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Experiential learning through simulation games: An empirical study*

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The paper analyzes the different approaches of experiential learning theories, applied in the theoretical framework of experiential learning through project management simulation games. As a key element of this research, PROSIGA, the simulation game in which several situations relating to a project management environment can be experienced, is used. The empirical analysis of 102 participants has shown very significant results, allowing the conditions under which the participant can achieve optimum experiential learning to be determined. It is also worth pointing out that mistakes are part of their experiential learning process, dissatisfaction providing a key learning mechanism, demonstrating one of the main strengths of simulation games.

Keywords: experiential learning; simulation games; serious games; learning conditions; empirical study; project management

INTRODUCTION

TO MEET THE GROWING DEMAND for project management training it is necessary to provide ways of experimenting in which it is possible to act out the management of a project without the risk of failure. The best way to learn how to manage a project is to manage it. A series of tools must therefore be developed that uses simulation to reflect the various aspects to be dealt with throughout the management of a project: negotiation, dealing with conflicts, decision-making, and technical concepts related to project management, such as project planning, resource management, budgeting, project execution, project control, group work, etc.

Simulation learning techniques are used in a wide range of fields, from quality [1] to supply chain management [2] and process re-engineering [3, 4], in order to learn without having to pay the price for mistakes. In the project management learning process, simulation games give us the opportunity to deal with 'virtual' situations that resemble those we try to solve in real life, and represent a way to simulate the learning process and even the innovation process through practice; this has been termed 'experimental learning'. In the field of project management, these tools allow individuals or groups to participate in active dynamic interaction with a 'living' project that the participants, during the simulation, have to manage.

In this experimental environment, simulation games have two main objectives that complement each other. On the one hand, they try to provide ways for training in specific management fields, and on the other, they may serve as a laboratory in which the behavior of specific groups, with different profiles and under various circumstances, can be experienced and researched [5].

Despite the widespread use of simulation games and the research that already exists, it is still not clear what the optimum learning conditions for simulation games are. The body of empirical research, examining all aspects of games, continues to grow. Comprehensive reviews of current research can be found in [6–9, 10].

The combined use of simulation games, field studies and laboratory methods yield more fruitful strategic management research than using field studies alone [11, 12]. This has encouraged our research to select simulation games for a wide range of research inquiries, specifically in the field of project management.

The paper has two main objectives. First it establishes the theoretical framework on experiential learning through simulation games. Then, via the application of this framework, the paper researches heuristic behavior of the users of simulation games and the optimum conditions for experiential learning through such games.

EXPERIENTIAL LEARNING USING SIMULATION GAMES

According to Nonaka [13], organizational learning requires individual learning. However, indivi-

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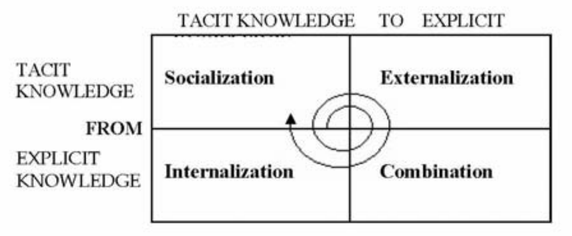

Fig. 1. The four modes of knowledge conversion and the knowledge spiral [13].

dual learning must interact in a dynamic social process to develop into organizational learning. This process can be modeled as a spiral of knowledge creation that takes place in the dynamics of learning through simulation games in groups. Organizational learning develops in a process of dynamic conversion between the individual and the organization, and between tacit and explicit knowledge (Fig. 1).

In the socialization phase, individual experience (tacit knowledge) is transmitted to other people; this tacit knowledge is then shared and registered by the group, which creates collective technical skills. In externalization, the tacit knowledge is articulated (conceptualized) into explicit concepts. The combination of concepts creates a new abstract knowledge system: an invention. The abstract invention has to be internalized by the individuals through concrete experience, through learning by doing. In this internalization phase, explicit knowledge is converted back into individual tacit knowledge. This new tacit knowledge (experience) has again to be shared (socialized) with others to become organizational knowledge (shared mental models). The knowledge spiral goes on.

The spiral is driven by the interaction of individual and organizational experience, by hands-on feedback from applying the ideas in practice. This experience can be achieved via everyday work, but also through simulation: experimenting with 'prototypes'. In the field of project management, the prototyping of projects can accelerate the learning processes: by experimenting with situations similar to those presented in real projects.

Complementing the Nonaka's approach to knowledge creation and regarding the learning dynamics in the use and application of simulation games, learning comes from three principal sources, which are essential to effective learning through simulation games: learning from content, learning from experience and learning from feedback [14–16]:

1. *learning from content*: the dissemination of new ideas, principles, or concepts;
2. *learning from experience*: an opportunity to apply content in an experiential environment;
3. *learning from feedback*: the results of actions taken and the relationship between the performance of each chronological phase in the experiment and the subsequent result.

In learning through simulation games, the source of learning is what the participants do rather than what they are told by the trainer. Above all, games are action-based learning, with all the advantages of that style of learning. Rather than talking about different ways of doing things, games offer an opportunity to practice skills in a relatively safe environment, and to try out different options without risking the full consequences of doing so in the real world.

The experiential learning method creates an environment that requires the participant to be involved in some type of personally meaningful activity. Such an environment allows the participant to apply prior knowledge of theory and principles while developing commitment to the exercise and experiencing a real sense of personal accomplishment or failure for the results obtained [12]. In order to bring about change in behavior, attitudes and knowledge, a circular, four-state experiential learning model developed by Kolb [15], termed Kolb's Experiential Learning Theory (ELT model), is used. It is shown in the outer circle of Fig. 2. Kolb's theory puts emphasis on sensory and emotional engagement in the learning activity. The model has received certain criticism because this original model does not 'adequately account for the relationship between social and personal learning' [17], so the ELT model has been supplemented with the experiential learning in teams approach [18]. To learn from its experience, a team must have members who can be involved with and committed to the team and its aims (concrete experience), who can engage in reflection and conversation about the team's experience (reflective observation), who can engage in critical thinking about the team's experience (abstract conceptualization), and who can make decisions and take actions (active experimentation). In an idealized learning cycle or spiral, the team and its members go through all the stages in a recursive process that is responsive to the learning situation. Team development is thus a process in which a team creates itself by learning from its experience. These authors identified learning as the key component of six aspects of team development: purpose, membership, role leadership, context, process and action. Thus, through structured written simulation, Kolb's Team Learning Experience (KTLE) enhances team effectiveness through learning, while engaging in the processes of knowledge creation, reflection, critical thinking and action taking [18].

Exploration, exploitation and dissatisfaction in experiential learning

Another approach to experiential learning that can be considered in the analysis of this conceptual framework concerns the experiential learning processes of exploration and exploitation [19]. This approach poses the premise that individuals can undertake experiential learning processes that yield behavioral outcomes that are reflected in organizational rules which encode the experiences concerned. Exploitation creates reliability in experience through refinement, routinization, production, and implementation of knowledge. Exploration creates variety in experience through searching, discovery, novelty, innovation and experimentation. The dynamics between exploration and exploitation create a mechanism of positive feedback between experience and competence, where retrieved experiences from the past have a controlling effect on what a group experiences and thus continues to learn from. When a group or organization enters an explorative process from an exploitative process, it is referred to as the opening-up process. The group creates variety in experience by opening up to new sources of experience. When a group enters an exploitation process from an explorative one, this is referred to as focusing. They then create reliability in experience by focusing their experiential learning. In both cases, dissatisfaction provides a key learning mechanism, and is produced between the team players when performance was perceived to be below the levels aspired to. It also arises with excessive explorative behavior that led nowhere in some of the team interaction.

The dynamics of learning through a simulation game provide a framework in which the dynamics between exploration and exploitation processes take place. The game shows and makes explicit the performance after the decision-making process. When this performance is below initial expectations, the group of game participants interacts with each other in order to explore new ways of performing, and they learn from the effects of these actions.

The process of a game goes through all of these stages. Kolb's four basic levels, combined with the acknowledgement that learning comes from these three principal sources, as well as the transactions from all these experiential learning processes, are relevant for skill acquisition in management through an experiential learning experience based on interaction with a simulation game (see Fig. 2).

The combination of the experiential learning models presented above has constituted the main theoretical basis for this research study about experiential learning through project management simulation games.

Keys and Wolfe [12] suggest that many research studies connected with simulation games have been applied to team performance, not learning, often with the assumption that high-performing teams learn the most from the game experience. Research is needed to evaluate the relationship between learning in a management game team and performance in a simulation game. Tracking learning processes with student learning diaries and/or test interventions at various points in a simulation might also be useful. We still know very little about the game-internal learning process.

Experiential learning can also be considered from the perspective of a multilevel phenomenon, involving dynamics of individual learning, group learning, intra-organizational learning and inter-organizational learning. This research focuses on the analyses of the complementary nature of the different levels of learning while interacting with the simulation game, considering the importance of the social setting for fostering the learning process and knowledge co-production. The individual, the participant in the game, is the critical starting-point and the most important carrier of new knowledge. Highly-motivated participants provide one of the most important success factors. The next learning locus is the group level. By sharing experiences and working on the same problem, individuals develop new knowledge, beyond the reflection of each participant. Through training experiences using simulation games, the sharing of experience and points of view while course participants tackle a problem together is probably one of the most valuable aspects of effective learning [20].

CONFIGURATION OF THE PROJECT MANAGEMENT SIMULATION LABORATORY SETTING

Smeds *et al.* present a Simulation Laboratory for analysis of change processes in industries [21, 22]. The aim of this Enterprise Simulation Laboratory is to provide opportunities to study simulation

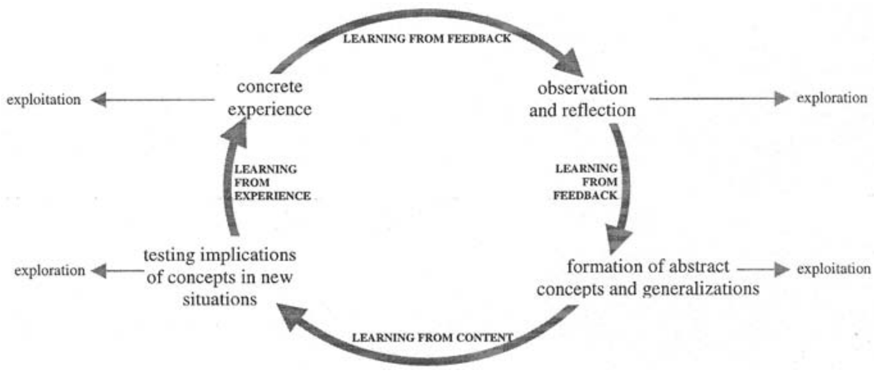

Fig. 2. Experiential learning cycle.

techniques and organizational learning in a laboratory setting. They suggest that simulations on enterprise models are needed to complement and support real-life learning in companies.

The development of the application of this to project management is the basic specification of a project management process simulation laboratory. With the idea of the Enterprise Simulation Laboratory in mind, a group of three or four participants act to manage a simulated project, all of them assuming the role of project manager. They share their tacit knowledge based on previous experiences related to project management or to previous working experiences. Via simulation, they achieve a shared understanding of the concepts and functions involved in managing a project. A Project Management game is used, where tailored models of the particular project being simulated are included in the simulation game. An experiment director or master takes part in the social simulation, and is in charge of the development and arrangements necessary for the simulation. As the simulation is tailored to the specific project, the participants' profile must take into account the model included in the game. A group of observers also participate in the social simulation as passive elements, watching the development of the project simulation and how the other participants perform in it.

The main aim of this simulation laboratory setting is to be able to analyze the users of the simulation game in an experimental environment, in order to observe their behavior when dealing with different circumstances [23].

The elements that make up the project management laboratory must be adapted to the specific experiment to be carried out. These elements are: the Master who designs and control the test situation that we are going to reproduce; the Participants, who are the core of the experiment; the Simulator, which is specifically developed to reproduce the reality of the process of the corresponding project-oriented business; the Observers, who will be watching and recording the interaction of the participants as the simulation progresses; and, finally, the Laboratory configuration itself, which determines the most suitable settings for all the elements of the laboratory in order to carry out the specific experiment through simulation.

This concept of a project management simulation laboratory combines various research approaches: acquisition and transfer of knowledge, organizational behavior, personality, experiment design methodology, sociology or group dynamics, simulation, hypothesis testing, learning processes and project management. All these aspects are included in the steps carried out in the experimental work via the project management laboratory.

With regard to the validity of research activities in a computer-based laboratory experimentation setting, the organizational behavior/personnel literature shows remarkable similarities between research findings obtained in the laboratory and field settings [24]. Simulation-based laboratory experimentation is particularly advantageous in the study of complex dynamic decision-making environments such as in project management.

The use of students as subjects raises the question of the extent to which the results can be generalized. Studies examining the use of students in decision-making environments have generally concluded that the formal properties of a task are much more important determinants of decision-making than subject profiles. Remus [25] found no significant differences between students and managers in making production-scheduling decisions. Project management decisions and production scheduling decisions are similar enough for us to apply his findings and assume that industrial engineering graduates are acceptable substitutes in this experimental investigation.

PROJECT MANAGEMENT SIMULATION GAMES

As explained in the preliminary section, the simulation game is the key element for providing an experiential learning environment in the field of project management.

There are a few examples of computer-based simulation games in the field of project management with a complementary approach, covering all the life-cycle phases of a project. Martin [26] presents a software environment for generating customized computer-based simulations that facilitate project management education from a management perspective. Vanhoucke *et al.* [27] present the *Project Scheduling Game*, which illustrates the complexity of scheduling a real-life project, based on the Critical Path Method (CPM), and focuses on the time/cost relationship in each activity of the project. Zwikael and Gonen [28] have developed the *Project Execution Game,* which provides the players with a set of realistic but unexpected events that occur during a project, in order to enhance their problem-solving capabilities and decision-making skills, as well as to hone their general reactions. Shtub [29] and Davidovitch *et al.* [30] describe a simulator called the *Project Management Trainer*, *PMT*, which integrates both phases, but focuses player interaction on the techniques of project scheduling and control, as well as on resource allocation. In the area of software project management, the use of two simulation games has been found. Abdel-Hamid *et al.* [31] use a role-playing project simulation game to analyze the impact of a different structure of project goals. These authors have also developed a research initiative on experience-based learning in complex environments, based on playing computer-based games with project manager professionals [32]. Continuing within the field of software project management education, Pfahl [33] used a System Dynamics simulation model in combination with a web-based role-play scenario in order to learn about typical behavior patterns in software development projects.

Berggren and Söderlund [20] suggest a model based on a 'social twist' of experiential learning theory in project management education and discuss different learning modes of how to rejuvenate, stretch and improve project management education. In this sense, project management simulation games combine the two directions of experiential learning (action and reflection), as well as individual, group and organizational levels.

Description of the PROSIGA game

PROSIGA (PROject SImulation GAme) is a training experience devoted to the development, improvement and motivation for group work, the decision-making process and the skills of the most common typical situations that arise when managing projects. Through the interaction with the PROSIGA game the participant takes part in the different processes around the management of a project from the preparation of the proposal to the tests prior to the end of the project [34].

The case proposed by the simulator is a project whose main purpose is to set up a new bicycle plant in a country bordering the European Union (EU), supported by an EU technology-transfer program. With this storyline, the participants form groups of three or four, assuming the role of project managers who are obliged to make decisions in order to achieve the targets required by the company's Board of Directors. From the very beginning, they are under pressure from time, trying to solve conflicts. The decisions made affect project development in different ways (costs, delay, team motivation, management support, etc.). Using simulation we create an interactive, real environment where management skills can be developed without the risk of failure.

The game is aimed at:

- companies that work to customer specifications (E.T.O., Engineering To Order), which need to introduce the project management philosophy;
- people who are interested in gaining experience in project management and need tools which reproduce real scenarios where decisions have to be made and conflicts have to be resolved;
- companies that require specific simulation tools in order to train them to deal with processes of fundamental change that involve changing attitudes and encouraging new working methods.

This simulation game has been disseminated and applied in more than a dozen universities in an international framework, including MBA, MSc and undergraduate students, and it has been fully transferred to four universities for their own regular use and application.

The seminar consists of two different phases that complement each other (Fig. 3).

Phase PROSIGA 1: Proposal preparation

The aim of this phase is for participants to collaborate in preparing a proposal for a European Union program. This phase handles the concepts of project scheduling, resource allocation under resource constraints, critical path, preparing an initial draft of the master plan and later adjusting it to time constraints, weighing up the various alternatives available, while minimizing the cost. The performance of this project phase is measured by means of the terms and the costs of the project master plan.

Phase PROSIGA 2: Project development

In this second phase of the game, a series of situations will be experienced. These situations occur during the project, up to the commissioning and final receipt of the plant. Participants in groups should therefore make a series of decisions that will be required as the project progresses (Fig. 4). This phase handles the concepts of project execution and control, budget control and project management skills. The position to be adopted in this case will affect the Project State Variables: Quality, Cost, Delay, Team Motivation, Management Support, Relationship with Stakeholders and

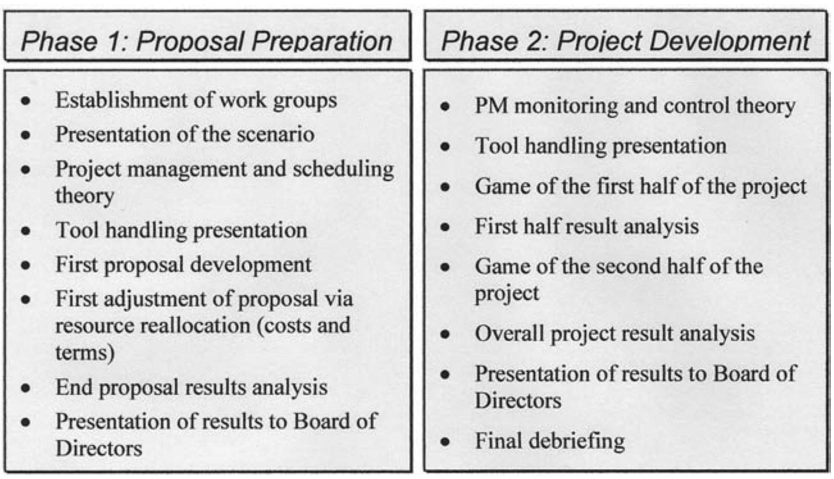

Fig. 3. The two phases of PROSIGA.

Fig. 4. Main screen of PROSIGA Phase 2: Project development.

Communication. In addition, they can observe the results that these decisions have for the project. They receive a target strategy for all the project development phase that should determine how to proceed in the decision-making process. These seven project state variables, together with the target strategy, are the variables for measuring the performance for this second phase.

At the end of this second phase of PROSIGA, each group must explain and justify the results to the Board of Directors what they have achieved while managing the project. The goal is that, have completed the course, all the participants should have an idea of how to implement these aspects in their own company and professional environment [35].

EMPIRICAL RESEARCH WORK ON EXPERIENTIAL LEARNING THROUGH SIMULATION GAMES

In this experimental case, via our project management laboratory, we have tried to go beyond the results of simulation games. The learning that the participant has acquired via the project management simulation game PROSIGA has been measured. The experiential learning provided by the simulation game is geared to both individuals within the group and the group as a whole, while they executed a common task.

The participant learning register is based on an experiential learning model presented in the sections above. It is based on the premise that an effective instructional style requires the balance of three factors that are considered essential to effective learning through simulation games: learning from content, learning from experience and learning from feedback. As learning from content is the process of moving from abstract conceptualization (exploitative process) to active experimentation (exploration), this can also be classified as an opening-up learning process [19] (see Fig. 2). Learning from experience transfers the experimentation (exploration) to concrete experience (exploitation), which corresponds to a focusing learning process. Learning from feedback goes from concrete experience to abstract conceptualization, passing through reflective observation (exploration), which implies both opening-up and focusing learning processes respectively.

After attending the training seminar for the PROSIGA simulation game, the participant followed a cycle in the combination of the experiential learning models analyzed previously. The participants in the simulation game have acquired learning from content due to the assimilation of the project management concepts. They apply this content in an experiential environment provided by the project simulated with the game. After this experiential learning they have the opportunity to learn from feedback when they test the implications of the experiential learning acquired with the simulation game in a new, real project. All these three stages are explained below. This research centers on learning in Project Management, and the model is interpreted taking the life-cycle of a complete project as the unit of analysis. This is why learning from feedback occurs when the participant is able to apply the experiential learning provided by the simulation game to a new project.

The learning from content factor is obtained by means of a questionnaire that the participants fill in before and after a training seminar, in order to analyze the improvement in their project management knowledge. The questions included cover concepts such as project scheduling, resource over-allocation or the role of the project manager.

Information on the learning from experience factor was collected by means of a questionnaire at the end of each PROSIGA phase. This questionnaire assesses the extent to which the participant values the experience provided by the simulation game.

The learning from feedback factor was analyzed after the participants had completed a real project (wholly independently of the project simulated with the game) in teams, as part of their practical assignment for the overall project management topic [36, 37]. This topic covers one semester. In this topic, the students took part in the PROSIGA training seminar during the first third of their practical work. The questionnaire analyzes the extent to which the knowledge acquired during the PROSIGA seminar has been applied to the real project that they carried out for the practical assignment.

Despite the widespread use of simulation games and the research existing up to date, it is still not obvious what group behavioral conditions have to be provided in order to optimize learning through simulation games. Comprehensive general reviews of some research evidence on this matter can be found in [38] and [8]. However, evidence on the application on the project management simulation games has not been found.

An analysis of the influencing factors has been divided into two groups: the factors that could affect the behavior of each one of the individuals who participated in the training seminar, and the factors influencing the behavior of the group as a whole. The influence of the following individual factors has been analyzed, some of them noted by the participants: evaluation of the presentation, amenity and didactic value of the game, the learning benefits they have gained after participating in the training seminar based on the project simulation game, the closeness of the game to the real world, entertainment component they perceived, how complicated they found the game, personal experience and participants' ages.

The variables that have been considered as part of the group behavior are: group compatibility, group dynamics, group experience, group participation. The first of these variables, group compatibility, is based on Shaw's formulation [39] concerning the FIRO (Fundamental Interpersonal Relation Orientation) Method, which explains interpersonal behavior in terms of an individual's orientation towards others, explained by three interpersonal necessities: inclusion, control and affection. The second variable, group dynamics, has been analyzed according to Bany and Johson [40] and Pallares [41], with the premise that the dynamics of a group can be deduced by observing the cohesion and the communication between its members and the decision-making process that exists within the team. Group experience considers that not all the individuals who participate contribute the same degree of experience to the group as a whole. Finally, group participation, based on the percentage of interventions and the quality of the interventions, during the group interaction with the simulation game.

Apart from analyzing learning via the simulation game, we have also analyzed the way in which a participant's motivation affects different factors related to the simulation game, such as learning, the results obtained after participating in training seminars, etc. [42, 43]. The motivation factor was measured using two procedures: first, the participant's profile includes questions concerning his/her initial motivation for participating in the training seminars, and secondly, the group of observers measured this factor for each participant throughout the simulation game.

In the research project, 102 participants were evaluated in these project management seminars. They were mainly final-year students carrying out Industrial Engineering Master's studies at the University of Zaragoza, on their project management major course. Each group had 3 or 4 participants. They participated with PROSIGA in more than 100 different decision-making points. Two internal tests were taken with the main purpose of testing the experiments to be performed at these seminars. All participants in the various training seminars were volunteers. Of the sample, 94.1% were aged 18–25 years, and 5.9% aged 26–30. The gender distribution was as follows: 72% of the individuals in the sample were men, and the remaining 28% women. In addition, 26.5% of the students had some experience of work, with very little experience in project management.

The laboratory framework has been specially configured for this experiment. The information has been collected from four main sources: the individual profile of each participant, questionnaires filled by the participants, observation protocol (the same group was monitored by two different observers in order to reduce the subjectivity of observations), and the user results register from the experiment with the project management simulation game.

Table 1 summarizes the different variables that were analyzed in order to deal with experiential learning on project management using simulation games, as well as the different tools and systems implemented for information acquisition in the lab experiments.

EMPIRICAL RESULTS

The most relevant statistical results obtained are shown below and the variables that are the basis for this empirical analysis are presented in Table 1. In order to carry out data analysis, the relationship

Table 1. Variables analyzed and systems for information acquisition.

SYSTEMS	VARIABLES
1. Participant's profile (P.P.)	• Age • Gender • Experience: Labor experience, Project management experience, IT experience
2. Participant's questionnaire (Q)	• Presentation • Entertainment component • Didactic value • Motivation • Learning benefits • Realism • Complexity
3. Observer template (Ob.)	• Progress of participants' motivation • Group dynamics: Cohesion, Communication, Decision-making • Compatibility: Personality • Participation: % participation, Quality of participation • Register of the session
4. Simulator results (URR)	• PROSIGA 1 (Proposal Preparation): Terms and costs of the project • PROSIGA 2 (Project Development): Project quality, cost, delay, motivation, relationship with stakeholders, management support, communication and target strategy

between certain key factors is established, at both individual and group level, using statistical methods that allow these relationships to be graded.

In relation to the mean and standard deviation for the three learning factors, as well as for the motivation factor (Fig. 5), we must consider that the learning from content factor is obtained by taking the participant's previous project management knowledge as the point of reference. This is why the mean is different from the two other learning factors. Figure 5 also shows that the simulation game is efficient from the point of view of the learning acquired by the participants, and consequently fulfils the aim for which it was created.

In order to study the models that best describe the influence of participant behavior factors on learning through simulation games, some multiple regression analyses, as well as analysis of correlation coefficients, have been carried out. To determine whether or not the relationship observed between the dependent and independent variables occurs randomly, with a 5% and 10% level of significance, two tests were used: the statistics of *Snedecor's F* and of *Student's t*.

Multiple regression analysis of the eight individual factors (presentation, amenity and didactical value, learning benefits, realism, entertainment component, complexity, experience and age) and the learning from experience factor shows very reliable results, since the Snedecor's F value (9.064) fulfils the Snedecor test with a significance of 5%. The adjusted R-squared we obtain is 0.45, which means that the eight factors are capable of explaining 45% of the variation in learning from experience. This result indicated a significant proportion for this type of statistical study.

In this study, we obtain the result that the didactic value perceived by the participant has a positive influence on learning from experience. This associative relationship is quantified by means of a correlation coefficient of 0.573, which indicates a very significant positive association. However, the complexity of the game as a whole has a negative influence, in other words the less the complexity that the participant perceives, the higher the learning from experience. This result is due to the fact that equilibrium must be obtained in the complexity of the game in order to provide optimum learning, and therefore extra complexity in certain participants can lead to a decrease in the learning provided by the experiment with the simulation game.

The following group of analyses examines how group behavior factors (group compatibility, group dynamics, group experience and group participation) affect the different types of learning

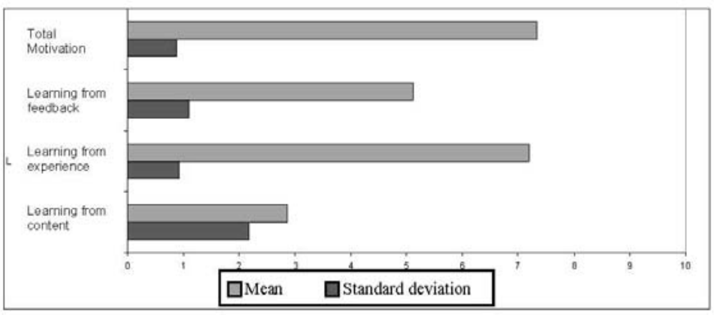

Fig. 5. Means and standard deviations for the learning and the motivation factors.

through simulation games. In this case PROSIGA Phase 1 and PROSIGA Phase 2 have been studied separately.

For PROSIGA 1 (Proposal Preparation), we have not obtained enough significance in the tests. For PROSIGA 2 (Project Development), we obtain a greater adjusted R-squared coefficient: 43.8% for learning from content, and 34.9% for learning from experience, and a high significance in Snedecor's F fulfillment (5% in both cases). These findings allow us to suggest which factors are influential in obtaining optimum learning in PROSIGA 2 (Project Development). Those groups that achieve a greater level of participation while playing the simulation game will obtain optimum learning. This allows activation first of the opening-up learning process, embedded in learning from content, and afterwards the focusing learning process of the complementary learning from experience. In this complementary process the level of participation within the group seems to play a key role. Therefore, in order to learn from the decision-making process included in the situations provided by PROSIGA 2 (Project Development), all group members should participate in giving their opinions. This means that the opportunity of transferring from exploration to exploitation and vice versa activates the experiential learning loop. The simulation game instructor should subsequently take an active role, encouraging the group so that this level of participation occurs.

We have also found that groups with a high level of group experience learn less with PROSIGA 2 (Project Development) than those who have a lower level of group experience.

The correlation coefficients between each learning factor and PROSIGA performance in phase 1 (Proposal Preparation) (from content: –0.137, from experience: –0.204, from feedback: –0.055) may indicate that the participants learn more about project management when their results obtained with the simulation game are worse. This means that they learn more when they can learn from their own mistakes, since the simulation game experience analyzes the impact of the participants' decisions on project performance (terms, costs and resources). It can be explained by the levels of dissatisfaction according to the theoretical framework on experiential learning, explained above. In this case, dissatisfaction arises when performance was perceived to be below the levels aspired to. Participants felt dissatisfied with their ongoing exploitative or explorative behaviors. They could understand which behavior might be more productive from the point of view of game performance, and they embarked on a search for other patterns of behavior. This behavioral change appeared to stem from experiential learning. Other research suggests that it is difficult to learn from mistakes [44, 45] and two issues seem to be key factors: information from failures can catalyze change and improvement, and learning from mistakes requires a thorough understanding of their nature. These two conditions are favorable in experiential learning through simulation games because of the analysis of the causes of their performance evaluation.

In the case of PROSIGA 2 (Project Development), no clear relationship between the learning factors and the game performance results has been established.

The motivation that participants have for the training seminar has also been observed. The group of observers also gathered information on the progress of the players' motivation while participating in the simulation. The two sets of data were combined to indicate overall motivation. We have found a positive association between learning, especially learning from experience, and the participants' motivation, quantified by means of a correlation coefficient of 0.261. Evidence of these findings can be found in other research [42, 43]. Participants who have a high degree of motivation have a previous positive disposition to learn. However, a certain balance in motivation must exist, because an excessive degree of motivation might cause the participant not to learn the key topics of the training seminar due to his/her excessive excitement.

CONCLUDING REMARKS AND FURTHER WORK

The paper establishes the theoretical framework of experiential learning through simulation games. This framework examines the learning cycle, developed by Kolb, with the interaction of exploration and exploitation processes, these transfers between the group participants being the drivers of experiential learning.

The simulation game provides an experimental environment where participants share their tacit knowledge and obtain new experience via the simulator, which reproduces the real world of project management as accurately as possible, and emulates all phases of the life-cycle of a project. Using this tool, they can understand the different organizational approaches applied to project-oriented processes.

They can experience what the effects are after the application of different project management strategies throughout all the phases of a project. We estimate this training approach has been efficient, judging from the results obtained. The experiential learning provided by the project management simulation game comes from the reflection of the overall results of the action or set of decision-making throughout the project phases. Additionally, the simulation game provides different scenarios that provide the participants with an opportunity to interact, sharing their experiences and points of view about the situation they have to tackle. This interaction in the core of the group is the driver of the team learning synergy.

The analysis undertaken on 102 participants has shown very significant results, allowing the conditions under which the participant can achieve optimum experiential learning to be determined. The research has identified the behavioral individual factors and group interaction factors that can explain around 40% of the variation in learning from experience, knowing the direction of the influence of these factors.

Greater experiential learning was achieved when participants' performance with the simulation game was worse, which means that mistakes should be part of the learning process. The driving mechanism behind these dynamics is dissatisfaction with performance levels, perceived as being below the levels aspired to. This preliminary result suggests further, more in-depth research, as it is one of the greatest strengths of simulation games, because they allow participants to interact with the effects of their decisions without paying the real cost associated with mistakes. The participants' motivation is positively associated with the learning from experience factor, which means that the simulation game instructor should track the status of motivation in order to act to maintain a high level of motivation and thereby promote more fruitful learning. Motivation appears to be a key aspect as a driver in promoting the right conditions during the progress in the interaction with simulation games and within the group dynamics, regardless of simulation game performance.

The results obtained in this research show that simulation games are powerful tools, not only for the training of future project managers but also as a part of a laboratory where behavior under diverse circumstances can be experienced; they thereby offer the possibility of learning through experimentation.

The experience achieved with the project management simulation laboratory and empirical experiments with it has recently been transferred to the scmLAB (supply chain management learning laboratory), using the arguments of Senge [46] on learning ecology for systemic change as a theoretical framework. The overall aim of the scmLAB is to stimulate supply chain innovation in real-life situations, while at the same time studying interorganizational behavior in a laboratory setting [47].

REFERENCES

1. G. G. Wang, Bringing games into the classroom in teaching quality control, *International Journal of Engineering Education*, **20**(5), 2004, pp. 678–689.
2. D. Knoppen and M. J. Sáenz, Supply chain collaboration games: A conceptual model of the gaming process, in Taisch and Cassina (eds.), *Learning with Games*, Mar.Co, Italy, (2007).
3. R. Smeds and J. O. Riis (eds.), *Experimental Learning in Production Management*, Chapman and Hall, London, (1998).
4. K. D. Thoben, J. B. Hauge, R. Smeds and J.O. Riis (eds.), *Multidisciplinary Research on New Methods for Learning and Innovation in Enterprise Networks*, Verlaag Mainz, Aachen, (2007).
5. J. Feller, A. Hirvensalo and R. Smeds, Inter-partner process learning in collaborative R&D—a case study from the telecommunication industry, *Production Planning and Control*, **16**(4), 2005, pp. 385–395.
6. D. Millians, Thirty years and more of simulations and games, *Simulation & Gaming*, **30**(3), 1999, pp. 352–355.
7. B.D. Ruben, Simulations, Games and experience-based learning: The quest for a new paradigm for teaching and learning, *Simulation & Gaming*, **30**(4), 1999, pp. 498–505.
8. J. Randel, B. A. Morris, C.D. Wetzel and B.V. Whitehill, The effectiveness of games for educational purposes: A review of recent research, *Simulation & Gaming*, **23**(3), 1992, pp. 261–276.
9. J. Wolfe and J. B. Keys, *Business Simulations, Games and Experiential Learning in International Business Education*, Ed. International Business Press, New York, (1997).
10. S. Meijer, G. J. Hofstede, G. Beers and S.W. Omta, Trust and tracing game: learning about transactions and embeddedness in a trade network, *Production Planning and Control*, **17**(6), 2006, pp. 569–583.
11. C. Elgood, *Handbook of Management Games*, Gower Press, Cambridge, (1993).
12. J. B. Keys and J. B. Wolfe, The role of management games in education and research, *Journal of Management*, **16**(2), 1990, pp. 307–336.
13. I. Nonaka, R. Toyama and P. Byosiere, A theory of organizational knowledge creation: understanding the dynamic process of creating knowledge, in Dierkes M., Berthoin A., Child J. and Nonaka I. (eds.), *Handbook of Organizational Learning and Knowledge*, Oxford University Press, 2003, pp. 493–498.
14. B. Keys. A review of learning research in business gaming, in B. H. Sord (ed.), *Proceedings of the Third Annual Conference of the Association for Business Simulation and Experimental Learning ABSEL*, (1976).
15. D.A. Kolb, *Experiential Learning*, Prentice Hall, England, (1984).
16. A. Kirby, *Games for Trainers, Vol. 1*, Gower, Aldershot, (1992).
17. D. C. Kayes, Experiential learning and its critics: preserving the role of experience in management learning and education, *Academy of Management Learning Education*, **1**(2), 2002, pp. 137–49.
18. B. Kayes, D. C. Kayes and D.A. Kolb, Experiential learning in teams, *Simulation and Gaming*, **36**, 2005, pp. 330–354.
19. M. Holmqvist, Experiential learning processes of exploitation and exploration within and between organizations: an empirical study of product development, *Organization Science*, **15**(1), 2004, pp. 70–81.

20. C. Berggren and J. Söderlund, Rethinking project management education: Social twist and knowledge-coproduction, *International Journal of Project Management*, **26**, 2008, pp. 286–296.
21. R. Smeds, M. Jaatinen, A. Hirvensalo and A. Kilpio, Simlab process simulation method as boundary object for inter-organizational innovation, in B.A. Hussein, R. Smeds and J. O. Riis (eds.), *Proceedings of the 10th International Workshop on Experimental Interactive Learning in Industrial Management*, Trondheim, 2006, pp. 187–195.
22. R. Smeds, Enterprise simulation laboratory for education, research and development, in R. Smeds and J. O. Riis (eds.), *Experimental Learning in Production Management*, *The Effect of Using Simulation Games in University and Industry*, Chapman & Hall, London, (1998) pp. 11–16.
23. J. L. Cano and M. J. Saenz, Project management simulation laboratory: experiential learning and knowledge acquisition, *Production Planning and Control*, **14**(2), 2003, pp. 107—110.
24. E. A. Locke and J. F. Bryan, *Generalizing from Laboratory to Field Settings: Research Findings from Organizational Behavior and Human Resource Management*, Health Lexington, Lexington, MA, (1986).
25. W. E. Remus, Graduate students as surrogates for managers in experiments on business decision making, *Journal of Business Research*, **14**, 1986, pp. 19–25.
26. Martin, A simulation engine for custom project management education, *International Journal of Project Management*, **18**(1), 2000, pp. 201–213.
27. M. Vanhoucke, A. Vereecke, P. Gemmel, The project scheduling game (PSG): simulating time/cost trade-offs in projects, *Project Management Journal*, **36**(1), 2005, pp. 51–59.
28. O. Zwikael and A. Gonen, Project execution game (PEG) training towards managing unexpected events, *Journal of European Industrial Training*, **31**(6), 2007, pp. 495–512.
29. A. Shtub, Simulators for education and for professional development, *19th Annual Conference of the Production and Operations Management Society* (*POMS*), May 9–12, 2008.
30. L. Davidovitch, A. Parush and A. Shtub, Simulation-based learning in engineering education: Performance and transfer in learning project management, *Journal of Engineering Education*, **95**(4), 2006, pp. 289–299.
31. T. K. Abdel-Hamid, K. Sengupta and C Swett, The impact of goals on software project management: An experimental investigation*, MIS Quarterly*, 23(4), 1999, pp. 531–555.
32. K. Sengupta, T. K. Abdel-Hamid and L. N. Van Wassenhove, The experience trap, *Harvard Business Review*, **86**(2), 2008, pp. 94–101.
33. D. Pfahl, O. Laitenberger, G. Ruhe, J. Dorsch and T. Krivokova, Evaluating the learning effectiveness of using simulations in software project management education: results from a twice replicated experiment*, Information & Software Technology*, **46**(2), 2004, pp. 127–148.
34. R. Turner, *The Handbook of Project Based Management: Improving the Processes for Achieving Strategic Objectives*, McGraw-Hill, England, (1993).
35. J. L. Cano, M. J. Sáenz and J. Puig, Knowledge capture through project management simulation games, *International Project Management Conference* – NORDNET, Helsinki, (1999) pp. 786–801.
36. J. L. Cano, R. Rebollar and M. J. Sáenz, *Curso de Gestión de Proyectos*, AEIPRO. Asociación Española de Ingeniería de Proyectos. Spain, (2003).
37. J. L. Cano, I. Lidón, R. Rebollar, P. Roman and M. J. Sáenz, Student groups solving real-life projects. A case study of experiential learning, *International Journal of Engineering Education*, **22**(6), 2006, pp. 1252–1260.
38. W. J. Wellington and A. J. Faria, The effect of time pressure, team formation, and planning on simulation/game performance, in D. Crookall and K. Arai (eds.), *Simulation and Gaming Across Disciplines and Cultures*, Sage, USA, 1995, pp. 204–212.
39. M. E. Shaw, *Dinámica de Grupos*, Herder, Barcelona, (1980).
40. M. Bany and L. Johson, La Dinámica de Grupo en la Educación, Aguilar, Madrid, (1981).
41. M. Pallares, *Técnicas de Grupo Para Educadores*, Instituto de Ciencias de la Educación, Madrid, (1982).
42. J. Gosenpud and P. Miesing, The relative influence of several factors on simulation performance, *Simulation and Gaming*, **23**(1), 1992, pp. 311–325.
43. J. Wolfe and T. M. Box, The teaching effectiveness of games in collegiate business courses: A 1973–1983 update, *Simulation & Gaming*, **16**(3), 1985, pp. 251–288.
44. J. S. Carroll, J. W. Rudolf and S. Hatakenaka, Learning from experience in high-hazard organizations, *Research in Organizational Behavior*, **24**, 2000, pp. 87–137.
45. A. L. Tucker, the impact of operational failures on hospital nurses and their patients, *Journal of Operation Management*, **22**, 2004, pp. 151–169.
46. P. M. Senge, B. B. Lichtenstein, K. Kaeufer, H. Bradbury and J. Carroll, Collaborating for systemic change, *MIT Sloan Management Review*, **48**(2), 2007, pp. 44–53.
47. D. Knoppen and M. J. Sáenz, A learning laboratory for supply chain collaborative redesign, in Thoben, Hauge, Smeds and Riis (eds.), *Multidisciplinary Research on New Methods for Learning and Innovation in Enterprise Networks*, Verlaag Mainz, Aachen, (2007) pp. 161–173.

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