Intelligent E-learning Systems and the Transfer of Novices into Experts

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ABSTRACT
In our knowledge society learning is a very important and broad topic that includes several unsolved questions. Among them the transfer of novices into experts remains elusive. The paper shows that the cognitive elements and mental models needed for the expert execution of a task or skill can be used in cooperation with suitable exercises and intelligent e-learning systems to obtain a faster and more robust transfer of novices into experts. The paper also discusses the role of mental models and how can they be obtained from human experts. It also includes a state-space methodology to know the obtained place for the apprentice within the transfer process and how to move him optimally towards the final or expert state. A particular example for decision making by using an intelligent e-learning system simulating a private Medical Centre is included and the obtained results for more than five years are assessed.

General Terms
Artificial Intelligence, Intelligent E-learning Systems, Multi-agent Systems, Human Learning.

Keywords
Transfer of Novices into Experts, Neocampus.

1. INTRODUCTION: THE TRANSFER OF NOVICES INTO EXPERTS
One of the many not fully solved learning problems in practice is the transfer of apprentices into experts. In spite of the studies and work done so far, this transfer remains elusive because educational institutions are only able to produce apprentices who must join (individually or in group) a human expert and work with him quite a long time to become experts themselves, no matter what grades and subjects they have studied.

The great majority of papers related to the subject have to do with the differences between novices and experts. Starting with the pioneer work by Chase and Simon [1] and De Groot [2] related to chess players, the remainder works by Lesgold [3] and others related to medicine are devoted to semantically richer areas. The human expertise already studied is ample and varied such as: mathematics [4], social sciences [5], politics [6], computer programming [7], newtonian mechanics [8] and even baseball [9]. Although the review of all the literature is out of place some more recent papers have to be cited as the work by B. Dale [10] concerning the differences in learning between novices and experts, and the detailed work by Parikh [11] in 2011 devoted to expert and novice differences in problem solving in heat transfer.

Papers have also been published dealing with the transfer problem and means to help it. Among them it is interesting to mention the work at Stanford by Hinds and Patterson [12] including a review of the related literature, devoted to the effect of expertise on knowledge transfer, the work by Shaw and Gaines [13] referred to knowledge initiation and transfer tools, and the very recent work by Lachner and Nückles [14] concerning the possibilities of engaging novices into deep processing because of the suitable explanations of human experts.

No doubt it is very difficult the comparison of the results obtained in different areas because of their peculiarity but the analysis of the scattered data obtained from reality concerning the differences between the problem resolution ways used by novices and experts allows to draw several conclusions such as:

a)-The amount of structured knowledge used by the expert is by far much more important that the one used by the apprentice. Also the kind of structure involved in the knowledge is different in both cases; in the case of the expert the structure is richer and more approximate to reality than in the case of the novice.

b)-Novices often try to obtain forwards the solution of the problem starting with data to obtain some unknowns which become data available for the remainder unknowns and so forth until they solve all the unknowns or they find out that the way is not valid. Experts also proceed forwards and also backwards from a pretended solution until they find the justification on the initial data. In both cases experts find clues for choosing the appropriate unknowns and the “ad hoc” relations to solve them, clues which are invisible to novices.

c)-The classification of the problems and data done by novices is mostly superficial leading to an unprepared representation, where experts use deeper aspects of the problem allowing the application of basic principles of the theory and the use of the present constraints.

d)-Apprentices usually produce a single (or a few) and large cognitive structure (mental models will be called later on) containing a great deal of inert knowledge. Experts have several families of mental models without inert knowledge; each model of a family describes a particular scenario but with shallower or deeper insight. Besides, the expert is able to choose at any point of the reasoning the precise model with the shallowest vision to cope with the different constraints and data. Families of mental models are usually interrelated in such a way that for complex situations it is possible to merge models of one family with others from a different family to include the minimum of elements yielding the total or partial solution of our problem.

It is important to know exactly the differences between a novice and an expert in any real case because as it will be stated in the presented methodology, the cancellation of those differences will imply the conversion of apprentices into experts.

2. NEW APPROACH TO TRANSFER OF NOVICES INTO EXPERTS

The general approach proposed in this paper is based on the decomposition of the task or skill to be learned into its cognitive elements and the use of intelligent e-learning systems to present suitable exercises in order that the novice can faster acquire those elements. Intelligent e-learning systems are very suitable for that purpose because of the functionality and flexibility they can get.

2.1 Cognitive Elements of the Skill: BCTA

It is obvious that the performance of a certain skill requires different cognitive elements, such as declarative knowledge, procedures and so on. The problem is to get a full classification of those elements and be able to get them in a real case. Probably the most important cognitive elements for our purpose are the expert mental models.

The nature of those expert mental models and their features were first studied and developed by Jhonson-Laird [15] and also by Gentner and Stevens [16]. Mental models integrate scientific knowledge, if needed, into a conceptual framework which allows the expert to think of the problem, to analyze it, make decisions and possibly to solve it. Mental models are constructed, in consequence, from tokens arranged in a particular structure to represent a concrete and real scenario. The tokens represent the final concepts and the structure the relationship among them, used by the expert for diagnose and decision making. The relations included in mental models can be causal, temporal, qualitative or quantitative, simple or very complex; in summary they reflect the perceived or conceived structure of the world (or a part of it) as a function of the world and the human cognitive capability without including meaning void elements or non-directly related to reality which other representations may include, such as semantic networks, truth tables, sentence representations by means of first-order logic, or Venn diagrams.

In order to get not only the human expert mental models but also the remainder cognitive elements needed for the expert execution of the task or skill, the tool BCTA (Behavioral-Cognitive Task Analysis) has been used. BCTA [17], [18] is a methodology to get all those cognitive elements needed. BCTA first decompose the task or skill into subtasks paying attention to the milestones and critical points, execution procedures, errors and efficacy as well as the relationships among subtasks and their integration. It is important to identify the key abstractions to reformulate the problem and its environment and obtain the instrumentation mechanisms or object structures able to cooperate to reach the problem goals under the existing requirements.

To obtain the cognitive elements from human experts BCTA uses knowledge elicitation techniques. Among them directed interviews, “on line” solutions of specific problems, parallel solutions of antagonistic problems, are included. The techniques are similar, in a certain way, to those already applied to obtain the rules from an expert to produce a knowledge-based data processing prototype.

The final elements that can be obtained with the aid of BCTA can be classified as:

-Declarative knowledge: such as concepts, properties, relationships among concepts and properties, equations, etc.

-Cognitive or behavioral techniques: algorithms, procedures, recipes, etc.

-Cognitive or behavioral strategies for long term decisions.

-Mental models: families of models representing totally or partially the task or skill and its execution.

-Learning techniques: specific procedures for easy learning of the knowledge, techniques, aspects or strategies.

-Learning strategies: specific strategies for long range learning of aspects of the execution of the task or skill.

Once the cognitive elements have been obtained it is convenient to classify them into several groups according to the levels of expertise we can consider. So far three of them have been taken into account. The first level of expertise is related to the *familiarization* with the task to be learned. Within this level the apprentice may know most of the concepts, some properties and relationships, but he/she will not be able to execute neither the task nor most of the subtasks. The second level is related to *normal execution* of the task or skill. Within this level the novice can solve normal or most usual situations of the problem or task but not the difficult ones. The cognitive elements of this level obviously include also those of the first level of expertise. The third level deals with the *expert execution* of the task or skill. Evidently it has to include all the cognitive elements obtained. The classification of the obtained cognitive elements according to the levels can be done with the assistance of human experts.

Therefore the transfer of novices into experts will go through the three levels of expertise already mentioned. To follow the path it will be necessary that the intelligent e-learning system that is used will provide the novice with exercises or learning elements containing the cognitive elements needed to reach each level. For that purpose EVALGEN [19], a knowledge-based system that is capable of selecting from Knowledge Bases containing exercises or learning elements according to one or several criteria, has been used. Each exercise includes a set of parameters defining the cognitive elements necessary for the solution of the exercise or execution of the task and their supposed intensity. The criteria establish the number of exercises to be selected and the set of cognitive elements (parameters) that they have to include as well as their intensity. Should the Knowledge Bases not contain a sufficient number of appropriate exercises fulfilling the chosen criteria, the system will notify the different possibilities of the Knowledge Bases. The intelligent e-learning system will be in charge of determining the “distance” between the actual learning situation of the novice and the human expert and of selecting the appropriate criteria to be sent to EVALGEN.

It would be possible to establish more levels of expertise than three (we have done so in some cases) but it is not easy to define them from an intuitive point of view and the results obtained are very similar.

2.2 Intelligent E-Learning Systems: NEOCAMPUS

E-learning systems have been improved during the last thirty years with the cooperation of different theories, tools and machines. Perhaps Artificial Intelligence has been more fertile for enhancing this paradigm, with the inclusion of expert systems, neural networks, genetic algorithms, etc. But it is the Distributed Artificial Intelligence paradigm with the introduction of multi-agent systems that shows promising results for the cooperation in the human learning process. The work by Sommaruga [20], Ferber and Drogoul [21], Katia Sycara and Michael Roboam [22], are good initial examples among others of this type of work.

It is out of the scope of this paper to review the broad field of intelligent e-learning systems, but closer to this paper, the modular agent architecture used in this work [23] and some of its applications [24], [25] have to be cited. The specific knowledge needed by the agents to execute the assigned task is divided in three layers according to the response time of the execution of the corresponding agent action; so, the reactive layer includes knowledge needed for rapid and vital agent responses, the tactic layer includes the knowledge for executing procedures and actions not so rapid, and the strategic layer supports the knowledge for long time decisions, long range planning and cooperation procedures.

NEOCAMPUS [26], [27] is a long-range effort fully devoted to do research on several problems related to a new generation of intelligent e-learning systems, and to the subsequent construction of different spin-off real systems devoted to reinforce the student learning process by means of coaching and decision making learning.

The main objectives of NEOCAMPUS, from the user point of view are the following:

a)-To build a software environment for the construction of multi-agent intelligent systems. NEOCAMPUS is basically an intelligent agent factory. The cognitive agents produced are able to be cloned if necessary, to execute assigned tasks, to make their own decisions, to learn from experience with the aid of machine learning techniques, to cooperate among them, and communicate among them by using natural language. The purpose of this agent factory is to provide a flexible system infrastructure with powerful capabilities for researching and solving educational problems.

b)-To build web-based tutors for collaborative e-learning and for enhancing tutorial functions. The upcoming development of e-learning services, most of them connected to Internet, requires the virtual presence of administrators and tutors to take care of monitoring, managing and helping the human learning process. Due to the different situations contemplated in the goals of the e-learning services, web-based tutor functions can be varied from helping individual students up to assessing collaborative learning in the case of a simultaneous group of students.

c)-To build several Knowledge Bases and that way built different "spin-off" intelligent e-learnimg systems, allowing users to make questions to those systems, get answers and learn about the topics installed on the Knowledge Bases by means of "learning elements" (not necessarily traditional courses) or exercises mostly designed, managed, tutored and controlled by the system agents.

d)-The system, as we will see later on, is available for the transfer of apprentices into experts by using human expert mental models and a methodology to do it that includes several tools for the purpose such as BCTA and EVALGEN already mentioned.

NEOCAMPUS includes a sort of tutorial and managerial functions from a generic point of view. This means that they will have to be inherited and extended for each "spin-off" system according to the peculiarity of its learning domain. The most important functions are:

-Track, manage and update the student log history including all the significant details: number of sessions, frequency, duration, number and time of errors.

-Analyze the students (and students group) errors by obtaining shallow and deep error reasons related to scientific knowledge or expert experience.

-Obtain from the user's interaction the constituents of the student model and its parameters such as: learning style, interest, effort, attention, capabilities, etc.

-Tutorial help in its different interpretations: advice, guidance, tips, remedial tactics, instructional design, evaluation, coaching exercises, etc., by using the specific cognitive elements of the ability to be learnt.

-Personalize the operation of the system, including its interface, to adapt it to the particular student features.

-Group guidance and help for the obtainment of the group structure integrated by a set of roles and profiles.

-Monitor the student group structure by tracking each role and their integration in the group.

-Evaluation (with different purposes) of each individual behavior and of the whole group.

-Monitor and enhance personal and group motivation.

-Manage and control simulators and tools for decision making, evaluation or problem solution.

-Promote group functioning, interaction and operation aiming at cooperative and collaborative learning

-Manage and control Knowledge Bases and Experience Systems.

3. GENERAL METHODOLOGY FOR THE TRANSFER OF NOVICES INTO EXPERT

Now a general cybernetic (closed loop) methodology for the transfer of novices into experts will be formulated. It will be completed with the use of the tools already mentioned.

The methodology follows a set of operational phases such as:

a)-Precise qualification of the initial state of the transfer: the real situation of the apprentice as it is.

At this starting point it is necessary to specify all details of the initial situation of the novice to obtain later on full indication of the differences with the expert from a cognitive, motivational and, possibly, social point of view. The full knowledge of this initial situation will allow to, experimentally, obtain his conceptions, tactics and strategies. This phase is carried out by means of interviews, questions, etc. with the aid of BCTA. The end result is the assignment to the novice of a set of cognitive elements and their intensity that describes his/her starting situation before learning.

b)-Specification of the goal states to be obtained: the expert state.

The final state (the expert) which by no means is unique, has to be specified. Within that concretion attention has to be paid to the procedures, tactics, strategies, structures and mental models used usually by the human experts for their life long learning, for remembering, for applying what they know and for problem solving.

For that purpose it is necessary to take into account the basic ingredients of expert behavior such as:

-the develop of pattern recognition procedures with a better use of human memory resources;

-the develop of procedures for actions suites;

-the improvement of solution search strategies; in general this improvement can be related with forward reasoning starting with data;

-the improvement in the knowledge structure to finally provide a full set of mental models and search procedures in the problem space;

-the consolidation and refinement of the acquired knowledge by means of the association of recurrent patterns with their particular solutions (condition-action) to improve speed and precision.

The phase is carried out by means of interviews, problem solving methods also with the aid of BCTA. The end result is the set of the cognitive elements of the human expert including the mental models.

c)-Comparison between goal and initial state.

The differences between expert and apprentice behaviors have to be translated into differences in the cognitive tasks execution carried out by both of them, including those corresponding to their mental models. In summary, it is a question of explaining the task execution mechanisms for both and their differences.

As an example, one of the significant differences between experts and novices is the expert skill to recognize significant patterns. Chess good players are able to remember a great amount of position pieces with a quick glance at the chessboard; actually their perceptive learning allow them to recognize a full set of position pieces as a perceptive unit.

Other important difference, already said, consists in the expert description of the problem by means of a scientific or profound representation, that is to say, by using scientific categories corresponding to scientific principles, instead of using naïve descriptions as novices do.

But usually mental models can explain a great deal of those differences and their use can facilitate a great deal the application of the methodology.

The phase is carried out by comparing the cognitive elements and mental models of the novice and the human expert. The final result is a set of the cognitive elements and mental models that the novice does not have so far.

d)-Design of the operators for the change of state.

In this phase the different learning elements such as questions, problems and projects including the needed ingredients for the novice state change are selected (possibly designed). To do that each learning element or exercise has to be characterized by a set of parameters relative to the needed ingredients for the change and a quantitative assessment of their intensity; assessments could be based on objective or subjective reasons.

The reason for those parameters and their quantification is the difficulty to design learning materials which directly transfer in one step the novice into an expert; experience shows that this is a gradual or step by step process. In consequence the process requires the precise evaluation of intermediate states and their distances to the goal in terms of those parameters and intensities for the application of new operators (learning elements) able to reduce that distance.

In the case of existing Knowledge Bases containing enough exercises or learning elements, the phase is carried out by means of the EVALGEN that chooses the appropriate exercises or learning elements (operators for the change of state) to reduce optimally the “distance” between the novice and the human expert. In case we dot have those Knowledge Bases appropriate exercises have to be designed.

e)-Use of the state change operators and evaluation of intermediate states.

The operators (exercises or learning elements) selected or designed in the previous phase are here applied causing the novice change of state. Once again the new state has to be evaluated and also its distance to the goal. As we can see it is a closed loop process finishing when the goal state is reached.

In principle there is no restriction concerning the kind of human expertise which this methodology can be applied to, but its operation relies on the incorporation of intelligent e-learning systems able to cope with intensive tutorial functions.

4. PRACTICAL CASE: THE TRANSFER OF JUNIOR MANAGERS TO EXPERT ONES

This is a real case of a Medical Centre interested in the transfer of novice managers into expert ones in a rapid and robust way. For that purpose three important milestones have been produced. First all the cognitive elements including mental models of the expert manager and the expert heads of the departments have been obtained with the aid of BCTA, then an intelligent e-learning system (CENTMED4, a NEOCAMPUS spin-off system) has been developed as a model emulating the Centre operation with great detail of the consequences produced by the decision of the persons in charge of the Center or of the Departments, and finally the learning exercises have also been designed. Input data for the model are the hierarchical organization of the Center and the tasks we want to consider according to the adopted resolution level and services offered by the Center.

The medical and clinical services of the Center are the usual ones and they will be taken into account in the following description of the units or Departments:

-General Manager; approves the Centre annual budget and its modifications under the supervision of the Board of Directors. The user of the system will take up his position and he will be in charge of accepting the modifications or actions proposed by the different Departments. Besides, he can introduce the decisions and changes he wishes into CENTMED4 to see their consequences. This is the upper level of the Centre organization; the second or lower level is composed of the Departments Heads, who have to take decisions according to the prescriptions, goals and constraints set up by the General Manager and observe the results of their decisions that are shown by the system.

-Commercial and Marketing; in charge of the publicity campaigns and the celebration of Medical Congresses and Meetings.

-Human resources; in charge of the regular tasks (payment roll, personnel hires and firings, education and training).

-Acquisitions of any kind but medical products.

-Pharmacy, in charge of buying medical products.

-Administration; it takes care of cash management, invoicing, and patient movement.

-Finance; it produces the economic and financial information for the General Manager and Departments; also it keeps and conducts relations with banks in order to obtain the funds needed at any moment.

-Technical Direction; it is in charge of the Centre doctors supervision and coordination of the external doctors, it has also to watch over the Centre quality and to inform about acquisitions proposals and personnel hires.

-Clinical services; it is the biggest Department, including medicine doctors, nurses, and staff. It provides all the medical, clinical services and surgical operations.

-Laboratories; it takes care of the following units: Emergency, Intensive Care, Radiology, Laboratories, Nuclear medicine.

-Physiotherapy; it is similar to the previous Department, but devoted to clinical services of this kind.

-Data processing; it covers all tasks related to hardware and software.

-Archive; it keeps medical reports, treatment and laboratories protocols and patients history.

-Repairing and maintenance of the installations and facilities of the Center.

-Laundry and cleaning; it takes care not only of the laundry, room and laboratories cleaning, but also of the medical theatres sterilization, and Congress rooms cleaning.

-Food and meals; according to the patient number, and their medical treatment, it serves meals and beverages according to medical prescriptions.

Data concerning the Center functioning has been obtained through staff interviews and analysis of the historic data. It is also possible to introduce statistical data guided by appropriate distributions in CENTMED4.

Concerning CENTMED4 which operates on a local computer network, it includes the model of the fifteen Departments of the Center and their structure. The tasks executed in each Department are carried out by an intelligent agent in charge of its daily and normal decisions according to the agent built-in knowledge that includes all the cognitive elements for the expert execution of its tasks. When a situation arrives exceeding of the possibilities or authority of the Department, it (the agent) has to request permission or budget increase for the execution of the appropriate action.

The user can play the role of the General Manager (there is an agent playing this role). He has to grant permissions or increase budgets and the system will show day by day the consequences of the decisions taken or given such as: increase the room rate, hire workers (nurses, medical doctors, staff,..) on a temporal or stable basis, invest to increase the number of available rooms, increase in the social security expenses, reduce the pharmacy inventory load, etc. But usually there is a full group of users, working as a team, where each member assumes the role of a Head of Department and another group member the role of General Manager. In this case they have to behave as in the real Center.

In the case of a group of students they can decide independently on their PC's and check together the simultaneous results of different actions on the same situation. They can also discuss first the different possibilities and then make together a common action. In consequence, the instructor can imagine many different learning situations mixing or combining the different possibilities of the prototype. The cooperative decisions made by the agents before specific situations can be used for cooperative learning among the Department Heads.

The main window tool bar on the system interface offers the possibility of controlling the simulation process by choosing the simulation cycle (day, week, month) or by starting, making a pause or stopping the process at any time.

The main window displays a tool bar allowing to run a previous stored Center situation or to begin a completely new one; in this case it is necessary to introduce all the operational parameters of the Center, such as:

-Number of rooms, surgical theatres, historic or fictitious data concerning room occupation, surgical operations, other medical or clinical services (radiology, physiotherapy, medical analysis), medical symposia, etc.

-Personnel; number of doctors, nurses, staff, technicians,... assigned to each Department.

-Inventories of available resources (even human resources also) related to each Department and consumption rate of each item by patient or room or medical or clinical service...

-Costs and benefits; resources, expenses, labor cost by category,.., recruiting cost, firing cost, training cost, room rate, prices for the different medical and clinical services,...

-Investments; prompt and deferred payments and earnings,...

The process can be stored and reinitiated some other time, with the same or different parameters. The user can change any time, the parameters of the simulation by interacting with the main window or with the specific window of a certain Department. Different situations of a Medical Center or belonging to different Medical Centers can be (multitasking mode) run at the same time. Each Department window or the main window has a smaller window inside it to show alarm messages related to the Department operation.

Mental models of the expert manager and department heads, as well as the other cognitive elements for the expert execution of the task, were obtained. The mental models can be expressed as a set of, at least, four families:

a)-Financial models

The expert uses a full range of models with increasing complexity, although he chooses the simplest one according to particular situation of the problem. The general schema is

$$\text{Benefit} = \text{Earnings} - \text{Expenses}$$

It can be developed up to any degree of resolution, expanding "Earnings" as sum of specific ones, and "Expenses" in the same way. The expansions can be done in terms of number of services "times" its price or rate, or in terms of occupancy percentage.

b)-Percentage financial models.

Models in the previous family can be modified to show the importance of a specific factor as a percentage of earnings or expenses. The knowledge of that percentage is a clue on the effect of changes of that factor.

c)-Operational models in terms of capacity.

Along this line another full set of models can be established, as to obtain the minimum number of personnel of a certain labor category in terms of the ratio needed to fulfill the necessary services; a similar procedure can be applied to express the capacity of the different Department services.

d)-Percentage capacity models.

As in b), the previous operational models can be modified to show the importance of a production factor as a percentage. It will give a clue on the effect of its changes.

The full range of financial, operational and percentage models, used by experts, have been implemented in CENTMED4 in order to be used as a tutorial aid for the transition of novices to expert managers and also for designing the exercises.

As far as the exercises or learning materials the guidelines are the following:

a)-Concerning situation analysis it is possible: to check the economic and financial situation of the Centre, benefits and cash-flow in short and long periods of time; to check the operational situation of the Centre and their Departments.

b)-Concerning diagnose it is also possible to establish concrete reasons of the situation such as: temporary alteration, normal situation, acceptable economic and organizational situation, structural problem, etc.

c)-Concerning measure tests; it is possible to essay changes or new actions in the Centre, such as: rate or price increase for the Centre services, general capacities increase, strengthen the strategic Centre capacities, outsourcing different services, introduction of technological innovations, organizational changes, etc.

d)-Consideration of other counteracting external actions: increase of labor cost, increase of social security costs, increase on the medical products prices, increase of the rate of interest; increase of taxes, etc.

e)-Final check of adopted measures including: sensibility to the Centre inner parameters, sensibility to the outer parameters such as number of patients, etc.

5. TESTS AND RESULTS

The system has been operated by four teams of General Managers running different normal, problematic and extreme situations of the Centre operation, during two weeks, to assess the system from a managerial point of view. All the reports produced by the teams assert the important capabilities of the system as a decision and decision learning aid due to the detailed reproduction of reality as well as its friendliness in the communication of the user with the system.

Besides, the results obtained with CENTMED4 have to be compared to those obtained with some other method or similar system. No other prototype including CENTMED4 features and ability has been found in the literature, so it has been compared with traditional e-learning systems including problem solving techniques and case studies.

Along this line it has to be reported the use of CENTMED4 by twenty teams of junior managers (twelve members each group) playing together with the specific role of Department Heads during a full month each team. For each team called the experimental one, another one was chosen as the control one; the first one used CENTMED4 and the second one an e-learning traditional decision making course supplemented with case studies and problem solving techniques during the same amount of time. Before any problematic situation the trainee belonging to the experimental group decided what to do before the agent in charge of the same Department chose the appropriate action. Both actions decided by the trainee and the agent were analyzed and discussed in the debriefings. The results have shown a range of 27% to 30% of decrease in the time required to obtain the third level of expertise (full competence) as Department Heads of the experimental groups compared with the results of the control groups. Similar results were obtained for the second (24%-27%) and first levels (15%-22%) of expertise.

Finally, the intelligent prototype has been used by twelve sets of junior managers (eleven members each group) for the transfer to expert ones. For each experimental set another control set was chosen using another traditional e-learning course, with case studies and problem solving techniques. The final tests after the training period showed a regular grade increase in the range of 25% to 31% in the experimental groups with relation to the control groups. After that evaluation the training sessions for the control groups continued until they reached a similar efficiency in decision making as the experimental ones. The amount of extra time required for that purpose was in the range of 30% to 34%.

6. CONCLUSION

From the results so far obtained and their assessment it is possible to reach the following conclusions:

1)-The fundamental process of the transfer of novices into experts can be accelerated with the aid of cognitive techniques and specifically the human expert mental models. The results obtained in this particular case look promising when they are compared to those obtained with e-learning regular courses supplemented with problem solving techniques and case studies.

2)-Mental models are an important resource for accelerating that process and, in principle, they can be used in many practical situations.

3)-The combination of cognitive techniques with information technologies including multi-agent systems and modeling can be the adequate mixture for solving a great deal of learning problems in practice, but specially the acceleration of the transfer of novices into experts.

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