vlab)

[3]   P.Falstad's, Math and Physics Applets (*http://www.falstad.com/mathphysics.html*)

[4]   A. Lumini, R. Cappelli, e A. Franco,*"Laboratorio on line per le verifiche di Query e Quiz"* h*ttp://bias.csr.unibo.it/ExerciseLab/EntraSessione.asp*

[5]   LabSubmittor, (*http://www.ugrad.math.ubc.ca/coursedoc/math100/labs/*)

[6]   Scuola Virtuale, (*http://www.scuolavirtuale.it*)

[7]   National Instruments Labview (*http://www.natinst.com/labview/*)

[8]   GONETWORK, (*http://www.gonetwork.it*)

[9]   R. Tecchio, Questionari On line (*http://www.tecchio.net/clienti/questionari/*)

[10] Smartlite Software, WinAsk2000 & WebQuiz 2002 (*http://www.smartlite.it*)

ABOUT THE AUTHORS

Prof. Marco Alfano, PhD, Anghelos Centre on Communication Studies, Palermo Italy, Phone: +39 091 341791, E-mail: marco.alfano@anghelos.org

Prof. Biagio Lenzitti, Researcher Dipartimento di Matematica ed Applicazioni, University of Palermo, Phone: +39 091 6040427, E-mail: lenzitti@math.unipa.it

Dr. Rocco Versace, Anghelos Centre on Communication Studies, Palermo Italy, Phone: +39 091 341791, E-mail: rvs096@tin.it