ABSTRACT
The object of this article is to propose a contribution to the development of remote laboratories for carrying on online practical activities in computer science by using virtualization technologies. After an introduction to the general concept of online laboratories, a description of virtualization technologies is done to show how their use is possible in the implementation of an online laboratory. This online laboratory is viewed as a pedagogical resource, which is used by the learners to realize pedagogical activities according to a project-based pedagogy named MAETIC. Our approach aims to provide an answer to the problematic of supervision and monitoring of students engaged in online practical activities and the evaluation of the skills acquisition.

1. Research Context
The works presented in this article contribute to the problem of carrying out practical activities in e-learning environment. We developed an online laboratory based on virtualization technologies for online activities which are essential to the process of skills acquisition by the learners. Indeed, virtualization technologies (VT), which allow combining multiple operating systems into a single host system, open up interesting perspectives in the realization of online environment. The main contribution of VT lies in the opportunities offered to teachers to develop various and rich learning scenarios [1]. It contributes also to provide a set of virtual machines to students, allowing them to perform online experiences through a web browser.

The adaptation of VT to the educational needs also helps to remove some constraints encountered in the conventional computer laboratories:

- Often security considerations prevent students to have a total control over the resources (machines, servers) in a classic lab. It is especially true when activities concern computer security administration. The use of VT makes it possible to overcome these limitations, by assigning students privileges on a set of virtual machines to perform certain actions.
- In application programming activities, students are often faced with different situations:
  - Programming environment (e.g. Windows) is different from the final production environment (e.g. Linux).
  - Difficulties to perform tests on multiple platforms to evaluate the robustness of an application.
- For some academic institutions especially in developing countries, the cost of the equipment can be a limiting factor to implement a science computer laboratory. The consolidation of resources would be an option. Indeed, the investment would focus on the acquisition of equipments such as a server allowing hosting virtualized environments.

2. State of the Art: a typology…
In the literature, technical devices which allow carrying out practical activities are called online laboratories. They are flexible environments used to realize experiments, alone or in collaboration with other participants in a distance learning [2].

The online laboratories cover a wide area ranging from the simulation to real experiment and are mainly divided into two mains categories: virtual laboratories (interactive environments based on real systems emulation or simulation of theirs behaviors) and remote laboratories (environment with distance access to equipments and real instruments). Often those devices are used together to design environments closely similar to conventional laboratories.

Apart from aspects such as the removal of geographical and temporal constraints induced by the Information and Communication Technologies (ICT), these devices also contribute to reduce costs by sharing often expensive and heavy equipments between universities [3].

3. eLINE: a Online Laboratory
Our online laboratory is designed to respond the needs of learners in science computer. We opted the acronym of “eLINE” which means in French “Laboratoire d’Informatique en LigNE” (Online Laboratory for Science Computer).
The architecture of eLINE is based on the three followings elements:

- **The virtualization server XEN** is an open source server included in most Linux distributions, used for management of virtual machines (creation, destruction, allowance of resources). XEN server is composed of a hypervisor that manages the virtual machines and the others domains in which the guests systems are running. The domain0 launched at the start of server controls access to materials resources by others domains. All virtual machines are under ubuntu, linux-based operating system.

- **FreeNX server**, a free version of NX server provides the remote connections to the virtual machines. The learners can control remotely virtual machines from a console or GUI depends on the needs of learning scenarios.

- **The web server hosts a platform** that manages the eLINE laboratory. This platform provides to actors (students, tutors) ways to interact with the virtual machines. We have integrated in this plateform a tiny Java applet called NX Web Companion developed by Nomachine Company that allows users to access to virtual machines throughout a browser. To allow virtual machines to be accessible on the Internet, a specific port on the firewall is allocated to each virtual machine by a script launched on each creation of a virtual machine.

Currently twenty five students divided into five groups, are performing remote activities on this platform. They carry out projects focused on the design and development of application. To do this, they use the virtual machines of eLINE into which free tools to design such as Umbrello, a UML diagrams creation program, or to develop such as Netbeans a open-source Integrated Development Environment for software developers are installed. The online tutor has also the possibility to access to virtual machines of each learner to supervise the students' work. Apart from these technical aspects our approach aims to provide an answer to the problematic of supervision and monitoring of students engaged in online practical activities and the evaluation of their skills as outlined in [3]. How to supervise, follow up and evaluate the skills acquisition and application of knowledges by the learners and with what method?

In this article, the eLINE laboratory is viewed as a pedagogical resource. This resource is used by the learners to realize pedagogical activities according to a project-based pedagogy named MAETIC. The project, built around the eLine laboratory respects the pedagogical activities, which are recommended by MAETIC [4], [5]. In this pedagogical context, our goal is to train students with a good level of professional competence. We aim to put students in action situations and to develop expertise in a field of application: remote practical activities and to develop expertise in a field of application: remote practical activities.

D. Lecllet and B Talon developed a teaching device since 2004, according to a spiral life cycle. The teaching device is a set of means (methods, tools, procedures, principles of action, actors) intended to support a training process in conformity with the pedagogy requirements.

Moreover, in order to support the implementation of project-based pedagogy, they wished that the teachers were easily able to implement teaching scenarios instrumented by the ICT. They have named their teaching method MAETIC, which is a French anagram for teaching Method instrumented by the ICT.

4. **MAETIC and the pedagogical layer model**

MAETIC is a pedagogical method which organizes a project-based pedagogy. MAETIC has been built to develop professional acquisitions. In the project-based approach, the learner builds his knowledge and know-how thanks to the project [6] such a way they identify and formulate their own problems.

MAETIC describes group’s activities directed towards a concrete production. The teacher activities consist to animate, not to decide a whole. The result of practice and the ground observations allow producing a guide and five technical booklets. The project rests on 5 phases, which are traditional activities of project management. During each activity students have sub-activities to realize and must produce deliverables.

The approach of design proposed by D. Lecllet and B. Talon aims at producing educational devices for teachers using the pedagogical method MAETIC. For that purpose, they propose a layer model based on three abstraction levels (Generic, Organizational and Instrumented). This model allows not considering simultaneously all concerns during the design of the device. Each layer is a perspective on the device to develop. The device designer can concentrate, according to the design phase, on various concerns according to the state of progress of this device. He can so imagine a device which is convenient for him (according to his constraint, his requirements). This layer vision allows building varied devices on a single method, the highest layers remaining the most stable. This layer model allowed formalizing MAETIC. The detail of this model was published in [7].
5. Modeling the pedagogical model with MOT

The figure 2 is a model of MAETIC with the MOT language [8]. MOT is an object-oriented modeling language intended to express various fields of knowledge as graphic models. MOT model helps to understand the interactions between the various concepts (activities, deliverables, and so on) of MAETIC, and the interactions between the levels (generic, organizational and instrumented) of the layer model. In the short-term, the goal of this modeling is to conceive a reference frame of competences and to estimate these competences during the realization of practical virtual activities in computer science. In future, we aim to develop from this model a tool to assist the implementation of the MAETIC method by the teachers. This tool could be integrated in Learning Management System (LMS) to help the evaluation process.

![Figure 2. MAETIC model with MOT](image)

We can see on the figure 2, the concepts of meeting, activities, deliverables that are linked by ties of composition (C) and Input / Product (I / P). For example the meeting concept is an Input link (I) of the activity.

The transverse links (shown in bold) between layers show dependencies between these levels. For example, the relationship between generic and organizational levels is symbolized by the links of regulation (a tutor regulates the activity). Concepts or procedures may also serve as a liaison between the levels as the steering process that connects the generic layer to instrumented layer.

6. Conclusion

In this article we have presented our online lab, and highlighted the contributions of learning this type of device for learners and their contribution to reduce costs for academic institutions.

Furthermore the application of the MAETIC method to remote activities is intended to enhance the professional skills in computer science.

For the rest of this work, the modeling work will be refined to establish a model for a tool using the MAETIC method, with the intention to assist teachers in the implementation of this method and develop an interface that could allow ELINE laboratory to be integrated into learning management systems.

7. References