



## POLized e-Learning using contract management

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Received 18 February 2003; accepted 14 April 2004

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### Abstract

We present an innovative way to manage online learning by administering experiential learning activities during a semester-long, web-based course that is designed with the Project Oriented Learning methodology. A consulting-style guiding thread for in-class and remote workshops is implemented using a professionally relevant project contract that describes teamwork actions. Specific project goals and deliverables are negotiated and a workplan is asserted in an XML database. Performance by a team is measured according to cumulative success or failure in one or more milestones that lead to such goals. We present an inference mechanism that reveals the behavior of a team, in terms of compromise, competition, precision, self-motivation, or individualism on every milestone session. Such behavior becomes evidence used by the instructor to scaffold students, both individually and as groups. This research embraces both content and activity management.

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*Keywords:* Project oriented learning; Collaboration; XML; Portfolio; Behavior

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### 1. Introduction

Learning on the Internet currently holds a predominant place in modern academic circles. Herein, collaborative learning is one of the mainstream areas of research today (Kuljis & Lees,

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2002). A related and key issue being investigated by the Artificial Intelligence in Education (AIED) community is modeling human tutoring strategies alongside adaptive content delivery.<sup>1</sup> Student Scaffolding (Hogan & Pressley, 1997), Socratic Teaching (Espinosa, Corlay, & Meza, 2000), Coaching (Selker, 1994), Didactics and Inquiry (Keegan, 1995) are just a few of these strategies being computer-modeled. Broadly speaking, we may refer to all these ontologies as *Computer Assisted Active Learning*<sup>2</sup> (CAAL) because they all depart from a traditional, lecture type, method of teaching, and center more on workshops and other types of teamwork. Countless educational institutions and government bodies have invested heavily in computer facilities for deploying an ever growing number of courseware and online learning management facilities, many of which are CAAL-oriented. This type of schooling that emphasizes group activities is a form of *active learning*.

Several dozen research products have been maturing over the last decade, and are in widespread use around the globe. It is commonplace nowadays to talk about e-Learning as information technology that provides explanation, tutoring and intelligent diagnosis of student's understanding of a knowledge corpus (Atolagbe, 2002), whether transmitting such knowledge, or executing a proactive method for learning. Another trend is the more socially-oriented application of theories of Cooperative Learning and Social Interdependence (Johnson & Johnson, 1998). On the technological side, intelligent tutors like DOCENT, ELM-ART, REDEEM and XAIDA, among others, excel in scientific innovations for curriculum planning and sequencing, simulation and characterization of pedagogical strategies.<sup>3</sup> On the commercial side, products, like Learning Space,<sup>4</sup> from Lotus Development, and WebObjects,<sup>5</sup> have proven useful in delivering mass online educational content in mission critical projects, like the Virtual University at the Monterrey Institute of Technology.<sup>6</sup>

## 2. E-Learning under surveillance

However, many people still think classroom computers have been oversold and underused (Ellis, 2002; Foster, 2002; Kaliym, 2002; Seagers, 2002). Other studies point out the fact that most computer assisted learning software is still not of commercial quality, and that there are still many unanswered questions, specially those that apply to modeling instructional situations precisely enough so that authoring tools for these can ever be in widespread demand (Murray, 1999).

Why the skepticism over successful technological and pedagogical advances? For two reasons: one belongs to a social trend, or viewpoint, and the other one corresponds to technological thinking.

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<sup>1</sup> As witnessed on recent publications list in the Artificial Intelligence in Education Society (AIED) website: <http://cbl.leeds.ac.uk/ijaied/home.html>.

<sup>2</sup> Note on style: On this paper, the authors will use italics for stressing a key concept, or idea.

<sup>3</sup> Top 100 most referenced papers of the International Journal of Artificial Intelligence in Education (IJAIED), at <http://cbl.leeds.ac.uk/ijaied/top100.html>.

<sup>4</sup> <http://www.lotus.com/products/learnspace.nsf/wdocs/about>.

<sup>5</sup> <http://www.apple.com/webobjects/>.

<sup>6</sup> <http://www.ruv.itesm.mx/>.

The first set of motives belongs to social sciences and humanities. Researchers on these fields argue that research has not been able to fully prove that students are motivated to learn when the instructor applies cognitive science, based on the theories of Piaget and Vygotsky, to their classroom's activities (Cook, Smagorinsky, & Fry, 2002; Wilson, 2001). Johnson and Johnson state that "... changing to a cooperative style of teaching is not simple. There is a big difference between putting students into groups to learn... and structuring your teaching so students learn cooperatively..." (Johnson, 2000). Stated in another way, grouping people in a classroom will reveal undesirable side effects: conflicts such as student *competition* and student *individualism*, rather than just *cooperation*. It takes skill and practice to handle these social phenomena, especially over the network, *because they convey careful negotiations, just as in a business scenario* (Hammer et al., 2000). As a result, the overall goal may get lost, and many teachers and professors achieve little benefit from adopting these new strategies, with respect to doing things the old fashioned way.

The second set of motives comes from technological thinking. Research and commercial groups estimate that computer-assisted learning has had particular problems: balancing computer science innovation with academic and teaching goals. Kuljis and Lees state that "... whereas most research projects attempt to implement the most recent technological developments, commercial products seem to focus in providing efficient e-Learning solutions using already available solutions..." (Kuljis & Lees, 2002). In other words, complex artificial intelligence ontological developments sometimes seem to render no educational benefit in real classroom situations. A prime example is the use of adaptative web content generators for online courses. Most of the pedagogic design behind commercial products is instructional, and thus based on textbooks. This is true even in multimedia and virtual simulation environments. We have shown in Espinosa et al. (2000) that students not always consult these types of online references and thus may tend to prefer traditional content sources, like photocopies of books and PowerPoint class notes. Moreover, overusing artificial intelligence or soft computing not always is the best solution for aiding in learning, simply because people tend to learn in unpredictable ways (i.e. using mechanisms hidden, or out of reach, to an instructional designer) (Heath, 1997). For example, many people prefer to chat rather than post items in a newsgroup or use some other sophisticated learning environment when working on a project at a distance, because it seems more "personal", and is real-time (Espinosa, 2000). Even then, they may have produced learning. The question is: how can we actually observe evidence that the learning process is [not] taking place?

We believe the solution may be filtering out the aforementioned side effects using IT, whenever they may take place (e.g. not only when the instructor and students are together), using for that purpose a set of socially relevant services and content on the Internet. The following sections attempt to prove this point.

### 3. Evidencing that the learning process is relevant

If we join the comments on both trends in Section 2, we may visualize phenomena common in the film industry. A story may be appealing to a large audience, and could become a recognized piece or art, without resorting to technological breakthroughs in animation and visual effects, *if it is told correctly*. Many of today's movie directors [completely] replace art with technology. The

audience may “like” the movie, but this attitude seldom lasts for long. The same thing happens when we try to stretch past the limits of artificial intelligence, information technology, and social science. If we want the student to incorporate long-term learning from the course, it must be relevant to the student in all professional, social and cognitive levels. For this to happen, an appropriate balance of socially pertinent content, plus motivating technological assistance, must be offered.

Therefore, a problem exists when we characterize and implement the following concepts:

- Intelligent Tutoring
- Web-based Content Management
- Collaborative Learning

The problem is that *disjunctive educational and technological methods* are typically used for attacking the problem from all the social and technological viewpoints, although the overall goal is *conjunctive in learning*. Our hypothesis is that: if we may draw closer to the conjunction, we may discover tools for revealing conduct which is evidence that [lack of] learning is taking place. Of course, learning will also be measured when students deliver projects, quizzes, or exams. However, in our course, students are required to execute a substantial amount of workshop activities. These emphasize skills, skills show off knowledge, and knowledge is based on specific behavior.

Workshops account for about 50% of all class sessions during the semester. Workshops sometimes take place at times that do not correspond to their class schedule (e.g. weekends, at night, after classes end, etc.). Activities are done in both synchronous and asynchronous ways. The instructor may or may not be present during workshops. The intention is for teams of students to exhibit skills (plus inherent knowledge) as they present posters, co-evaluate their work, and auto-evaluate partial results. The evaluation criterion is always twofold: compiler construction must be efficiently done, but why? The project must be designed to become an e-Business or m-Commerce product. Under what circumstances we may argue that the project was a success? The project must be scientifically sound, but it must also have a target audience, and the development team must be efficient along the way (i.e. workload and compromise must be balanced). All workshop activities are designed for contributing a bit to the final project. As the side effects discussed in Section 2 will inevitably surface, all students are required to maintain a log of their work (more on this in Sections 5 and 6). The instructor will observe the log, group and teams, both physically and virtually, and make milestone interventions, playing roles (e.g. client, investor, end-user, etc.) whenever she considers necessary (or when trouble arises). The tutoring tools will allow her to be more efficient when interacting with her students.

In this paper, we will try to innovate from the ontological point of view, by proposing a new way to characterize the problem of offering a relevant learning experience as a *hybrid* experience. By hybrid we mean that a hardcore computer science course like compiler construction is full of social activities. This mix is generally seen as impractical by students at first. The challenge is to convince the students that this mix is relevant to their professional lives.

In the sections that follow, we will be focusing on CAAL-oriented research. We will depart from Computer Assisted Instruction (CAI) and Intelligent Tutoring Systems (ITS's), simply because we do not address content delivery and adaptation by characterizing human tutoring techniques, by themselves. Rather, we add another element: asynchronous perception of student activity for making inferences about the internal states of learning in the students. That is, we attempt to gather evidence of the learning process making use of a Project Oriented Learning

(POL) device, *a portfolio* (Young, 2002). We show how we implemented a web-based system that melds collaboration, content management, and tutoring. Finally, we present conclusive evidence that the POL portfolio does bring out behavioral components during learning, and discuss our current limitations and propose further work.

This work is also relevant because it proposes a low cost, high impact and pedagogically sound method that makes use of state of the art Java-based technology for accomplishing the task of promoting understanding (analysis, synthesis and other traits described in Bloom's Taxonomy). Therefore, we depart from behaviorism and adhere more closely to constructivism via the POL method.

We have identified similar research in the works of Barros, Verdejo, Read, and Mizoguchi (2002) on Collaborative Learning Ontologies. We adopt a similar approach to their characterization of knowledge about the study and analysis of the learning process, but add a sounder pedagogic framework by describing knowledge based on POL and Constructivism. We believe such approach is still unique.

#### 4. What may go wrong when applying active learning: The business side

The POL didactic strategy portrays active learning as an educational paradigm that transforms direct experience into a tool for supporting, and stimulating, learning (Miller & Boud, 2002; Sabine, 2000). In cognitive terms, POL is a direct descendant of the works of Piaget, Vygotsky, and Constructivism (Twomey Fosnot, 1996). Learning is thus characterized as *experiential learning*, where learners are active, but holistic in the construction process. It has been successfully used in a variety of learning environments. However, since this is a socially and culturally guided process, it is subject to interpretation and is commonly mishandled in otherwise well-structured projects because there is a widespread lack of knowledge about the very nature of what learning skills and human interaction are. Che and Zhang (1999) argue that most schools adapting themselves to deal with the structural change involved in creating a transformation movement miss the key issue in experiential learning: that *it is not by presenting content prepared to mimic an instructor's proprietary version of the domain knowledge that we will be able to foresee, or promote, learning by the students.*

The business side of e-Learning is relevant in this context. Technified youngsters<sup>7</sup> will expect to receive dependable Internet and web services for accessing educational resources. These services must be appealing, reliable and continuously available. Keep in mind that children and adolescents are the principal users of online games, newsgroups, IRC's, chat P2P's, MUD's, MOO's, and many other forms of very commercially successful virtual communication. What distinguishes popular sites and software is their marketing appeal *and their direct applicability*. The same "selling chain management" principles (Kalakota & Robinson, 2001) applied to market Internet portals and online services could be applied to e-Learning offerings. In other words, if a learning service on the web can be proven to be experientially useful for professional (i.e. consulting) or

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<sup>7</sup> "Technified" youngsters are children or adolescents who have grown using computers, mostly as video game stations, and have surfed the web extensively. They are also called "techies". The term is found at: (<http://dictionary.cambridge.org>).

commercial (e-Business/m-Commerce) purposes, *and is directly applicable*, then it will probably be more successful as a product on the web.

The idea of delivering applicable experiences and knowledge in Computer Science is not new. Denning (1998) questioned whether academic computer science will adapt to the demands for a profession in a skeptical world seeking pragmatic returns. Under this philosophy, innovation is seen as the act of (1) generating new *ideas*, (2) generating new *practices*, (3) generating new *products* and (4) generating new *businesses*. Hereby, students who have finished a typical compiler construction course will be seen as producing new ideas, but lacking the insight to produce the remaining three elements. Thus, a purely scientific approach will have little impact on a society that has begun viewing computer science as a profession. Additional elements, inter-disciplinary ones, are thus required to deliver effective skill-specific training, so students may then produce practices, products, and businesses.

How much demand exists for an online course is fully quantifiable, so its *operational* goals are measurable, say, in terms of user access hits on an Intranet, evidence that the site is acknowledged as *useful*. However, their *educational* success depends on keeping their inherent educational intention, provided by pedagogical insight of instructors and other school staff, such as laboratory and teaching assistants. In instructional terms, deployment of project-oriented tools alone will not render true learning. The professor must still scaffold the students to help them perform properly in individual and group activities that promote learning (Corbett & Knapp, 1996). Please note that scaffolding begins with the instructor, not with the student: *it is the teacher's initiative*. This is contrary to elements of Constructivism which emphasize that students must be allowed to initiate actions that favor their own learning (Che & Zhang, 1999; Yager, 2000). Overall success in these terms is not easily measurable, since most of the learning process will take place outside the realm of the computer system and will thus have to be assumed whenever there is evidence of its existence through visible actions (Espinosa & Ramos, 2002). Most CAI, Computer Supported Collaborative Work (CSCW), Intelligent Computer Assisted Instruction (ICAI), ITS Shells and ITS Toolkit systems deal with the instructional design of a course, characterized as curriculum planning and sequencing, tutoring strategy execution, device simulation-based knowledge acquisition, domain expert system knowledge transfer, and multiple knowledge types learning content presentation. All of them make efforts *so that students will browse through on-line pages of courseware*, either by using multimedia resources, dialogue systems, virtual worlds, laboratories, or tool repositories. Most of these have proven insufficient in terms of learning usability, because, again, they are complex systems *for presenting content on diverse media* (Henze & Nejd, 2001; Melis et al., 2001; Weber & Brusilovsky, 2001). The authors have not found evidence that such tools promote practices, products, or businesses.

It seems important to introduce e-Learning methods that break with the instructional, cognitive, and behavioral thought, and present new ones which contribute to building a representational mechanism for describing collaborative actions that take place in the classroom, assuming that such actions are the manifestation of the learning process where students expect direct applicability of theory and practice. The actions will be especially nourishing if they *are initiated by the student, not only by the professor*. For this to happen, a strong motivational element must exist. The goal then is to provide web services that the target audience considers are relevant to their context and current professional situation. For example, if a team of developers is able, at the end of the course, to organize itself for outlining key activities, pinpointing deliverables, assigning due

dates and responsibilities, keeping track of partial deliveries, and thus preparing the project budget, then maybe they will consider the whole endeavor as relevant. All this will be additional to learning compiler construction. If this were to happen, we could argue that Constructivism, and thus Active Learning, are happening, because problems in the two realms presented in Section 3 above would be jointly dealt with. These, and others, *are the challenges facing the e-Business of e-Learning*.

POL comes in handy. It proposes that a course must be guided by a single learning thread that requires active learning situations to occur. All these situations must contribute to developing a single course project. The project must be evidence of skill and knowledge acquisition that identifies and solves a real life problem.

We now proceed to describe the actual methodology behind our proposal for dealing with such challenges.

## 5. An introduction to POL

This pedagogic technique was first introduced in the University of Aalborg, Denmark, in 1985. It was later adopted in the University of Twente. Currently, the Monterrey Tech is employing it in a number of re-engineered courses with great success. POL emphasizes involving students in active learning processes that help them develop skills for solving real-life problems. The end-product of any course is a comprehensive project that demands a course programming schedule. The learner's task is to identify, design, and execute, key tasks for accomplishing the objective. Along the way, the instructor will aid with establishing and internalizing skills and knowledge necessary for the success of the whole endeavor.

The project must contain the following characteristics:

- Be appropriate for teamwork among 2–5 people.
- Have a consistent and realistic schedule that reflects compromises, both individually and as a group.
- Establish a list of fixed deliverables to be presented at the end of the course, as evidence of learning and knowledge acquisition.
- Details on the work plan, its outcome, and overall objectives must be open. That is, they must be defined from the perspective of the student (Yager, 2000).
- Must be concisely, and structurally, formatted.
- The professor, and the student, must be able to point out evaluation criteria for the whole course, based on the schedule.

In addition, the work plan must be the initial stem that eventually lets the student reach activities for:

- Self-Assessment and Reflection.
- Use of a portfolio.
- Teamwork.
- Collaborative work.
- Playing roles with classmates, teammates, and instructor.

On this research, *the work plan is called a Work Contract*, because it is modeled as a consulting device. Under the POL philosophy, teams will follow a process that starts with an initial

exploration phase, which later derives in conflicts, a “honeymoon phase”, an integration or disintegration critical point, and a final maturity stage which still allows for more conflicts to be solved in a more auto-critical and adult manner. This process is hereby characterized as a guiding thread, using a consulting methodology, for reaching teamwork objectives as listed above. Collaborative work and role playing are done during workshops (described in Section 3). This will be further discussed on the next section.

## **6. Using POL to evidence learning in a collaborative environment**

We use POL to characterize learning actions in a CAAL-type course in Compiler Construction for B2B Systems. This course has been a traditional target for obsolescence and irrelevance in the Mexican business context as a consumer of foreign technology, rather than a producer of its own high-tech. Throughout the years, students have questioned the pertinence of studying advanced discrete mathematics and systems programming for building compilers that are already distributed as freeware on the Internet. The new course deals with programming middleware that allows data to be shared and executed (i.e. transformed using compiler technology) across multiple platforms. The vehicle is Java programming for XML, which is a hot ticket on the market nowadays. The end-product is software that can be used in a number of popular telecommunications devices, such as cellular telephones, personal data assistants (PDA's), and the new generation of Pocket PC's.

The new course makes an effective mix of high-tech, which is appealing to the average Computer Science major, and attractive business processes that promise innovation, as well as well-paid jobs for those who are able to market their curricula in a multi-disciplinary fashion. The bottom line is that all of the above require countless translators to be written as part of the integration process, which is clearly a part of the Enterprise Resource Processing (ERP) trend in e-Business B2B (Bhaskaran et al., 2001).<sup>8</sup>

During a consulting and learning-type semester, a guiding thread that asks the students to build a project portfolio is run. The portfolio records a consulting job, divided into the following phases:

- Hiring and contractual agreements;
- System analysis and design components;
- Integration and recovery units and
- Recap and delivery actions.

The first three units of the course are designed, among other things, to give the student an insight as to what they can promise, or how can they negotiate a correct and plausible breadth for the project, as they tackle theory and practice during the semester. All sections are worked through using a combination of lecture and workshops. The course syllabus schedules all these activities, and outlines which are to be conducted online, and which will require a physical presence.

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<sup>8</sup> This course is partially available online at: <http://paginas.ccm.itesm.mx/~eespinos>.



**Workshop #0, B2B Proposal**

This workshop requires you to start Phase I of the Project Management Process. It is very important that you read about this in :**Project Administration Management Activities using POL**.

In order to accomplish this, you need to do the activities described below. Please note that these will constitute a public & group report which has no connection to other activities (simply because this is the first one of the semester).

Activity	Product	Time
Fill out registration electronically	Team entry	Before workshop starts
Fill out registration form in worksheet	Excel Docmt.	Before workshop starts
Perform the workshop	Required	Before Due Date
Enter workshop log electronically	Team entry	After finishing workshop

**Fill out registration form electronically**

Team Name:

Team Member Registration			Leader
Last	First	ID	
<input type="text"/>	<input type="text"/>	#####	<input type="radio"/>
<input type="text"/>	<input type="text"/>	#####	<input type="radio"/>
<input type="text"/>	<input type="text"/>	#####	<input type="radio"/>
<input type="text"/>	<input type="text"/>	#####	<input type="radio"/>
<input type="text"/>	<input type="text"/>	#####	<input type="radio"/>

Fig. 1. Online action registration entry form.

### 6.1. Hiring and contractual agreements

The first part of the consulting project will consist on establishing the following key elements of the project:

1. The team itself, that is, who conforms it, and what are each member's strengths and weaknesses.
2. What will the project be all about?
3. What will the scope and depth of the project be. This will depend on (a) the number of members of the team and (b) the nature of the project itself. We use the software engineering CO-COMO<sup>9, 10</sup> model for project depth and breadth evaluation and apply it in calculations within the portfolio.
4. What will a correct balance between (a) e-Business (Ingham & Shrivastava, 2000; Kalakota & Robinson, 2001), (b) Compiler Technology, (c) Data Transfer and Sharing, and (d) Project Management, be for this particular project?

All these items will be filed online, using a registration form shown in Fig. 1.

<sup>9</sup> <http://sunset.usc.edu/research/COCOMOII/>.

<sup>10</sup> <http://www.softstarsystems.com/>.

### 6.2. System analysis and design components

The second four units of the course tackle the core of the theory the course rests upon. Over these weeks, the students must elaborate a development plan to do two things:

- Deliver a credible IT solution to a data sharing and translation problem, in terms of its feasibility as an electronic or mobile business.
- Design a coherent model and architecture, in terms of Internet and web-based systems development.

For these purposes, the knowledge on what a compiler system is, what its principal components are, and how they are assembled into relevant information systems, is critical. A collection of programs that perform lexical, syntactical and semantical analyses of data and code will be developed using diverse techniques. An average learning curve assures that technical preferences and strengths will change drastically over time. Therefore, the work contract will most likely be modified from its original format at this point. This is OK as long as the major definitions are not altered. For example, the basic target industry and cluster are not to be changed at this point. The basic input and output documents will not be altered either. However, technical aspects of translation may be redefined. Linkages between components in the main model and architecture may be added, deleted, or changed. Other conditions and changes will be negotiated with the instructor by the team leader as required.

The POL portfolio must now include complete blueprints of the system architecture and data model. It is recommended that Unified Modelling Language (UML)<sup>11</sup> diagrams be used for specs, in addition to the online documentations using JavaDocs<sup>12</sup> that are required in the final project's requirements document.

### 6.3. Integration and recovery units

A loosely set of scanners, parsers and semantical analyzers will not do the job by themselves. The third set of four course units deal with the ability to integrate these, using the business plan and specifications developed in phase one. As a result, the work contract will be modified once again, specifying all changes, revisions, and additions to the architecture and system model. These two, architecture and model, must be partially executable by now, so a set of demos and test cases must be included in the workplan. Success in building a coherent set of test suites will evidence that integration is becoming a reality, or will prove weaknesses in the development plan, the business specs, or the group's performance as a team.

By now, it is key that the following aspects be fully documented:

- Number of hours worked individually, and as a group.
- A list of modules to be delivered at the end of the course, plus a status report on these.
- A list of documents (manuals, architectural specs, etc.) to be delivered at the end of the semester.

<sup>11</sup> <http://www.rational.com>.

<sup>12</sup> <http://java.sun.com/j2se/javadoc/index.html>.

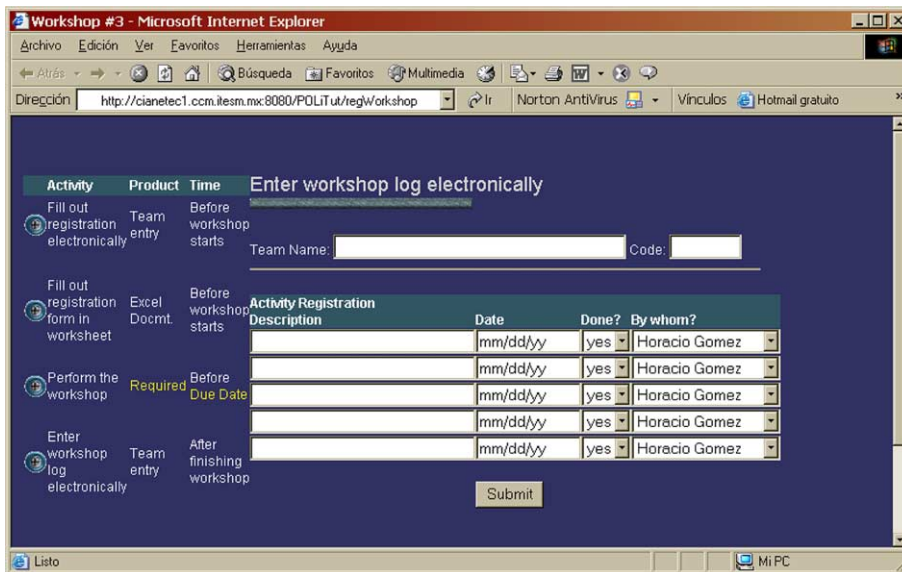


Fig. 2. Integration and recovery online.

- Compliance reports, based on the original project blueprints.
  - A list of future works and deliverables, based on work not feasible on one semester.
- Students enter these data online using the service shown in Fig. 2.

The POL portfolio must now include documented samples of code analysis, and runtime evaluations. These data will be easily obtained from homework assignments and workshops (if these are done correctly, of course). Please note that, at the end of this phase, each team leader will deliver a signed copy of the work contract that faithfully maps the electronically compromises stored.

#### 6.4. Recap and delivery actions

The last three units will face the student with state of the art tools that may evidence obsolescence and lack of portability in the techniques and API's used so far. Whether final adjustments should be made to the already existing development will be a decision to be taken by the team members, and informed through the project leader.

Therefore, the work contract may be simply given final adjustments and corrections, or it may be subject to one or two major changes, given the importance of adopting State of the Art (SOA) technologies. As a result, key points to be included in the work contract at this point are:

- Refinement of future work, or extensions, to the project. These must be clear and sound.
- Modifications to the main system's architecture in a plug-and-play fashion.
- A final revision of workloads, compromises, and compliance to these, by all members.

The project portfolio must be assembled in its final form (probably a CD-ROM), and prepared for final delivery. The structure and characteristics of this portfolio include all aspects outlined in the final project's requirements document, but also include the work contract itself, all assessments provided by the instructor, and two properly filled out questionnaires provided by the instructor. Please note that, at the end of this phase, each team leader will deliver a signed copy

of the work contract that faithfully maps the activities and compromises that were stored electronically.

The method is Collaborative because students have to exchange information, privately (co-operatively) or publicly (competitively), as teams, or individually (individualistically) (Johnson & Johnson, 1998), but always in shared modes of interaction using both client–server and distributed software. The client–server infrastructure contains data servers, and clients which allow entry and retrieval. Distributed segments of the network are those which allow non-hierarchical communication, either one-to-one, or one-to-many, or many-to-many. The instructor may or may not participate in either of these.

Consider Fig. 3 above. The complete portfolio is presented in its current version, a servlet-generated webpage. Related automated facilities for data entry are explained in the following section.

## 7. Delivering POL-ized collaborative e-Learning services

All the teaching material and support structure (i.e. presented as content in a website) are to be used by the student, while teamwork and assessment, actions that allow learning to actually occur, will be stored as evidence of collaborative actions. In practical terms, a WEBified delivery of POL courseware, a *POLized Service*, must include facilities for observing and recording concrete experience, observations and reflections, formulation of abstract concepts and generalization, and

The screenshot shows a web browser window with the URL <http://cianetec1.ccm.itesm.mx:8080/POLit/ut/WorkContractRep...>. The page title is 'Work Contract' and it is for the 'Compilers Course Spring Semester 2002' at the 'Instituto Tecnológico y de Estudios Superiores de Monterrey Campus Ciudad de México'. The team name is 'NEO' with 4 members. The workload is 2.0 person-months and 10.2 modules. The activity log is as follows:

Activity log		Dates		Effort	
Activity ID	Activity Name	Starting	Ending	hrs/week	person/month
1	Study of B2B Scenario	10/01/2002	18/01/2002	5.00	0.033
2	Study of XML Technology	21/01/2002	25/01/2002	5.00	0.033
3	Specify working business model	28/01/2002	01/02/2002	8.00	0.053
4	Make examples for XML	04/02/2002	06/02/2002	3.00	0.020
5	Make skeletons of XML Scanner and Parse	07/02/2002	08/02/2002	3.00	0.020
6	Define state machine for XML Scanner	11/02/2002	13/02/2002	5.00	0.033
7	Meeting to establish module links	14/02/2002	14/02/2002	1.00	0.007

Fig. 3. Portfolio as a work contract.

testing implications of concepts on situations. In our case, each of the four portfolio phases presented in Section 6 are deployed in the web as shown in Fig. 2.

In technological terms, the following elements were devised to implement such a system:

- An action planner.
- A task recorder.
- A surveillance module.
- A report generator.
- A User Model.
- A Database Management module.

These elements are implemented in the course website as shown in Fig. 3. Semi-structured data (Abiteboul, 2000) is implemented in XML because the resident information needs to be published using a growing number of platforms and formats. Therefore, these data sources are managed using Apache Xerces, Xalan<sup>13</sup> and Cocoon.<sup>14</sup> A set of auxiliary agents (Kotay & Kotz, 1994; Russel & Norvig, 1995; Yanping & Amieur, 2001) help the student in finding useful information sources that may be used for learning about negotiation (Hammer et al., 2000; Lei Zhao, Wee-Keong Ng, & Ee-Peng Lim, 2001) in a P2P-based (Parameswaran, Susarla, & Whinston, 2001) workshop on B2B processes that may be implemented using popular frameworks (Shim et al., 2000).

Fig. 3 shows the course roadmap to the left, the corresponding portfolio phases in the center section, and the technological implementation of both on the right-hand side. The User Model, to be explained in the following section, contains a program that makes an analysis of performance data obtained from the portfolio. This analysis consists of making inferences about a team's soft skill acquisition. Skills are hard to model, so unstructured XML (Abiteboul, 2000) data is used. An example is shown in Table 1.

Such data is asynchronously filled out by the students themselves, and by the instructor, as she provides feedback on assignments and workshops. Later, surveillance on how the team has complied with the assigned tasks and duties, in all categories, is assessed automatically by the Surveillance Module. Further actions to be executed by the students, or professor, may be extracted by the Action Planner.

The state of the learning process, and all related coaching actions, are reported using the Cocoon publishing framework,<sup>15</sup> a sophisticated web-based content management engine. Cocoon implements XML-to-HTML data transformers for executing the presentation management process. The user (i.e. student) model consists on analyzing the XML database, by planning and recording tasks, and by making a comprehensive surveillance of portfolio work in progress.

## 8. Inferring coaching strategies from contract compliance

During a semester in progress, all work contracts templates are filled out and an initial set of compromises is entered into the system. A typical set is as shown in Table 1. Later on, all four

<sup>13</sup> <http://xml.apache.org/xalan-j/index.html>.

<sup>14</sup> <http://xml.apache.org/cocoon/index.html>.

<sup>15</sup> <http://xml.apache.org/cocoon/index.html>.

Table 1  
Initial contract template

---

```

<team name = "Harris" id = "A1" nMembers = "4" dateCreated = "13/01/02">
  <teamMember name = "Charlie" lname = "Balderas" studentID = "923563">
  <teamMember name = "Hector" lname = "Loredo" studentID = "921916">
  <teamMember name = "Joaquin" lname = "Baltazar" studentID = "711474">
  <teamMember name = "Gerardo" lname = "Sanchez" studentID = "924820">
  <project name = "P.O.'s in Procter and Gamble" dateStarted = "13/01/02">
    <forecast manHrs = "104" hrsSemester = "312" personMonth = "2.05">
    <deliverable name = "Course Website with A&D, Portal and Business plan"
      type = "WebSite/HTML+JS"
      url = "http://paginas.ccm.itesm.mx/~923563/index.htm"/>
    <deliverable name = "Business plan, P&G XML-based P.O.'s "
      type = "Document/HTML"
      url = "http://paginas.ccm.itesm.mx/~923563/bplan.htm"/>
    <deliverable name = "CRM webservices suite"
      type = "Java/Servlets+JavaDoc's"
      url = "http://cianetec.ccm.itesm.mx/~923563/pg/crm"/>
    <deliverable name = "SLCM webservices suite"
      type = "Java/Servlets+JavaDoc's"
      url = "http://cianetec.ccm.itesm.mx/~923563/pg/slcm"/>
  </project>
  <workplan>
    <activity name = "Specify business" leader = "923563" started = "13/01/02"
      ended = "15/01/02" effortHrs = "3" personMonth = "0.020"></activity>
    <activity name = "Setup website" leader = "711474" started = "13/01/02"
      ended = "15/01/02" effortHrs = "6" personMonth = "0.039"></activity>
    <activity name = "meeting to establish general goals and ideas"
      leader = "924820" started = "14/01/02"
      ended = "14/01/02" effortHrs = "1" personMonth = "0.007"></activity>
  </workplan>
  <contract>
    <leader studentID = "923563"/>
    <milestone date = "15/01/02">
      <compromise signedBy = "923563" status = "OK" comments = "none"/>
    </milestone>
  </contract>
</team>

```

---

progress phases presented in Sections 6.1–6.4 must be worked on, and all resulting data must be entered into the system for later analysis.

Filling in a contract where compromises are to be settled is not a trivial task, especially for an undergraduate. Decisions have to be taken according to a self-evaluation of production lines per month, time to install and configure software, and effort invested in delivering a piece of error-proof text, like an abstract or a report. The authors have realized that a substantial amount of coaching is needed during the early stages of the project, and this is land of opportunity for a web-based tutor aid, but is also responsibility of the instructor to use her pedagogical skills, rather than just delegating this work to artificial intelligence tools.

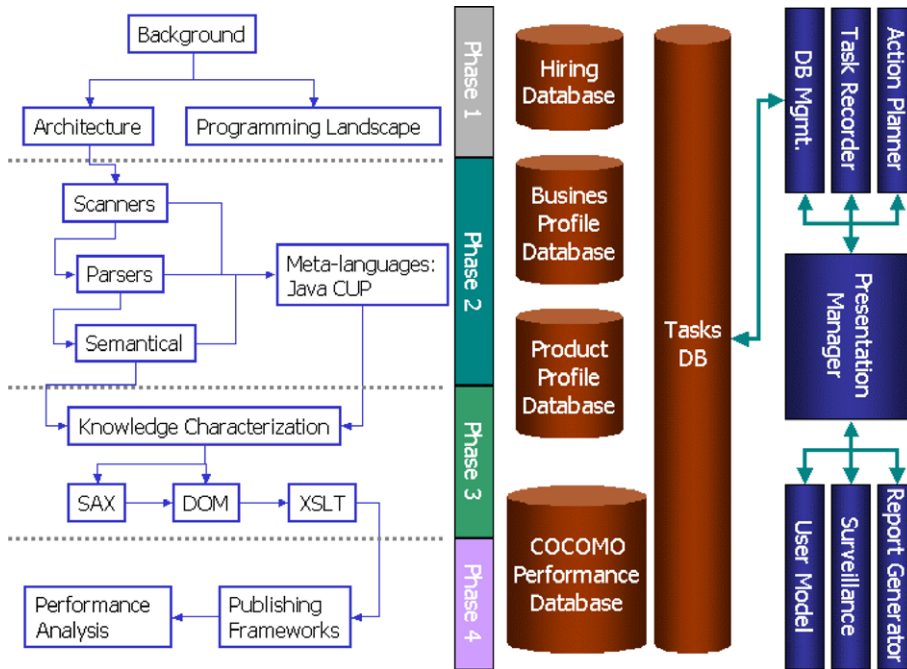


Fig. 4. Generalized POL-based model for collaborative and semi-structured behavior description.

We have developed the Action Planner, a recommendation generator based on manipulation of unstructured knowledge (Abiteboul, 2000). Such knowledge is created as the students enter more and more data into a *Task Recorder* (witness Fig. 4). Recommendations are then created on demand by a *User Model* and a *Surveillance Module*. The User Model runs a Bayesian Network, and the Surveillance Module is a XML knowledge base scanner that performs task-oriented forms of Temporal Logic (Espinosa & Ramos, 2002), while acting like a simple web agent (Kotay & Kotz, 1994; Yanping & Amieur, 2001). The complete architecture works as integrated web services (Bhaskaran et al., 2001; Ingham & Shrivastava, 2000; Shim et al., 2000). In this paper we do not make an extensive description of the temporal tool, since at the time of writing this module is still experimental and not a final part of the course.

We present a static Bayes’ net commonly applied to learning in a non-monotonic content presentation tutor shell. In this case, the net is applied to learning that is a direct result of building the portfolio, given that correct actions are entered into the work contract, and later executed. This is a two-state learning model with no forgetting. The first model describes how “... skill  $S_n$  is perfected at the  $n$ ’s opportunity to apply work plan action  $AC_n$  provided that such action has been correctly applied ...”. The latter is a transition state, from “incorrectly to correctly, applied” and is formalized as  $p(T)$ .

$$p(S_n|AC_n) = p(S_{n-1}|AC_n) + (1 - p(S_{n-1}|AC_n)) * p(T), \tag{8.1}$$

where

$$p(S_{n-1}|AC_n) = p(S_{n-1}) * \{p(AC|S)/(p(S_{n-1}) * p(AC|S) + p(GC_{n-1}) * p(AC|GC))\} \tag{8.2}$$

and

$p(S_n)$  is the probability that a skill will be applied correctly after  $n$  opportunities,

$p(S_{n-1})$  is the probability that a skill has been mastered at the  $n$ th opportunity to apply it,

$p(T)$  is the probability that an action will transit from incorrectly to correctly applied,

$AI_n$  is an action at the  $n$ th opportunity to test a skill

$p(AC|GC)$  is the probability that the action will be executed by guessing or chance.

A second case describes how “. . . skill  $S_n$  is perfected at the  $n$ 's opportunity to apply workplan action  $AI_n$  provided that such action has been **incorrectly** applied. . . ”.

$$p(S_n|AI_n) = p(S_{n-1}|AI_n) + (1 - p(S_{n-1}|AI_n)) * p(T), \quad (8.3)$$

where

$$p(S_{n-1}|AI_n) = p(S_{n-1}) * \{p(AI|S)/(p(S_{n-1}) * p(AI|S) + p(GC_{n-1}) * p(AI|GC))\} \quad (8.4)$$

and

$p(S_n)$  is the probability that a skill will be applied correctly after  $n$  opportunities,

$p(S_{n-1})$  is the probability that a skill has been mastered at the  $n$ th opportunity to apply it,

$p(T)$  is the probability that an action will transit from incorrectly to correctly applied,

$AI_n$  is an action at the  $n$ th opportunity to test a skill,

$p(AI|GC)$  is the probability that the action will be executed by guessing or chance net.

Applying the above models, we can build a network like the one shown in Fig. 4. This is a static network where the prior probabilities for nodes without parents will either have a uniform value or be computed from student's online input (witness Fig. 2).<sup>16</sup> In Fig. 4, such nodes are referred to as *DO nodes*. In POL-educational terms, this is where the milestone activity appears and teamwork is evaluated or negotiated, either by the student, or by the teacher, or both. The probability tables for context nodes contain the precision of each activity ( $A_{mn}$ ) given the precision of context  $A_{mn-1}$ . This probability depends on the degree of complexity a given task is modeled by. This means, the deeper detail the student(s) give to an activity, the better the skill will result. Of course, all activities will have to be approved by the instructor, either individually, or in blocks.

The following table is possible.

Activity	Skill obtained	Skill in Progress
$A_{mn} = SC_m$	$A_{mn} = 1$	$A_{mn}^i = 1 - A_{mn}$

(8.5)

This corresponds to precision when evidencing learning. Compromise and self-motivation are not quantified, but assumed as true in direct proportion to precision. Thus, internal learning states are investigated, but not modeled from the cognitive point of view. If skill acquisition values are the numbers 1, 2, and 3, then the formula for  $p(A_{mn} = SC|skill\ in\ progress) = 1 - p(A_{mn} =$

<sup>16</sup> Recall that in POL, the students will be required to do out-of-class work out of view from the instructor. In other occasions, they will do in-class work that the instructor will not necessarily close-check.



SC|skill obtained), where  $p(A_{mn} = SC|skill\ obtained)$  will be validated manually by the instructor when examining teamwork using the Surveillance Module (witness Fig. 3).

Activities are further decomposed into simple tasks (ST), each of which also contains a probability distribution calculated from its parents. The updating of the probability distribution of the static net is done forward by Do nodes, and backward by surveillance of the Activity nodes, whose values can then be propagated as needed. Since an action can be performed and refined several times, the surveillance module takes into consideration the past history, activity fixing, and a forgetting function (see 8.1–8.4).

Using this asynchronous probabilistic surveillance mechanism, the instructor was able to consult (online) every team’s performance, using the Action Planner. The action planner is not a proactive agent. It does not provide automated tutoring. It only makes use of the above network to implement a user model that works as a probabilistic (i.e. Bayes’) network, but is not intended to provide automated advice. Therefore, this tool is not an ITS. Neither is it a CAI. The intention is to provide insight on the student’s performance, but not in a totally automated way.

For example, a student may enter an activity as follows:

[Assignment #2] Establish project’s objectives.

The instructor must assess the skills in the process. Therefore, she tags the activity as incorrectly applied. The skills involved are: [problem] abstraction, identification and technical writing. In the opinion of the instructor,  $p(S_n|CA_n)$  is low. When the student consults her contract, the system will come back with appropriate feedback about her team’s performance. For example (see Fig. 5).

[Workshop #1/Feedback] You need to better your skills in identifying the problems.

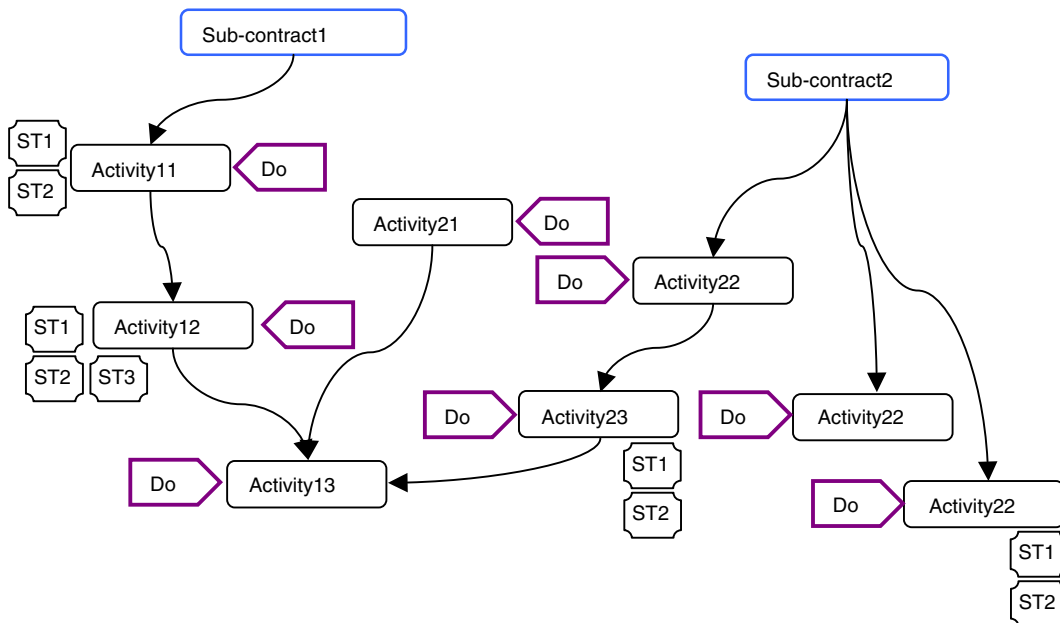


Fig. 5. Static Bayes’ Net for contract management.

[Workshop #2/Feedback] You need to better your skills in stating your objectives in a more detailed fashion.

The current learning state will be saved in the XML database as follows:

```
<activity name = "Specify business" leader = "923563" started = "13/01/02"
ended = "15/01/02" effortHrs = "3" personMonth = "0.020">
<feedbackState skill = "identifying" status = "0.2"/>
<feedbackState skill = "abstracting" status = "0.1"/>
</activity>
```

The process is subsequently applied, and the database grows accordingly. For example, if the students reconsider their project proposal activity, new data might be entered, as follows:

```
<activity name = "Specify business" leader = "923563" started = "13/01/02"
ended = "15/01/02" effortHrs = "3" personMonth = "0.020">
<feedbackState skill = "identifying" status = "0.2"/>
<feedbackState skill = "abstracting" status = "0.1"/>
  <subactivity name = "Identify problem" leader = "923563" started = "13/01/02"
  ended = "13/01/02" effortHrs = "2" personMonth = "0.012">
  </subactivity>
  <subactivity name = "Write hypothesis" leader = "923563" started = "13/01/02"
  ended = "13/01/02" effortHrs = "1" personMonth = "0.005">
  </subactivity>
</activity>
```

New feedback by the instructor is assembled with help from the Bayes' Network, as new Do Nodes appear and the values are re-calculated.

```
<activity name = "Specify business" leader = "923563" started = "13/01/02"
ended = "15/01/02" effortHrs = "3" personMonth = "0.020">
<feedbackState skill = "identifying" status = "0.2"/>
<feedbackState skill = "abstracting" status = "0.1"/>
  <subactivity name = "Identify problem" leader = "923563" started = "13/01/02"
  ended = "13/01/02" effortHrs = "2" personMonth = "0.012">
    <feedbackState skill = "identifying" status = "0.6"/>
    <feedbackState skill = "classifying" status = "0.9"/>
  </subactivity>
  <subactivity name = "Write hypothesis" leader = "923563" started = "13/01/02"
  ended = "13/01/02" effortHrs = "1" personMonth = "0.005">
    <feedbackState skill = "writing" status = "0.7"/>
  </subactivity>
</activity>
```

The new coaching content might be displayed as follows:

[Workshop #6/Feedback] Your problem statement seems to identify your problem better. You seem to have improved your identification skills.

Please note that the feedback text is built from keywords, and is not a natural language generator. There is still plenty of room for improvement in this area.

Additional services exist. For example, many tasks are tied to one goal. When a [large] number of teams have input a long series of tasks, the instructor may then assess strategic conduct patterns

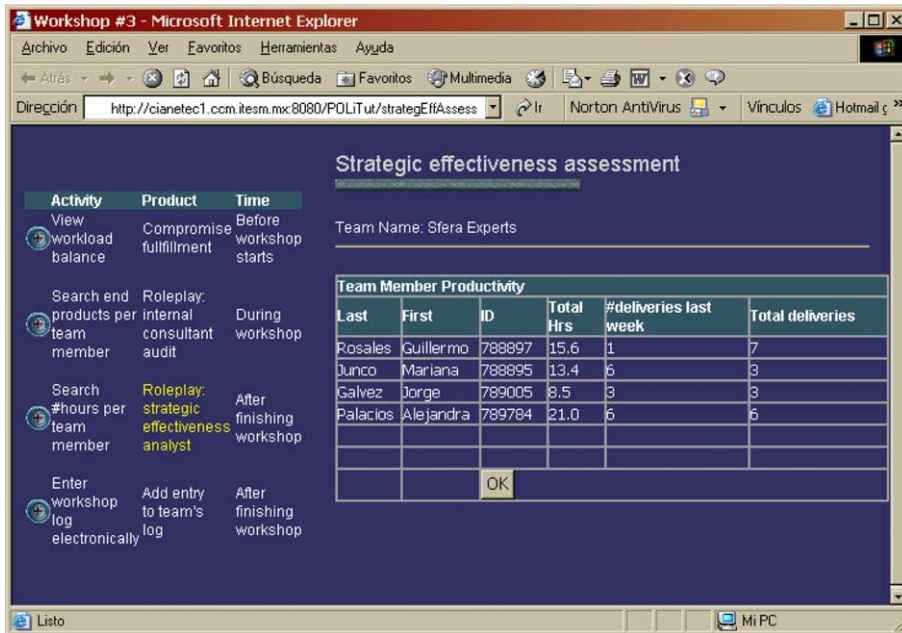


Fig. 6. Strategic effectiveness assessment.

for efficiency, as shown in Fig. 6. In this example, the first student on the report has slowed down on his performance. He has proven substantial work on previous weeks, but not on this one. The second student has tried to deceive the instructor by arguing six deliveries over the last week, but only three overall deliveries. The third student is average: she does not offer too much effort. The fourth student had been almost out during previous weeks, but has experienced a substantial increase in her effectiveness. Thus the first student requires string motivation, the second and third ones have to be pushed continuously, and the last one will obtain congratulations for her recent effort. Of course, all these actions will be on a person to person basis. Many other conducts, such as personal conflicts, are evidenced in the same fashion.

As said in Section 3, the instructor will scaffold teams and team members. Using POL, it is typical that she will play roles:

- An investor with no IT credentials.
- A hard-to-convince CFO.
- A skilled IT manager.
- A secretary.
- A non-technical end user or client.
- An IT-enabled, but not expert, customer.

As she plays these roles, she confronts the students will real life situations deriving from their conduct as consultants. For example, the contract may have the following characteristics:

- Has barely been filled out. Hence, only the major tasks are revealed (i.e. give the project a name, do research on the project, deliver results).
- Has no due dates.
- Has no end product list.

- Has no detail on which team member will do what task.
- Has no insight as to whether the assigned tasks have been effectively completed by the team member that originally made the commitment.

In Section 2, we talked about *competition* and *individualism*. Look back at Fig. 6. The first student happened to be an individualist. This was evidenced by assessing his stored contract record. This student had registered for himself the set of activities in the critical path of the project. Thus, he had been given feedback as follows on a number of occasions:

[Assignment #2/Feedback] Your research work seems to tackle your problem better. You seem to have improved your research skills

[Workshop #3/Feedback] Your design seems to characterize your problem better. You seem to have improved your identification skills

[Workshop #4/Feedback] You need to better your skills in programming solutions for XML interoperability.

These feedback items, along with the assessment in Fig. 6, reveal individualism. Furthermore, when the team is faced with these phenomena, conflicts emerge. Competition is one very common flaw revealed when milestone interventions detect that the team leader is not really performing as such, or when all team members are registering the same activities.

Finally, at the end of every month or whenever milestone reviews occur, the total amount of workload per team may be computed. It tends to happen that students perfect their portfolio/contract maintenance skills, and are more truthful about the whole process. Thus, a simple run of an appropriate webservice allows the instructor to witness the detailed set of work hours, per team, and by student. This is shown in Fig. 7. The student identified by his initials “MD” has

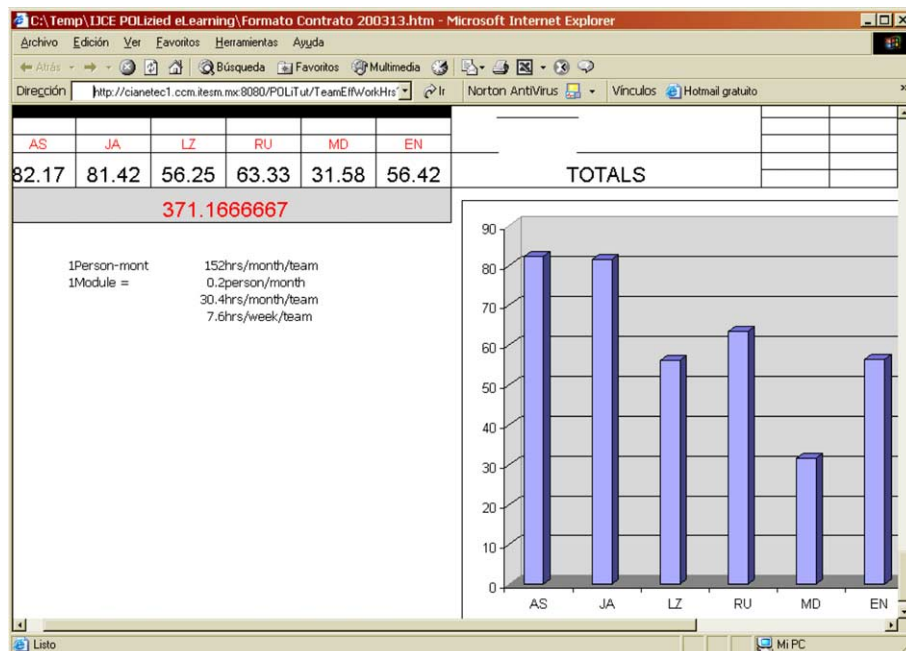


Fig. 7. Computing effort vs. project cost.

worked substantially less, and his teammates have ended up expelling him from the group. This is a drastic measure, in which the professors' scaffolding and dealing-with-conflicts skills are put to the limit. Student "MD" must still receive equal treatment, but his credentials have been hampered. It may be time for him to look for a new project to deliver at the end of the semester.

This is the premier example of experiential learning that rests on the e-Business side of e-Learning. Students are graded proportionally to the amount of finished, verified, and documented work, which amounts to  $K$  hours. Every student is then told that in a real life project,  $K$  would be multiplied by a factor (the number of US/cy per hour). The resulting amounts, minus taxes and other expenses, would be the payment each member of the team would receive. We then ask each student to tell us what percentage of their semester study time  $S$  they have spent on this project. When confronted with such panorama, different things happen:

- Some teams find out they have reported a small number of hours, so the final payment is scarce. This tells them that they have not really reported all their activities, or that they have not been precise on the number of hours per activity.
- Some teams declare they would engage in conflict if money was on the line. This reveals that they have been "friendly" to each other, candidly allowing someone else to report their own work.
- Sometimes the professor stresses that the project would be too expensive to be cost-effective, regardless of the technical merit involved.

The number of input possibilities and numerical combinations is large when evaluating a standard teaching load of five groups per semester. Thus the relevance and usefulness of the web-based information system; without it, the instructor will have little chance of keeping track of and interpreting all the qualitative and quantitative details, especially when she is committed to large teaching loads.

We have observed that engaging on discussions with the students about such comments, both face-to-face, and over the net, trigger conflicts in the students. They tend to realize that the overall performance of their team is affected by behavior not easily brought forward. This is consistent with the statements in Sections 2 and 5. Machine intelligence and IT helps pinpoint sensitive actions. Web technology helps distribute feedback all around. In all cases, the mix is kept to a healthy balance with the pedagogical role-playing and milestones in POL. It is up to the instructor's skill to coach the learners in these social learning situations.

Because POL is used in a consulting project fashion, it is expected that the professor do a substantial amount of face-to-face coaching work with the students. Web tools serve for the purpose of examining face-to-face, plus individual or teamwork that does not necessarily involve the instructor. This is what we consider a CAAL-oriented tool (as said in Section 3).

Finally, this method is consistent with the need for appealing web services as explained in Section 4. The contract management tool is presented as a web service that will provide a product for the student: a guiding thread with milestone feedback. Therefore, a portfolio is still a guiding thread. As we now turn to report, the success of this guiding thread has become the core argument that proves the efficiency of CAAL, and of a POLized e-Learning methodology that uses XML as an information vehicle that allows us to deliver learning-rich environments based on project planning (i.e. Contract Management).

Similar work in student modeling has been done by Conati, Gertner, Van Lehn and Druzdzel for the ANDES project, reported in (Conati, Gertner, Van Lehn, & Druzdzei, 1997), and by

Mayo and Mitrovic on Data-Centric networks (Mayo & Mitrovic, 2001). However, their work has been more focused on plan recognition and prediction of student's actions. On the contrary, our network operates on student's actions in the past, the present and the future. Furthermore, these actions are controlled by a pedagogical-consulting framework, rather than by navigation on a website or online course. We believe the pedagogical framework adds educational value to any learner action, because it renders them *relevant* or *significant*.

## 9. Initial results of work in progress

Our goal is to contribute towards bringing the social technology trends described in Section 2 together, and at the same time observing evidence that the learning process is really taking place. Please note that the learning process also includes actions, or other evidence, or flawed performance. The close inspection of the process via which a group executes teamwork using Constructivist Learning Models while building a consulting-style portfolio, using as information vehicles semi-structured data in XML, all constitute the heart of the mixed initiative which attempts to solve some of the problems involved in the combined characterization of Intelligent Tutoring, Web-Based Content Management, and Collaborative Learning.

We now proceed to prove that our hypothesis is true: *achieving educational and technological conjunction* actually evidences the results of a *collaborative learning process*. For this matter, we assembled 15 teams, with an average of 3 students per team. All teams took the course and proposed their corresponding work contracts (as shown in Fig. 1). After initial compromises were made, the four phases described in Section 6 were executed. Midterm and final presentations rendered proof of the success in the collaborative work, as every team was evaluated based on a [marketing and selling] presentation to an audience made up of professors (CS, Business, Marketing, Information Science), plus actual entrepreneurs, and classmates.

The probabilistic reasoning method in Section 8 was used as a metric for assessing contract quality. A contract with a deeper nesting level in its activity definition had a better grade than one with fewer activities. Using the surveillance module, the instructor assessed all proposals. Out of 15 contracts, the average was 77/100 points. This quality was later compared to the final grade obtained in the course (which includes all workshops and assignments in the course). A close relationship between contract quality and evaluation is shown in Fig. 8. This graph clearly proves that proactive organizational effort by a team renders a better grade when exposed to showing a finished product to an audience and peers.

The next step in proving that the POL mechanism actually guides a learning process was to determine if activities derived from the work contract: workshops and assignments actually had a correlation like the one in Fig. 4. When we examined records, first from the workshops, and then from the assignments, we discovered no conclusive evidence of impact by the work contract.

In Table 2 we observe that the average score in the combined workshop-assignment set by the instructor is always lower than the auto-evaluations the students make up of the same job, from a 5% low to a 20% high. Since the work contract establishes the evaluation standard for all assignments, the standard deviation exhibited here is too wide to make for a reliable statistic. However, following collaborative learning and social interdependence principles (Johnson &

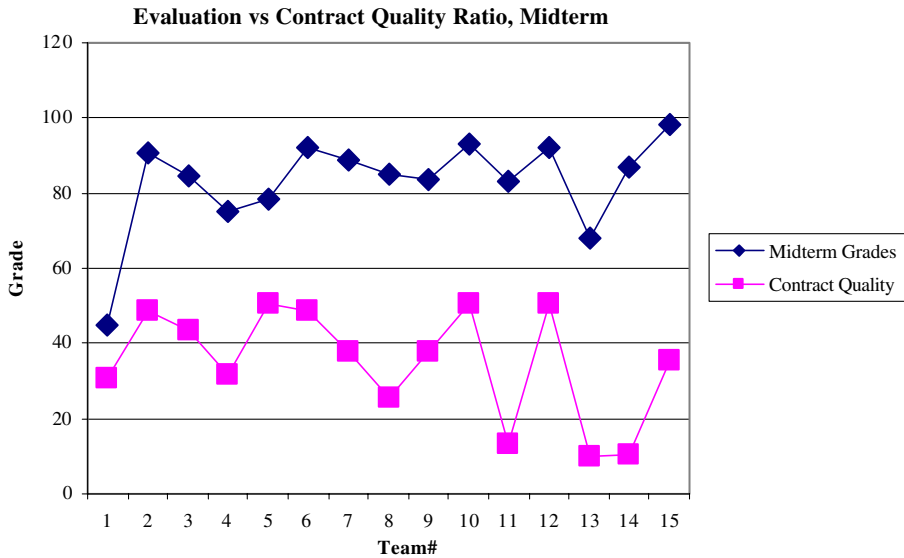


Fig. 8. Evaluation vs. contract quality.

Table 2  
Midterm combined statistics

Average Professor	75.1304348		Midterm evaluations statistics			
Average co-evaluations	88.3857076		Team #	Team #	Team #	
	1	2	3	4	5	6
deta team	-7.29545455	-10.9418605	-8.91304348	-2.62195122	-10.8953488	-14.0116279
co-eval	85.7954545	89.4418605	87.4130435	81.1219512	89.3953488	92.5116279
	7	8	9	10	11	12
deta team	-8.45348837	-10.8023256	-15.3181818	-14.047619	-13.7045455	-11.775
co-eval	86.9534884	89.3023256	93.8181818	92.547619	92.2045455	90.275
	13	14	15			
deta team	-11.6162791	-10.5	2.61111111			
co-eval	90.1162791	89	75.8888889			

Johnson, 1998), we then compared the final grade to the contract precision and to the self evaluation standard (the same one as in Table 2). The result is shown in Fig. 9. Since the correlation now shows up, we may then infer that the *deta team* values in Table 2 do reflect a hidden impact from the work contract.

Furthermore, as we now have direct evidence that the work contract does make a difference, we proceed to make a projection of workshops, assignments, contracts, and final grade. This time, a clear match is revealed (see Fig. 10).

But, why does this happen? Since this is an experiment on collaborative work, we needed to investigate the closeness or distance between the persons that make up a team and the team’s results per se. We selected the number of elements in a team as criteria for efficiency. Three teams out of fifteen evidenced severe conflicts during the semester. These are exactly the ones that show up with

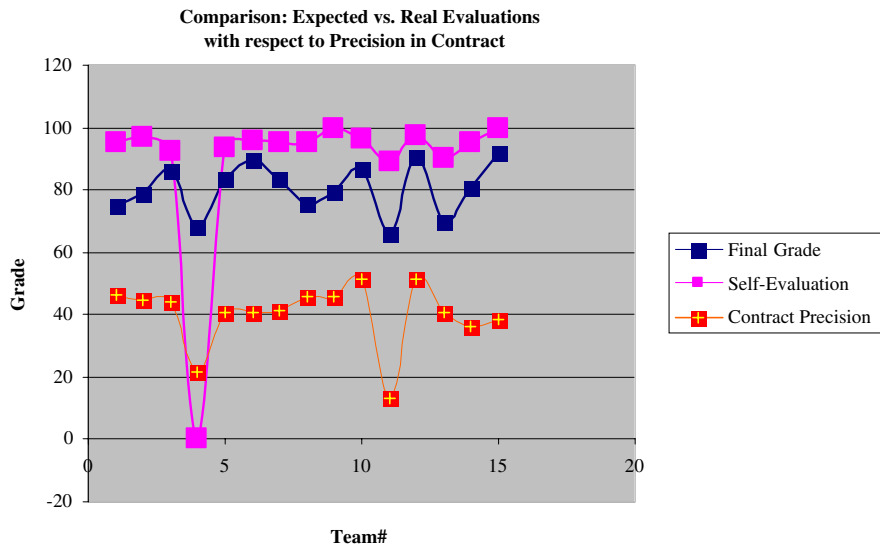


Fig. 9. Expected vs. real evaluations.

lower scores in all the previous graphs. Taking this new factor into consideration reveals the statistic in Fig. 11. Here, it is clear that teams with more members have a slight probability of performing better on the course. However, contract quality does not depend on size or number of activities defined in the contract per se. It is evident that the score given to a team's work contract by the instructor can be as high or low as the team members want it to be, regardless of their size as groups. So, a strategic move by a constructivist professor using POL resides in making an initial bet for large groups, where a large group consists of 3–5 people. Close coaching of the team will be required since any conflicts will have to be solved, allowing the contract to be as neat as possible, because the quality of the contract is a determining factor in the overall success or failure of the group.

From these results, we conclude the following: The data obtained by the professor from the Action Planner at any time during the semester effectively allows her to coach the team into a better situation as they move from phase to phase in the course map (Fig. 4). The better the data, the better the advice. However, it is adequate that this information system only creates semi-structured knowledge, which must be interpreted by the human teacher, not in an ITS fashion. Keeping a distance from pure, content delivery and adaptation allows us to draw closer to CAAL-oriented development, in an asynchronous perception of student activity for making inferences about the internal learning states. These states are not explicitly modeled, but evidenced by precision in the working contract, which obviously exhibits the presence or absence of analysis, synthesis and overall understanding.

## 10. Down the road

The pedagogical method has been exercised for three consecutive semesters with relative success. Our hypothesis is strengthened because social activities and scientific developments effec-



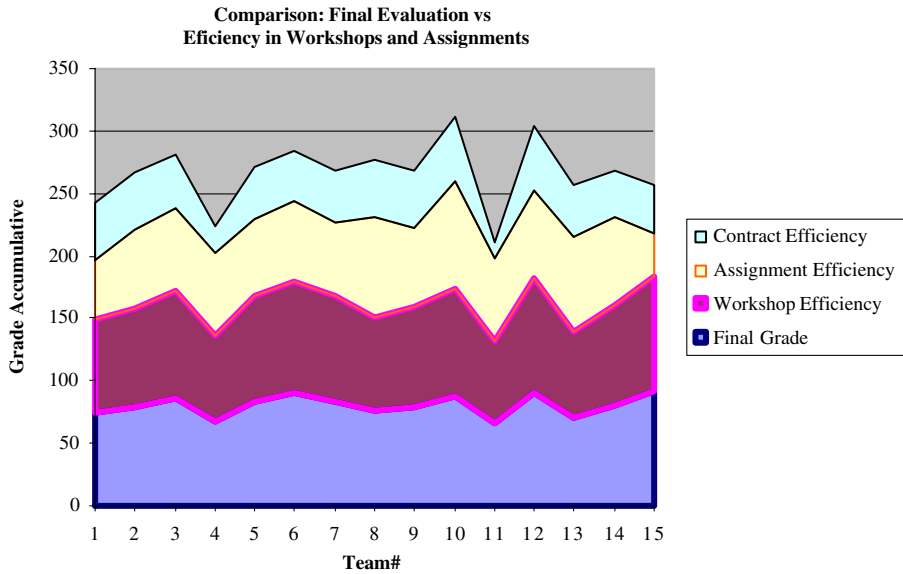


Fig. 10. Projective comparison, all elements.

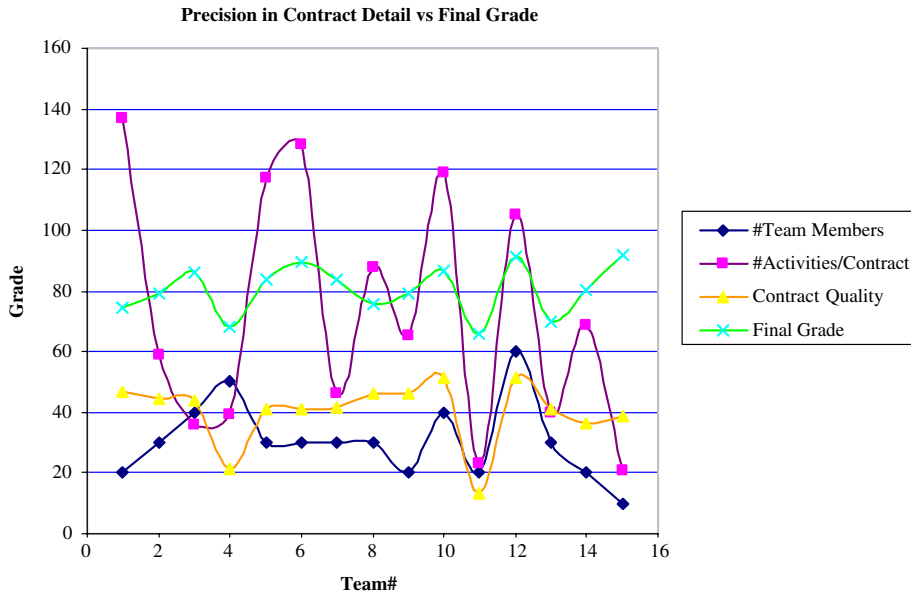


Fig. 11. Contract details impact on final grade.

tively bring people together. The POLized contract proved to be subject of student’s initiatives, because their format and contents differed greatly between teams, causing discussion and conflict along the way. This is true indication that such contracts are *professionally appealing to learners*,

more than plain vanilla adaptation of content. Moreover, the portfolio is proof, or evidence, of the learning process [not] taking place. The roles of the teacher as consultant, coach and professor still need to be refined, and properly informed to the students during the first day of classes of the semester. The portfolio has proven to be an excellent tool for administering learning-by-doing, conflict resolution, and overall synthesis of all products derived from the final team integration and maturity. It also serves to point out elements that have not been completed, and thus contribute to the teams' relative failure in the course.

The information system is just an aid. The professor still needs to spend a considerable amount of time with the students, both individually, and as teams, or even as groups of teams. However, this results from a balance, the e-Business of e-Learning. The method is inexpensive from the technological point of view, given that it does not require intricate pieces of artificial intelligence software to be developed and installed. The course is easily massified using a simple webservice (i.e. Tomcat Server plus Xalan XML processor and existing UDB DB2<sup>17</sup> database engines). On the other hand, it requires a substantial amount of pedagogical training. However, high-tech training is drastically more costly than its educational counterpart. As a conclusion, the overall effort is economically more feasible than sophisticated ITS authoring tools or shells.

The POL-based course existed before the IT infrastructure was developed. Its introduction proved valuable, since, before its deployment:

- The instructor had to elaborate a number of spreadsheets and word processing documents, linking them on every milestone activity, and assembling reports from them.
- Human error occurred both as the students filled out the work contracts, and as the instructor mined their data. Formatting errors caused miscalculations and/or omissions along the way.
- Students had to (1) sign and print, or (2) email the contract and other supporting documentation to the professor. Email tends to be faulty and is increasingly plagued with viruses. This caused delays in feedback by the instructor.

• All these documents were not easily shareable among students.

On the contrary, after the deployment of the webservice system:

- It became easier for the professor to mine the XML database and come up with calculations like the ones shown in Figs. 1–3, 6 and 7.
- It became easier to port the course to other professors in the department.
- A new responsibility was added to the workflow: managing the databases (hiring, business profile, product profile, and COCOMO performance, witness Fig. 4).
- Students find it interesting to be able to compare their efforts to others' in a detailed level of abstraction. Thus, relevance was added to the whole educational method.

Further steps include testing the course as the completed Generalized POL-based model for collaborative and semi-structured collaborative behavior description is refined, adding new ways to produce feedback. The efficiency of the course will be measured in terms of improved dynamics for teamwork management, enhanced capacities for active listening and tolerance by all actors, continued focus on optimized learning by the student.

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<sup>17</sup> [http://www-3.ibm.com/cgi-bin/db2www/data/db2/udb/winos2unix/support/v7pubs.d2w/en\\_main](http://www-3.ibm.com/cgi-bin/db2www/data/db2/udb/winos2unix/support/v7pubs.d2w/en_main).

Future work includes:

- Adding a quantification metric for compromise and self-motivation (work in cognitive science and pedagogics). We will pursue work like the one reported by Dillenbourg on (Dillenbourg, 1996).
- Expanding the user model so that it conveys a dynamic Bayesian network that represents a lesser workload for the computer platform.
- Refining the unstructured (i.e. semi-structured knowledge) XML database for contract characterization.

The course has been tested locally, so far. Next, it will be implemented on geographically close sites, later in VU courses, and finally in purely online courses called TEC.COM<sup>18</sup> courses, provided that it proves to be efficient in all pedagogic and technical aspects.

The course is being adopted by other professors during 2004. More experiences in geographically distant domains will evidence additional areas of opportunity and will allow us to further develop this educational product.

Maybe, after using all this IT, Artificial Intelligence, Pedagogic and Cognitive technology, we will be able to conjunctively tell a good story to e-Learners, without overdoing high-tech “special effect” resources. Maybe there is a way to make things relevant, and even “entertaining” to an audience that sometimes is thirsty for knowledge, and some other times lacks interest and needs to be motivated. Maybe we will be able to contribute towards incorporating innovation that heals current criticisms haunting e-Learning.

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<sup>18</sup> <http://www.tec.com.mx>

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