Comparing different approaches in teaching System Dynamics in Italian Universities

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Abstract

There has been two main objectives with which the idea to write this paper was started. First of all, to exchange, and hence put in common, the knowledge of different experiences in Italian academic context dealing with teaching of a consolidated but still innovative (at least in Italy) methodology. Secondly, to put in evidence possible pros and cons of each teaching approach in order to better face (at least be aware of)the next teaching years (learn one from the other!) .

The paper will describe four teaching experiences in four different university contexts; three are so called hard faculties (Sciences, Statistics and Engineering), and one could be considered soft faculty i.e. Communication Sciences. Two are sufficiently consolidated courses (more than five academic years) and two are less experienced (both three academic years).Three are placed in Master programme and only one (but this one is related to, maybe, the "hardest" faculty-Engineering) is collocated in Bachelor programme. A final synthetic comparison table is sketched and an overall general common consideration is suggested.

Introduction

The work has been conducted, collecting information related to the teaching System Dynamics(SD) courses through a general description of the course and seven specific points;

I. Course specific characteristics
II. Students characteristics
III. Course topics
IV. How the work practice is approached during the course
V. How the students are evaluated
VI. Results acquired
VII. Notes and comments

Once the information per each specific course is detailed , through an overall comparison between the main characteristics of the courses, some peculiar points were underlined and some final considerations are sketched.

Teaching System Dynamics courses

The four courses which have been considered under investigation are the following:

1. "System theory for modelling and simulating enterprise processes" - Communication Sciences Faculty at Communication and Sociology department – Rome University "La Sapienza" , conducted by Habib Sedehi
2. "Dynamics of Complex Organisations" – Faculty of Mathematical, Physical and Natural Sciences; Computer Sciences Department – Bologna University, conducted by Edoardo Mollona
3. "Production System Modeling" – Business & Economics Engineering Faculty at the Department of Business Engineering - Rome University "Tor Vergata", conducted by Stefano Armenia
4. "System Dynamics " - Second Level Master in Data Intelligence and Decision Strategies (DISD) at Statistics Department – Rome University "La Sapienza", conducted by Roberto Berchi

1. "System theory for modelling and simulating enterprise processes" - Communication Sciences Faculty at Communication and Sociology department – Rome University "La Sapienza"

This course was borne at the academic year 2005-2006, on the base of more than 5 years of debate between its promoter (Habib Sedehi) and the different department council members for its initiation. Since its starting year it has encountered the faculty students "curiosity" as it surely is not included in the fundamental matters of the **Enterprise Communication Master** programme where it is presently located. After three years of presence being as an alternative laboratory course (each master student is ought to select at least one laboratory course/year out of three) with a continuous positive students attending trend (almost 20% per year), is today known in the department as a singular and interesting matter!

I. Course specific characteristics

The course is planned for 30 hours lecturing and is placed at the second (last) year of the Master programme in Enterprise Communication. It collects, for the students who get through the formal exam, 4 European credits. In fact the hours for completing the course are much more. The students are invited to prepare a project work on a specific enterprise process (at their choice) which force them to interact (over the 30 hours lecturing) a number of hours between 20 to 30 with the teacher to better understand the principals of System Dynamics and try to develop a sufficiently detailed causal loop graph and possibly a synthetic but clear flow-level diagram. Each project work is normally developed by 3 students in collaboration.

II. Students characteristics

All students attending the course have a Bachelor degree in general communication sciences (3 years degree). Commonly they are weak in scientific matters and have very low knowledge in mathematics. This forces to spend few hours in describing some fundamental mathematic concepts. Today the number of the students which attend the course are approximately 30, composing around 10 groups for elaborating project works.

III. Course topics

The structure of the course is based on three keywords System, Model, Simulation (SMS, it sounds good !). In fact the first part of the course mainly describes the fundamentals of **System** Thinking starting from General System Theory (Ludwig Von Bertalanffy). Once the students get familiar with the concept of System the second key word is introduced; **Model**, its meaning and different classification, its diverse use together with costs and benefits of its potential development. At this point the methodology of System Dynamics is introduced with all its principals and peculiarities. Now the class is mature enough to "appreciate" the concept of **Simulation** which is explored through different methods, putting in evidence the advantages of SD simulation modelling.

IV. How the work practice is approached during the course

After the introduction of SD methodology, a number of examples (population dynamic, heat-cooler, bathtub, beer game) are presented and discussed. In addition, on the base of how much time is left (depending on how fast the students grasp the main SD concept) a number of microworlds are presented. During this time the project work groups are stimulated to select and choose a topic (system/process) to analyse by SD method. At this stage there is a lot of interaction with groups (out of lecturing time). Once each group has identified its topic to analyse, the practice work starts with some hints and support during the lecturing and continuous autonomously by group components with weekly supervision of the work in progress by tutor assigned (teacher or selected older students who have already went through the exam). The project work ends with a document produced by each group.

V. How the students are evaluated

The students are evaluated through their project work which beyond a description of the topic selected and analysed by SD methodology contains both causal-loop and stock & flow diagram. Each group, once concludes its project work which is continuously supervised by its tutor, prepares a Powerpoint presentation. During the presentation, which is conducted by all components of the group, the main concepts (both theory and practice) are checked (by examiner) in order to be sure that everybody is aware of what has be done. The presentations are always public and all course students (both the old and the new one) are invited to participate.

VI. Results acquired

The results obtained are very interesting. The course which was started three years ago, as an experiment for the faculty, is now confirmed by department council members. As mentioned before the attending students are increasing by a rate of 20% each year. Last and most important fact is the following; since its starting there has been more and more request of Master dissertation *per* year in SD. This last issue is absolutely a real success, considering the peculiar characteristics of Communication Sciences faculty in the Italian context.

VII. Notes and comments

The main problem with this course is the limited time (only 30 hours lecturing) related to its unfolding i.e. too short in order to explain all the topics which are necessary for its completeness. An addition of 18 hour lecturing would let a much better knowledge transmission. The project work development approach has given excellent results, but as it can be imagined this imposes for the course runner to undertake much more time to manage one by one group of students during the development of their work. Having based the introduction of the course on General System theory, another success key could be pointed out through the fact that beyond learning an operative method of simulation modelling, a high percent of the students following the course, came to know (often for the first time !) about System Thinking that is for them a new (innovative) way of approaching problems.

2 "Dynamics of Complex Organisations" – Faculty of Mathematical, Physical and Natural Sciences; Computer Sciences Department – Bologna University

At University of Bologna (Edoardo Mollona) SD practice has found ground within the Department of Computer Science in the Faculty of Mathematical, Physical and Natural Sciences. In particular, the history of SD development at Bologna runs in parallel and is intertwined with the creation, in the academic year 2001/2002, and the prospering of a programme of studies, including bachelor and master degrees, named Internet Sciences. The programme blends credits of computer sciences, management, law and economics and is aimed at creating appropriate skills to deals with complex dynamics that characterise the evolution of economic systems and societies. In this respect, Internet is both a fundamental communication tool that channels economic activity and social interaction, and a metaphor to represent economies and societies that are increasingly interconnected, complex and self-organising. Within the intellectual background blossoming in Bologna, one way, among the others, to connect the description of the trends in economy and society to the teaching activity was the design of teaching programmes that introduce students to the practice of modelling social and economic systems and simulate these systems using computer in order to explore emergent behaviour. The idea underpinning the offer of training in computational methods, these latter specifically applied to social sciences is that, as the complexity of object of study evolves, students have to be endowed with appropriate tools to explore evolutionary dynamics and learn how to deal with complexity while embedded in challenging decision-making contexts. In this respect, the Department of Computer Science provided an appropriate context since competencies in management, economics and sociology were integrated with technical skills in programming in a truly multidisciplinary teaching and research agenda.

I. Course specific characteristics

Within this intellectual context, SD easily found its location animating a 6 European credit course (48 hours of lecturing) named Dynamics of Complex Organisations. The course is a fundamental of the master programme in Internet Sciences. In the course, SD is taught in association to principles

of strategic management and organisational theory. Firms are represented as complex systems in which human, financial, intellectual resources, tangible and intangible, are accumulated. Emerging differences among firms, as well as creation of competitive advantages, depend on distinctive traits that the resources systems acquire over time. In the course, the repertoire of SD conceptual tools and techniques are taught in parallel to principles of strategic management. The idea that underpins the unfolding of the course is that system thinking is a prerequisite to create a good strategy and SD is presented as a discipline that supports the developing of appropriate mental models to interpret dynamic interplay among people, decisions and resources. The design of the course reveals a proclivity to nurture an international flavour by including a module taught in English by international teachers well known within the SD community. Since 2006, the international visiting professor is Paal Davidsen, from the University of Bergen in Norway and past president of the SD international society.

II. Students characteristics

Students attending Dynamics of Complex Organisations have a bachelor degree either in Internet Sciences or in other disciplines. On average only half of the students have a degree in Internet Sciences; the other half generally holds degrees in other fields, frequently, in Economics, Management or Computer Sciences. We consider this a strength of our programme in Internet Science because it gives evidence that its multidisciplinary attracts students from other fields.

III. Course topics

The course structure is articulated in four key areas. The first area deals with the description of decision-making processes. In particular, within this first section of the course, rational decision theory is compared with the concept of bounded rationality with particular regard to the impact that the evolving theorising on decision-making processes had on the evolution of economic science. In this light, the course reviews the evolution of theory of the firm and delineates the emergence of the concept of strategic management. The second area of topics provides key definitions, concepts and principles of strategic management assuming that the students already have some background in strategy. After an introduction on the field of strategic management, the course focuses on the Resource-Based View of the firm, a theory that postulates that different in firms' performances and sustainable competitive advantages can be explained looking in at the specific and heterogeneous resources those firms are endowed with. In particular, the course assigns emphasis to Dierickx and Cool (1989) dynamic analysis of properties of asset stock accumulation processes. This angle provides an intriguing connection between the field of strategic management and the field of SD. The third area of the course is a pure SD module; the themes span from fundamental such as the concepts of feedback, the analysis of loop polarity, stock and flow variables to technical analysis of structure-behaviour relationship, loop gain and role of non-linearity. Finally, in a last section, SD and Strategic Management are bridged. SD approach provides the conceptual, and technological, environment to model properties of strategic asset accumulation processes and investigate their properties.

IV. How the work practice is approached during the course

After having been exposed to principles of SD and topics in strategic management, with particular regard to the Resource-Based view of the Firm, the students are required to apply those concepts to business cases. Typically, we use business cases associated to flight simulator. In addition, the students are involved in practice work only at the moment of writing their dissertation or during specific applied projects that students have to complete to accumulate credits and fulfil their requirements. In both cases, if they decide to apply SD, they have a tutor that guide them throughout the process of building a formal model, analyse its behaviour and explain findings. In this respect, we report as an interesting outcome emerging from our course the fact that, increasingly, firms propose to us agreements that concern the joint tutorship of SD dissertations.

During these projects, students apply SD modelling to real strategic and organizational issues thereby building hands-on experience on the delicate process of translating problems and issues verbally reported into formal models.

V. How the students are evaluated

Typically, students are evaluated with written examinations including both multiple choice tests and problem-solving exercises.

VI. Results acquired

Teaching activity nurtured an atmosphere that stimulated a number of ideas for theses both at the bachelor and master level. Dissertations that have been recently discussed deal with such diverse topics as industry dynamics and, in particular, videogame industries (Mandelli, 2003), start-up dynamics (Maoret, 2003), industrial districts (Tatullo, 2004), learning environments (Dusi, 2005), technical issues in the comparison of analytical and computational methods to analyse complex dynamic systems (Paparoni, 2005) and analysis of outsourcing and supply-chain management in software production (Sposito, 2005). Within the Department of Computer Science, SD has also found an important place in the research agenda. In 2003 two large projects were funded by the Ministry of the University and Scientific Research. Both projects focused on the analysis of evolving dynamics of industrial districts. Within these projects, SD stimulated one thread of research specifically aimed at capturing common underlying structures that may explain long-term observed dynamics (Antonelli, Mollona and Moschera, 2006; Mollona and Presutti, 2006; Marafioti, Mollona and Perretti, 2006).

VII. Notes and comments

Concluding, SD activity and practice is firmly rooted in both the research and teaching agenda at the Department of Computer Science at University of Bologna (runned by Edoardo Mollona) and is flourishing as an appropriate intellectual and methodological environment to explore issues connected to strategic management and organisational theory. To highlight two elements that characterise the SD programme in Bologna, it can be mentioned the strong foothold in the Strategic Management field and the attempt to facilitate the connection between students and firms willing to structure their strategic thinking within the framework of SD. In this respect, it has proved particularly useful to associate SD concepts with the *jargon* which is familiar to managers and to ground SD principles within theorising in Strategic Management.

3 "Production Systems Modeling" – Business & Economics Engineering Faculty at the Department of Business Engineering - Rome University "Tor Vergata"

This course has been carried over by a young researcher, Stefano Armenia, at the faculty of Engineering, "Tor Vergata" University, Rome, Italy. Armenia started his research career in SD in late 2002 when he started his PhD in Business Engineering at Tor Vergata. He approached the System Dynamics methodology while dealing with simulation & modeling, and decided that the SD approach was worth being studied, also because his initial PhD focus was on business games, microworlds and simulated learning. After deepening his SD skills by studying Systems Thinking (Senge - 1990), Organizational Learning (Argyris, 1978) and System Dynamics (Sterman - 2000),

he had the chance to start talking about SD in a Production Systems Modeling course, by means of a module of 15 hours). This further allowed to disseminate SD also by teaching in many master's degree courses in business administration in various faculties of "Tor Vergata" University, as well as promote among students several degree dissertations dealing with various business and engineering issues by means of an SD approach.

In this context, the focus will be mainly on the basic module in System Dynamics that Armenia has been teaching in his courses at the "Tor Vergata" University of Rome, as well as also on a research on the value of SD teaching (Armenia, Bertini, Onori - 2004), with referral to the bathtub dynamics topic and related previous research (Sweeney, Sterman - 2001).

I. Course specific characteristics

The SD module was being taught in the context of a wider course dealing with the issue of Production Systems Modeling. This is a 3rd year course at the Faculty of Business Engineering, thus one of the first innovative courses after the first two years where students are faced with basic subjects like physics, mathematics, geometry, informatics, graph theory, operations research and so on. It is classified as a technical course in which students also start to acquire some advanced tools for modeling systems. The course does not focus particularly on System Dynamics, rather uses several simulation techniques (like discrete simulation, especially based on the *Arena* modeling environment). The SD module is particularly useful in order to extend the toolbox available to students both with a new approach of thinking in systems modeling as well as a different simulation technique and environment (the various SD software tools are presented, without any particular choice). Some hints on Agent-Based simulation were also given to the students.

II. Students characteristics

The overall composition of the class is, in average, made out of 120 undergraduate students at their last year of a Bachelor Engineering Degree (B.Eng.). Most of them have mainly undergone the following courses: Control Theory, Microeconomics, various Calculus courses (mathematical analysis, Algebra, Geometry, Physics, etc…)

All of the students are undergraduates at the "Tor Vergata" University in Rome - Italy -, and attend the faculty of Business and Management Engineering.

It is possible to infer some simple statistical data on the students sample having asked them to fill out, before the test, a form in which they were asked their age, gender, specialization and typology of passed exams, especially those typical ones of the Italian traditional engineering degree (Laurea). As undergraduates at their last year, their age ranges from 20 to 23. The population is fairly distributed on genders, with a little predominance in males.

Moreover, most of the students are from the Management Engineering Specialization (88%) but there were also students from other specializations, Logistics Engineering (6%) and Production Engineering (6%). The students are also asked to tell more about their mathematical background, that is, any passed Calculus exams or similar. Collected data allowed the researchers to establish that the three more followed courses until then had been Mathematical Analysis, Operations Research, Probability and Statistics. The students usually have no prior experience with system dynamics, nor they ever played the Beer Game, both before and after the first test. Moreover, since the SD module is placed right in the middle of the "Production Systems Modeling" course, the students have acquired a basic knowledge, even if partial, on production models and production systems issues. The statistics, by now, confirm that , the course students are fairly a homogeneous group.

III. Course topics

The course is based on some basic key-concepts: differences between system and model, the need to improve systems performances by evaluating the possible outcomes before the reengineering is carried over (i.e. by simulation techniques), understanding systems complexity and behaviors.

The first part of the course, is mainly devoted to setting the context, that is describing modeling approaches and the basics of concepts related to the "Continuous Improvement" theory as well as the Business Process Re-engineering (BPR). In the second part, the basics of Systems Thinking and Systems Dynamics are explored, with peculiar reference to concepts like Complexity, Structure, Behavior, Feedback, Causal Diagrams, Archetypes, Stocks & Flows dynamics and advanced SD topics. In the last part, the students are faced with the "problems" of developing a model from scratch as well as validating and simulating it. Then they are also instructed about the various SD modeling and simulation software on the market. At last, some application examples, in different knowledge areas, are given, as well as the concepts of microworlds, decision support systems, policy evaluation and electronic business games.

IV. How the work practice is approached during the course

During the course, right after the introduction of the basics of System Dynamics, the students are divided in groups and each group is asked to start building up a simple model based on a topic which may be either concerning the aspects of their everyday jobs or rather which may be taken from an article found on the newspaper that may "sound" systemic! This task is referred to as "Project Work". Also in this case, the project work usually ends with a document produced by each group.

Moreover, as also reported in detail later in this chapter, at the beginning and at end of the module, the students are asked to perform some tests in order to examine either their initial abilities to understand the dynamics of stocks and flows as well as (at the end of the module) to test how their systemic skills have eventually developed after the SD module itself.

V. How the students are evaluated

The students are evaluated according to different "performance indicators" each one concerning a different and specific task. First of all they are evaluated on a final examination that basically consists in a theme which has to be translated first into a causal map, and then, by a quantitative method (described in Burns - 2002), developed into a Stock & Flow diagram, with (basic) equations describing the variables in the system. Part of the evaluation is also performed by analysing the project work

VI. Results acquired

The results obtained over the last years form this SD experience in teaching at Tor Vergata are very interesting. Although the module in the "Production Modeling Course" has not been regularly carried over, due to several reasons, it has been noticed an upsurge of interest for System Dynamics notwithstanding this aspect. This is certified by the increasing students requesting their Master Degree dissertation in SD issues as well as by a higher attention (also curiosity) paid by other professors (belonging to the faculty council members) to the SD methodology. Increasing are also the "contaminations" which SD is able to provide in Master Degree dissertation requested to other members of the teaching council. This, together with the attention paid to the methodology also from nearby faculties like Sciences but mainly form the faculty of Economics has already lead to common and inter-faculty initiatives especially in terms of seminars dedicated to the students, PhD students but also interested professionals, which is quickly bringing the Tor Vergata SD Group to the attention of the Italian Chapter of the System Dynamics.

VII. Notes and comments

It is interesting to report here about an experiment which was carried over and registered during the first year of teaching SD at Tor Vergata.

In February/March 2004, the students abilities were tested to understand the dynamics underlying counterintuitive system behaviors in two different moments: before and after the SD module, as a part of the Production Systems Modeling course at the faculty of Business Engineering.

The experiment has, thus, constituted a very interesting experience which allowed to better understand which are the mental obstacles that students find while trying to solve mathematical and/or physical problems, as well as designing their own mental models of the reality under examination.

The results are available in (Armenia, Bertini, Onori, 2004) but some of the considerations from the cited work are reported in this section for the sake of understanding of how the students may have benefited from the SD courses. The research on Bathtub Dynamics is still in progress and the so called by now "entry" and "exit" tests are performed every year in the Production System Modeling course.

However, with specific reference to the research carried over in 2004, it is interesting to note that, as the results presented also in Sweeney/Sterman (2000) suggests, even subjects with previous training and/or background in mathematics and science have a poor understanding of the basic concepts presented in the tests, which seems to be in contrast with for example reported in our CF2/case1. The subject, presenting typical mathematical argumentations, effectively found the correct solution.

Probably such a discrepancy may be mostly due to the fact that the effective students level of education (i.e.: mathematical skills, etc…) was not taken into proper consideration. This to mean that probably an inference test concerning statistics on the average performance of students on related exams would help in confirming good results. This issue appears to be confirmed by the fact that a student with a good educational level correctly handling the first task, was then also able to correctly manage the second one. Moreover, it was noticed that students who said to have studied SD in an accurate way, were effectively able to positively manage both tests and reported SD disciplines as being very important.

According to BT1 results, the course students showed an overall poor performance, reaching a rate which was 20% worse than MIT students and 16% worse than those at WPI. However, also taking into consideration such an overall bad performance, there were some correct solutions both to the BT1 and to the CF2 tasks. According to CF2 results, overall performance was still poor, and the results were 10% worse than those obtained at MIT and 16% worse than those obtained at Portland Symfest.

The second test (DS/MC group 2) presented some improvements on overall performance. In fact, the students' performance in the DS task was only 4% worse than MIT and 10% worse than WPI. Thus probably this showed that the SD module had at least some effect in developing the students' systemic skills. On the MC task, students reached quite good results, 16% better than MIT and only 6% worse than those at the Portland SYMfest. This was probably due to the SD topics learned in the SD module, which, according to the main topic of the overall course, were mainly focused on production systems models. Those students presenting a good performance also showed quite a deep interest in SD topics.

This was confirmed by the fact that those students applying SD concepts (as well as saying that SD had been useful to them) were on average performing better than those who either didn't apply it or just said that SD had not been useful to their understanding of production systems. Finally, it was interesting to notice how the joined use of the SD discipline with ones from other scientific areas often underlines the ability to reach excellent results and improved solutions.

4 "System Dynamics " - Second Level Master in Data Intelligence and Decision Strategies (DISD) at Statistics Department – Rome University "La Sapienza"

This experience of teaching System Dynamics started in 1997 at "La Sapienza" Rome University postgraduate specialization two years course named Operation Research and Decision System (ROSD). With the change in University laws the school was replaced by second level Masters , so

the Master in Data Intelligence and Decision Strategies was established. The upper school and the master had their life within the Applied Statistics Department . It is important to point out that the Operations Research group working within this Department was the first group introducing Operation Research in Italy (Professor Aparo) . So the course was placed in a cultural rich environment open to different modeling approaches.

A shorter but very interesting teaching experience was that done in Catholic University of Piacenza where the same type of course was taught in the master MINE (Master in Network Economy) . The peculiarity was presented by student coming from all over the world . In both the Master the feedback from the students results has been always very good and rating has always been very near to maximum.

I. Course specific characteristics

The basic ideas driving the teaching approach (derived from past working experience) are very simple : "Learning by doing" ad "Group Working". Coherently the lessons are always in the computer room . The course starts immediately with use of computer in SD environment (normally VenPle of Vensim Corp.) and the final examination consists in presentations of a problems (possibly real) that the groups have solved using SD modeling concepts and tools.

This approach were quite difficult in the past because Universities had few (or no) PC computer room and many students did not had computer skills . It took quite a relatively long time in order to train all the students to use a PC and then a Simulation tool. The situation is completely different now : Computer rooms are easily available and the students use PC in a very efficient way . Moreover the availability of very good Helps and example in the simulator tool adopted make it possible to save time in the class and stimulating students to study by themselves at home. In fact in the course new course, which will be starting in May 2008, a certain number of hours (10) are allocated to E-Learning activities.

II. Students characteristics

Nearly all students work in private or public organizations . The students age is ranging from 26 to 50 years old. They own a scientific degree (statistics (80%) , engineering (8%), economics(8%) , computer science(2%) and others(2%)). Some of them are Managers in the organization where they work . They are very motivated in learning new approaches that can help them in improving their career . Number of students in the class range from 20 to 35.

A very challenging atmosphere and plenty of real problems usually are already present in order to be solved.

III. Course topics

The actual duration of the course in the class is 24 hours (of which 4 hours are for the examination session) . Naturally since it is asked for a formal presentation of a real problem many other hours are spent at home for the group work . It is difficult to estimate, but at least 30 hours (in average) of home work is a good guess of the additional effort needed.

The number of lesson are 6 each of 4 hours. The lessons are planned in 2 month period . Normally the introductory lessons are concentrate at the beginning (16 hours) leaving one month period in order to prepare the examinations. In this period the teacher behaves as a consultant, in order to help the groups to develop a consistent and useful model.

In short : in the first lesson some time is spent in order to interact with the students and testing together the complexity in estimating the evolution of a system with feedback Second topic is a 'bird view' presentation of the Simulation applied to the studies of organizations or companies as is it now : System Dynamics , Discrete event Simulation, Agent Based Simulation . It is an occasion to show some of the modern simulation environments. The cases shown come from the work in progress (as emergency health service) or made in the past (as 2000 Rome Jubilee).

After the introduction the lesson continues with Cause Effects diagramming examining some of the most interesting archetypes . Some exercises are given to students in order to be developed at home, possibly in a group work. The second lesson starts with correcting the home work and continuing with stock flow modeling. In the second and third lesson, some classical models (Diffusion, Aging chain, Control system, production) are presented in order to show the peculiarities of the models and of the simulation tool in use. The models are built, on line, together with the students. In the meantime the students propose the topics to be developed and define the working groups (no more than 5 students per group). In the successive lessons the problems are modeled and simulation results are discussed.

IV. How the work practice is approached during the course

Since the first lesson a set of libraries made of already solved , simple problems are given to students . They encompass many disciplines : from Physics to ecology , from macro economy to supply chain. Sometime , depending on the class composition, the number of students and the availability of time the "Beer Game" is also played.

V. How the students are evaluated

The working groups are free to choose any problem they want . The teacher advices them in order to be sure that the problem is appropriate to SD and that the complexity is within the skill and time the participant have. The project developed by the group is evaluated in term of : complexity , quality of Cause Effect model , the quality of the stock flow model , the kind of experimentation done, the presentation quality. Naturally all the student that are part of the group present some aspect of the model. The group dimension is between 3 to 5 students.

VI. Results acquired

The results obtained are very interesting. In 10 years experience a lot of problems has been studied. Some of them has been published (Leukosy , Aedes Albopictus). The available list is very motivating for the new students that at the beginning , in the orientation phase when they think that they do not have interesting problems to propose.
The models developed since 1997 in summary: 13 models related to business process analysys and reengineering, 7 related to health service,. 16 related to strategies of which 4 related to the evolution of forensic system and 7 to marketing models , 2 to ecology.
The most important result is that the System Dynamics is still part of a very prestigious Master.

VII. Notes and comments .

There is full satisfaction of the results acquired by teaching activities. The number of teaching hours seems to be enough. The only practical problem seems to be the fact that presently there is no availability of an open simulation environment with all the characteristics needed. VenPle is a very good introductory tool , with a very high usability, it is very reliable and is optimally documented but a good model/simulation learning environment should also include Agent Based and Discrete simulation and other advanced methods/tools including Optimization and Sensitivity analysis.

An overall comparison of different SD courses

It is a hard job to compare, in an efficient way, courses of different characteristics and contexts even though having a general common objective, i.e. teaching a new/different approach in analysis of complex dynamic systems. Hereby it is presented a synthetic table where the main characteristics of each course is sketched.

Department → **Course characteristics** ↓	Communication & Sociology	Computer Sciences	Business Engineering	Statistics
Course "age"	3 years	7 years	3 years	8 years
N. of students per year	50	40	120	25
Year of course (since initiating university courses)	5th	4th	3rd	After 5th
N. of course hours	30	48	15	24
Course topics key words	System Thinking Modeling, Simulation	System Thinking, Strategic Mgmt, Organisation	System Thinking, Organisation Learning,	System Dynamics, Discrete event Simulation, Agent Based Simulation
Use of Case studies (when)	After theory	After theory	After theory	From beginning
Students evaluation	Project work	Written exam	Written exercise	Project work
Results acquired	Regular course with a 20% students increasing rate	Consolidated course, Involvement in national research projects	Interesting interactions with other faculties/departments under SD "umbrella"	Introduction of SD in Private & public organisation with practical problems resolution,
N. of SD dissertations per year	4	5	6	-

As it can be seen each course has its peculiarity and specification. One common issue is the full use of business cases in all of them. It is also interesting to underline the fact that System thinking principals seems to be "necessary" in order to best introduce System Dynamics methodology.

A final consideration, which has been spontaneously suggested by all the four authors of this paper who are also the main teachers of the courses described, is the fact that; "*it would be very useful if each could dedicate, at least one hour lesson, participating in the other colleagues course in order to distribute each one teaching experience/knowledge to the other courses*".