COLLABORATIVE E-LEARNING IN ENGINEERING AND ARCHITECTURE: INTELLIGENT SYSTEMS FOR KNOWLEDGE SHARING IN ON-LINE DESIGN LABORATORIES.

Vittorio Spigai[1], Massimiliano Condotta[2], Cristina Stefanelli[3]

ABSTRACT

From 2000-2004 the activity of the research group working at the Faculty of Architecture of Venice and its associates focused on the construction and the experimentation of an e-learning system based on the idea of a "virtual atelier" intended to be used both as a didactic environment (virtual class) and as a teacher-student dialogue tool able to check the designs developed by the students in the virtual laboratory.

Since 2001 the "TDraw" system, installed on a IUAV (University of Venice, Faculty of Architecture) server, has been used by about 300 students from a number of training Courses of different academic fields. From this experience it is possible to affirm that in a didactic system (like this proposed) formed by one or more virtual laboratories, the practice of the teaching can provide a universe of notions which grows quickly during the progressive utilization of the system. It is a precious whole of information, dense and heterogeneous, potentially separable into individual learning objects which can be taken from the context where they have been utilized. Their didactic value, however, increases if linked and related to other learning objects (for example those which make up the on-line lessons of the Courses).

For this reason the "TDraw" laboratory method needs to be supported by a parallel system that is able to transform it from a pure tool of communication into a more complex system of semantic examining of the data in order to have an automatic acquisition of the information, as well as to be able to suggest solutions already experimented to problems already dealt with; in this way we shall avoid losing the abundant knowledge produced in the atelier activity.

In this background and with this aims, after four years of experimentation, the IUAV research group is now improving the system establishing some supervisory functionality of the operations aimed at index and classify the atelier's experiences, toward a system updated in real time and open to self-learning perspectives: the new "T-Labs" system.

The main objective is to combine the previous experiences in an integrated tool ("T-Labs") able to link and relate the e-learning system, the whole of the notions grown in the

[1] Professor, University IUAV of Venice, Faculty of Architecture, Department of Construction Building, Venice, Italy, spigai@spigai.191.it

[2] Architect, University IUAV of Venice, Faculty of Architecture, Department of Construction Building, Venice, Italy, massimilianocondotta@alice.it

[3] Architect, University IUAV of Venice, Faculty of Architecture, Department of Construction Building, Venice, Italy, cristina.stefanelli@iuav.it

course and the galaxies of theoretical and documentary information which orbit in the web. Therefore associate the user-system with tools of research based on interactive writings of navigation routes' representation and filters not exclusively based on lexical keyword systems but also on image analogies, graphic lines, morphological and tectonic typologies, materials, textures, etc.

With this system, starting from the interrogatives that arise during the teacher-student relationship in the virtual atelier, or from the real interrogatives of the real design activity, each student, teacher or worker in the field of architecture and construction, can search and found possible solution to his design problems.

KEY WORDS

E-learning, Research tool, Virtual atelier, Intelligent tutoring system, Cognitive Sciences

OBJECTIVES

The subjects and the topics dealt in this essay are the results of a four years experience in collaborative e-learning, which practice, experience and developing process, that constitute the scientific starting point of the research work, will be illustrated in the following paragraphs.

As stated in the abstract, in this phase of development of the collaborative system, the work is concentrate on merge the various collaborative and learning systems into a one interactive system. As a whole, nevertheless, this research is directed to the following sections:

- Collaborative e-learning. The study and the develop of e-learning for those disciplines that largely use the technique of "learning by doing", the construction of virtual environments with student-teacher interaction, performed according to synchronous methods or according to methods extended internally in advances systems (collaborative manipulations on the web, between students and teachers, collaborative production of papers, advances systems of mark up). To sum up a system that works as a "virtual atelier" (fig 1) where share and store all the practice exercises: the student's tasks and relating teacher's annotation and correction.
- Protocol analysis for knowledge sharing. The study and the develop of monitoring systems and protocol analysis of generative processes of the project. Recording and description of the flow of typical and significant concepts that are at the base of the solutions operated by expert teachers. Every flow is connected to a particular problem or objective. Every flow contains in its development multiple references to relevant cases and concepts. This representation can be used as a foundation for comparison and as an element of reference in the valuation of the flow of projects effectively used by students. The aim of the system is to link and relate the whole of the notions grown in this e-learning system with the student's tasks and with the galaxies of theoretical and documentary information which orbit in the web.
- Didactic Environment. Insert the previous points in a combined didactic environment featuring didactic materials: theoretical written lessons, recordings of class lessons,

references, links and other documentation, but also the whole of the knowledge arisen from the collaborative system.

THE TRANSMISSION OF THE KNOWLEDGE IN ARCHITECTURE

In school, in the university and in the world of industry, in many applied sciences and in many applied arts, the transfer of knowledge occurs only partially through lessons in the classroom or through theoretical notions of the course books.

It is well-known, in fact, that students in such fields of study learn by means of continuous interaction between theoretical knowledge (from lessons) and concepts acquired through examples and advice from experts, and especially through practice on the field (guided with the teacher and/or technical experts that are directed personally and exclusively to the individual student, staff, and workers.

A big amount of learning is entrusted to practical exercises conducted with various methods and instruments according to the discipline, characterized by the constant commitment of large amounts of time and energy to every single student to develop his/her personal, individual and specific preparation. Such an accumulation of didactic experience generally gets burnt into the training of only a single student. In some cases they are recorded, enabling them to be handed down and entrusted on the average to the majority of obsolete and ineffective cases.

Regarding architecture even today the didactic transfer methods of theories and design remain assigned principally to a visual-oral tradition (conference with projected images) to practice in the studio (exercises, ex tempore, and workshop) and mainly to the periodically correction of the student's tasks (executed by students individually or in a group at home) by the teachers, correction done one by one but attended by the whole class, in fact, this is one of the most important didactic moment in the teaching of architectural design.

It is easy to affirm that all these transfer method of the know how of architecture have great difficulty in being established in a unified and shared body of ideas. The difficulty is even greater than for more solid fields, due to the scientific establishment and traditional technical-training practices divided by contents of theory (for example, courses and practical studies of science of construction and rational mechanics, applied chemistry).

In fact, the architectural design - even due to the inconsistent theories of the subject - creates a moment of great effort of synthesis, in which various knowledge tied to artistic-poetic inclinations (ideas, social and cultural messages of the project) as well as to technical inclinations (functionality, habitative well-being, constructibility) but also to knowledge of the different levels of the project (from urban responsibilities, to the choice of materials, of details, of components produced by the industry) are gathered to merge simultaneously, even daringly, in the synthesis projected since the first layout on the drawing board.

The collaboration and the sharing are afterwards, among the cluster of the knowledge transmission feature, very important and in this field the input of the computing and information technology can be significant. To do this is necessary to find a way to monitor the multiple experiences and the activity that normally take place in a didactic room, to record this activity, to select it, use it and make it beneficial in an expert system capable of assisting and monitoring the multiple experiences.

The peculiarity of teaching in applied disciplines resides greatly in the physical support of the student-teacher interaction, which consists of scripts, prototypes, handmade products, or presentations (artistic, sporty, etc) produced by the individual student.

In architecture, the presentation generally consists in an illustrated paper/composition. The corrected and revised paper, marked with suggestions, annotations and notes from the instructor, represents an inalienable moment of synthesis in the teaching and is a very powerful didactic instrument.

THE VIRTUAL ATELIER

The educational development passes inevitably through communication of knowledge and operative know how with a relevant flow of ideas and abilities from the expert (teacher) to the student. The complex path of reception and view of papers and their corrections, validations of methodological and enlightening elements, needs constant references to previous experiences, experimental cases etc. Particularly in architecture, in the correction-revision phase, the instructor, describing the better strategies to the solution in relation to the project, making suggestions, references, technical foresight, advises possible choices and the text references to which the student can find the necessary documentations.

The critical interiorization of the ensemble of stratagems carried our is the foundation on which one builds the cultural and technical knowledge of the student. We know that this process is widely destructured and left up to the practice and experience of the teacher. On the other hand, the new interest towards economies of scale caused by the introduction of teaching at a distance in all sectors of education, points out the problem of analyzing and rationalizing these cognitive processes that traditionally happen only in presence.

In such a direction, from 2000-2006 the activity of the research group of Venice focused on the following: the construction of an e-learning system based on the idea of a "virtual atelier" intended to be used both as a didactic environment (virtual class) and as an instruments of student-teacher dialogue for a practice of revision at a distance of the student's design task and papers (fig1, 2).

This system of revision at a distance (the TDraw system evolved in the new and current version named T-Labs) has been the first operative experiment of exercises online in Italy in the Department of Architecture and has been successively inserted in the European research system WINDS, inside the V program quadrant IST-CEE4

[4] The research "WINDS- WEB BASED INTELLIGENT DESIGN TUTORING SYSTEM IN ARCHITECTURE AND ENGINEERING" - coordinated by prof. Mario De Grassi- IDAU - Department of Engineering in Ancona, was financed internally by the CEE program: Information Societies Technology (IST) - Fifth Framework Programme, European Commission, 1998-2002 and 2002-2004. Twenty-seven institutes collaborated to the research from European universities, research institutes (METE s.r.l., CNR-Institute of Psychology) and software and computer programme production companies Nemetschek and FIT.

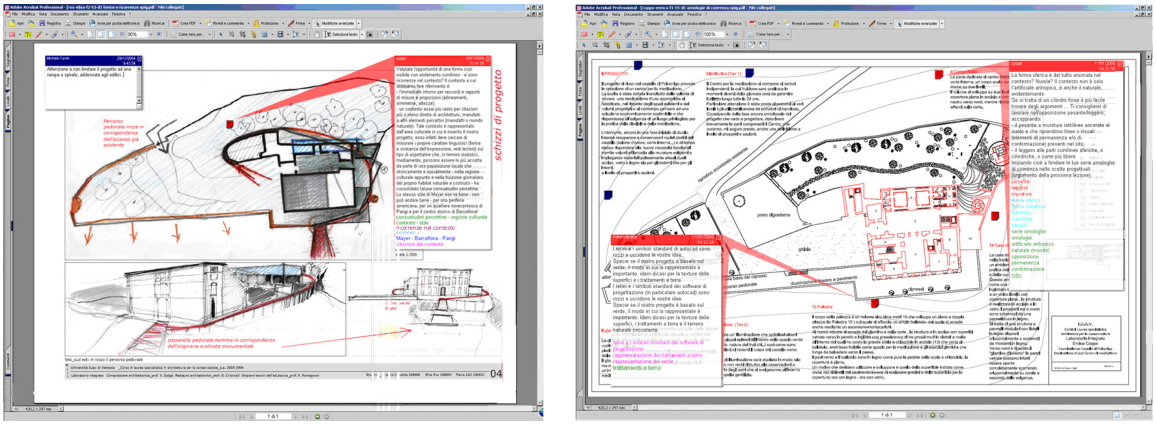

fig. 1: examples of student's design task with teacher's annotation and correction as exchanged in the "virtual atelier". The annotated paper is the most important teacher/student comunication means. In the T-Labs system it has been transferred from the paper space to the digital computer space.

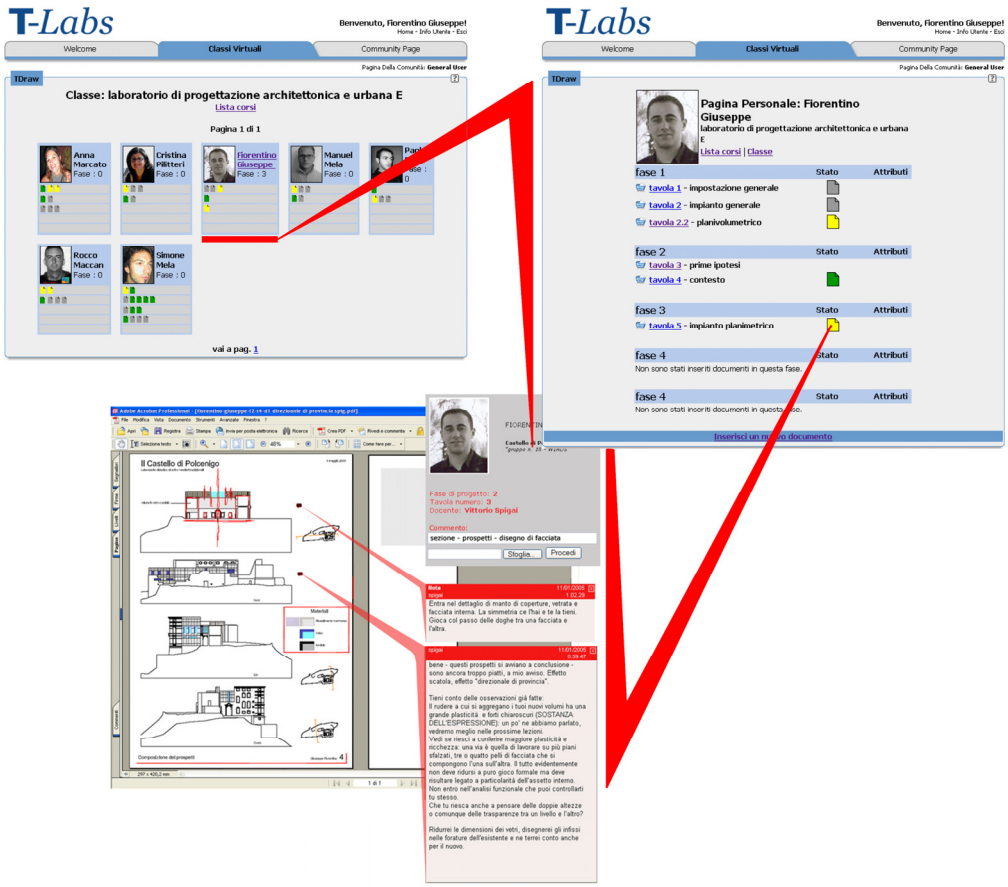

fig 2: The virtual class, the personal page of a student and the design task like appears in the T-Labs system

The virtual atelier can be physically placed in fixed areas within the university (computer science classrooms deliberately equipped) as well as in private terminals spread around the territory and insert as a portlet in the home site of the school, or of the institution.

In the current academic year it held numerous courses and laboratories of the IUAV and of other external users, all of which take advantage of this service.

Since 2001 the TDraw (and from now T-Labs) system, installed on a IUAV server, has been used by about 300 students from a number of training courses of different academic fields. In the academic year 2003-04 alone there were over 150 students from official Architectural Design courses and laboratories, from Restoration and Construction Technology courses of the Faculty of Architecture and from the Engineering courses of Venice and Ancona.

In the 2004-05 academic year the system has had an experimental use by the following:

1 laboratory of design, restoration and installation (major in architecture-conservation-IUAV-Venice) - 70 students enrolled. 1 laboratory of degree (architecture-conservation major - IUAV-Venice) -10 students enrolled. 1 laboratory of degree (major in quinquennial system - IUAV-Venice) - 40 students enrolled. 1 Computer programming course of the Istituto Tecnico Industriale di Stato "F.Severi" of Padova. – 20 students enrolled. 1 laboratory of degree "Architecture of steel, glass and high technologies" - IUAV-Venice - 30 students enrolled. 1 Construction technique course - IUAV-Venice - 30 students enrolled. 1 Architecture and architectural composition course, Faculty of Engineering of Ancona - 70 students enrolled. 1 Architecture and architectural composition course, Faculty of Engineering of Ancona - 60 students enrolled.

During these years of work and teaching, the system has stored a great quantity of students' works files. An enormous quantity of data that presents hints, indications, and suggestions related to the questions pertaining to the project. This material, the recording of the activity of a community of designer-students and a designer-teacher expert, strongly outlined in the pedagogic point-of-view, is presented as very destructured, at first impression, confusing and difficult to consult with. We asked ourselves if and with what methods this wealth of knowledge- in the traditional didactic activity, destined to be erased after use - could be reused and exploited in different contexts; for example, as a new offer within a course.

However, the very nature of the education acquired through studio-practice is nonlinear and this difficult to organize, carrying the risk of reducing it into a list of abstract rules for the project-design or into a manual.

For such reasons, we developed system that provides the possibility to navigate in a personal manner through the internal contents; a system, who link the exercise to one or more keywords the instructor assigns to the student work.

This indexation motor refers to the decomposition model on a semiotic basis that recaptures the lucid and always valid intuitions of Hjelmslev, revived by Greimas and his young students at school of Paris in the 70's. the model was later further adjusted with the decisive influence of the work of Thurlemann (Greimas's student) in the visual arts field and was reworked by our group in Venice starting from 1980.

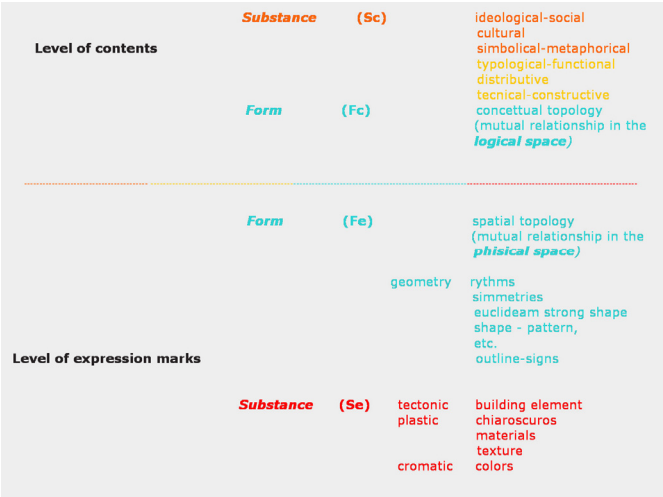

Fig 3: Decomposition model for indexation. The colors signal the different categories of concept (orange), typologies (yellow), spatial topologies (blue), and perceptive feauter (red), chosen to sum-up the complessity of the mental mechanism that presiede the design process.

INDEXATION SYSTEM

A designed course represents, as it has been said, an effort of synthesis in which different abilities and understandings unite. The student-designer, in order to make them merge and interact in a designed exercise, generally refers to:

- his/her own synapses (individual and personal information, notions, intuition);
- explicit knowledge, the education based on the world of architecture- but also of painting, music, the natural world, etc.- understandings that are traceable and quantifiable and that are transferred through diverse media and are accessible in consolidated "repositories" (libraries, archives, etc);
- tacit knowledge, which is the know how transmitted at the drawing table in a collaborative interaction between the student and teacher, groups of students, and which is based on the comparison of experiences and imitation. This knowledge is "tacit" which is subliminal to the experiences (of studio practices) and in the traditional didactics of projection it is not formally transported in any medium; therefore, it is not collectively useable at different times.
- The aim that brought to the integration of an indexing system into the virtual atelier, was to understand if and how it is possible to render explicit the tacit form of understanding of collaboration by way of:
- conserving the liberty of the authors with the process to use communication protocols, consolidated and natural (the table, sketch, non-verbal communication);
- rendering the contents and flow of tacit know-ledge useable even tto users who are strangers to the process, even in different locations and time.

The activity of the virtual class has permitted, in the span of five years of activity, to accumulate an enormous quantity of data that presents hints, indications, and suggestions related to the questions pertaining to the project. This material, the recording of the activity of a community of designer-students and a designer-teacher expert, strongly outlined in the pedagogic point-of-view, is presented as very destructured, at first impression, confusing and difficult to consult with. We asked ourselves if and with what methods this wealth of knowledge- in the traditional didactic activity, destined to be erased after use- could be reused and exploited in different contexts; for example, as a new offer within a course.

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Such occurs through concepts that refer to other concepts and which tend to guide and produce the associative process that the student, measuring himself/herself on a projected exercise in the special and stimulating environment of the virtual classroom, puts into action during the brainstorming phase of ideas and solutions to the proposed theme.

In the indexation system, having identified the number of the exercise and the brainstorming phase, the instructor assigns one or more keywords to objects which will gradually accumulate in the system.

The keywords refers to: theoretical concepts, significance and a profound sense of the project, constructive and architectonic typologies, perceptible materials (texture, color, etc), geometry, form, conformation, syntactic structures, projected actions, compositive operations in the composition and manipulation of the project (deformation, superposition, addition, subtraction, stretching, scaling, etc), architectonic, historical and geographical references, instruments and techniques of the plan, recurring errors and didactic suggestions, etc.

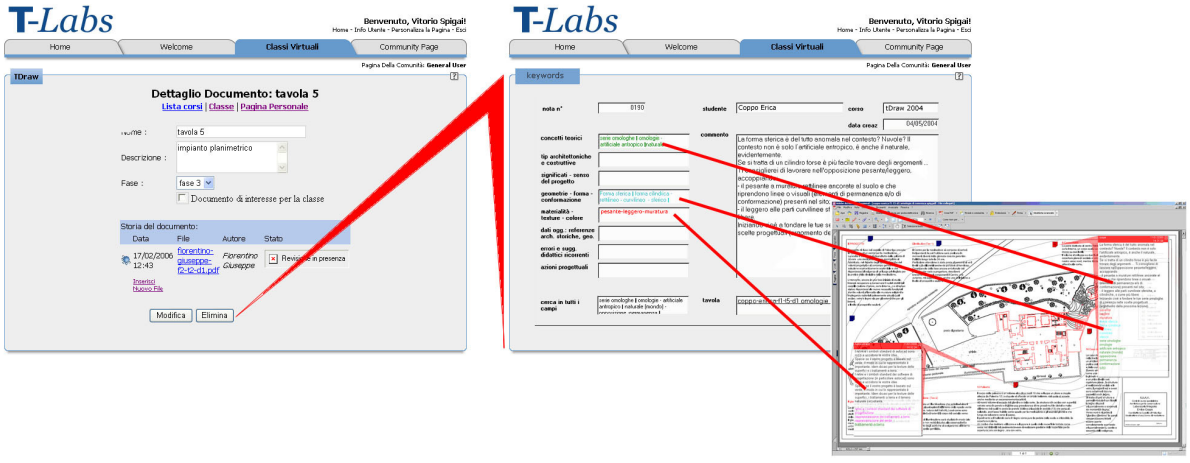

Fig 4: This indexation system is featured by T-Labs and monitor and classify all the design tasks according to the instruction of the teacher while is correcting the papers.

INTEGRATION BETWEEN E-WORKS AND E-LESSONS

In this background, after five years of experimentation, the work of the IUAV research group, beside being addressed to improving the system establishing some supervisory functionality of the operations (the evolution from TDraw into T-Labs), is also turned towards create a more complex and dense didactic environment obtained by the correlation between the whole of the notions featured in the exercises and the theoretical lessons that will be inserted in the portal of the course.

The basis idea of this operation is that the whole of information contained in the exercises are potentially separable into individual learning objects (which can be taken from the context where they have been utilized) and usable like single notion pills, but that their didactic value increases if linked and related to theoretical lessons or papers which deal with the topic of the exercise themselves.

TOWARDS AN OPEN SYSTEM

If on the one hand, the T-Labs methodology make easier the diffusion of the didactic moments grown in the virtual atelier and in the real classroom, and make this didactic moments reusable setting up a consistent store of knowledge, on the other hand, paradoxically, there is the risk of transform this in a close system disavowing the primary objective: the collaboration and the sedimentation of the knowledge focused on the sharing. The risk afterwards is that the system regenerate itself without share its knowledge and without being contaminated by external contributes.

The first step to improve the system is to transform the inner structure of the system: from a database to a complex web portal able to manage various elements and external inputs.

In this technical phase, still ongoing, the research group avail himself of the Archeometra s.r.l collaboration (a society working at a national level in the computer science field and in software programming), with the aim of get together and insert the previous experiences in a sole tool ("T-Labs") able to link and relate the e-learning system, the whole of the notions grown in the course and the galaxies of theoretical and documentary information which orbit in the web.

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