Achievements teaching Systems Thinking and Systems Dynamics to Graduate students through e-learning

María-Angélica Martínez
Graduate Program in Engineering and Technologies
Virtual University - Tecnologico de Monterrey
angelica.martinez@itesm.mx
angemtzm@gmail.com

Gloria Pérez Salazar
Department of Industrial and Systems Engineering,
Tecnologico de Monterrey
Campus Monterrey
gloria.perez@itesm.mx

Carlos Scheel-Mayenberger
EGADE
Tecnologico de Monterrey
cscheel@itesm.mx

Av. Eugenio Garza Sada 2501, 64849
Monterrey, Nuevo Leon. Mexico
Telephone +52 (81) 83284114

ABSTRACT

This paper shows a course' design and its knowledge transfer process when teaching the changing paradigm of systems thinking, systems dynamics and simulation, through e-learning. The course uses the methodology for changing the analytical approach to the Systems dynamics thinking paradigm -in three months-; and was designed under the "thought on-line" approach. Action research method is used to observe the course evolution and to evaluate: new knowledge, skills developed by students and student's improvements on the changing paradigm. This is an on-going research; we present preliminary results about the achievements up-to-date. Even that ST, SD and simulation are difficult topics, they can be successfully taught on the right e-learning environment. We can state that, teaching this kind of topics can result in a good learning experience for students. These results can contribute to broadcast the e-learning experience to other related topics.

Key words: e-learning, system thinking, system dynamics, simulation, learning experiences, skills development, action research, "thought on-line".

INTRODUCTION

Tecnologico de Monterrey (ITESM) is one of the top 3 universities in Mexico and Latin America with more than 60 years of experience. System thinking, Systems Dynamics and Simulations topics are taught on a face-to-face format in two level courses: at the undergraduate[1] and graduate[2] programs. These courses have the following common

[1] Industrial and Systems Engineering course: Systems Dynamics (Code: IS00-851); Dynamic Modeling (Code: ISO00-853).
[2] Mater on Information Technology Management course: Modeling the Systems Dynamic (Codes: SIO00-219, SI95-219, SI98-219).

characteristics: small groups (varies from 20 up to 60), reading, case's analysis, lecturers, etc. Professor helps student at the moment clarifying the misunderstandings of ideas or concepts. The difference between these courses is the duration: 6-months for undergraduate and 3 months for graduate program.

Practitioners, professors and teachers who had worked with systems concepts and systems dynamics know the big challenge implied when it comes to introduce and to teach this topics to newcomers. For students it is not easy to understand this new paradigm in a short time. It requires developing the right mood for an open-minded in order to innermost this new vision and understanding of our environment. On adult education the process of teaching can be harder and requires more time to innermost the learning.

Through the past 15 years, the three months course based on a face-to-face format had proved the possibility to get a well-understanding of systems thinking, system dynamics and problem simulation. A new challenge arrived: Would be possible to teach this changing paradigm topic on an e-learning approach?

The Virtual University of Tecnologico de Monterrey

Tecnologico de Monterrey System is composed by the Virtual University and 33 Campus across Mexico, 12 International liaisons offices through the world. Virtual University delivers online graduate programs and undergraduate courses combining Internet and satellite, with students in 18 countries around the world. The Master's degree on Information Technology Management belongs to the Engineering and Technology Program where the course "Systems Dynamics Modeling" is taught.

Since August of 2000, I work as full time Professor and teach the *Systems Dynamics Modeling* course in team-teaching[3]. I have give instruction to more than 1050 graduate students from Mexico, Central & South America and have participated as mentor in more than 220 projects related to the dynamic systems models on industry, business, organizational dynamics, strategy and policies (health, public, energy and resources, environment and ecology), all projects developed by students.

During this period, I have captured the essence of different ways of teaching this topic from excels Professors[4] and have developed special skills in the student's learning needs and Professor's objectives to be transmitted and evaluated. I have developed my own teaching style using technology resources (*e-teaching*).

The online course version challenges

[3] Team-teaching with Dr. Carlos Scheel (Professor, EGADE Tec de Monterrey).
[4] Dr. Carlos Scheel; Ing. Gloria Pérez Salazar (Associate Professor, Industrial and Systems Engineering Department, Tec de Monterrey), MC; Dr. Rafael Bourget (Assistant Professor, Industrial and Systems Engineering Department, Tec de Monterrey).

To be considering when designing the course:

- The topic: it is a changing paradigm topic.
- The time: a 3 months course (11 weeks in effective time).
- Student's hours for the course: 12 hours/week (average).
- Group diversity: undergraduate from different background, and disciplines.
- Student's availability: part-time and full-time.
- Group size: massive groups from 100 to 250 students.
- Course format: on-line course.
- Resources provided: by electronic format through the website.
- Resources used: readings, individual and group activities, project development, short videos, non-synchronic mentoring, feedback evaluation, exams, on-line coaching[5].
- Approach: single student, group students, geographically diverse (multi-campus all over Mexico and Latin America and some parts of USA and Europe).
- Coaching / Mentor: 14 hours/week.
- Teacher assistant / Tutor: 40 hours/week.
- Synchronic communication: interaction by on-line coaching, phone line.
- Non-synchronic communication: interaction by forums inside the webpage, groups restricted areas and email.
- Response time to answer an email: before 24 hours.
- Response time for activities feedback: 7 days.
- Student's feedback requirements: individual and group activities.
- Type of activities: learning activities for paradigm change, improvement on system thinking, system dynamic and simulation concept and paradigm application and skills development (on paradigm and simulation software tools[6]).

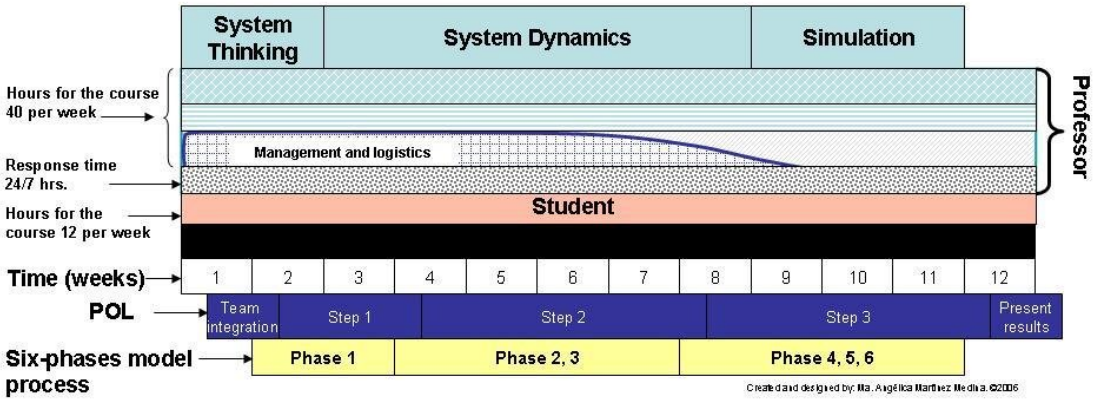

Figure 1 The online version course's challenges.

[5] The Professor talks and the students write on a chat window their questions.
[6] We have used Ithink® and Vensim® simulation software. Nowadays we use VEMSIM PLE ®.

Figure 1 shows the course restrictions to be considered in the design. Other important considerations when designing a course for online are:

- The topic: it is a changing paradigm topic.
- Group diversity: undergraduate from different background, and disciplines.
- Student's availability: part-time and full-time.
- Group size: massive groups from 100 to 250 students.
- Resources provided: by electronic format through the website.
- Resources used: readings, individual and group activities, project development, short videos, non-synchronic mentoring, feedback evaluation, exams, on-line coaching[7].
- Approach: single student, group students, geographically diverse (multi-campus all over Mexico and Latin America and some parts of USA and Europe).
- Synchronic communication: interaction by on-line coaching, phone line.
- Non-synchronic communication: interaction by forums inside the webpage, groups restricted areas and email.
- Student's feedback requirements: individual and group activities.
- Type of activities: learning activities for paradigm change, improvement on system thinking, system dynamic and simulation concept and paradigm application and skills development (on paradigm and simulation software tools[8]).

Following pages describes the conceptual framework, the implementation, the continuous course improvement cycle through action research, results, a brief discussion section and conclusions in order to evaluate the complexity of the knowledge transfer through e-learning and to validate the successful learning achievements shown in this paper.

THE CONCEPTUAL FRAMEWORK

E-learning framework of the Virtual University of Tecnologico de Monterrey

The Virtual University's learning model is based on the Constructivism theory, and from this, a very sophisticated teaching-learning mechanism has been elaborated and tested for many years.

E-learning model from the experience

There are two different roles in a virtual course: issues related to the course administration and logistics, and as the expert in the topic.

[7] The Professor talks and the students write on a chat window their questions.
[8] We have used Ithink® and Vensim® simulation software. Nowadays we use Vensim PLE®.

When implementing a virtual course the responsibilities as the course administrator are: answer emails related to administrative, logistics issues and personal situations (with emotional and feelings content such as: stress, tension, angry, sadness, worried, anxiety, run out of steam, enthusiasm, full steam a head too, etc.); do grading based on pre-defined criteria (almost all were split in to qualitative and quantitative items); to keep the students records –grades- up to date; attend to student's phone requirements and prepare statistics and reports..

By other hand, the expert in the topic has two different role's responsibilities when designing and implementing a virtual course:

a) During the designing phase: do the planning, design[9] and course preparation; design the evaluation student's learning (through grade examinations); prepare lectures, assignments and reports to students.
b) During the implementation phase: advise students on course and academic matters, mentoring and advisor activities; encourage the individual, interpersonal, team competencies for learning and collaboration among multidisciplinary professionals and virtual groups; answer all questions related on content send by emails or posted on forums; do grading and be the student's topic advisor and project's mentor.

Three stages when designing virtual courses

I have experienced what I call the three stages of a virtual course evolution: *Web-page supported by satellite's lectures, the transition (Web-page with lectures reused - recorded from past satellite's lectures) and "thought on-line" approach.*

The first stage courses were designed on a three months period and the learning activities were individual and group, exams and a lot of different readings from different authors; plus an hour of satellite session[10] for Professor's lecture and a short period for student's participation. In the second stage the use of the satellite the diminished. This was the first strategic step forward to on-line courses where students could have more flexible courses under the concept: "any time, any where". Previews professor's lecture and its presentations were included in an electronic format. Additional to this, new readings and short videos were including explaining more concepts. Professor invested too much time to interact with students who demanded concept's clarification. Student's stress level increased and the learning was regular. The beginning of the third stage was on 2004, with the first version designed under the ***"thought on-line"*** approach.

The "thought on-line[11]" approach

[9] Detailed design of academic and e-learning course, prepare specifications.
[10] There were Institutional changes that decreased the use of satellite sessions to 1 session each 2 weeks.
[11] *"thought on-line"*© is a newly minted concept conceptualized by Ma. Angélica Martínez Medina, resulted from my experience on distance learning techniques and tutoring activities. This concept establishes the need to create from nothing an on-line course in order to incorporate the students and professors goals when going into an e-learning experience. This is an holistic perspective which includes: the student (background, learning needs, etc.), the Professor (teaching objectives, learning activities, evaluation, e-teaching experience, expertise, etc.), Instructional designer (providing learning

This is a holistic perspective approach when designing an on-line course which incorporates the students and professors goals when going into an e-learning experience. This perspective is based on the knowledge what an on-line course must be based on technology resources able to provide the content, be the media for learning and coaching with excellent support to students.

The “thought on-line” approach focuses on design an e-learning environment were the student develop the learning ability (“able to”), with a positive attitude (“want to”) in order to acquired new knowledge or skills (“know-how to”).

Methodology for teaching system thinking and systems dynamics modeling

This methodology includes the learning spiral which scaffold the design and planning process on the construction of lessons, activities, or projects; not only eliciting target the development of students' thinking skills and habits of mind, but also sets standards for those performances. It also includes the Six-phase model process for generating dynamic models and uses the Project Oriented Learning (POL) methodology for project development, providing readings, learning activities and examinations, coaching and simulation’s software skills development. Table 1 and 2 give more details (see annexes).

---

methodologies, mix of activities and technology resources for a better knowledge transference), the topic (identify the best way to innermost the concepts and skills), technology resources (knowledge of the best technologies to use), a multimedia team (producer, web-designer, graphical designer) and the application of the “*learning’s dynamic cycle for knowledge transfer*”©.

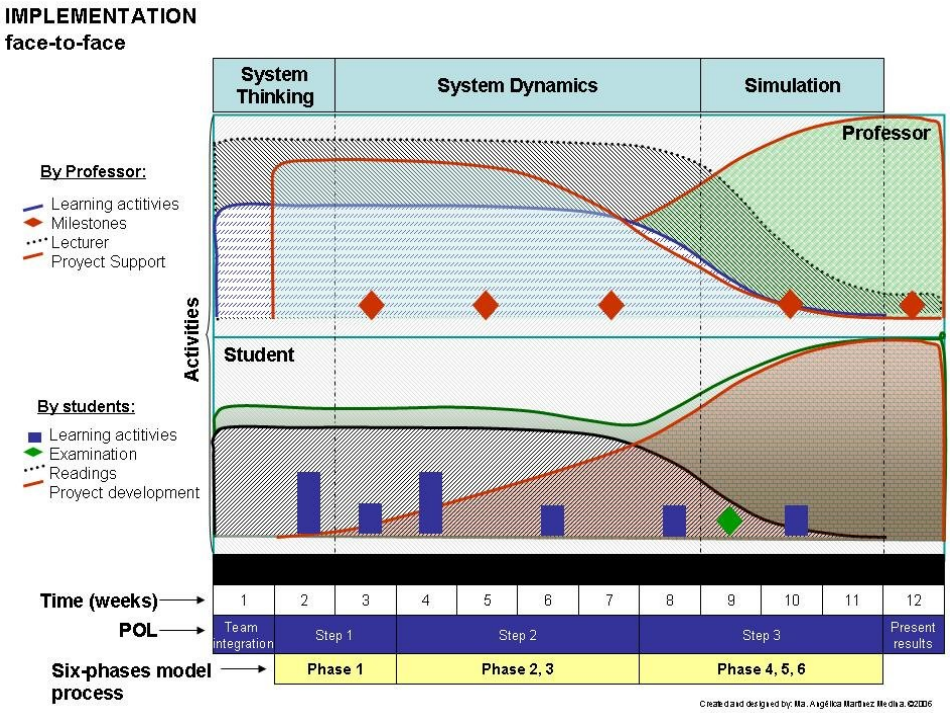

Figure 2 Methodology for teaching system thinking and systems dynamics modeling (three months course).

E-learning additional components when designing a course on-line

- Mentoring and coaching challenges.
- Knowledge and skills evaluation.
- E-teaching requirements and strategies
- Information security (confidentiality of the information).
- Dishonesty academic actions.

Application of the "learning's dynamic cycle for knowledge transfer[12]"

The "*learning's dynamic cycle for knowledge transfer*"© is a dynamic perspective of how the knowledge is transferred. In it, we can identify clearly the incorporation of the student and professor's goals and can be use on any learning object (course topic, lessons, activities and project). It involves the evaluation of the: context, inputs, the process and the product, as well as the instructional description.

[12] The "*learning's dynamic cycle for knowledge transfer*"© is a newly dynamic perspective of the knowledge transfer, developed by Ma. Angélica Martínez Medina. This involves concepts such as: action learning, the learnativity cycle, learning objects, the learnativity spiral for learning objects, knowledge transfer knowledge; and include the supportive ideas developed inside the CIADS Group formed by Angélica Martínez M., Rafael Bourget and Jose Luis Alatorre.

Based on the “learning’s dynamic cycle for knowledge transfer”, we applied in the new course design in two levels: the course structure and in selected learning activities with different taxonomies. Figure 3 shows these dynamics.

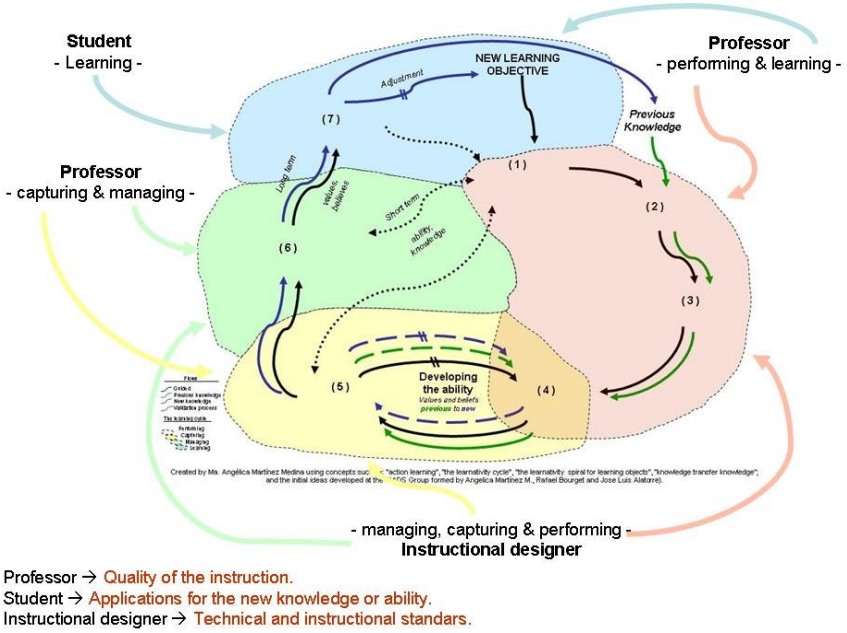

Figure 3 The application of the “learning’s dynamic cycle for knowledge transfer” to teach the systems dynamics thinking paradigm.

Figure 3 shows the dynamics of the knowledge transfer which different flows inside the cycle. The black line (1-7), represents the guidance proposed by the (1) teaching objective until it is reach. The green line (2-5), represents the student’s previous knowledge along the guided instruction until this knowledge is transformed. The blue line (4-7) represents the new knowledge acquired. The long-dotted line (4-5) creates feedback loops that represent the acquisition process that begins with a green line (student’s actual values and beliefs), those are transformed (green dotted line) in to a blue dotted line (student’s begin to acquire new values and beliefs) to becomes a blue line representing the end of the transforming process. The back small dotted lines (5-1, 6-1, 7-1) represent the validation’s attainment. The transverse small lines represents the existence of a delay period during the process, this is the lap needed to be adapted to the know state.

E-learning design for the Virtual University of Tecnologico de Monterrey
Based on the Methodology for teaching system thinking, systems dynamics modeling and simulation

General plan (Course design):

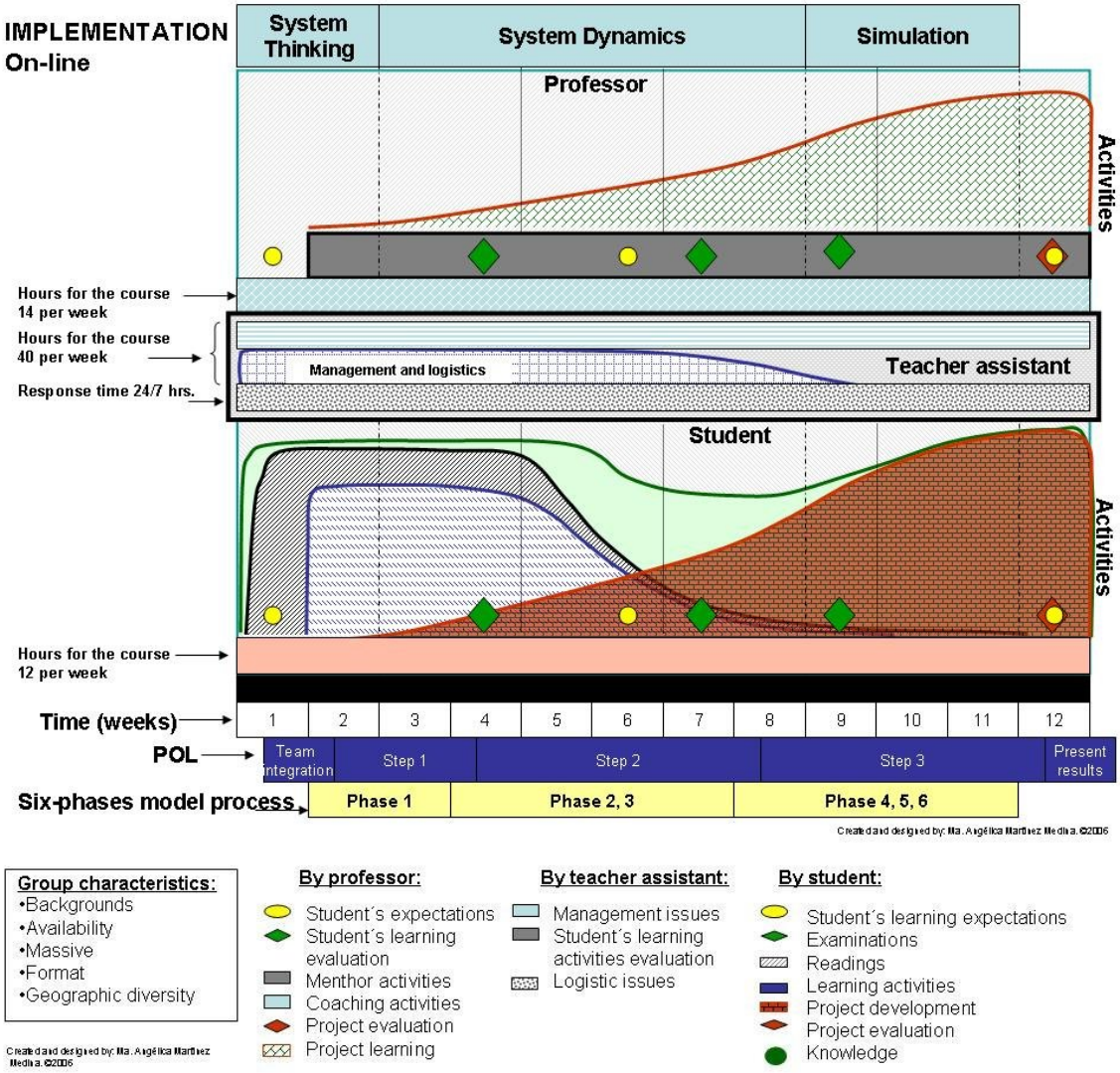

Figure 5 The online version implemented covering the course's challenges and using the Methodology for teaching system thinking, systems dynamics modeling and simulation in three months.

The figure 5 shows the general plan for the course online. This design include all the challenges, constrains and limitations described in the previous sections of this paper. The detail description of the course evolution is stated in the Implementation section as part of the research methodology.

RESEARCH METHOD

This investigation is based on a qualitative study since the investigator observed and described several aspects of the experience from three perspectives: course, professor skills and student's behaviors and learning improvement.

Our evaluation focus was on the course evolution, and observed and measure three perspectives: the course goals, the professor role and student's learning improvement.

As **course level**, we evaluate course's balance in the learning activities, as well as the professor and students activities and behavior. We supported our observations based on the **action research method** to study a social situation in order to see improving in the quality during the action within the implementation (Elliott, 1991). This research method aims to feed practical judgment in concrete situations, and the validity of the 'theories' or hypotheses it generates depends not so much on the 'scientific' test of truth, so on their usefulness in helping people to act more intelligently and skillfully.

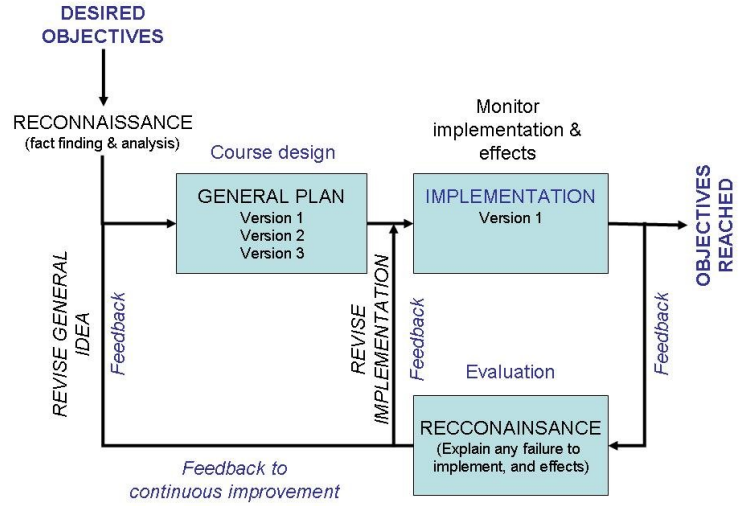

Figure 4 The continuous course improvement cycle through action research and the teaching-learning process.

Figure 4 shows the continuous course improvement cycle through action research and the teaching-learning process. It begins with the **desired objectives** to obtain. A previous analysis of the situation[13] leads to identify the **reconnaissance** to be included. The improvement cycle begins with the **course design** with a general plan defining the number of version needed to reach the desired objectives. Each course version is **implemented and monitoring its effects**. During the action the students' behaviors are observed on the different technologies resources as: the web platform (forums, restricted group pages, assignment's repositories, quizzes, exams, etc.), emails, phone calls and faxes. The professor' behaviors are observed in the efficiency and warming of his/her responses to manage the amount of assignments to mark, emails answered, coaching and mentoring activities, phone calls received and the use of the different technologies resources. When the implementation finishes the course is evaluated in relation with the desired objectives, if those are reached, the cycle closes. If not, we go to two feedbacks steps. The first lead us to the **evaluation** of the version implemented in order to have a reconnaissance of the failures and effects. From the results, a continuous improvement feedback must be defined. Failures improvements generate a **revise implementation** or

[13] Lack of presence of student's learning objectives in the course design. Learning activities aligned to the course objective.

there are major changes to be done in a **revision of the general idea** affecting the course design.

The Professors' behaviors were monitored in the students' individual and collaborative inquiries. Focuses on the type of questions received, warming of his/her responses, quality of the feedback (content) and time for feedback.

Professor' efficiency were observed on how the amount of assignments were managed, emails answered, the coaching and mentoring activities attended, phone calls received and how the different technologies resources were used.
The Students' behaviors were observed in their individual and collaborative environments within the different technologies resources as: the web platform (forums, restricted group pages, assignment's repositories, quizzes, exams, etc.), emails and phone calls.

Observed students' learning improvement:

- In their clear ideas showed in their posted messages or emails sent to the Professor as individuals or collaborative.
- The questioning of their inquiries of information and guidance.
- The criteria applied on their cross-evaluations.
- The inter-students coaching in messages posted at content forums.
- Their consciousness of their knowledge' acquisition stated in their two individual *course's expectations* reports.
- During the mentoring sessions (synchronic and non-synchronic).
- In the products of each project phases.
- In the methodological appliance of the model and quality of the research presented in the final report.
- In their deep understanding of the problem modeled noticed in their final presentation.

IMPLEMENTATION AND COURSE IMPROVEMENTS THROUGH ACTION RESEARCH

Objectives

To design an on-line course that improves the student's learning experience and assure the innermost of this paradigm through e-learning, balancing the course learning activities, using the technology resources for course management, the technology resources for course-learning evaluation and software simulations tool's skills development.

Reconnaissance:

- Course administration difficulties.
- Time for feedback.
- Learning course evaluation.
- Learning student's evaluation.

- High student's negative emotional feelings (stress, tension, angry, sadness, worried, anxiety, run out of steam, enthusiasm, full steam a head too, etc..

Implementation version 1 (Design)

Course structure: none, it remains the same. (See annexes. Table 1).

Coaching: increased and delivered using different technologies.

Learning activities: well selected and some adapted following the "The learning's dynamic cycle for knowledge transfer". (See figure 5).

- Team integration activities.
- Examinations: theory and practice.
- Feedback: pre-programmed.
- Evaluation activities: cross-activities, team's activities evaluation, team's project evaluation.
- Research activities.
- Poster presentation with project's achievements.

New support activities:

- Videos to support concepts, feedback activities and guess speakers.
- Visual support material for selected learning activities.
- Short guided videos of the simulation software.
- Student expectation's learning: statement and evaluation.

New coaching and learning activities for the online course: See table 6 (Annexes).

Implementation version 1 (Monitored implementation & effects)

Version's objective reached: the student's most common learning requirements[14] and the Professor's requirements[15].

Reconnaissance: Course administration is little easier to manage, time for feedback is faster and with quality, the student's stress decreased significantly, course's global evaluation was improved.

Implementation version 2 (Monitored implementation & effects)

***Version's objective reached*:** problem on descriptions or non-clear instructions on learning activities were presented.

Reconnaissance: some learning activities descriptions must be improved.

Revise implementation: Course administration is easier to manage, feedback is faster and with quality, the student's satisfaction has increase significantly,

[14] Related with personal's learning objectives, course expectations.
[15] Related to the course objective, student's evaluation learning and administrative issues.

course's global evaluation was improved. The coaching process is good but could improve with support (2 facilitators).

CONCLUSIONS

The objectives defined for these research discussed in this paper were:

- To describe the e-learning model on a web-based course.
- To describe differences and experiences designing e-learning courses.
- To describe the "thought on-line" approach.
- To describe the design and implementation process through e-learning of a 3-months on-line course to fulfill the student and professor's learning objectives through the understanding and application of the changing paradigm of the system thinking, system dynamics and simulation.
- To describe the implementation outcomes; in particular, the outcomes related to: student's expectations learning, learning activities; course evaluation, course management, feedback and project development.
- To generalize and capitalize the experience and its results to contribute to the continuous course improvement and to share this approach to other e-learning courses.

Although this research is mainly a qualitative study, according to Bodgan (1982), the observations and descriptions from the investigator present several aspects of the experience such as the course evolution, the professor skills and students learning improvement when going in to a new on-line course designed under the "thought on-line-approach". We are still working on it, so the feedback will be welcome.

REFERENCES

Anderson V. and Johnson L.. Systems Thinking Basics. (March 1997) Ed. Pegasus Communications. ISBN: 1883823129

Anderson V. and Johnson L.. Systems Thinking Basics: From Concepts to Causal Loops. (March 1997) Ed. Pegasus Communications. ISBN: 1883823129

Aracil J. *Introducción a la Dinámica de Sistemas*.(1983) Ed. Madrid: Alianza Universidad. Primera Edición. ISBN: 8220680583

Bodgan, R.C and Biklen, S. K. (1982) *Qualtitative research for education: an introduction to theory and methods*. Allyn and Bacon 1982.

Bourguet R. (2003) *Qualitative knowledge acquisition using fuzzy logic and system dynamics*. Thesis (Doctor in Philosophy in Artificial Intelligence) - ITESM Campus Monterrey. Monterrey, NL

Dever, M.; Hobbs, D. (1998). *The learning spiral. Childhood Education*; Fall 1998; 75, 1; Career and Technical Education. Page 7

Kauffman, D. L. (June 1980) *Systems One: An Introduction to Systems Thinking*. Ed.Future Systems, Inc

Forrester, J.W. (1958) *Industrial dynamics: a major breakthrought for decision makers*. Harvard Business Review, July-August, 37-66

Forrester, J.W. (1975) Industrial *dynamics – alter the first decade. In: Collected Papers of J.W. Forrester*, Cambridge, Wright-Allen Press. (Original paper in Management Science 14(7), 398-415, 1968

Martínez M.A. (Feb. 2005) *Notas sobre origenes, antecedentes y supuestos de la dinámica de sistemas*. Curso Modelación Dinámica de Sistemas 2005. ITESM. Monterrey, N.L. Mexico

Martínez M.A. (Feb. 2005) *Notas sobre Modelos en la Dinámica de Sistemas y el Proceso de construcción*. Curso Modelación Dinámica de Sistemas 2005. ITESM. Monterrey, N.L. Mexico

Pantel, C. (1997) *A Framework for Comparing Web-Based Learning Environments*. Thesis for Master of Science in the School of Computing Science. Simon Fraser University. October 1997.

Pérez G. (Sep. 2000) *Notas del profesor*. Curso Modelación Dinámica de Sistemas 2000. ITESM. Monterrey, N.L. Mexico

Pérez G. (Sep. 2003) *Notas del profesor*. Curso Modelación Dinámica de Sistemas 2003. ITESM. Monterrey, N.L. Mexico

Paton, G. (2001). A Systemic Action Learning Cycle as the Key Element of an Ongoing Spiral of Analysis. Systemic Practice and Action Research; Feb 2001; 14, 1; ABI/INFORM Global. Page 95.

Richardson, G.P. and Pugh, A.L. (1981) Introduction to system dynamics modeling with DYNAMO. Cambridge (MA), MIT Press.

Rojas F.. (2003) *Desarrollo de simuladores basados en casos y modelación dinámica para el sostenimiento de sistemas de calidad*. Tesis. Monterrey, N.L.

Scheel, C., Martínez M.A. (2006). *"Methodology of a Graduate course to change paradigms, from the analytical approach to the systems dynamics thinking."* Written for the 24th International Conference of the System Dynamic Society. July 23-27. Nijmegen, The Netherlands.

Senge, P. (1992) La *Quinta disciplina: el arte y la práctica de la organización abierta al aprendizaje*. Editorial Granica. ISBN: 84-7577-351-6

Sterman, J. (2000) *Business Dynamics: System thinking and Modeling for a Complex World*. Editorial Mc Graw Hill. ISBN: 0-07-231135-5

Titone, R. (1981). *Psicodidáctica*. Editorial NARCEA. Madrid.

Vennix, J. (1996) *Group Model Building: Facilitating Team Learning Using System Dynamics*. John Wiley & Sons Ltd.

ANEXES

Table 1. The course structure of the Methodology for Teaching System Thinking, Systems Dynamics Modeling and Simulation in a in a three-month period (Scheel, 2006).

Module 1	**Philosophy** System thinking concepts. * Introduction to system dynamics: antecedents and assumptions. * - *Feedback, models and decision making, BOT.*
Module 2	**Tools** Systems dynamic: concepts and tools. * - *Loops, Archetypes, Cause loops diagram, Forrester's diagram.* The six-phases for generate dynamic models: theory and practice. * - *Problem definition, Conceptualization model, Representation model, Behavior of the model, Evaluation of the model, Politics analysis and sceneries.*
Module 3	**Applications** Dynamic systems model applications as support decisions tool. +

** Theory and practice; + Theory*

Table 2. Coaching and learning activities of the Methodology for Teaching System Thinking, Systems Dynamics Modeling and Simulation in a in a three-month period (Scheel, 2006).

Learning activities		**Supported material**	***Learning spiral framework***
Readings	Week: 1-12	Textbook, manual of selected readings ad articles.	*Introduce the new concept -Performing-*
Learning activities	Weeks: 1-8, 11	Contemporary and selected cases (Kaibab, People Express, among others), activities and topic research.	*Learning the language -Capturing-*
Project: • Phase 1 • Phase 2, 3 • Phase 4, 5, 6	Week: 3 Weeks: 6 Weeks: 11	Application to a complex problem –a real situation.	*Integrate new learning -Managing-*
• Presentation	Weeks: 12	Outcomes	*Application of the concept -Learning-*
Examination	Week: 9		
Simulation software[16] skills development	Weeks: 6-11	Short videos, self studied guides (roadmaps)	
Coaching activities			
Coaching: • Phase 1 • Phase 2, 3 • Phase 4, 5, 6	Weeks: 2-3 Weeks: 4-6 Weeks: 7-11		

[16] iThink®, Vensim®.

Table 3. Students graduated since 1985 (face to face).

	Division	Master Program	Year	Quantity
	DTIE	MTI	2005	22
Graduados	DTIE	MAT-I	2005	1
	DTIE	MTI	2005	5
	DTIE	MTI	2005	22
	DECIC	MTI	2004	32
	DECIC	MTI	2004	13
	DECIC	MTI	2003	46
	DECIC	MAT-I	2002	9
	DECIC	MTI	2002	56
	DECIC	MAI	2001	1
	DECIC	MAT-I	2001	10
	DECIC	MTI	2001	55
	DECIC	MAI	2000	4
	DECIC	MAT-I	2000	8
	DECIC	MTI	2000	42
	DECIC	MAT-I	1999	3
	DECIC	MTI	1999	23
	DECIC	MAI	1998	7
	DECIC	MAT-I	1998	3
	DECIC	MTI	1998	34
	DECIC	MAI	1997	39
	DECIC	MAT-I	1997	1
	DECIC	MTI	1997	6
	DECIC	MAI	1996	68
	DECIC	MAI	1995	57
	DECIC	MASI	85-94	106

Students graduated since 1985: **651**
Total students who took the course since 1985: **673**
Total students who took the course (2000-2005): **326**

MAT-I, MTI	Master in Information Technology Management
MASI	Master in Information Systems Management
MAI	Master in Information Management

Table 4. Students who took the course since 2000 (virtual).

Division	Master Program	Year	Quantity
PGIT	MAT-I	2006	190
PGIT	MAT-I	2005	156
PGIT	MAT-I	2004	121
PGIT	MAT-I	2003	104
PGIT	MAT-I	2002	119
PGIT	MAT-I	2001	163
PGIT	MAT-I	2000	231

Current students (January, 2006): **190**
Total students who took the course (2000-2005): **894**
Total students who took the course since 2000: **1084**

MAT-I Master in Information Technology Management

Table 5. New coaching and learning activities for the online course.

		Supported material	***Learning spiral framework***
Readings	Week: 1-12	Scheel, Sterman, Manual's selected readings[17]	*Introduce the new concept -Performing-*
Videos	Week: 1, 2, 3, 4, 5, 7, 9, 10, 11, 12	If available.	
Learning activities	Weeks: 1-8, 11	Selected cases[18], activities[19] and topic research	*Learning the language -Capturing-*
Project: • Phase 1 • Phase 2, 3 • Phase 4, 5, 6	Week: 3 Week: 6 Week: 11	Real cases	*Integrate new learning -Managing-*
• Presentation Examination	Week: 12 3 during the course	Outcomes	*Application of the concept -Learning-*
Simulation software[20] skills development	Weeks: 2-8	Short guided videos, self studied guides (roadmaps)	
Coaching			***Communication type & reach***
Forums	During the course	Topic, administrative and logistics related.	*Non-synchronic (1-all)*
Emails		Topic, administrative, logistics related and personal comments.	*Non-synchronic (1-1)*
Phone calls			*Synchronic (1-1)*
Internet broadcast radio	3 during the course	Topic, administrative and logistics related.	*Synchronic (1-all), (all-all)*
Project: • Phase 1 • Phase 2, 3 • Phase 4, 5, 6	Weeks: 2-3 Weeks: 4-7 Weeks: 8-11	Project related.	*Non-synchronic (1- team)*
Information security	During the course	Open repositories for activities, individual access, and only team-member's access.	*(1, team members, all-all)*

[17] Notes from selected authors: Aracil (1983), Bourguet (2003), Forrester (1958, 1975), García (2003), Kauffman (1980), Pérez (2000, 2003, 2004), Richarson (1981), Rojas (2003), Senge (1992), Sterman (2000), Vennix (1996), Anderson (1997) and the Vensim ® Software. Translated and written in to Spanish by Angélica Martinez Medina.

[18] Cases: Kaibab, People Express, among others.

Table 6. Statistics comparing the face to face and e-leaning course implementation.

	Learning approach	
	Face-to-face	**E-learning**
First course implementation	1984	1991
Courses implemented	Since 1984: - Since 2000: 6	Since 1991: - Since 2000: 7
Duration & Frequency	3 months[21], once a year	3 months[22], once a year
Student graduated	1984-2005: 651	1991-2005: -
Total students who took the course	1984-2005: 673	1991-2005:899
Current students		190 (Jan, 2006)
Students who took the course (2000-2005)	326	899
Course global evaluation opinion[23]on 2005	1.31	1.38
Projects developed	- 2005: 7	2000-2005: 200
Current projects		49 (Jan, 2006)
Courses with this approach related to topics [ST, SD, simulation]	Systems Dynamics Modeling	Systems Dynamics Modeling
Topics of projects developed	Social cases Industrial clusters e-business …	Social cases Industrial development Natural resources Bussiness …
Professor's global evaluation[24]		
2003 – P		-
2003 - S		1.95
2004 - M		1.68
2004 - S		1.75
2005 - M		1.38
2005 - S	1.31	1.50

[19] Activities: The beer game, Pérez (2000, 2003, 2004), Anderson (1997).
[20] iThink®, Vensim®.
[21] Period term: September.
[22] Period term: September until 2003, January since 2004.
[23] Evaluations available at ECOAS System. Rank: 1 to 5. (1.0 is the highest)
[24] Data obtained by the ECOAS internal system.