PROLEARN

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Deliverable ***3.4 "First draft report on roadmap towards a common technical framework for online experiments"***

Part of task 3.4 "Summarize technology used for building current online experiments and write a roadmap towards a common technical framework for online experiments"

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1 About Online Experiments

Online Experiments are remotely controlled experiment equipment or software simulations of real experiments built for learning purposes. They enable students and professional learners to get hands-on experience without the need to leave their workplace to go to a traditional local laboratory. Measuring and manipulating real or virtual objects in experiments is common in many disciplines, for example in science, engineering, technical education, medicine and economics. Compared with local experiments, remote and virtual experiments open the potential for flexible learning in time and place, access to a large number of experiments and cost savings through experiment sharing.

Online Experiments are experiments performed on virtual experimentation instruments, remote physical experimentation instruments, or both, built for learning purposes. Therefore, in the context of Online Experiments and with respect to their "virtuality" characteristic, experimentation instruments may range from physical instruments accessed locally, physical instruments accessed remotely, software simulations of physical instruments, and virtual objects.

2 Technical Framework for Online Experiments

2.1 Deliverable 3.4 overview

In order to specify a technical framework for online experiments we plan to follow four phases. The first one is to elaborate different and challenging use scenarios for online experiments. The objective is to define the requirements of end users in different contexts (academic, industrial, and institutional). The second one is a study of existing and deployed online experiments in order to define the common services provided by online experiments and to devise generic and modular software architecture for online experimentation environments. The third phase will consist of investigating technical solutions to integrate heterogonous resources. Finally, the last phase will provide a description of a technical framework of online experiments.

This document is the deliverable D3.4 (M12) and represents the results of first and second steps. It resumes the results of our work on challenging use scenarios, and then, gives a description of the generic software architecture we propose to cover the requirements of end users (learners) in term of online experimentation.

2.2 Scenarios for online experiments

In proposing a technical framework for online experiments, our objective is not only to describe the current situation and enumerate the existing solutions but also to study, define, and move towards the next generation. To discover the requirements of end users and their expectations for the next years, partners within WP3 had participated in order to elaborate different challenging, but realistic, scenarios for using online experiments. The idea was to focus, for each partner, on one or two situations, depending on its current research and current expertise. All the scenarios proposed by WP3 partners are documented in the project's server and can be resumed as follows:

- L3S - Hanover: The scenarios proposed by L3S illustrate the use of online experiments in lifelong training and continuing education.
- EPFL - Lausanne: The scenarios proposed by EPFL focus on the integration of online experiments in e-Work, in particular within mobile work modalities.
- RWTH - Aachen: The scenarios proposed by RWTH describe the role of online experiments within university engineering education.
- UPM - Madrid: The scenarios proposed by UPM, like RWTH, demonstrate the important role of online experiment in higher education.
- ETHZ - Zurich: The scenarios proposed by ETHZ illustrate the benefits of online experiments for researchers, in both academic and industrial contexts.

- IESE - Kaiserslautern: The scenarios proposed by IESE focus on the integration of online experiments in workplaces and the benefits of this integration for workers.
- KTH - Stockholm: The scenarios proposed by KTH give some examples of the potential use of online experiments by universities in developing countries.

During this activity, Niniek Angkasaputra (FH IESE) has been responsible for tracking the scenario contributions and editing the joint document. This document is accessible on the project server at: https://agws.dit.upm.es/key/82853

2.3 Introduction to the technical framework

To be able to define a technical framework for online experiments, we need first to define a functional decomposition of an Online experiment into modules. The idea is to be as exhaustive as possible and to cover all the services that can help a student to perform hands-on activities and to support tutors to supervise such activities. For this purpose, we have studied a set of European deployed online experiments, in particular all the experiments described in the EducaNext portal (deliverable of Task 3.2).

The result of our study shows that the principal services within an online experiment can be grouped into 5 major modules (see figure1):

- Manipulation and operation module: this module involves all the components required to access the experimentation resources and to manipulate and operate them. Experimentation resources can be real physical devices, virtual devices, and/or simulation tools.
- Tutoring and supervision module: This module involves all components that help tutors to supervise and control the students' work. This includes, for example, visualization of students' work progress, results evaluation, examination, and so on.
- Collaboration and teamwork support module: This module involves all the components required to sustain a collaborative work during hands-on activities such as communication tools, awareness tools, and planning tools.
- Authoring and deployment module: this module involves all the components that a tutor needs to, first, define and manage the pedagogical scenario around an online experiment (authoring), and second, to deploy the environment for the student end users (deployment). Authoring tools allow tutors to define links to theory and lecture notes, tasks and deliverables, deadlines, and all support resources. Deployment tools focus on rendering, configuration, and personalization of the resources. It also involves integration components such as import/export APIs and communication APIs.
- Management module: this module involves all the classical management functions such as resources access management, users and groups management, documents managements, and so on.

In fact, only the first module (Manipulation and Operation Module) is specific to online experiments. The other modules are important in online hands-on activities, but are also basic modules in any eLearning solutions.

Figure 1. Principal modules in an online experimentation environment

2.4 Manipulation & Operation Services

The manipulation and operation components are very important for an online experimentation environment, as they allow the student to carry on the major experimentation activities such as design, tuning, command, observation, and analysis of results. As there are many types of experiments, each with a somewhat different manipulation interface, the following list reflects the most common services found in the majority of experiments (see figure 2).

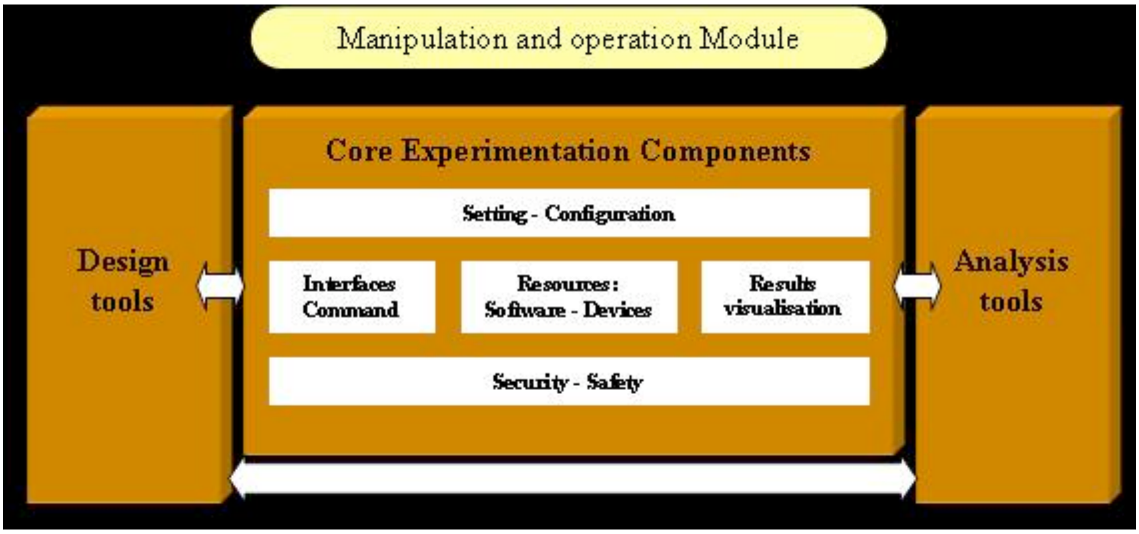

Figure 2. Principal services within Manipulation and Operation Module

Computation and simulation algorithms

Two categories exist in this case. The first category contains algorithms and applications developed using specialized tools like Mathematica, Matlab, and LabView. The second one involves applications developed from scratch using general purpose programming languages such as Java, C, C++ and Fortran.

Hardware Interfaces for physical devices

In the case of real device manipulation, we need, in addition to classical software interfaces (GUI for command and visualization), some hardware to be able to interact with real devices. In general, this interface is transparent to the end user.

Command services for manipulation and observation

The command services are usually developed as GUI components. They allow to control, manipulate and observe the experiment devices. Depending on the experiment, they can utilize standard widgets known from typical window-oriented applications, or more sophisticated interfaces designed to mimic control panels of real physical devices.

Setting and configuration services

Generally, experiments are developed to support many settings and configurations. Thus, in many experiments, the user has to define the setting of the experiments before starting the work session. The teaching staff can also perform this setting and configuration phase in advance.

Security and safety services

In many cases, the manipulation of real devices must be controlled and limited by security and safety policies in order to avoid illegal uses or accidents (destructions, explosions, etc.).

Results Visualization services

The principal objective of many experiments is to observe experimental phenomena and collect experimental results. The visualization component makes these measurement data accessible to the human observer by providing numerical results in textual form, graphical results (curves, 2D graphics), and also multimedia results (WebCam videos, sounds, 3D graphics).

Design tools

Design tools support conceptual and preparation work done before accessing the core experimental components. They allow users to define mathematical models and to carry out simulations and calculations. In the engineering field, examples of such tools are Mathematica, MATLAB, SysQuake, and LabView.

Analysis tools

In many experimental activities, students have to analyse the collected data in order to obtain physical parameters, check predictions from theory or to improve the design. Generally, the same tools used for design can also be used for data analysis.

2.5 Collaboration & Teamwork Services

Generally, as for example in engineering education, hands-on activities are performed collaboratively. Students realize these activities in small groups and in continuous interaction with the teaching staff. Thus, it is necessary for an experimentation environment to offer dedicated services to sustain the collaboration between students and between students and teachers. As shown in figure 3, the most important services required to sustain collaboration are data sharing, communication, work planning, and awareness (see figure 3).

File Sharing Services

The first requirement for collaborative online experiments is to offer file sharing facilities. This allows students to store, retrieve, share and exchange files representing the knowledge obtained during their experimentation work. These services offer to a group of users, which collaborate together, a kind of repository for several kinds of data and information such as experimental motivation, experimental details, the process of scientific discovery, the procedures followed, the raw data collected, the resulting data and its analysis, any ideas or observations as they occur, as well as thoughts on future directions.

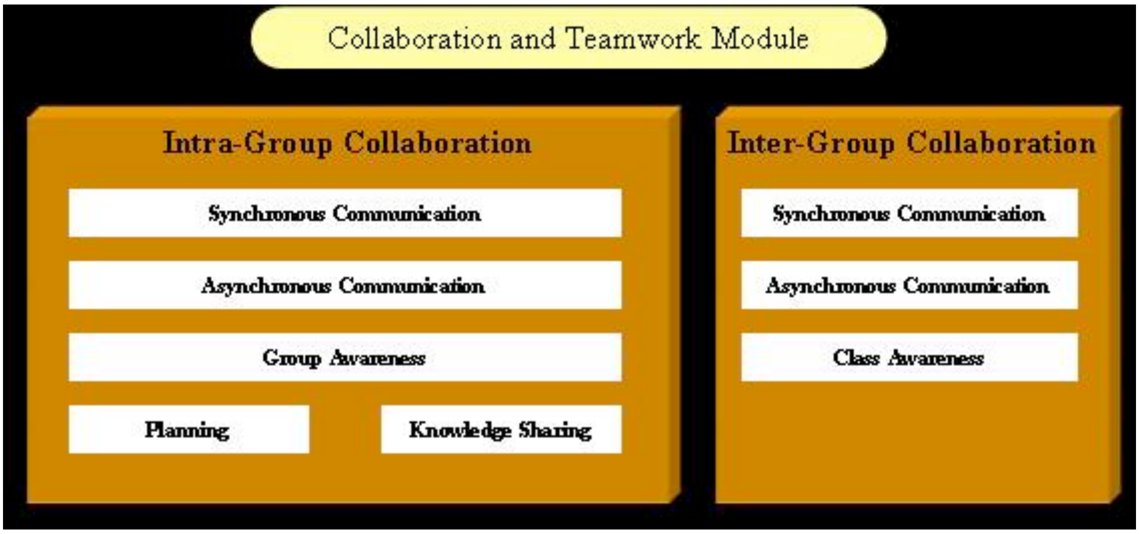

Figure 3: Collaboration and Teamwork Module

Synchronous Communication

Synchronous communication tools enable real-time communication and collaboration in a "same time, different place" mode. These tools allow people to communicate at the same time. They possess the advantage of being able to engage people instantly and to have rich and immediate dialogue and feedback. The primary drawback of synchronous tools is that, by definition, they require same-time participation which is not always easy to ensure (availability of tutors, time zone differences, etc.). In addition, they tend to be costly and may require significant bandwidth to be efficient.

Currently, the most used synchronous communication tool, for collaborative online experiments (and e-learning in general) are:

- Audio conferencing: generally used for discussions and dialogue. They are very efficient but can have a high cost, especially when international participation is involved
- Web conferencing: usually used for sharing presentations and information. They are also very efficient but like audio conferencing, they have a high cost and require high bandwidth. They may also require audio conferencing to be useful.
- Video conferencing: used for in-depth discussions on a mostly abstract level. They have a high cost, and are limited by the reduced number of video conferencing systems
- Text chat: used for information sharing of low-complexity issues. They usually require good typing skills. They are simple to use and easy to integrate or develop.
- Instant messaging: usually used for ad hoc quick communications. It requires that all users use compatible system. It is usually best for 1:1 interactions.
- White boarding: usually used for co-development of ideas and designs. It has a high cost, requires high bandwidth, and may also require audio conferencing to be useful.
- Application sharing: usually used for co-development of documents. It has a high cost, requires high bandwidth, and may also require audio conferencing to be useful.

Asynchronous Communication

Asynchronous communication tools enable communication and collaboration over a period of time through a "different time, different place" mode. These tools allow people to collaborate at each person's own time schedule. Asynchronous tools are useful for sustaining dialogue and collaboration over a period of time and providing people with resources and information that are instantly accessible, day or night. Asynchronous tools possess the advantage of being able to involve people from multiple time zones. In addition, asynchronous tools are helpful in capturing the history of the interactions of a group, allowing for collective knowledge to be more easily shared and distributed. The primary drawback of asynchronous technologies is that they require some discipline when used for ongoing communities of practice and they may feel "impersonal" to those who prefer higher-touch synchronous technologies.

Currently, the most used asynchronous communication tools, for collaborative online experiments (and e-learning in general) are:

- Discussion boards: they are used for dialogues that take place over a period of time. When using such tools, it may take longer to arrive at decisions or conclusions.
- Web logs (Blogs) and forums: generally used for sharing ideas and comments. Also in this case, it may take longer to arrive at decisions or conclusions.
- Messaging (e-mail): used for One-to-one or one-to-many communications. The problem is that email is not well suited as a "group collaboration tool" and can become overwhelming.
- Shared Calendars: generally used for coordinating activities and planning work and task decomposition. However, it generally requires system compatibility.

Planning and Workflow Management Services

In collaborative work, coordination of activities is a key point in order to reach common objectives. Coordination of activities involves, in particular, three aspects, which are work decomposition, scheduling, and workflow management. When performing online experiments, and in particular in project-based laboratories, students within the same group have to coordinate their activities by:

- Adopting a decomposition of work in order to attribute separate and clear tasks to each group member. In some cases, the teaching staff can predefine a decomposition of the laboratory work into subtasks. Then, only association of subtasks to the group members has to be decided by the students.
- Defining a global schedule for the realization of all tasks. Depending on the adopted learning modality, the students can follow more or less flexible scheduling. In fact, if strict deadlines and intermediate deliverables are defined by the teachers, students have to adjust their schedule to satisfy the requirements of the teachers. In more flexible context, students can define and follow personalized schedules.
- Managing the workflow and the sequencing of tasks. Management of workflow can be more or less complex depending on the number of tasks, the number of collaborators, and the dependency between the different tasks.

An experimentation environment needs to provide students with services to sustain the coordination of their work, in particular, in the cases of experiments with multiple tasks and deliverables (for example, project-based laboratories).

Awareness

Knowing the activities of other co-workers is a basic requirement for group interaction. In a face-to-face condition, users find it naturally easy to maintain a sense of awareness about the activities of others. However, in other conditions, supporting spontaneous interaction is evidently much more difficult.

To support effective collaboration, systems should provide to each member of a group an understanding of the activities and progresses of others, which provides a context for his own activities. In learning, awareness plays a very important role in facilitating the learning process, especially in e-learning context. Students need awareness to have a view about their progress compared to other groups. Awareness is also necessary for students to find potential collaborators for exchanging documents and ideas, and to ask for help.

The concept of awareness plays an important role in collaborative Web-based experiments. In its basic form, progress of groups can be displayed and compared numerically and with simple statistical figures. To visualize the activities and location of other persons and groups in a virtual cooperation space several mechanisms have been used:

- Tele-pointers

- Radar-views
- Distortion-oriented lenses
- Icons

2.6 Tutoring and Supervision Components

In face-to-face learning, it is easy for teachers to communicate and interact with students and to provide them with explications, helps, hints, comments, and answers, which are required tasks to be performed by a teacher. These tasks form what we call the tutoring process. It is also easy for teachers within face-to-face learning to evaluate the work progress of students and their outcomes quality, and to regulate the learning process in order to maintain a coherency within classes and groups in term of progress and quality. This is the second category of tasks a teacher has to ensure. This category forms what we call the supervision process.

Due to time and place distribution of the learning actors in flexible eLearning scenarios, the tutoring and supervision processes can no longer be based on direct observation and communication, but must be based on services provided by the learning environment. Thus, online experiments, as one kind of learning environment, must provide such services in order to sustain teachers in their activities. In those specific environments, the main services are awareness, work progress supervision, and synchronous and asynchronous tutoring and support.

Awareness and Work Progress

To supervise their students, teachers need to be aware of student interactions, work progress and quality of deliverables. Thus, online experiments shall provide visualizations of high-level indicators of these factors. The indicator variables significant to build an effective awareness for teachers depend on the experiment, the learning modality adopted, and organizational factors.

Synchronous and asynchronous Tutoring and Support

Tutoring and support are mostly based on communication. Thus, the communication channels, described in section 2.5, are useful to sustain tutoring and support services. However, in addition to these communication channels, others communication media are frequently used when implementing tutoring and support services. The most important are:

- Streaming audio
- Streaming video
- Narrated slideshows
- Document libraries, survey and polls
- Web site links

2.7 Authoring, Deployment, and Management Services

Despite all the advantages of the existing WBCMT (Web-Based Content Management Systems), their major drawback is that they are restricted to the deployment of static multimedia pedagogical resources such as texts, images, and videos. The term ‘static’ is used here in contrast to *active components*, which can perform internal calculations and/or adaptations and can communicate with other components. Thus, current WBCMT are not suited for the authoring and the deployment of online experiment resources to strengthen hands-on practice.

In the majority of cases, current online experiments are developed from scratch and deployed using non generic and non reusable architecture. Only few efforts have been done to design and develop authoring and deployment environments for online experiments. This is due to the difficulty to define a common architecture for online experiments, and then the difficulty to define the functions of such an environment. It is also due to the technical difficulty to integrate several heterogonous components and tools during the authoring and deployment process. In fact, online experiments are not only juxtaposition of documents and multimedia elements, but are built from an integration of program development environments, applets, tools, services, and other active components.

In term of management services, nothing is special for online experiments. As any other learning support system, an experimentation environment must offer services in order to manage:

- Students
- Teachers
- Resources
- Access rights
- Documents

3 Conclusion

This first draft of a technical framework for online experiments describes the services and the functional decomposition of an online experimentation environment. These results are based on a study of experiences with online experiments of the project partners.

Currently, the members of the WP3 “Online Experiments” are investigating the existing technical solutions for the services mentioned in this document, and their integration in order to define a common technical framework for the building of online experiments and a network of European Online Experiments.