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Cooperation of Business Games with Intelligent E-learning Systems

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors managed the analysis of the study, the literature searches and made the tests. Author MEA performed the changes in the BG and the IELS and the statistical analysis. Author FDA wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

The desirability of increasing the capability of business games in the direction of pedagogy raises the possibility of cooperation with existing intelligent tutors or intelligent e-learning systems. This is an issue not yet studied until now because the lack of detailed standards make that collaboration very difficult and laboured.

The article analyses the possibility of such cooperation and the characteristics of business games and intelligent tutors or intelligent e-leaning systems that would make possible and favour such cooperation. The tutorial aids provided by such a cooperation can be in conflict with the competitiveness among the companies involved in the game. This problem has been considered when discussing such cooperation. A particular experience of the collaboration of a known business game with an existing intelligent e-learning system is described as well as the changes that have been necessary introduce in both for such cooperation. Several tests have been carried out and their results and the analysis of students' opinion show the effectiveness of this cooperation.

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1. INTRODUCTION: INTELLIGENT SIMULATION, BUSINESS GAMES AND INTELLIGENT E-LEARNING SYSTEMS

Although we do not intend to describe the development of intelligent simulation, by the decade of the 1980s intelligent simulators were already being used. Among the examples KAOS [1] developed by NASA, ALADIN [2] developed at Carnegie-Mellon University, and PROSS [3] of the Rand Corporation, can be cited. Also, intelligent simulation has been reported in international conferences such as the one held in San Diego in 1987. Intelligent simulation applications for learning were beginning to appear at the same time [4], but it would be the advent of multi-agent systems that would provide simulators with greater flexibility and boost their production. For instance, EMMA [5] is one of the first intelligent games dedicated to flexible coordination of activities and business decisions. For more information see [6-8]; they provide a good overview of the subject up to the time of the publication. More recent are the reviews by Gosen [9] and Anderson [10] which point to possible future directions of research.

The introduction in the University of Business Games (BG), also known as business management simulators, dates back also to the second half of the last century. First installed in U.S. Universities, after that they spread exponentially around the world. According to Faria and Wellington [11] there are more than 200 BG currently being used in nearly 2000 Universities. Today BG include the design and development of software, processes and best practices for integrating, warehousing and analysing business information. As far as the benefits of BG, see [12].

BG features are very different but their success has to do with the inclusion of Artificial Intelligence (AI) techniques. Thanks to AI, BG can describe with higher fidelity a complex international business world and many of the relations among companies, markets and institutions, as well as the consequences of the decisions taken in the game by the students. However, most of them include just a few tutorial functions. Therefore, the student or group of students can sometimes be lost having to deal simultaneously with a large number of economic relations, their dynamics and results.

The development of intelligent tutors (IT) and intelligent e-learning systems (IELS) falls outside the scope of this paper. However it is worth to state that the design of IT has suffered important changes during the last thirty years caused also by impacts of AI and specifically the incorporation of multi-agent architectures. As a result of those changes in the functionality of IELS new educational problems have been studied, we can cite among them:

- Design of a tool for the cognitive analysis of tasks and their breakdown into cognitive elements, including mental models of experts to help students acquire them in their training [13,14].
- Incorporation of cognitive modelling and learning styles to better represent the student's performance and enhance the system efficiency [15].
- Collaborative learning of decision making and involvement of the student in the process [16,17].
- Massive document filtering in accordance with certain profiles and automatic retrieval of the summary of these documents [18].
- Incorporation of affective computing for a better understanding of the affective state of the student and possible improvement thereof [19,20]
- Incorporation of fuzzy logic techniques to better reproduce both the student performance and his/her appreciations. [21].
- Automatic construction of ontologies to be able to automatically update the knowledge bases used for learning with additional knowledge [22,23].
- Evolutionary Multi-Agent Systems [24] allowing the evolution of the full systems, not only that of the agents involved.
- Design of Consensus Protocols for Linear Multi-Agent Systems [25] in the case of systems with directed graphs.
- Acceleration of the transfer of novices into experts [26]
- Assessment of IELS [27].

On the other hand, in the field of education, a new approach known as “student centred education” [28-30] based on active, collaborative and cooperative learning environments has contributed to a new and more powerful generation of IT known as IELS. Among the many contributions to the subject we would like to quote, as closer to our work, the research carried out by Vassileva et al. [31], and that of Canut, Gouraderes and Sanchis [32].

In spite of the capability of IELS there is always the alternative of building IELS/IT, or adapting, if possible, the existing ones to provide a set of aids and initiatives that can contribute to improve student learning when they are using jointly IELS and BG. In the case of distance courses, our case, the problem is more important as learning has to be acquired without regular classes. A good cooperation between the two computer systems, in addition to contributing to the integration of the whole process, would reduce and even improve the human tutorial effort that can be enormous, as in the case of the Spanish Open University, where distance courses are offered to approximately 250,000 students per year.

The paper discusses the basic characteristics of IELS, BG and their isolated operation with users in order to reach a satisfactory cooperation between the systems. By satisfactory cooperation we mean an automatic cooperation that makes use of BG and IELS functionality after introducing slight modifications. As we will see later on, the tutorial aids provided by both systems can be in conflict with the competitiveness among the companies involved in the game. There is no doubt that those advices, if followed, can improve the economic and financial situation of a company over that of its competitors. The paper also describes the adaptation of an existing IELS and its cooperation, after increasing its tutorial and pedagogic functions, with a BG. The integration gave rise to FINANTUTOR, used as an aid for several postgraduate distance courses. The tests performed and results obtained, including the point of view of the students, are encouraging.

2. COOPERATION BETWEEN IELS

Up to the present and in accordance with the literature, the issue of cooperation between general IELS has not been raised although some precedents could be traced. It is understandable that in the absence of clear and binding standards for these systems, their cooperation is complicated because it would oblige to get in depth into the architecture and even into the programming code of the cooperating systems. Both architectures can be very different forcing to carry out a craftsmanship work very difficult to justify.

Pedagogical agents [33] could be considered as a precedent of this remote cooperation, although these agents are introduced or integrated into one and the same IELS. In summary there is a single computer system and not two as in the case of cooperation.

We can agree that the current situation is the polar opposite of an ideal cooperation between systems represented by a magical concept widely used in other environments: *interoperability*. In accordance with it IELS would be able to cooperate among them directly or with very slight modifications.

However, in our current status it is possible to find circumstances and systems that could lead to reasonable cooperation. The case which we are about to describe is one of those which, for their kind of operation, is possible to reach cooperation. But before going further it should be pointed out what we understand by cooperation, its objectives and methods.

We assume the existence of two different IELS. We shall say that some cooperation between them is established when it is possible the simultaneous (quasi-simultaneous) actuation of both on users or groups of users, in a manner that enhances human learning. The operational integration of both computer systems must be complete so that the user does not notice that he is dealing with two systems. If not, the work of the user may be complicated by having to elucidate at any moment which of the systems he has to work with. The obvious goal of cooperation is the improvement of learning, if this improvement is not obtained there is no reason, in principle, to establish such cooperation from our point of view. It is clear that it would be possible to speak of cooperation of more than two IELS, but for the time being we prefer restrict cooperation to only two systems.

We could say that learning improves when, as a result of cooperation, it is clarified or intensified the learning domain including the human expert experience, usually introduced in the domain, or when it improves student evaluation, or when the customization of the man/machine communication is accentuated, or when the pedagogic and tutorial functions offered are improved. However, cooperation can provide very different benefits, in addition to those outlined above, that positively affect learning.

Cooperation could be reached when its purpose is the enhancement of some of the features of an IELS by connecting it to another that includes these ameliorated features or many of them. The ideal case would be when both systems comply with a full set of standards. If standards are very elaborate and entire it will not be difficult to establish the coordinated work of such systems. Similar situation, though not exactly the same, arrives if both informatics architectures are compatible; in that case changes and connections of both systems can easily be completed. In the remaining cases such cooperation can be problematic by the logical and computational difficulties that would entail. The alternative that arises in these remaining situations is to adapt one of the systems by increasing its functionality to achieve the desired objectives, without taking into account the second system: cooperation is avoided.

However, the problem presented in this work belongs to those remaining cases but with special conditions that can favour cooperation. The conditions in our case are: the two IELS are focused on the same scenario with different visions and both user/system operations are compatible. We will detail these two points in the next section.

3. METHODOLOGY FOR THE COOPERATION OF IELS WITH BG

The BG more used in Spain according to the conducted study by the Ministry of Education and Science in 2010 are: INTOP, INTOPIA, GLOBSTRAT and SIMBA. They all reliably represent the current global economic environment and the performance of a set of companies in various international markets. Each company is represented by a group of students; each of them assumes one of the key business functions and all of them agree a set of business decisions that are introduced in the game as company decisions. The game, on a competitive basis, provides the economic and financial results of the decisions for each company, including those obtained in each international area operated by the firm, as well as the consolidated balance sheet. Each company also receives information on the behaviour and performance of the remaining. Operations Manuals usually spell out in detail the circumstances considered by the game and the economic and financial functions included.

However, the tutorial functions of the BG are very limited or almost non-existent. Thus, for example, the game usually does not assess the student behaviour, or determines his/her errors, nor gives any opinion on the decisions taken. If the student or group of students asks for some help or advice the human tutor is obliged to give an answer in most cases. In summary, the BG provides experience related to the world of international business that constitutes the basis of student learning, but not accompanied by other tutorial or pedagogical aids that, without doubt, could improve human learning.

On the other hand, IT or IELS are usually equipped with important tutorial and pedagogic functions. In the latter case they usually also have a learning domain that the student has to acquire.

From another point of view BG operation, at least in the case of BG mostly used in Spain, encourages cooperation with IELS. Although students can access the game at any time to acquire certain information of the business environment, only at certain times all companies must introduce simultaneously their decisions in the game. BG operation can be described, therefore, as a set of cycles composed of two phases. The first one is devoted to the analysis of the results provided by the game and obtained by each company after the previous decisions, and to the study of the actions that could or should be taken to improve the situation of the enterprise to achieve its predetermined goals. For the group of students it is the time to work without connection with the game, or with a minimum connection in the case of requesting additional information. At that time it is required that the joint system performs the tutorial and educational functions not contained in the BG.

The second phase would be dedicated to introduce into the game the set of decisions adopted as the most desirable for each company. It means a real interaction with the game to enter the decisions agreed upon but no intervention of IT or IELS is required.

In accordance with this operation the cooperation of the BG with the IELS can be reached in a simple way. The BG would initially send to the IELS the economic and financial objectives adopted by each company and the corporate responsibility of each student within the group. Later on, in the second phase, it would send to the IELS the decisions proposed and results obtained by each company. The IELS would be responsible for analysing the results, advising, assessing, etc. during the first phase, with no intervention in the second one. Besides, the IELS would store all the information in order to maintain the full history of the learning process for each company. Both systems have to be integrated in only one final system to avoid the feeling of working with two different systems.

The main consequence of this operation is that the communication between both computer systems is only unidirectional from the BG to the IELS. In the first phase of every cycle, the student or students group would address the integrated system, which would yield control to the IELS to solve the questions posed by the student or to realize some educational or pedagogic function even without intervention of the student/group. Only when the request is related to information contained in the BG the integrated system would yield control to the BG. This system would send the information requested by the student also to the IELS.

During the phase two of the cycle the integrated system would allow the students group to introduce their decisions into the BG. After finishing the introduction of all decisions the second phase would be automatically closed down the results of the decisions would be obtained, sent to the students and to the IELS, and opened the first phase of a new cycle.

Once the operation of both systems has been devised, the question of its achievement comes into picture. The task could appear complex and extensive mostly when the IELS lacks many of the desired tutorial functions but it is not complicated if enough information of both systems is available. Actually IT and IELS have many pedagogic and educational functions but even in the case that they do not have all of them, to increase them would be a more bearable task than introducing all of them into the BG. Therefore, it seems worthy to consider the cooperating performance of both learning systems on the following sense: BG specialized in the managerial topics and IELS in the pedagogic and educational tasks.

Having decided in favour of cooperation let us analyse how to put it into practice. First of all a basic control system that gives entry to the BG or to the IELS according to their operation is needed. This control system is the integrator of both systems. It is very simple with independence of the architectures of both computer systems. Secondly the BG has to be slightly modified just to send to the IELS the information requested by the student/group, the managerial decisions adopted and their results. Even if the requirement of introducing managerial decisions for all companies at the same time is suppressed in order to get a more real situation in the game, the control system would not be complicated. It would be enough to establish in advance the moments to send the results to the participants in the game and also to the IELS.

Possibly the modifications of the IELS are more important. First of all it is necessary to verify if all the pedagogic and educational functions required are compatible with the BG and its dynamics. Also, it is necessary to develop the functions not present in the IELS, taking into account that for their execution it would be necessary to extend the learning domain and the human expert experience. As a particular case it will be necessary to analyse in detail the communication of the IELS with the users, especially if this communication does not include a natural language.

Tests have to be carried out to check the behaviour and results of such cooperation. Tests should compare the results obtained by companies using the cooperation (experimental groups) with some other companies using only the BG. Considering that companies are integrated by a set of students, the assignment of those students to companies should be at random. The same random criterion should be used to assign companies to the experimental and control groups.

Besides those objective tests, students' opinion according to their experience along the game should be considered.

4. FINANTUTOR: A PARTICULAR EXPERIENCE

In this paragraph we are going to describe a concrete experience: the cooperation of an IELS, FINANCE, with INTOP, a BG used as support technology for several graduate distance courses.

4.1 Finance

FINANCE [34] is a NEOCAMPUS spin-off dedicated to learning of financial accounting, management accounting and business analysis. NEOCAMPUS [35,36] is a software platform with the function of a factory of intelligent agents. It is a research laboratory of problems relative to IELS to increase their functionality and, therefore, the utility and efficacy of these systems. A multidisciplinary approach of considering the integration and coherence among the educational aspects, the experts in the knowledge and the computer infrastructure has been adopted. That way its global performance and automatism can also be maximized.

The agents produced with NEOCAMPUS are cognitive or intelligent according to Newell [37] and they also have the following features: they are autonomous, that is to say, every agent realizes tasks without the persons' intervention although it can receive orders and interact with them with the collaboration of other agents; they are capable of learning new knowledge, or of improving its capacity of decision, acquisition of skills and/or cognitive strategies from their own experience using diverse machine learning techniques; they have mobility, alluding to its possible transference to other places of a local or wide area computer network as it would be the case for Internet; they operate as moved by specific goals that are assigned in advance, or communicated by other agents, or chosen by the proper agent according to the circumstances; they can interact with other agents and with the users for the attainment of the targets that they have or for the resolution of the assigned problem, even using a natural language; they fulfil their tasks and targets with acceptable efficacy, usually major than that of the human beings considering their speeds of calculation, of search and of decision making; they can be easily "cloned" or multiplied to increase the number of agents that realize the same task when it is needed.

FINANCE, NEOCAMPUS spin-off, inherits all the features installed in the software platform. The prototype is designed for the help, management and tutorship of the learning process of something like the first and second course of business accounting. Consequently, the student is supposed to have reached the university level although previous knowledge in accounting is not required. The system is capable of attending to a group of up to 25 students working individually or in groups with a limit of 25 groups. The prototype is guiding gradually the student/group learning of these matters up to achieving the preparation of: accounting entries, annual accounts, commercial and financial margins, and also to interpret with diverse techniques the annual accounts of the company.

The mental models of the human expert were obtained initially from manuals of financial accounting, management accounting and business analysis but also they were extracted from human experts by means of BCTA [13], [14], a tool previously developed for that purpose. Those human mental models contained remarks on the effective value of many accounts of the plan, as well as relations to be verified between diverse accounts. The existence of these relations would change drastically the evaluation of the company balance sheet.

The learning domain is conceived as a graph constituted by 9 fundamental nodes; every node refers to a group of accounts of the accounting plan. In a similar way, second order nodes corresponding to their accounts hang form first order nodes, and similarly third order nodes. Every node has associated the account definition, possible relations with other accounts and, sometimes, advice or recommendations on its book-keeping and evaluation. Also, it has associated remarks to really interpret this account. Finally, every node presents a link to related exercises of the knowledge base, integrated by a collection of problems, questions, and exercises to be used at any moment for the student evaluation.

Fig. 1 shows FINANCE architecture. The number of agents can vary according to the system work. Initially it is integrated by Agent F1, which is the general system control: Agents F2 to F10, in charge of portions of the learning domain and pedagogic and educational functions; Agent F11 in charge of helping agents in their machine learning techniques to learn from their experience. If necessary, when the number of tasks increases, F1 can “clone” new agents to take care of the work. Fig. 1 shows also the most important functions assigned to each agent.

FINANCE was selected for the cooperation as the only IELS, as far as we know, with plenty of educational and pedagogic functions and also with a learning domain complementary to BG.

4.2 Intop

INTOP is a BG, design and implemented at the University of Chicago, focusing on specific international problems and transactions on several continents. It does this by a balanced interweaving of classical real world business functions such as finance, marketing, production and research and development, through strategic management.

Ag. F1: main tasks

- FINANCE general control
- Solution of agents conflict
- Agents cloning and suppression
- Interface control
- User/system communication understanding and control.

Ag. F2-F10: main tasks

- Pedagogic and educational functions
- In charge of part of the learning domain
- Specific knowledge: domain sub graph
- Techniques and strategies related to the sub graph
- Human expert knowledge associated
- Relationships with other sub domains
- Relationships with the problems KB
- Cooperation with other Agents

Ag. F11: main tasks

- Functional-link neural networks learning
- Case learning
- Reinforced learning

Fig. 1. FINANCE multi-agent system

Although it is a Knowledge-Based system, it is not a Multi-Agent system. It has a monolithic architecture although it takes into account random effects to better simulate reality. It has been selected after considering the specialized expert knowledge included, such as the demand function, and the information provided to the student.

It has many advantages over others. Players are obliged to explore the scheme of openly managerial decisions referred to goals, business philosophy and strategy. Players are subjected to an endless set of choices: To act as a national or international company, in the latter case to decide whether to export by licensing to other companies, sell abroad through importing companies or manufacture abroad.

INTOP accepts up to 20 companies competing in an international scenario which includes randomness according to reality. Each company is represented by a team of students who has to agree on the decisions made by the company. The number of the decisions or periods is established at the beginning of the game. The results of such decisions are provided by INTOP. Besides, the game can supply, with cost, information relative to the market and the situation of the remaining companies. The relative financial and economic situation of the enterprises allows the evaluation of the behaviour of the companies.

4.3 Intop and Finance modifications

INTOP modifications, as foreseen, have been very limited: just include FINANCE as recipient of both decisions and results of all companies and the requests of information by the students/group and the corresponding answers by the BG.

FINANCE modifications have been more important. On one hand it was necessary to complete the learning domain with the company comparative analysis by means of diverse techniques such as ratios. This increase of the domain was reflected in new human expert models obtained by means of BCTA, which it was necessary to incorporate into the specific knowledge module of the agents in charge of the diverse microcosms that integrate the learning domain.

Now the tutorial and pedagogic functions have to appear within the competitive environment of all the companies that use the system. There is no doubt that with a set of suggestions, the company can easily improve its economic and financial situation over its competitors. Even more, in some cases with luck, it might even place the remaining companies in a delicate commercial or financial situation. As result of the analysis of this problem and in agreement with the students, the following decisions were adopted.

- FINANCE will not act spontaneously except if a difficult company situation is present. FINANCE action will take only into consideration the company knowledge of itself, of the market, and of the remaining companies.
- FINANCE will answer to the raised questions relative to accounting, financial topics and business analysis, beyond INTOP, but only bearing in mind the knowledge detailed at the end of the previous paragraph.
- FINANCE evaluation of the members of the game will consider the requests of help formulated by the companies so that student learning will be rewarded in any case.

It has been necessary to incorporate new educational and tutorial functions into the agents in charge of similar tasks. The most important ones keep reference to comparative business analysis and the evaluation of the company decisions in this scenario. The knowledge of the corresponding tutor agents has been enhanced with these new functions.

The control system that integrates both INTOP and FINANCE, is a simple program that usually yields control to INTOP. Only when spontaneously FINANCE decides to intervene or when the student asks about questions that exceed INTOP, the control is transferred to FINANCE.

5. TESTS, RESULTS AND ANALYSIS

At first seven tests were performed. In each a group of eight companies used FINANTUTOR (experimental group) and other eight used only INTOP (control group). The results are shown in the accompanying tables.

Table 1 shows only the mean values of the experimental and control groups experience levels, as well as their increments (percentage). The Appendix includes Tables A1 to A7 that disaggregate Table 1. Both experimental and control groups used their respective systems the same amount of time, pre-set in advance.

Companies were assigned randomly to the experimental or control groups. Also, all the students were randomly assigned to each company.

As can be seen from Table 1, experience levels achieved by the experimental groups using FINANTUTOR are always higher than those of the control groups using only INTOP, with values ranging between 24% and 39%. Also, as shown in Table 2, the time required for the control groups to attain a certain level of experience always exceeded between 20% and 48% that of the experimental groups.

Table 1. Experience levels reached by 7 experimental groups (FINANTUTOR) and 7 control groups (INTOP) with the same time for learning. Mean values

Test Nº	1	2	3	4	5	6	7
FINANTUTOR	93	97	98	91	96	93	93
INTOP	75	76	71	71	69	73	75
Δ EXPER. %	24	27	38	28	39	27	24

Table 2. Times required (hours) for 7 experimental groups (FINANTUTOR) and 7 control groups (INTOP) to acquire the same level of experience. Mean values

Test Nº	1	2	3	4	5	6	7
FINANTUTOR	35	31	39	38	33	33	37
INTOP	42	46	48	50	47	49	52
Δ TIME %	20	48	23	31	42	48	40

As a second proof, three different tests were carried out with groups of five companies in each test using FINANTUTOR. The companies were chosen at random among those which they had previously used only INTOP. The adjoined table shows the new values obtained with FINANTUTOR and the previous values with INTOP

Table 3 indicates that the times required to reach the pre-set experience level by the companies using FINANTUTOR increased between 43% and 54% when using only INTOP instead.

Table 3. Times required (hours) for 3 experimental groups to acquire the experience level pre-set to the tests shown in Table 2. Mean values

Test Nº	1	2	3
FINANTUTOR	32	31	34
INTOP	46	48	49
Δ TIME %	43	54	41

Fig. 2 gives the impression of a stable time difference between experimental and control mean values.

Moreover, in addition to the objective results presented before, the subjective students' opinion has been searched trying to discover how they feel or see this integrated cooperation in relationship to the accomplished learning, objectives or goals achieved and pedagogical communication with the system when FINANTUTOR is used.

The significant factors to rate the effectiveness of BG as a teaching method by the students, have been previously obtained [12]. According to that study only four factors including 14 variables are needed for such evaluation. Factor 1 reflects the features dimension of the game and includes the variables: total number of decisions, game complexity, business realism, creativity and previous instructions. Factor 2 has to do with expectations and includes: Achieved goals and fulfilled expectations. Factor 3 is related to the acquired knowledge, divided into: Marketing knowledge, finance knowledge, production knowledge and human resources knowledge. Factor 4 reflects the communication aspects. It includes: Teamwork learning, communication with instructors and instructor feedback.

To get the students' opinion a survey was e-mailed to all the students (135 students) after participating in the FINANTUTOR, containing a questionnaire composed of 17 questions divided into four separate blocks. The answers were analysed with the same methods and techniques as in [12].

First of all the correlation matrix of all the considered variables was obtained. In order to check if it met the requirements to be treated by the factor analysis method, the KMO indicator was obtained. Its value was 0.69 (>0.5) therefore the data obtained could be analysed by that method.

Now the principal component analysis technique was selected because it can transform a great amount of information into the least number of factors. Table 4 shows the variance-covariance matrix and the initial eigenvalues as well the amount of variance they represent.

Table 4. Principal component analysis. % of variance explained

Compon.	Eigenv	% variance	% cumulat.
1	4,78	33.46	33.46
2	1,97	15.62	49.08
3	1,41	10,43	59.51
4	1,23	9,12	68.63
5	0.90	6,12	74.75
6	0.85	6,1	80,85
7	0.72	5,95	86,8
8	0.69	4,32	91,12
9	0.60	3,28	94,4
10	0.38	2,03	96,43
11	0.27	1,04	97,47
12	0.21	1,22	98,69
13	0.16	0,78	99,47
14	0.09	0,53	100

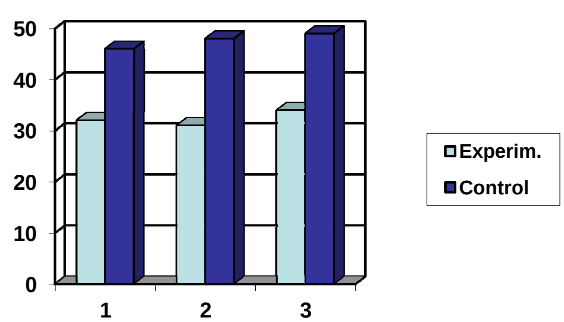

Fig. 2. Comparison of values shown in Table 3

Table 5. Rotated component matrix

Variab.	Factor 1	Factor 2	Factor 3	Factor 4
Instruc.	**.571**	.260	.127	-.210
Creativ.	**.850**	-.076	.257	.246
Busin, realism	**.661**	.187	.021	-.201
Complex	**.782**	.178	.015	-.187
Adeq. nº decision.	**.635**	.132	-.185	-.211
Market. Knowl.	.215	-.076	**.811**	-.018
Financ Knowl.	.078	-.069	**.771**	-.610
Prod. Knowl.	.439	.075	**.632**	.008
HR knowl.	.120	.198	**.678**	.072
Teamw. learn.	.110	-.023	.127	**.753**
Commu. Instruc.	-.118	.069	.115	**.895**
Instr. feedb.	.055	.311	.219	**.785**
Fulf. Expect.	.119	**.874**	.088	.249
Achiev. goals	-.029	**.881**	.193	.047

As usual, eigenvalues with a numerical value less than 1 were neglected, that way only the four factors we mentioned before were considered. Those four eigenvalues taken into account explain 68.63% of the variance (60% of explained variance is a reasonable level in social sciences). Now the factors have to be rotated to differentiate them from each other. Varimax rotation is the particular technique used for that purpose.

The values for the 14 variables within their corresponding factor obtained in the rotated component matrix have been:

Factor 1: game features.
Instructions: 0.571; Creativity: 0.850; Business realism: 0.661; Game complexity: 0.782; Adequate number of decisions: 0.635;

Factor 2: expectations.
Fulfilled expectations: 0.874; Achieved goals: 0.881

Factor 3: acquired knowledge.
Marketing: 0.811; Finance: 0.771; Production: 0.632; Human resources: 0.678

Factor 4: communication.
Teamwork learning: 0.753; Communication with instructors: 0.895; Instructor feedback: 0.785

The values above show the importance of each factor as far as the explanation of the variance is concerned and the relative importance of each variable within its factor. The results obtained show that the students assess FINANTUTOR very positively.

Unfortunately there are no other published results, to our knowledge, concerning cooperation of BG and IELS to compare with, therefore we can only state the values obtained of this cooperation experiment.

6. CONCLUSIONS

From the above the following conclusions can be stated.

Although in general terms IELS cooperation is far from real due among other reasons to the lack of construction standards, it is feasible in some cases attend this cooperation to enhance the overall learning process of the users. Of course the work of adaptation for such cooperation can be very different depending on the constituent elements of IELS and even rule out that cooperation by the volume of work entailed.

One such possible case of cooperation is that of BG with IT or IELS. The reasons in principle to enable such cooperation lie in their different specialization and compatible operation. BG would be mainly devoted to economic and financial issues and IELS to tutorial and educational functions. Moreover, the usual game operation in cycles of two phases facilitates the communication between the two systems which is unidirectional. An important consequence of this is that BG modifications can be very small.

In the specific case described in this paper, the cooperation between FINANCE and INTOP, it was found that the changes made to the latter have been minimal. Also, the construction of the control system, FINANTUTOR which integrates both systems, has been very easy. Regarding FINANCE, changes have meant the enhancement of the knowledge domain to include comparative business analysis, and to add some tutorial functions relative to the knowledge introduced. The flexible multi-agent structure of FINANCE eased the introduction of those modifications.

The results obtained in the experimental tests prove that the use of FINANTUTOR has achieved an important improvement in the users learning process that has ranged from 20% to 48%.

On the other hand it has also been found that, according to the opinion of students, FINANTUTOR is a very valuable aid for learning.

In summary, an interesting possibility of improving human learning by means of the cooperation of these intelligent systems, even with limitations, is now starting.

For the near future we would like to study the cooperation of two IELS with compatible architectures, that is to say, with a similar agent model and flexible collaboration policies among agents. At least for the time being it is another way to look for that cooperation.

ETHICAL ISSUES

The BG used in this work was selected as the best option for learning results considering the peculiarities of distance education, the random effects and human knowledge included. The IELS selected was the only one existing, to our knowledge, with a flexible structure, plenty of tutorial aids and a learning domain, business analysis, complementary to the BG.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

First seven different tests have been carried out, each relating to a different edition of the same graduate distance course.

In each test 8 companies (considered as experimental groups) that used FINANTUTOR, or the integration of INTOP and FINANCE, have intervened, and also 8 other companies (considered as control groups) that used only INTOP. Each company consisted of 6 students so that in each test all (96) students in the distance course were involved.

The assignment of students to each company was randomly as well as the use of INTOP or FINANTUTOR for each company, maintaining the same number of experimental groups and control groups in each test. This was intended to avoid any situation of favour for students or for companies.

Each test had two parts: in the first a fixed number of INTOP cycles was specified for all companies as the limit time. At the end of that time the experience level of each company was measured considering its economic and financial results. Table 1 appearing in paragraph 5 is aggregate because for each test reflects the average of the values obtained by the 8 control and the 8 experimental companies. Tables A1 to A7 containing the values obtained by each of the 16 companies in each trial disaggregate the values in Table 1. Each Table contains also two statistical parameters for the experimental and control groups: difference and standard deviation.

Table A1. Test nº 1-Experience obtained by 8 experimental and 8 control companies

Comp.	1	2	3	4	5	6	7	8	Mean
Exper.	88	91	94	96	99	93	92	91	93
Cont.	75	68	77	79	73	78	72	77	74.88
ΔExp.	13	23	17	17	26	15	20	14	18.12

Experim. Group: Dif.= 10; Stand. Deviat. = 3.16, Control Group: Dif. = 11.86; Stand. Deviat. = 3.44
ΔExp.: Dif. = 18.11; Stand. Deviat. = 4.26

Table A2. Test nº 2-Experience obtained by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	105	91	98	96	97	101	100	91	97.3
Cont.	75	67	77	79	75	81	72	83	76.1
ΔExp.	30	24	21	17	22	20	28	8	20

Experim. Group: Dif.= 20.23; Stand. Deviat. = 4.5, Control Group: Dif. = 22.85; Stand. Deviat. = 4.78
ΔExp.: Dif. = 34.75; Stand. Deviat. = 5.89

Table A3. Test nº 3-Experience obtained by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	104	93	98	96	97	103	99	94	98
Cont.	78	67	73	69	65	71	72	75	71.25
ΔExp.	26	26	25	27	32	32	27	19	26

Experim. Group: Dif.= 13.5; Stand. Deviat. = 3.67, Control Group: Dif. = 15.68; Stand. Deviat. = 3.96
ΔExp.: Dif. = 14.94; Stand. Deviat. = 3.86

Table A4. Test nº 4-Experience obtained by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	82	83	94	96	95	96	95	90	91.37
Cont.	67	78	73	69	71	65	72	73	71
ΔExp.	15	5	21	27	24	31	23	17	20.38

Experim. Group: Dif.=29.48; Stand. Deviat. = 5.43, Control Group: Dif. = 14.25; Stand. Deviat. = 3.77
ΔExp.: Dif. = 56.73; Stand. Deviat. = 7.53

Table A5. Test nº 5-Experience obtained by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	104	93	97	96	95	98	95	90	96
Cont.	75	60	70	68	66	70	71	73	69.12
ΔExp.	29	33	27	28	29	28	24	17	26.87

Experim. Group: Dif.= 14.5; Stand. Deviat. = 3.80, Control Group: Dif. = 18.61; Stand. Deviat. = 4.31
ΔExp.: Dif. = 19.36; Stand. Deviat. = 4.4

Table A6. Test nº 6-Experience obtained by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	102	93	94	89	95	88	95	90	93.25
Cont.	79	60	79	74	66	72	75	77	72.75
ΔExp.	23	33	15	15	29	16	20	13	20.5

Experim. Group: Dif.=17.44; Stand. Deviat. = 4.17, Control Group: Dif. = 38.93; Stand. Deviat. = 6.24
ΔExp.: Dif. = 46.5; Stand. Deviat. = 6.81

Table A7. Test nº 7-Experience obtained by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	92	97	87	89	99	88	95	97	93
Cont.	81	64	79	78	71	75	75	77	74.75
ΔExp.	11	33	8	11	28	13	20	20	18

Experim. Group: Dif.= 18.75; Stand. Deviat. = 4.33, Control Group: Dif. = 25.69; Stand. Deviat. = 5.07
ΔExp.: Dif. = 69.5; Stand. Deviat. = 8.34

Tables A1 to A7 show that in all cases, without exception, the experience levels obtained by the experimental groups were significant higher than those corresponding to control groups. The first line indicates the company number. The experience increase varied from 5 to 33 and their mean values from 18 to 26.87. Two statistical parameters are included: difference, and standard variation. The value of those parameters corresponding to the control groups was always higher than those of the experimental groups except for test nº 4.

In the second part, each test lasts a variable time that ends when companies have reached a high level of expertise, previously pre-set. Table 2 appearing in paragraph 5 for each test reflects the average time needed for the 8 experimental and 8 control companies. Tables B1 to B7 show the times that each company needed to achieve that level of expertise in each of the tests, disaggregating Table 2.

Table B1. Test nº 1-Time required by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	31	34	35	38	40	34	30	39	35.12
Cont.	39	41	47	33	50	38	43	45	42
ΔTime	8	7	12	5	10	4	13	6	8.13

Experim. Group: Dif.= 11.64; Stand. Deviat. = 3.41, Control Group: Dif. = 25.75; Stand. Deviat. = 5.07
ΔTime: Dif. = 9.36; Stand. Deviat. = 3.06

Table B2. Test nº 2-Time required by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	30	32	35	29	36	31	30	28	31.37
Cont.	42	41	48	37	53	50	48	47	45.75
ΔTime	12	9	13	8	17	19	18	19	14.38

Experim. Group: Dif.= 6.98; Stand. Deviat. = 2.64, Control Group: Dif. = 24.44; Stand. Deviat. = 4.94
ΔTime: Dif. = 17.48; Stand. Deviat. = 4.18

Table B3. Test nº 3-Time required by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	30	37	38	39	44	41	42	40	38.88
Cont.	43	45	49	42	54	52	52	47	48
ΔTime	13	8	11	3	10	11	10	7	9.13

Experim. Group: Dif.= 15.61; Stand. Deviat. = 3.95, Control Group: Dif. = 17.5; Stand. Deviat. = 4.18
ΔTime: Dif. = 8.36; Stand. Deviat. = 2.89

Table B4. Test nº 4-Time required by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	34	36	38	37	42	41	42	35	38.12
Cont.	46	48	50	43	57	53	54	49	50
ΔTime	12	12	12	6	15	12	12	14	11.88

Experim. Group: Dif.= 8.86; Stand. Deviat. = 2.98, Control Group: Dif. = 18; Stand. Deviat. = 4.24
ΔTime: Dif. = 6.11; Stand. Deviat. = 2.47

Table B5. Test nº 5-Time required by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	30	26	38	32	40	31	33	35	33.12
Cont.	43	42	48	41	53	52	50	47	47
ΔTime	13	16	10	9	13	21	17	12	13.88

Experim. Group: Dif.= 17.61; Stand. Deviat. = 4.2, Control Group: Dif. = 18.5; Stand. Deviat. = 4.3
ΔTime: Dif. = 13.61; Stand. Deviat. = 3.69

Table B6.Test nº 6-Time required by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	30	26	37	33	40	31	32	35	33
Cont.	45	46	49	43	55	53	54	47	49
ΔTime	15	20	12	10	15	22	22	12	16

Experim. Group: Dif.= 16.9; Stand. Deviat. = 4.06, Control Group: Dif. = 17.75; Stand. Deviat. = 4.21
ΔTime: Dif. = 19.75; Stand. Deviat. = 4.44

Table B7. Test nº 7-Time required by 8 experimental and 8 control companies

Comp	1	2	3	4	5	6	7	8	Mean
Exper.	36	33	37	35	47	34	34	40	37
Cont.	48	50	52	47	59	53	56	51	52
ΔTime	12	17	15	12	12	19	22	11	15

Experim. Group: Dif.= 18.5; Stand. Deviat. = 4.30, Control Group: Dif. = 14; Stand. Deviat. = 3.74
ΔTime: Dif. = 14; Stand. Deviat. = 3.74

Tables B1 to B7 show that in all cases, without exception, the times needed by the experimental groups to reach a specified experience level were significant lower than those corresponding to control groups. The time decrease varied from 4 to 22, and their mean values from 4 to 16. All the tests, but nº 7, show higher values for the difference and standard deviation of the control groups than those of experimental groups.

Three other tests were carried out. Each test involved 5 companies chosen at random among those which had previously used only INTOP. They used FINANTUTOR until they reached the experience level pre-set in the second part of the first seven tests.

Tables C1 to C3 disaggregate Table 3.

Table C1. Test nº 8-Time required for 5 companies to reach the preset level of experience

Comp.	1	2	3	4	5	Mean
Exper.	33	35	25	32	36	32.2
Cont.	45	50	44	39	51	45.8
ΔTime	12	15	19	7	15	13.6

Experim. Group: Dif.= 14.96; Stand. Deviat. = 3.87, Control Group: Dif. = 18.96; Stand. Deviat. = 4.35
ΔTime: Dif. = 15.84; Stand. Deviat. = 3.98

Table C2. Test nº 9- Time required for 5 companies to reach the preset level of experience

Comp.	1	2	3	4	5	Mean
Exper.	31	34	22	30	36	30.6
Cont.	47	54	44	42	53	48
ΔTime	16	20	22	12	17	17.4

Experim. Group: Dif.= 23.04; Stand. Deviat. = 4.8, Control Group: Dif. = 22.8; Stand. Deviat. = 4.77
ΔTime: Dif. = 11.84; Stand. Deviat. = 3.44

Table C3. Test nº 10- Time required for 5 companies to reach the preset level of experience

Comp.	1	2	3	4	5	Mean
Exper.	33	36	39	29	32	33.8
Cont.	50	52	48	45	50	49
ΔTime	17	16	9	16	18	15.2

Experim. Group: Dif.= 11.76; Stand. Deviat. = 3.43, Control Group: Dif. = 5.6; Stand. Deviat. = 2.37
ΔTime: Dif. = 10.16; Stand. Deviat. = 3.19

Tables C1 to C3 indicate that the time increase changed from 7 to 22 and the mean value from 13.6 to 17.4.

Besides, students' opinion was studied by means of a survey as it is described in the text.

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