Virtual Environment Online for the Project-Based Learning Session

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Abstract*—Project-Based Learning (PBL) has become a necessity for the Moroccan higher education reform. PBL is an approach that transforms teaching from "teachers telling" to "students doing". However, implementing PBLs brings new challenges to higher education. In this paper, we present a set of Technology-enhanced Learning environments integrating the needed aspects in a synergetic way to fit well PBLs, especially in our context of use. The collaborative environments we developed, called respectively Smart-Project, Moulinette, M@roc Téléformation and Multi Agent Reporting System (MARS), were used to support PBL in the process of reform. In response to the challenges, the synergetic way in which our developed environments collaborated to provide interactive tracking data and semantic reports plays, in our sense, an important role in structuring and supporting effective PBL sessions.

***Index Terms*— E-learning, PBL, CSCL, Multi-Agent System, Reporting system.**

I. Introduction

OVER the past eight years, Project-Based Learning (PBL) has become a necessity for the Moroccan higher education reform. PBL is an approach that transforms teaching from "teachers telling" to "students doing". Teachers are facing several challenges during PBL implementation [1]. These challenges could be summarized in tree kinds of difficulties: (1) how to design a PBL specifications; to design projects that support learning of specific concepts, skills and production in the real context, (2) how to assist several projects and give feedback where and when is needed, (3) how to use technology that support effective modeling of project-based learning (Figure 1).

These challenges represent then the motivation of our research in this paper, according to two distinct hypotheses:

- Hypothesis n°1: The project-based learning session can be divided on three main phases (Figure 2): Pre-project phase (modeling), Project phase (realization) and Post-project phase (evaluation).
- Hypothesis n°2: In each phase, environments and methods should be provided to all actors to model, to execute and to evaluate PBL sessions.

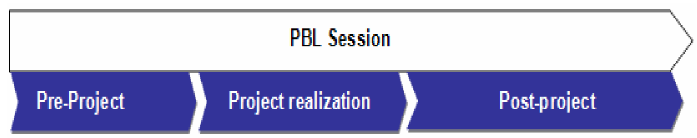

Fig. 2. *The tree main phases of a PBL Session.*

Our research aims to validate these two hypotheses. Hence, we have implemented as a part of the first phase two environments, called Smart-Project and Moulinette that support teachers in modeling and implementing PBL adequately [2]. Using above prerequisites, we have also created a virtual environment of collaborative learning based on a workspace metaphor called “M@roc Téléformation” that helps students in the second phase, to realize projects. Finally, to support the third phase, we have implemented a multi-agent system called “Multi Agent

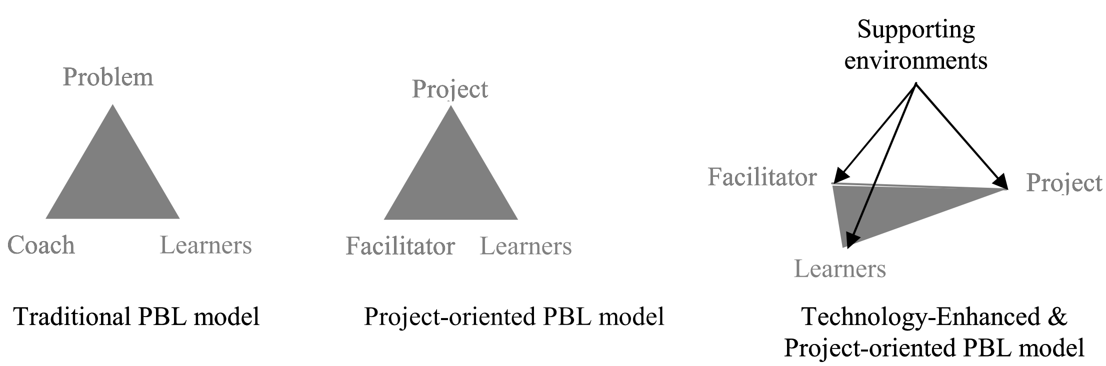

Fig. 1. *The shifting from a Traditional PBL model to a Technology-Enhanced PBL model.*

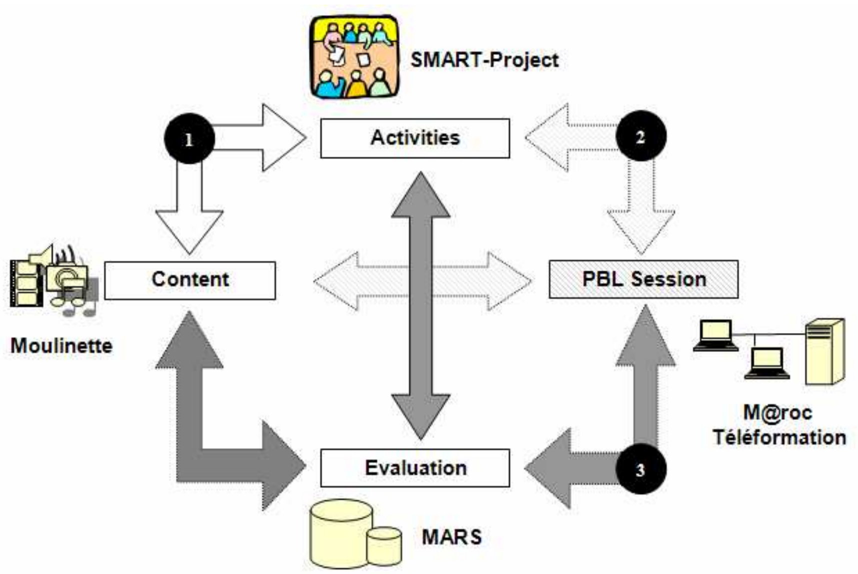

Fig. 3. *The Combining online environments to support the PBL sessions over tree phases*

Reporting System (MARS)" in order to extract the relevant data related to the interaction of the various actors and give semantic statistics and appreciations of the PBL session (Figure 3).

In this paper, we first present one by one the online environments that we have implemented (i.e. Smart-Project, Moulinette, M@aroc Teleformation and MARS). We give a short overview of their purposes and potential benefits for the PBL sessions, their conceptual models and sketch scenarios in which they can be applied. Finally conclude with an outlook.

II. Smart-Project environment

A. Presentation

Smart-Project is a multi-agent system to support online student group projects. For establishing the specifications and the modeling of such environment we have followed the following steps. We started by a definition and an analysis of our needs. Then, based on related research works [3] [4], we have identified their shortcomings and we have proposed our own approach. We have also inspired by works done in domains of:

- Project-based learning (PBL),
- Project management,
- Computer-Supported Collaborative Learning (CSCL),
- Computer-Supported Collaborative Working (CSCW),
- Agents Supported Cooperative Work
- Artificial Intelligence in Education.

Based on these studies, we have elaborated our own model (figure 4) as an environment gathering the following actors:

- Technical-teaching team,
- Student group,
- Tutor.

B. Technical-teaching team

We call it "Technical-teaching team" because it can be constituted of heterogeneous actors from the educational and technological domains (teachers, administrators, company engineers, economic operators, etc.) managed by a project manager. Its mission is to propose projects which may be realized during the academic year, to observe the progress of these projects by the student group and finally to discuss with the tutors. Project must be obligatorily located in the matrix LRP (Learning, Respect of constraints time-cost, Production) that we propose (next section).

C. Student group

Student group is constituted of a group manager and a team. The manager is just a motivated student, who is having a spirit of leadership. He (or she) must accompany his (or her) team to realize the project according to the methodology of the project management (preliminary analysis, development of a list of tasks, planning, etc.). This learning strategy has double roles:

- To prepare students efficiently for their future jobs and professional projects by involving them in real situations of work similar to these in industry.
- To make easy for the teacher to follow several project at the same time.

Each project comprises specificities and requires an adapted approach and tools, but the majority of the projects can be modeled like a succession of phases in time. Each

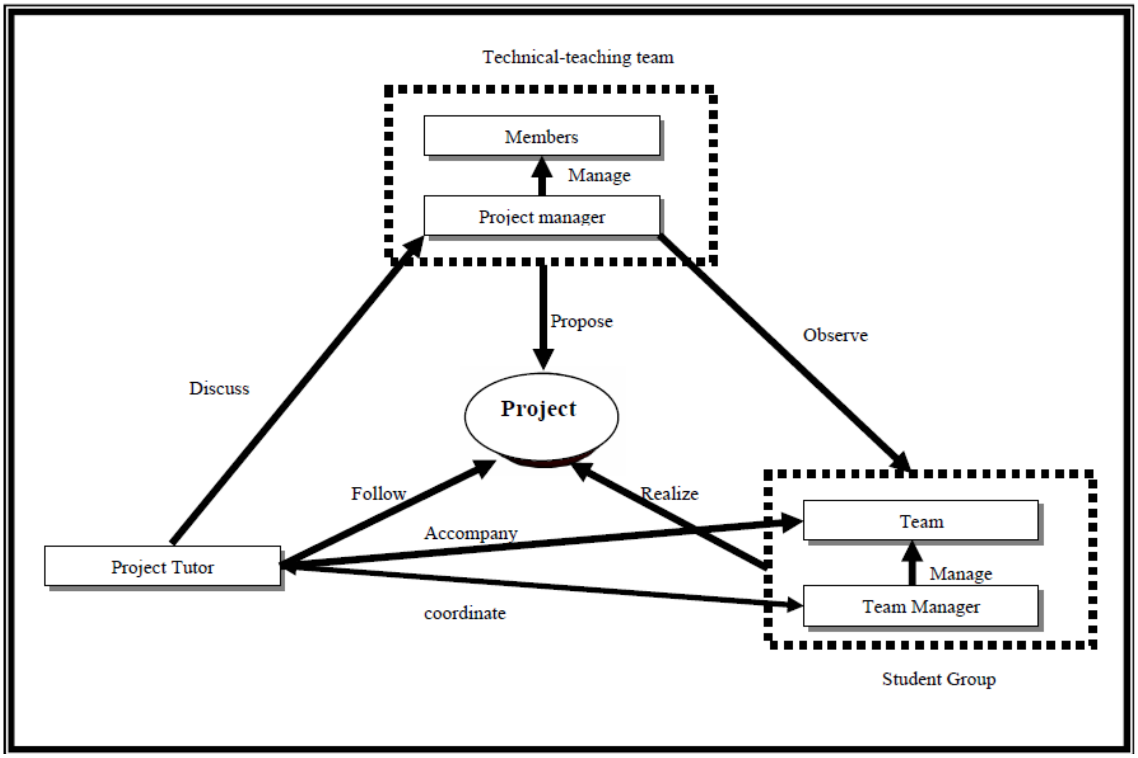

Fig. 4. *Structure of the Smart-Project Environment.*

phase consists of doing a set of tasks (ΣTi). The realization of a task Ti can be ensured by one or more students. The outcome of each task is stored in the Smart-Project environment and

validated by the manager and/or the tutor of the project, by alternating individual and collective stages in synchronous and asynchronous phases. This process is described by model RDV (Realize, Deposit and Validate) which we propose.

D. *Project tutor*

The Project tutor is a teacher who can follow one or more projects at once, accompany one or more teams and coordinate with one or more managers. If necessary, he can discuss with the project manager.

E. *OFTP Methodology*

The goal of our research is to help students to learn by doing, and to develop skills of how they should conduct a project. Then, it is necessary for the technical-teaching team to write correctly the project specifications. So, we propose the OFTP methodology made up of a succession of four kind of requirements:

• Opportunity requirement that aims to define the perimeter of the project (or context of project), to identify the general needs for the project and to formulate the objectives of the project.

• Feasibility requirement that aims to analyze the technical and economic feasibility of the project.

• Technical requirement that aims to express the sets of technical specifications characterizing the project, and on which one will be based thereafter to evaluate his success.

• Pedagogical requirement that aims to define the teaching objectives to reach competences to be acquired, after having made an analytical study on knowledge/skills which will require the project in its realization, new knowledge/skills to be acquired and knowledge/skills to be deepened.

SMART-Project helps the technical-teaching team to specify automatically PBLs via the PBLS agent, supervised by the OoP agent (Organizing of Project agent). This agent who is based on OFTP ontology will allow the automatic creation of the PBL specifications (figure 5).

Project must be obligatorily located in the LRP matrix (Learning, Respect of constraints time-cost, Production) which we propose (figure 6). So, the principal objective of the project must be clear and precise for all the actors (technical-teaching team, student group and tutors). It must indicate if the project supports the learning (case located in the CSCL field) or the production (case located in the CSCW field), according if there is a respect or not of the constraints (time, cost).

Fig. 5. *OFTP Methodology*

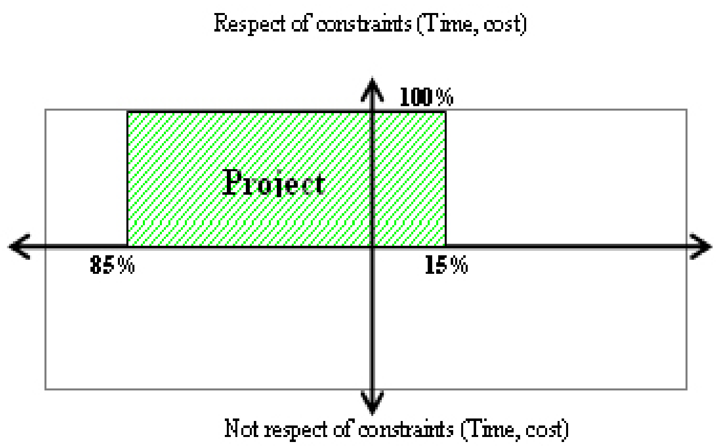

Fig. 6. *Project located in LRP matrix (CSCL)*

III. Moulinette Environment

The content production is an important step to support the PBL sessions. The production of e-Learning content is a time consuming and an expensive process. To save time and money, making the production of e-Learning content more effective and easier seems to be a good approach to sustain the PBL as it was adopted by us. Therefore a platform, called Moulinette (figure 7), was designed to support the whole production process of an e-Learning content. Based on the PBL requirements, our purpose of implementing a new online environment is how we can support a teacher to create easily and efficiently contents for a PBL session. However, a teacher is usually an expert of his teaching domain and he (she) does not have all required skills, such technical skills, to produce the content by his own. Hence, we have proposed the collaborative production as realistic way to create content for PBL session. The teacher produces his content in a multidisciplinary team where each member of the team is assuming tasks corresponding to his expertise. In this way, the teacher is free to choose to which extend he (or she) can be involved in the production tasks, just according to his profile. Other tasks are done by the supporting team under the teacher's guidance. However, sharing tasks in a

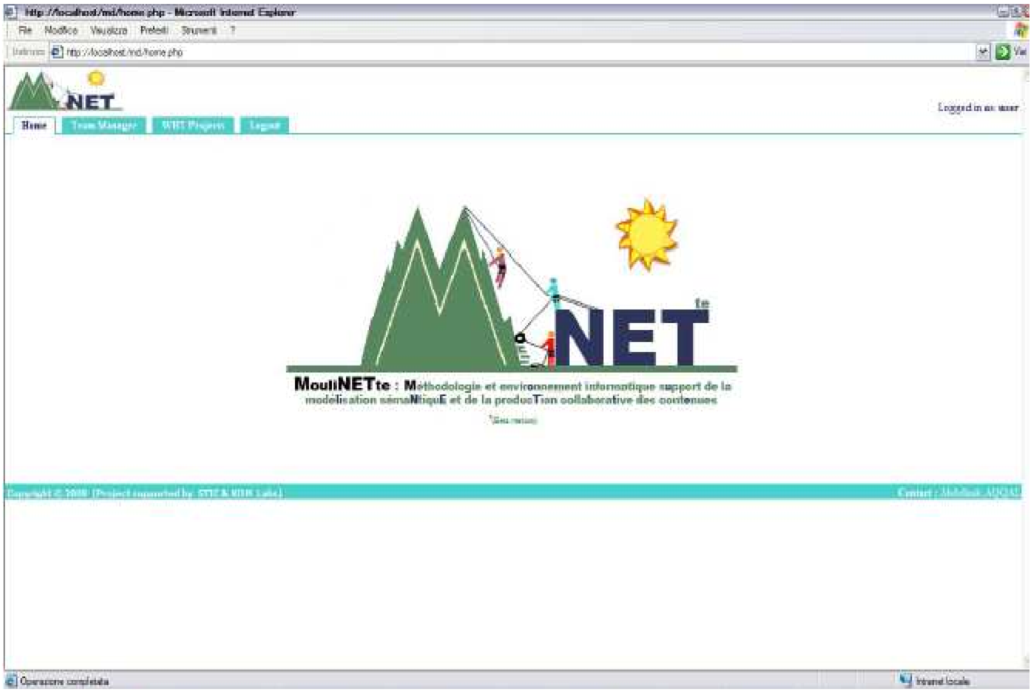

Fig. 7. *Moulinette Environment*

corporate environment is not easy and requires additional paradigms.

For example, how can a teacher represent his intentions, his content model and all technical details to explicit how he expects the content and how he can lead the overall process during the pre-phase of a PBL session?

Regarding these needs, a new methodology to support the collaborative production was proposed [5]. This approach is based on two fundamental concepts:

- A content production management: A level of the teacher skills should be taken in account. In other word, the competence which does not fit with the teacher profiles will be delegated to the supporting experts. More than ever, we need a new authoring paradigm to shift from the traditional content authoring with its incapacities to new collaborative authoring methodology which will provide a better investissement of the teacher energy so that he can be involved easily in modeling of PBL sessions.

- A content modeling based on the Macro Design: Most of the time, the authors focus on the presentation

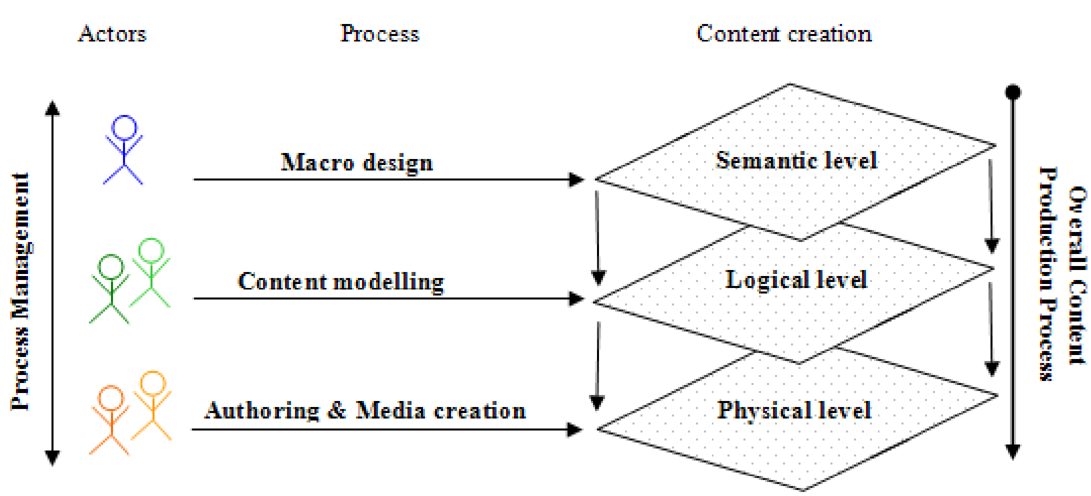

Fig. 8. *The proposed approach for the overall content production process*

aspects of the content production and worry about formatting and layout. A content modeling is often neglected in present authoring approaches and design methodologies. This critical aspect remains fuzzy or is missing from these methodologies. In our point of view, the content modeling comes at the mid-point of content production and includes the following specifics parts (figure 8):

a. **The macro design** attaches much importance to the didactic background and implicit intentions. A generated semantic structure should make clear the semantic meaning of the e-learning content with respect to pedagogical situation, the training goals and the teacher intentions.

   The Macro design can be separated – from a technical viewpoint – in three parts:

   - Didactic modeling which allow to express the instructional design of the e-learning content and the intentions behind;
   - Domain & Learner Knowledge modeling which has the goal to describe the entire Knowledge domain and the learner domain in form of a collection of concepts or skills.
   - Abstract content segmenting which specifies segments of a content consisting of parts of knowledge and didactic elements (e.g. definition, example and test). This segmentation is located in an abstract level and driven by knowledge modeling and didactic modeling.

b. **The content modeling** provides the logical structure regarding the table of contents.

c. **The authoring** consists of media creation and layout presentations described with metadata and linked to the content model.

IV. M@ROC TELEFORMATION ENVIRONMENT

We present in the following a Learning Management System (LMS) that we have developed in-lab. This LMS, called M@roc TéléFormation (MTF), is the first e-learning platform in Telecommunications and networks filed in Morocco. This device, carried out in 2002 and since that, it is used in Web Based Training as a support for the blended learning in various Masters of telecommunications and networks (DESS Telecommunications and Networking) [6].

MTF Platform (Figure 9 and 10) is founded on a space metaphor which puts in scene the usual places in a real university. Tools that are proposed by MTF Platform allow the following:

- Consultation of e-learning contents ,
- Uploading the required documents for the PBL activities,
- The contact between tutors and learners in order to solve encountered problems.
- Collaboration between users on MTF platform using the forums, the chatting and the e-mail,
- The realization of the projects by the learners' group
- The planning of the learning events by using an additional agenda.

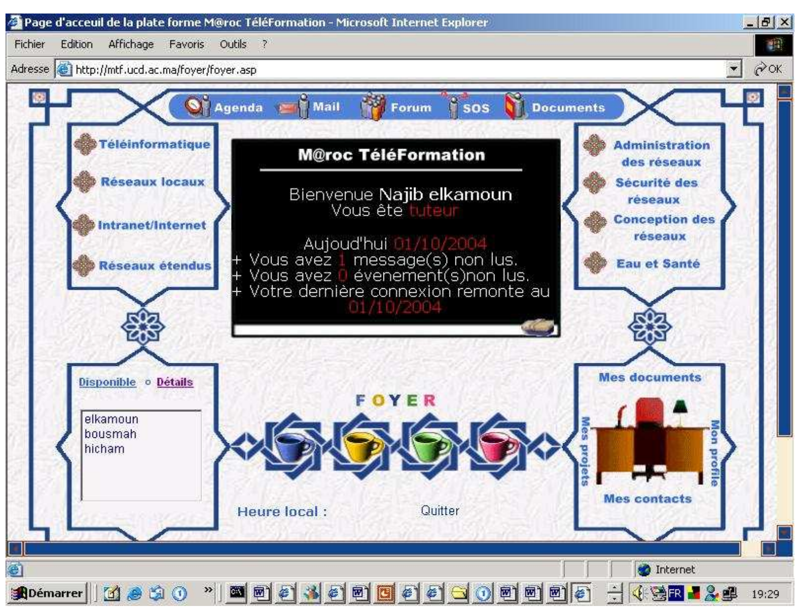

Fig. 9. *The public space on MTF platform*

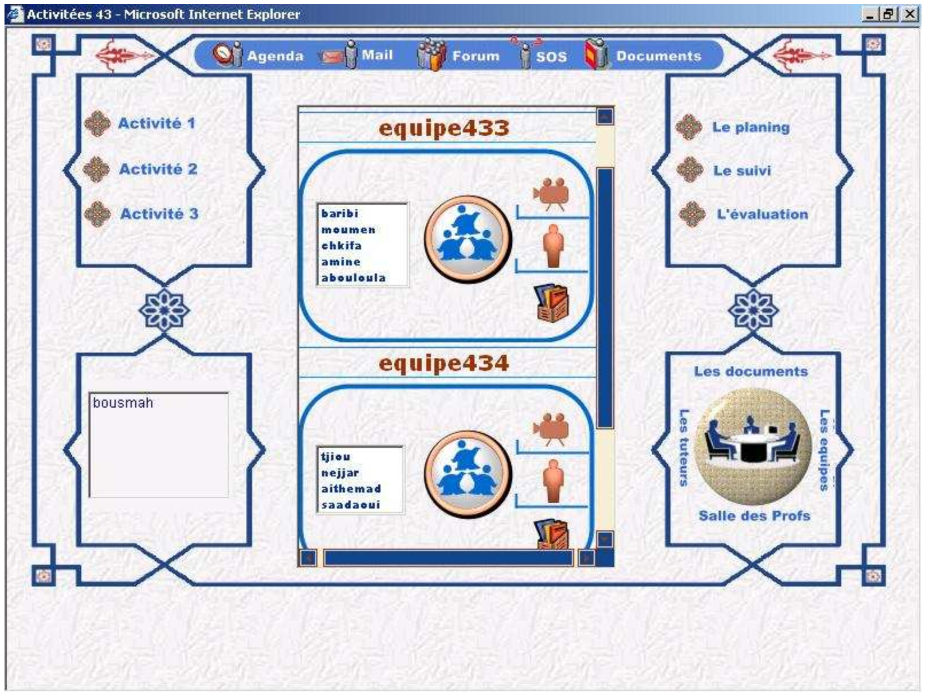

Fig. 10. *The activities space on platform*

The MTF platform provides the main tools used usually to support PBL sessions:

- The e-mail, a space of which allows the communication by mails.
- The forum, a space that allows discussion between learners and tutors on a given topic.
- The Chat allows a real time discussion between all MTF members.
- The uploading space where learners can store and share e-learning contents in various digital format (Word, Excel, Acrobat, etc.) .
- Tools supporting projects' management (a shared planner, process management).

V. MARS (MULTI AGENT REPORTING SYSTEM)

A. Multi-agents approach

In the literature, we find a multitude of the "agents" definitions, and thereafter of Multi-agents System (SMA), here the definition of [7]:

"*Un agent is an information processing system, located in an environment, and which acts in an autonomous way to achieve the goals for which it was conceived*".

It comes out from these definitions some basic properties like the autonomy, the action, perception and the communication. The e-learning supports are: opened, complex, evolutionary and distributed, that's why the agent paradigm is used because it makes possible to equip the systems with the properties of autonomy, pro-activity, reactivity and adaptability. If OOP (Object-Oriented Programming) approaches It facilitates the task of the developers by supporting the implementation of the properties of reutilisability, interworking, co-operation. The paradigm of the agents and multi-agents systems is a good solution for our system, because this approaches increase significantly our capacity to model, conceive and build complex distributed systems [7]. Moreover, the SMA approaches are a natural step in the logical evolution of a range of software engineering.

B. Methodology

Several methodologies were proposed for the development of the MAS (Multi-Agent System). These methodologies, constituting either an extension of methodologies Object-Oriented (AAII, Gaia, AUML, MaSE) or an extension of methodologies knowledge-Oriented (Farmhouse-CommonKADS), remain incomplete [8]. For us, after an evaluation of all these methodologies, we took as a starting point the MaSE methodology (Multiagent System Engineering) for the development of our observant system of use. This choice is justified by:

- The simple, modest and pragmatic vision which MaSE gives to the definition of an agent and thereafter to the system SMA which is perfectly appropriate to us.
- The automation of the "agentification" process.
- The documentation availability.

MaSE divides the development process into two major phases:

- the analysis phase and the design phase. For each phase MaSE provides a set of stages need to be performed. Figure 11 presents the development process proposed by MaSE. The analysis phase consists of the following stages: capturing goals, applying use cases, and refining roles.
- the design phase consists of the following stages: creating agent classes, constructing conversations, assembling agent classes, and system design.

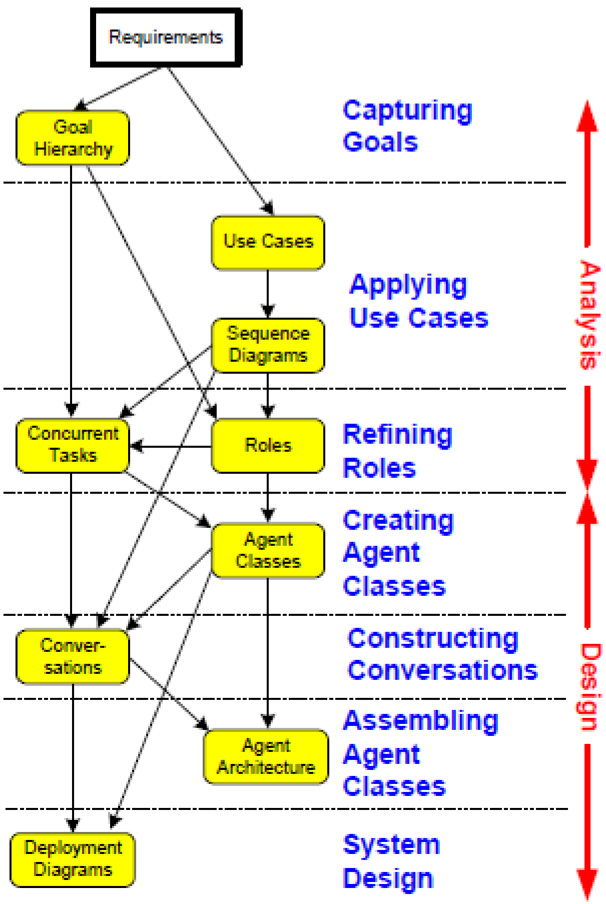

Fig. 11. *The MaSE development stages [9]*

C. *Tools*

The MAS (Multi-Agent System) specified by these methodologies are often difficult to implement directly starting from the standard programming languages like Java or others. Several tools (software elements offering the services for the MAS development) of various types were developed recently for the programming agent-oriented like JADE [10], Zeus [11], MadKit [12], Agent Builder [13].

So, after an evaluation of these platforms, we chose JADE (Java Agent Development Framework) which is a multi-agents platform developed in Java by CSELT (Group of search for Gruppo Telecom, Italy) and which facilities the construction of the multi-agents systems and the realization of applications in conformity with FIPA standard [14]. This choice was made on the basis of several reasons whose principal ones are:

- JADE is an open platform source, documented well and updated periodically.
- The platform JADE can be distributed on several hosts, the communication inter-agents is carried out by ACL messages which can be directly formulated or supervised thanks to a dedicated interfaces.
- JADE offers a graphic user interface to manage several agents and multi-agents platforms, the activity of each platform can be supervised and recorded.

D. *The Multi Agent Reporting System (MARS)*

Figure 12 represents our model of a virtual campus and how it is organized in spaces. Just like in a real campus, each space has an evocative name, allows actors to get in, provides tools and e-learning contents and holds activities to be done. Integration and management of these four elements (Resources, Tools, Actors and activities) in a space should be well taught to fit all objectives in a synergetic way [15]. Every space requires a valid profile and an authentication. Such authentication defines a kind of membership that gives privileges and a social status to the MTF members to use tools and resources.

Basing on our model of a virtual campus and on the MaSE methodology, we can specify and identify the agents which will build our reporting system of use. We present in figure 13 our reporting system of use in a given space. The agent model of our reporting system is made around several supervisory spaces agents (i.e the public space, the group space, the team space and individual space). Each agent-supervisor of a space communicates with four agents: the agent-supervisor of the actors, the agent-supervisor of the activities, the agent-supervisor of the resources and finally the agent-supervisor of the tools. Each one of these four agents can supervise other agents of lower hierarchy. For example, the agent-supervisor of the tools can supervise the mail agent, the forum agent, the discussion agent, the document agent and the agenda agent. Finally the communication with the user is supported by an GUI agent. We summarize features of the agents of our reporting system:

- **Graphic interface agent (GUI_Agent):** its role is to ensure the human/machine communication trough a simple and convivial graphic interface.

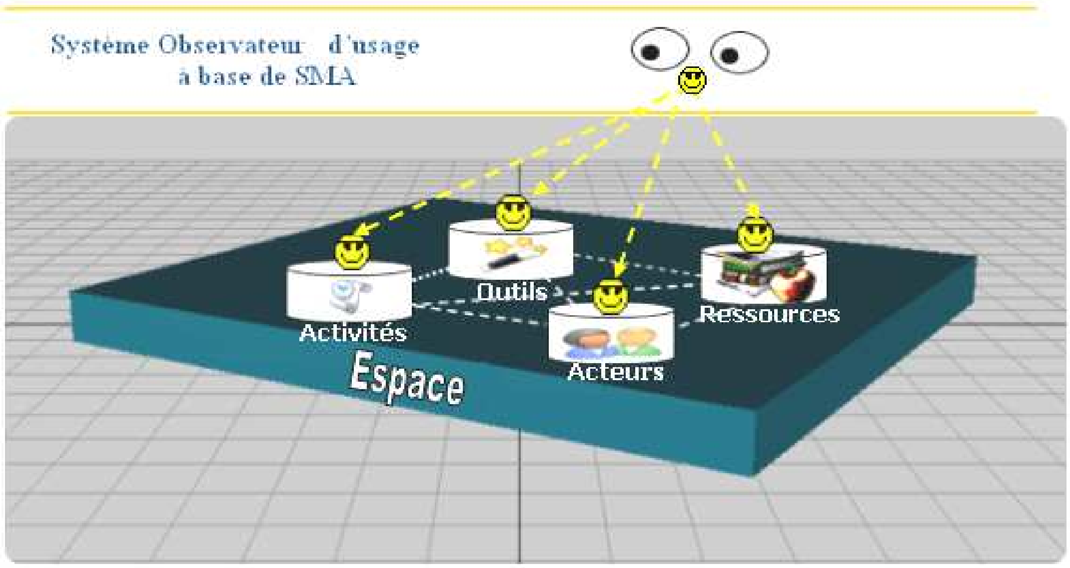

Fig. 12. *The virtual campus in spaces.*

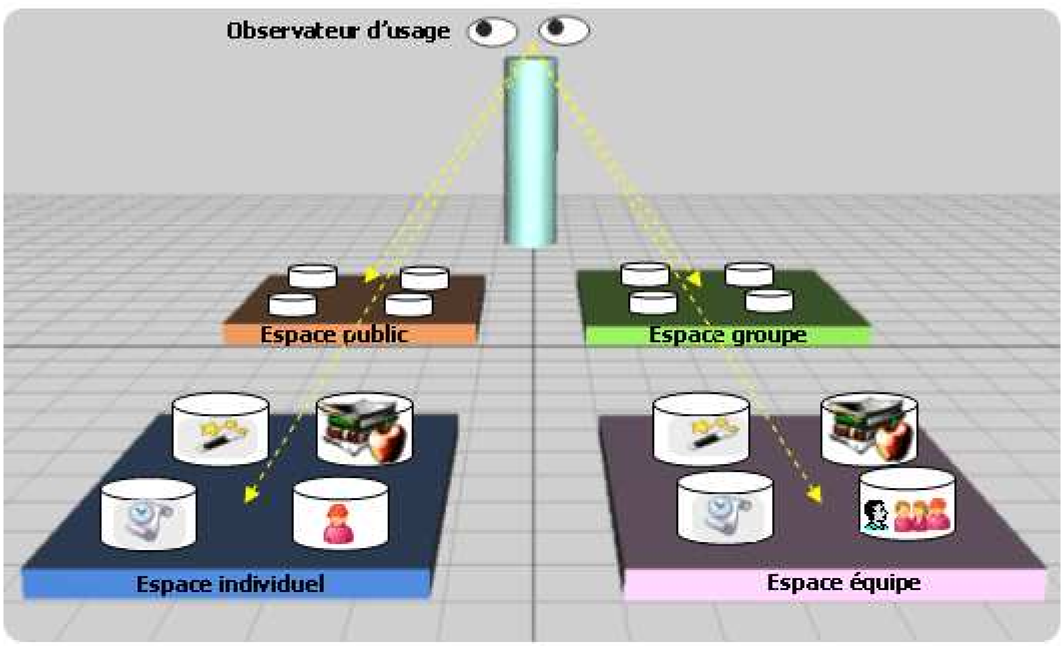

Fig. 13. *A reporting system of use*

- **Agent-supervisor of space AS_Space (i.e public, group, team and personal spaces):** This agent is reporting information and semantic data about a specific access.
- **Agent-supervisor of the actors: (AS_Actors)** This agent supervises connections and actions carried out by an actor. It provides a decisional report about a given actor during a training session.
- **Agent-supervisor of the activities: (AS_Activities)** This agent indicates to which extend the requirements of a PBL session are fulfilled.
- **Agent-supervisor of the tools: (AS_Tools)** This agent provides statistics data concerning the use of the tools in a given space and related to a specific activity.
- **Agent-supervisor of the resources: (AS_Ressources)** This agent provides information about the use of resources of a given space.

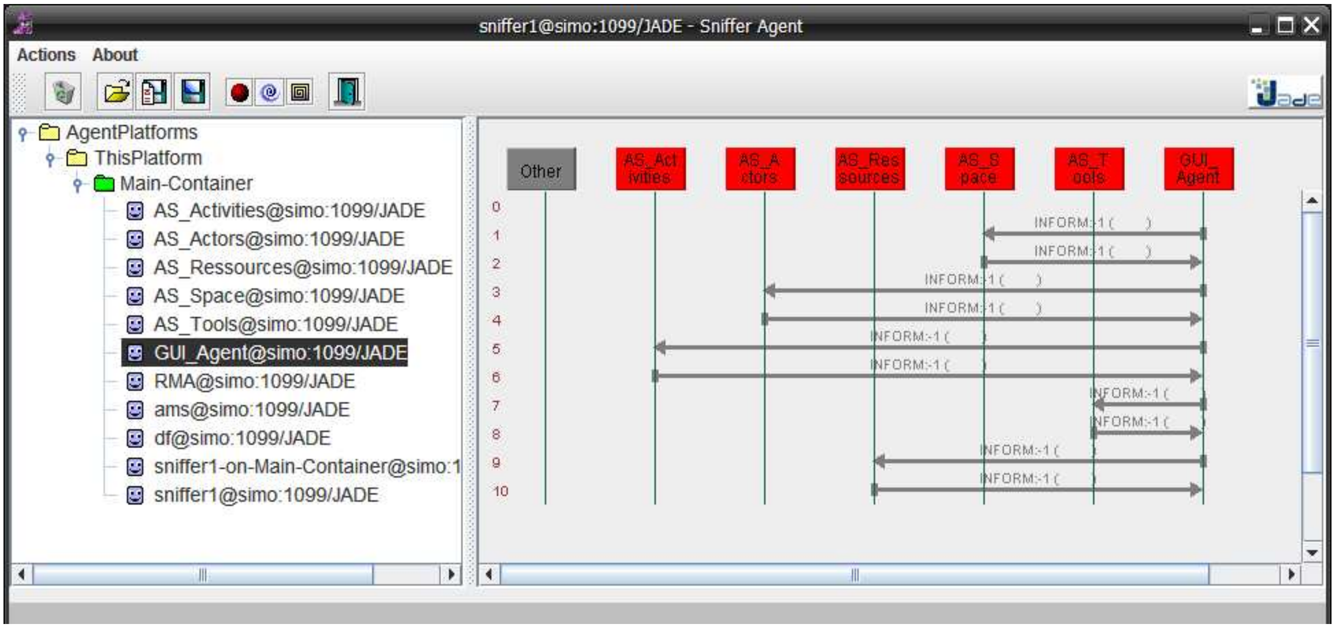

Fig. 14. *Sequence diagram in jade using ACL as agent communication language*

Now the question is how agents establish communication, share and exchange information?

The most popular Agent Communication Language (ACL) are:

- FIPA-ACL (by the Foundation for Intelligent Physical Agents, a standardization consortium) [14]
- KQML (Knowledge Query and Manipulation Language) [16]

Jade is an example of a framework that implements a standard agent communication language (FIPA-ACL). For this reason that our Multi Agent Reporting System (MARS) will use FIPA-ACL as communication language.

Figure 14 represents an example of a sequence diagram in jade using ACL as agent communication language.

Figure 15 represents an example of statistics of the tools provided by the AS_Tools Agent.

Figure 16 shows our online environment based on client server architecture, technologies of Internet and multi-agent systems. Client side, using a simple browser, which simplifies the subsequent handling of the device and eliminates the cost of deploying client software. Server side, using a 4-tier architecture: Web Server (IIS), application server (Tomcat, Jade) and database server (SQL Server).

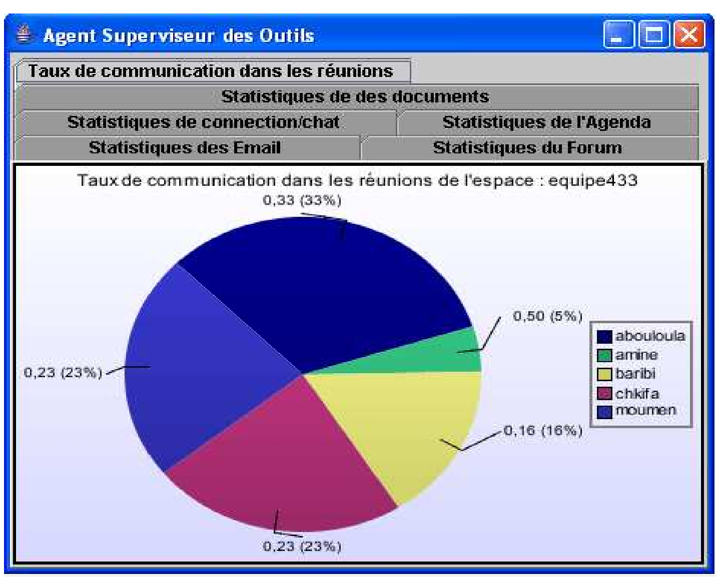

Fig. 15. *Statistics of the tools provided by AS_Tools Agent.*

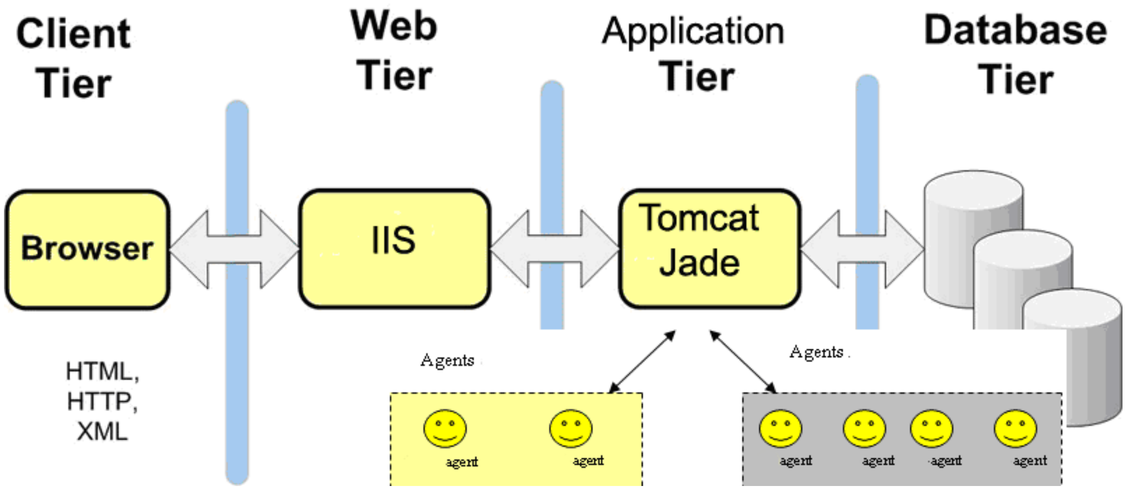

Fig. 16. *Architecture of our online environment for the project-based learning session*

I. Conclusion

In this paper, we have proposed many online environments for the project-based learning session. So, we have elaborated two environments called Smart-Project and Moulinette that support teachers in modeling and implementing PBL adequately, and we have created a virtual environment of collaborative learning based on a workspace metaphor coupled with a multi-agent system called "M@roc Teleformation" that can helps students to realize project, coupled with an observer of use. The principal vocation of the observer is to provide to the various actors very useful information for better training in collaborative distance learning.

Several experiments have been separately conducted in such environments that we detail in a future paper.

For the future work, several tracks remain to be explored. As an example and without being exhaustive, we can cite the design and the implementation of multi- agents system to expose proactive and opportunist behaviour. The system would be able all alone to take the initiative at the "good time" to warn the various actors. We could thus avoid in time the abandonment of the learners, the bursting of a group and the failure of a PBL session.

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