THE EVA TELETEACHING PROJECT - THE CONCEPT AND THE FIRST EXPERIENCE IN THE DEVELOPMENT OF VIRTUAL LEARNING SPACES[1]

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Abstract

In this paper we present the EVA project, which consists in teams of ? number of Mexican universities developing an approach to distance learning, based on modern information technologies that support the work of teams distributed geographically. We show how this approach can be applied and result in a highly re-configurable, interactive computer aided teaching modules. We show examples of such technologies and applications in the domain of the Master and Doctorate education in Computer Science, which are effectively used by the students at Computer Science Research Center of the National Technical University (CIC IPN).

1. Introduction

In this moment a great effort is dedicated to the investigation and development of the information technologies that provide spaces of communication, coordination and collaboration for supporting the work of teams separated geographically who maintain common conversations, activities, matters, and projects **- Resnick, P., Lacovou, N. et al. (1994) -**

All of them are based on the intelligent exploitation or development of the advantages proposed by the modern communication technologies and employ techniques derived from the Artificial Intelligence. They allow to include learning, reasoning and activities planning to the system characteristics. It is the general subject matter of the Laboratories of Agents and Artificial Intelligence (CIC IPN), the main promoters of the EVA Project.

This investigation project applies the methodology and tools of Distance Learning (DL), Intelligent Tutoring Systems (ITS), Interactive Learning Environments (ILE), Internet, groupware, workflow, and Process Engineering (PE) to obtain a new paradigm of the Automatic Configurable Distance Education, which we have named *EVA (Espacios Virtuales de Aprendizaje - Virtual Learning Spaces).* This concept does not pretend to substitute a human tutor by an intelligent software system with one-on-one tutoring model, but tries to use the ITS technology to accomplish with some rudimentary tasks. As well as in the ILE, the intelligence invested in EVA is distributed across a range of tools rather than centralized in a tutor, but the proposed methodology does not use the

[1] The CONACYT and IBM-Mexico sponsor this project at the national level.

basic principle of the ILE - it doesn't permit students investigate and learn topics absolutely free of external control. It also completely differs from the concept of Virtual University, introducing the artificial intelligence and interactivity in the virtual learning environment. The EVA philosophy is congruent with the existing classroom practice: mainly aims at learning goals and outcomes that are already embedded in traditional curricula, do not neglect the use of conventional learning materials, and can usually be plugged into existing curricula with minimal change to course plans. It benefits from some explicit representation of the topics that students investigate, but it doesn't need to be omniscient. Further, since EVA does not attempt to tutor, it is free of obligations to model students' cognition and to make complex pedagogical decisions.

The major goal of this project is to encourage the development of teaching methods and tools so as to improve the knowledge and understanding with a special focus on individual, cooperative and competitive approaches, more particularly in the field of higher education. This article selectively highlights a few important issues in the use of modern information technologies but makes no attempt to survey all key ideas in educational technology. Discussion is limited to the two main applications of them in education: AI and Telecommunications. The article reflects the general principles of the EVA philosophy and the software and hardware infrastructure of the DL environment being developed.

2. The EVA philosophy

The EVA members are led by a general philosophy of teaching sciences. The main idea being to enable the learner to gain a deeper understanding of fundamental phenomena in scientific and technical domains by means of the provocation of the conflicts between the viewpoints and their subsequent resolution as a key educational strategy. The personification of the process of learning, based on reasoning with beliefs and belief revision, and a high level of interaction in the individually assigned and monitored discussion and collaboration groups achieve it. The cooperative dialogues based on reasoning with nested beliefs (beliefs about other's beliefs) play important role in the construction of new beliefs in the educational process.

The philosophical basis of the project is constructed over the modern trends in the pedagogy, which reject the model of education as simply the "process of knowledge transmission" **- Wenger, E. (1987) - - Ohlsson, S. (1986) -** in favor of an "education as growth" model **- Self, J. (1990) -**. According to it, 'knowledge' is not the kind of commodity to be transmitted. It can not be simply received and stored by students, but must be constructed by them, based on the understanding of the fact that 'knowledge' is not a received wisdom but the creation of human beings. The later has caused the development of the ILE technology, based on the inquiry-based or constructivist and student-centered methods of learning **- McArthur, D., Lewis, M., and Bishay, M. (1994) -**, **- Davis, R. (1991) -**. From the AI technology point of view, this conjectural nature of knowledge means the transition from the "expert system" model of ITS, based on the concept of 'knowledge', to the "agent" model, based on the concept of 'belief'. The theory of agency, where the logics of belief from the theoretical AI plays an important role, can be considered as the formal basis of the proposed approach **- Wooldridge M. Jennings N.R. (Eds.). (1995) -.**

The proposed approach comes from the study and analysis of our former experiences in the field of DL and PE **- Núñez G. (1997) -**,**- Sheremetov, L.B. (1997) -** and introduce a qualitative change in the traditional model of computer-based *teaching and learning* with new concepts and tools for knowledge storing, acquisition and recovering, as the following:

1. The Virtual Spaces of knowledge, collaboration, consultation and experimentation.
2. A Computer Science and Engineering Taxonomy, as the data storing structure and the basis of the teaching process simulation and control.
3. The concept of a multi-book ("Polilibro").
4. Computer tracking tools, as the general automatic evaluation of intentions and performance.
5. Computer tools that make possible consistent re-configuring of knowledge spaces, workgroups and consulting groups and permit collectively share and enrich the knowledge and practices derived from application and experimentation.
6. Models based on modal logics that permits to change from the 'knowledge' oriented to the 'belief' oriented modeling of teaching process.

EVA is based in the investigation of three fundamental aspects of the development of human beings, i.e. methods, techniques and technologies of:

- *Knowledge Acquisition.* This subject involves the analysis of all the elements of how agents, humans or computers are able to acquire information (readings, classrooms, newspapers, broadcasts, movies, lectures, questions to experts, visiting places, experimentation, Internet, etc.) to determine its adequate potential and use in EVA.
- *Communication.* This point involves a review and definition of the communication facilities (sights, audio, text, graphics, animation, video, multimedia, virtual reality) searching the best combination and development for EVA.
- *Collaboration and coordination.* These elements study different forms where human beings are related (competition, collaboration, negotiation, imposition, distribution, centralization, etc.) to carry out collaborative work. In each particular case its application in EVA is determined.

These three points cover the investigation, design, development and implementation of software and hardware that support the application of the determined methods and techniques for their use. Another very important factor of EVA is the evaluation of the results (quantity of acquired knowledge) of the "EVAnauts" versus the students who take common classes at the CIC. Further we consider the main concepts of the project in more details.

3. The EVA virtual learning spaces

In the concept of EVA, the person does not learn alone, neither decides by himself the specific materials to use, the student is not a self-taught. EVA is a computer environment in which the persons obtain all the necessary elements to learn. The learner navigates the learning spaces by routes (*study plans*) suggested in an automatic manner by EVA and contacts with other persons to acquire knowledge. In this sense EVA is a

generator that guides, orients and evaluates the *evanauta (student)* in the learning process providing him with all the physical, electronic and human means that are required to learn. We propose the development of information that allows the learner to:

- Process by itself and plan his learning as he needs.
- Obtain the adequate orientation.
- Access the efficient knowledge.
- Contact with persons with the same interest to form working groups.
- Perform the experimental required work to learn effectively.

The conceptual architecture of EVA is structured into four essential knowledge elements formed by four information deposits and the set of programs called Virtual Learning Spaces (fig. 1):

1. *knowledge* - all the necessary information to learn,
2. *collaboration* - people that get together to learn,
3. *consultation* - the teachers or assessors, who give the right direction for learning and consult doubts, and
4. *experimentation* - the practical work of the students to obtain practical knowledge and abilities.

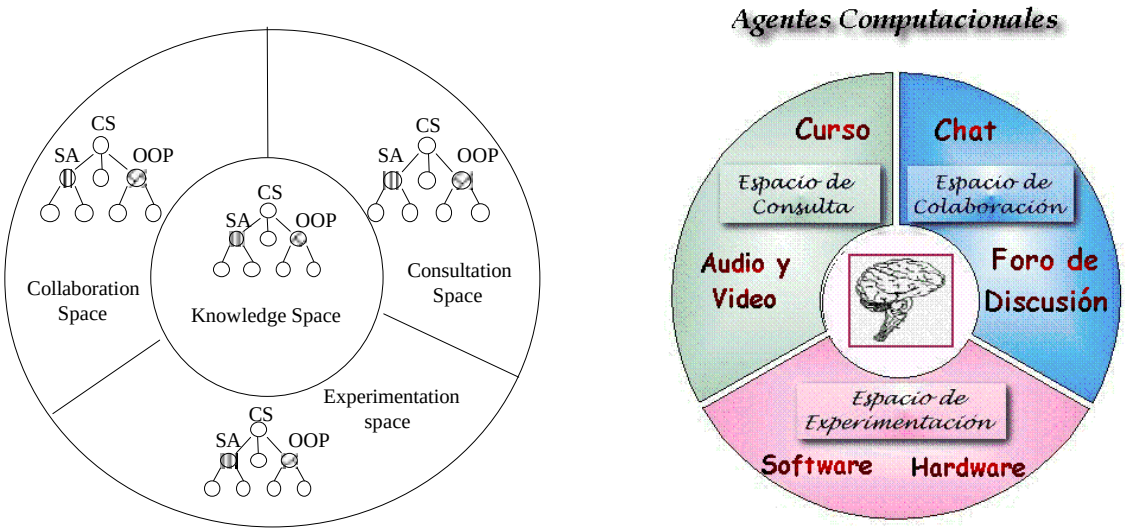


Figure 1. Virtual Learning Spaces:
a) a concept view: CS - Computer Science, SA – Software Agents, OOP - Object-oriented Programming
b) the project front-end for "Software Agents" course

The Virtual Learning Spaces are associated with the knowledge taxonomy of Computer and Engineering Sciences. The nodes of the taxonomy are named in the same form in each space but its contents are different in each one.

In the *Knowledge spac*e the *taxonomy of knowledge* constitutes an agglutinating center of the space, and is elaborated by "Polilibros". In the first stage of the project we

develop 20 "Polilibros" that belong to the courses more important for the Master Degree in Computer Science at the CIC. "Polilibro" is a book, where the chapters are made of units of learning material (ULM), which can be presented in several ways. An ULM can be a text in Word, Audio, Power Point Presentation, Video, Multimedia or Virtual Reality, etc. Each chapter has five elements, as follows:

a) Knowledge Axe.
b) The necessary knowledge for their comprehension.
c) A test that evaluate if the EVAnaut has knowledge in b.
d) Knowledge that contains what is taught.
e) Test of knowledge that he obtains in d.

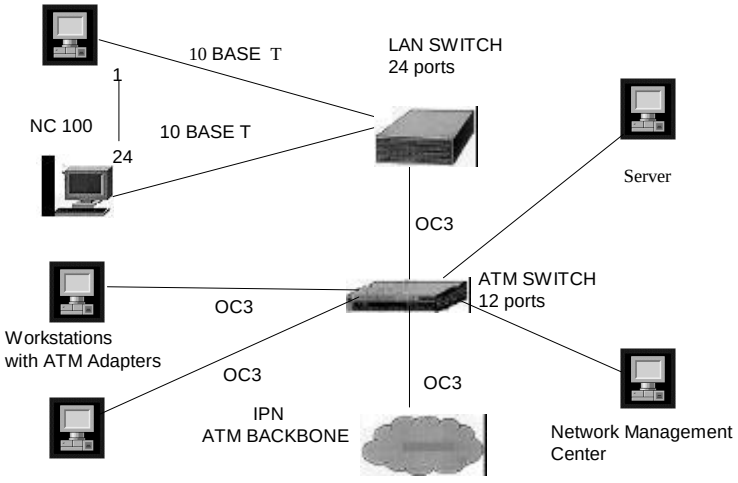
Collaboration space is based on the same data structure but instead of the knowledge taxonomy it is arranged as the collaboration tree, which nodes are constructed by the groups of geographically distributed students having to carry out the same activities and collaborative work.

Consultation space is described by the tree, which nodes refer to the groups of students and tutors (real or virtual) in the corresponding area. Each group is associated with one tutor available at the moment or virtual participant to process the questions automatically.

Experimentation space is described by the tree, which nodes refer to the virtual laboratories, composed of simulators, virtual reality models, JAVA applets or other programming systems accessible through the Web.

4. The EVA Telecommunication Facilities.

Developments like those proposed in this paper would not be possible without nowadays achievements of computer networking and telecommunications. In this context we find some key concepts like bandwidth, audio and video transmission and Asynchronous Transfer Mode (ATM) technology. Then, to be able to test EVA Teleteaching Project, it was decided to install an Experimental Distance Learning



Laboratory (EDLL) shown in Figure 2.

Figure 2. EVA Experimental Distance Learning Laboratory

The core of the system is an ATM switch connected to the IPN ATM backbone that is under construction. It is possible to connect up to 24 Ethernet inputs (10 Megabits each) from multimedia PC´s or IBM Network Computers (NC´s) to a LAN switch provided with a 155 Mbps ATM output. As an alternative, the NC´s may be linked through an Ethernet LAN directly to a server. The system has also two workstations provided with ATM adapters. For the time being, all the ATM links will be implemented at 155 Mbps, but the ATM switch permits to upgrade them to 622 Mbps.

A Network Management Center will permit to analyze the network behaviour. The LAN and the ATM switches will group together computers from the EDLL and from the Artificial Intelligence and Agent Laboratories.

The EDLL has as his aims to test the integration of data, audio and video transmission in the frame of EVA Teleteaching Project, inside IPN campus, in order to be able to extend this experience to different locations in the Republic of Mexico and abroad.

In the EDLL we are working in the direction of the simulation of ATM networks to forecast network behaviour in the presence of different kinds of traffic, including TCP traffic over ATM. For this purpose we are using the CLASS simulator (ConnectionLess ATM Services Simulator) developed in the Turin Polytechnic Institute, in Italy - **Mufano, M., Class (1995) -**. We are trying to show also the technical and economical feasibility of the use of NC´s in the frame of EVA project, taking as starting point the results obtained in North Carolina for their use in secondary schools.

The network shown in Figure 2 will be provided with special hardware and software for video transmission, like AVA/ATV-300 from Fore Systems.

5. The EVA software infrastructure

5.1 Virtual structure of the environment

The software development in EVA is based mainly in the technologies and tools of AI, software agents, and intensive use of software which permits to create virtual environments of learning and collaborative work for students and tutors communicating via Internet (Fig. 3).

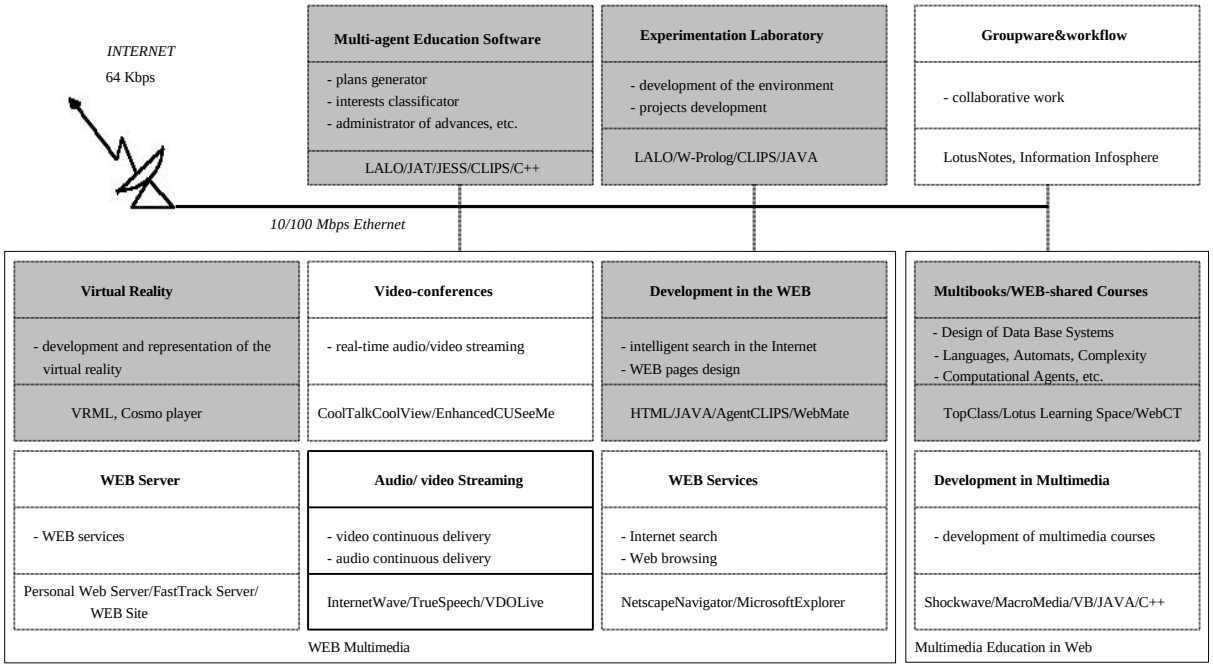


Figure 3. Software layer of the EVA

This software is used to develop the key EVA concepts of automatic configurable distance learning environment:

- *Virtual Classroom* that permits to assist a traditional classroom from the Web site. It uses teleconferences, multimedia materials and the tools of interactive synchronous communication.
- *Virtual Tutor* that permits the students to access the tutor directly in a synchronous or asynchronous way, using communication facilities as teleconferences, chats, discussion lists or e-mail.
- *Virtual Didactic Support* that permits the students to have an access to all the materials as multimedia-based virtual courses and "polilibros", the CIC library and virtual libraries, to have interactions with the students with the same specialization area and level of knowledge.
- *Virtual Administrative Support* that permits to accomplish with all bureaucratic procedures accompanying the process of education by means of using virtual admission, virtual bookkeeping, and virtual education process maintenance systems.
- *Virtual Evaluation* that permits to evaluate the students the same way as in the conventional classroom practice, considering classroom assistance, participation in discussions, tasks and projects, and virtual exams.

5.2. Education Server

Education server (ES) forms one of the principal parts of the education network infrastructure. It performs the following functions:

- didactic material delivery, processing student requests,
- maintenance of the models of the course, students, tutors, and tutoring techniques,
- maintenance of the data bases of the principal concepts: users, ULM, communications, etc.,
- maintenance of the asynchronous communication between the users (e-mail and discussion list),
- provide the access to the on-line practice tools, etc.

DL system uses the client/server architecture. The ES works with the Web server, which transmits the information of HTML pages, using the Hypertext Transport Protocol (HTTP) to control and deliver didactic material to the students throughout the network..

At the current stage of the ES development we use the software systems like Learning Space, WebCT, TopClass, developed for the course delivery throughout the WEB - **TopClass, Version 1.2 (1997) -**. For example, TopClass along with Microsoft Personal Web Server, CUSeeMe, Real Audio/Video are used by the students at the seminar on "Software Agents" as additional collaborative and delivery facility (Fig. 4). The ES is accessed by about 12 students at a time from the PC computers of the LAN of the Center and from remote computers, situated in the periphery of the Mexico-city, from about 50 miles away distance.

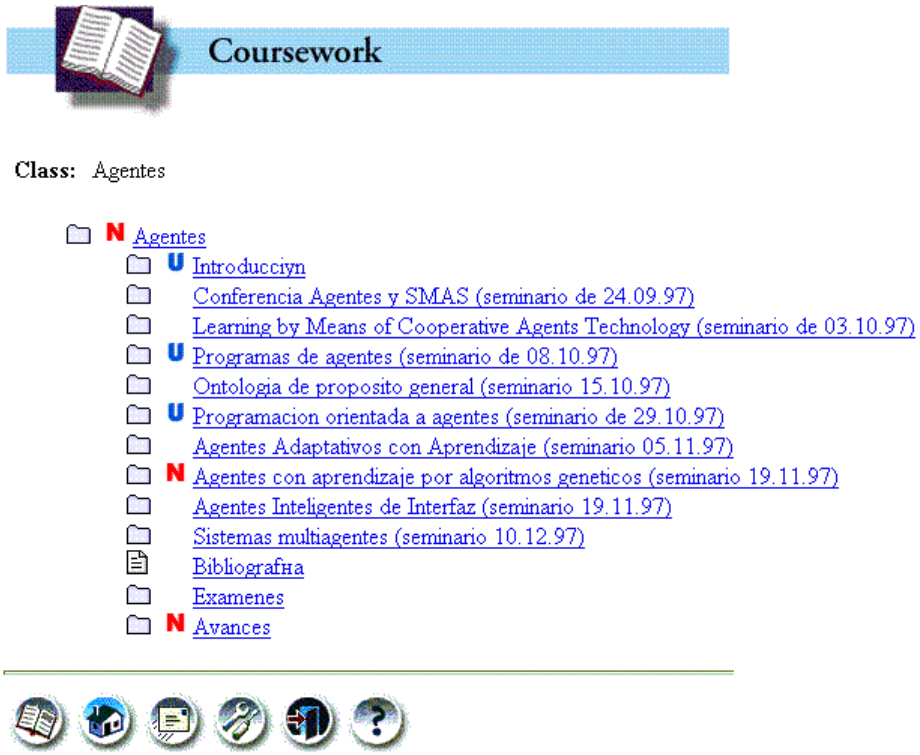


Figura 4. "Software agents" class announcement

5.3 Multi-Agent Education Software

The application of modern technologies of ITS and ILE shows the possibility to improve significantly the velocity and the ability of learning - **Murray, T. (1996)** -, - **Youngblut, CH. (1994)** -. The key feature of these systems is the possibility to acquire, represent and use knowledge. This knowledge usually contains the model of problem domain, which relate the concepts to be taught, a model of students believes, and a set of situations with current goals, current states and search mechanisms to find solutions and applicable rules to improve the level of learning. The multi-agent technology seams to be the most promising for the implementation of the systems of this type - **Shoham, Y. (1993) - - Guzmán A. (1996)** -.

A multi-agent system is composed of a set of agents, each of them with it's local knowledge. In EVA these agents form the personal environment of a student or a tutor (Fig. 5).

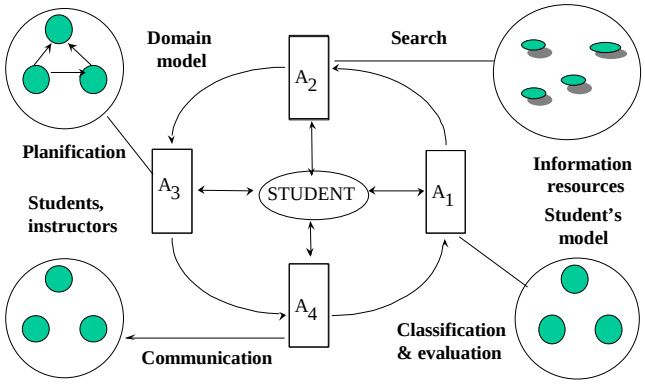


Figura 5. Multi-agent environment

The agents of 4 types with the following set of characteristics have been developed and used by the students:

Evaluation agents (A1):

- Evaluate knowledge,
- Try to find the reasons of misunderstanding,
- Communicate with the personal assistant agent to restructure information to be studied,
- Maintain the model of teaching techniques.

Internet search agents (A2):

- Search for the information relevant to the theme of study, analyze, aggregate and represent it to the student or tutor,
- Realize the connection functions with NNTP newsgroup servers,
- Realize the connection functions with HTTP Web servers,
- Collaborate with the other agents through the message transfer in the KIF format.

Personal assistant agents (A3):

- Select, integrate and order the information to be studied,
- Communicate with the search agent to find the relevant information,
- Communicate with the communication agent to collaborate with the other group members,
- Maintain the domain model,
- Advise problem resolution.

Communication Agents (A4):

- Select, integrate and order information to be shared by the tutor and students or within the group of students,
- Maintain the student model.

Our experience in the use of the agent technology permits to conclude the following advantages of its application to the DL systems development:

- The agents facilitate the analysis and recovering of additional didactic information,
- While processing large amounts of data they reduce the network traffic,
- The tasks fulfilled by agents can be accomplished in night hours,
- The delegation of the routine tasks to agents can liberate the students and tutors for more creative activities.

Conclusion

The principles of learning, validated through the prototype systems and tested through the project development, add to the enduring knowledge of learning and teaching that can guide the construction of new generations of intelligent tutoring systems. The proposed technology tries to overcome the well-known shortcomings of the ITS - **McArthur, D., Lewis, M., and Bishay, M. (1994) - - Clancey, W.J. (1987) -**:

1. the need in the complete knowledge of a subject domain and possible errors in knowledge (the nature of the 'expert system' approach),
2. the relatively "thin" subject knowledge and the capability therefore of imparting only a shallow understanding of topics to students,
3. the restricted knowledge of teaching (the need for the expert system, which we can not yet build because of the absence of good tutoring heuristics),
4. and the lack of flexibility in applying the teaching methods.

The first results show that the students are very interested, and have a really higher participation ratio than during traditional sessions. We think that the key factor allowing the students to better focus their attention, is the possibility for them to personally step in. A strict scientific evaluation of the improvements due to these teaching techniques in the domain of learning seems particularly difficult. We are nevertheless convinced that a strict evaluation of the improvements brought by the mentioned techniques, not only based on the user's satisfaction, will be necessary.

Our first experience in the development of new technologies like DL shows us that these efforts will require a division of labor - different groups or projects working in a coordinated fashion to put together the technology, curricula, assessment tools, professional standards, and teacher training pieces of a package of broad educational reform.

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