PRACTICING ATIVE AND COOPERATIVE LEARNING USING LIVE SIMULATION GAMES IN THE CLASSROOM

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Abstract — This paper suggests the use of live simulation game to practice principles of Active and Cooperative Learning as one alternative way to improve learning and develop social skills in the classroom. In spite of the fact that live-simulation games are intrinsically an active learning methodology, they usually do not contemplate all the principles of a collaborative learning. Then, it is necessary to develop or modify existing games to make them appropriate in order to practice collaborative learning. The authors of this paper have been modifying games to practice collaborative learning. This paper presents two cases.

Index Terms ¾ Simulation Game, Experimental learning, Kolb's Cycle, Active and Cooperative Learning.

INTRODUCTION

As a consequence of the development of information technology and other important innovations, the organizations have been re-formulating their decision-making process and their hierarchical structure searching for new ways to acquire competitive advantage. In all their hierarchical levels, the capacity to understand the system as a whole has been increasingly requested. More sophisticated and more complex personal and interpersonal abilities have been substituting the abilities demanded in recent past. Teams deliberately created in order for each member to bring a different perspective to an issue have been substituting the individual centralized power. In this new context, the problem solving approach comes from a different set of experiences and wisdom, and the organizations comprehend an interdependent atmosphere of distinct and conflicting individual's constructs. Now, engineer, as a member of a team, needs to know how to share knowledge, and how to cope with conflict as a politician instead of a commanding officer.

These innovations have faced the education system with the challenge of producing a workforce with new abilities that go beyond the abilities requested in past years. The Engineering System Education, in special, is requested to form graduates who not only possess a strong foundation in mathematics, science and technology, but also have the ability to creatively apply these foundations to develop and share knowledge. The engineers must also have the ability to develop interpersonal relationships, manage conflicts, use system thinking to anticipate the social and environmental impacts of technological solutions, work as part of a team, and possess the ability to engage in life-long learning.

Engineering professors, aware of the impossibility to accomplish this social demand through their traditional teaching methods, have actively been searching for alternative ways to cope with this challenge.

Active and Cooperative Learning, in the last ten years, has been one of the methodologies proposed in engineering education conferences as an alternative way to develop in the engineering students the new abilities requested by the modern organizations. *An passant*, Johnson, Johnson & Holubec, [1], define Cooperative Learning as "the instructional use of small groups so that students work together to maximize their own and each other's learning". According to the Foundation Coalition Project, the Active learning can be understood as a learning process in which "students are engaged in activities other than listening and taking notes, e.g., reading, discussing, writing, problem solving, and students are involved in higher-order thinking, e.g., analysis, synthesis, evaluation", [2].

At the same time, other specialized professionals, using different expressions such as "microworld", "flight simulator", "live simulation game" or "simulation game" and etc… have also been developing an other alternative way to improve and modernize the learning process. The methodology of this latter alternative is based on traditions of social psychology and cognitive psychology, and its main concern is to develop environment learning where the learners can be actively and creatively involved in the construction of their own understanding.

There is not a clear-cut connection between these methodologies. The latter is by nature an Active Learning methodology, but it is not necessarily a Cooperative Learning methodology. This paper suggests the use of live simulation game to practice the principles of Active and Cooperative Learning prescribed by Foundation Coalition Project as one alternative to improve learning and develop in the engineering students the abilities requested by the modern engineering practice.

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ACTIVE AND COOPERATIVE LEARNING

The Foundation Coalition, a program sponsored by the National Science Foundation, has developed and implemented an Active and Collaborative learning technique that prescribes the following five principles, [2]:

(1) *Positive Interdependence*: Tasks are structured to encourage team members to rely on each other in order to accomplish team goals. Each team member should perceive that his/her individual success depends on the success as a team;

(2) *Individual Accountability:* Tasks are structured to encourage team members to be held accountable for doing their share of the work, as well as mastering all material. Each team members should perceive that he or she must be able to demonstrate mastery of the material on an individual basis;

(3) *Group Processing*: Encourages each team to reflect on it performance as a team. Teams should periodically reflect on what they do well as a team, what they could improve, and what they might need to do differently.

(4) *Interpersonal and Social Skills*: Team members practice and receive instruction in leadership, decision-making, communication, and conflict management.

(5) *Face-to-Face Interaction*: Structure team tasks so that members spend all or some of their time working together. Encourage physical arrangements so that team members can see each other as they are working. For example, with teams of four persons, encourage teams to arrange themselves so that they are all facing each other instead of sitting in a row.

LIVE SIMULATION GAME

Simulation, in general terms, means the imitation of a certain situation in order to achieve certain objective. In this context, game and simulation are similar, because game is a special kind of simulation. The distinction between both is a subtle one. The word "game" involves a word – *play* – that has in it an important means. The word "play" implies an active participation of people. The word – *simulation* - however, does not necessarily imply "to play". The essential difference between game and simulation is that in a game there are always people interacting actively through strategic decisions.

In most recent publications in specialized literature, the words live simulation game, manual game, physical game, and simulation game, [3], flight simulator and microworlds, [4]-[8], have been used to distinguish a modern kind of game from the traditional computer-based game.

One of the characteristics that distinguishes this kind of modern learning game from the traditional computer-based game, is the role of the computer in both. In the traditional computer-based game, the players take decisions, feed the system and then the computer, based on a computational model, makes a computation and answers the results as consequences of the decisions. In general, the model is a sort of "black-box", and often it does not offer conditions to players to understand the interdependence and consequences of their own decisions. In the modern game, the "machine" is open, showing "its set of gears and the connections among them". In other words, the components of the game are disclosed in a such way that the participants not only can understand the structure of the situations that they are involved in, but they can also understand as the interaction among their decisions, under a same structure and under different structures, produces results.

Authors such as Sterman, [4]-[6], and Senge, [7]-[8], using the expression microworld or flight simulator, define this kind or modern game as a simulated environment learning that:

- Compresses time and space so that it makes possible to experiment and to learn when the consequences of our decisions are in the future and in distant parts of the organization;
- Brings about principles and organizational phenomena;
- Develops understanding about interdependent decisions and its consequence to organization;
- Offers opportunity to experience the timing of decisions and their integration and coordination with decisions in other areas of the organization;
- Improves the ability to work in teams; and mainly
- Develops system thinking and shows the necessity of its use.

Other authors, such as Taskinen and Smeds, [3], using the term simulation game, describe this kind of modern game also as a simulated environment learning that involves:

- "Socialization: the individual, tacit knowledge is shared through the joint game experience;
- Externalization: tacit knowledge is made explicit through conceptualization and dialogue in the game and in the debriefing;
- Combination: different bodies of explicit knowledge are combined into a new design in debriefing, or design teams as a simulation game after the effect rather than during the actual game;
- Internalization: alternative designs are experimental in games; learning by doing and adopting the new way of working, converting explicit knowledge back to tacit individual knowledge".

Whatever the word used, "microworld", "flight simulator", "live simulation game", "simulation game" or "role-play simulation game", the meaning is the same: a simulated learning environment where people play an active role in the construction of their own knowledge through an experiential way. It can be developed totally based on computer or as an experiential game, that is, directly playing on-board, permitting the participants acquisition of knowledge thought all their senses as suggested by Forester, [9].

These pedagogical instruments have the strong potential to improve active and cooperative learning in the classroom. They offer an opportunity for accomplishment of experiences that can bring about human behavior knowledge involved in the decision making processes, as well as can help people learn by doing general laws of organizational behavior. The users can apply and test concepts already learned, acquire new concepts, improve the skills necessary for working in teams, and practice the principle of active and cooperative learning.

Live simulation game is a constructivist pedagogical instrument because it allows the students to form concepts through their own experiences and it provides an exploratory environment to practice and develop knowledge. It is active because when the students participate in live simulations, they are learning by doing, that is, they are taking part in a "hands-on experience". Therefore, live simulation games are naturally and intrinsically active.

However, in spite of live the simulation games are naturally and intrinsically active, they are not necessarily a collaborative learning methodology. Usually, they do not contemplate all the principles of collaborative learning, but they can be modified to incorporate the principles of Cooperative Learning to help the faculty improve Active and Cooperative Learning in the classroom.

PEDAGOGICAL FOUNDATIONS OF LIVE SIMULATION GAMES

A live simulation game is essentially an experiential learning

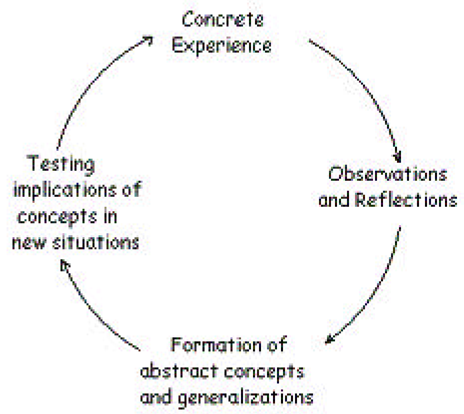

Figure 1: The Lewinian Experiential learning Model. (From [11], p17)

methodology in the meaning derived from Kolb, [10], [11]. According to Kolb, [11], learning is something essentially experimental, and he uses the term "experiential learning" for two reasons: to connect it clearly to its intellectual roots, Dewey, Lewin and Piaget; and to call attention to the important role that experience plays in the learning process.

To Kolb, [11], the knowledge is created through the dialectical transformation of experience. He suggests that the most effective learning process requires the four different learning steps outlined in the feedback loop of figure 1.

The immediate concrete experience is basis for observation and reflections. After that, the observations are assimilated into a theory from which new implications for actions can be deducted. These implications then serve as guides in acting to transform new experiences in knowledge in a learning spiral process. The sequence - *experiencing*, *reflecting*, *generalizing*, and *applying* - is called the experiential learning cycle or Kolb's learning cycle. *Experiencing* involves sensory and emotional engagement in activity. *Reflecting* involves watching, listening, recording, discussing, and explaining the experience. *Generalizing* involves integrating theories and concepts into the overall learning process. *Applying* involves engaging in a trial-and-error process in which the accumulation of sensory experience, reflection and conceptualization is tested in a particular context.

In accordance with the recommendation of the 4MAT learning system from McCarthy, [12], complete learning occurs by passing through the four quadrants of Kolb's cycle. Live simulation game can be projected to attend to this requisite and to accommodate all learning styles, [10] [13], present in the classroom.

DEVELOPMENT OF LIVE SIMULATION GAMES

It is very difficult to write a precise manual describing how to develop a live simulation game because it is a creative process and totally experimental. It involves a long period of experimentation with people, and consequently involves uncertainty about the time necessary to be finished. Sometimes, good ideas can not be implemented as live simulation games due to a lack of the necessary resources and constraints involved. Usually, it is necessary to have an appropriate laboratory and available people to participate in the experiences.

One reasonable recommendation is to establish the objectives to be achieved and to begin the development with some structure of an already developed game. As the game is applied, the changes can be made step-by-step in order to make the game consistent with the objectives established previously. This was the procedure used for the development of the two cases present in this paper. Two structures were used:

(1) The structure of the Beer Game

The Beer Game, [2], is a live-simulation game that simulates a supply chain where a team composed of four people representing a factory manager, a distributor, a wholesaler, and a retailer (figure 2) must manager their respective inventory, and decide every week how much beer to demand in order to minimize the inventory costs, and, at the same time, avoid backlog costs. The teams compete with each other to achieve the minimal cost of the system.

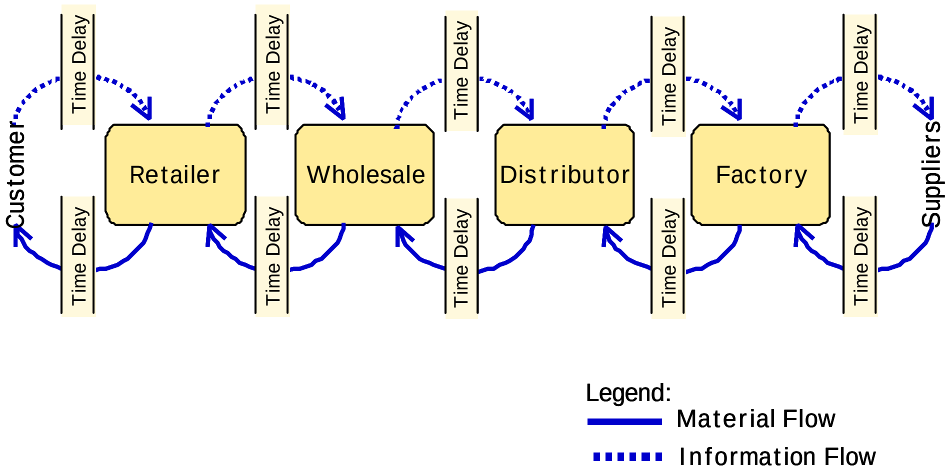

Figure 2: Structure of the Beer Game

This game simulates a process of interdependent decisions. The result of the each team depends on the set of decisions made by its members, and the decision of each member influences the decision of the others. This aspect of the game allows exploring the development of *Positive Interdependence* and *Individual Accountability*, because the success of the team depends on the behavior of its members.

Although the people work in teams, they do not have *Face-to-Face Interaction*. The members of the team are positioned at the same table, but they do not work face to face and they cannot communicate except through ordering and receiving products. During the game, they do not have the opportunity to discuss in-groups, or to establish joint strategies. Therefore, this game needs to be re-structured to create a situation that encourages or shows the necessity of making the players practice *Group Processing, Interpersonal and Social Skills* and *Face-to-Face Interaction.*

In terms of engineering concepts, the beer game structure permits the introduction of the notion of timing to the students, as well as the difficulty of controlling inventory, lead-time and time-delay. It also introduces the problems of making decisions in situations involving interconnected delay and feedback loops, the process of inventory oscillation, and gives students practice in system thinking. The structure of the game can be enlarged to test demand forecast models, techniques to control inventory, and introduces statistic control and notions of modeling and simulation.

(2) The structure of the Gantt Game

The main question involved in this game is the problem of production scheduling. Different from the beer game where each member of a team manages one specific position, the Gantt Game has members of the team working together. They are in charge of managing a company that has several machines and receives daily order. Each order implies a job to be done. Each job is manufactured according its own process, using a different machine sequence and different operational time in each machine. Every week using a Gantt Chart (figure 3), the teams have to decide which jobs the factory will complete taking into account the selling price and the constraint of raw materials, machines, labor and the costs in order to maximize the profit of the company.

The structure of this game offers the opportunity for the players to practice *Group Processing, Interpersonal and Social Skills* and *Face-to-Face Interaction*, because they work in teams and they have to decide together about production scheduling. At each turn, members of the team have to communicate efficiently to persuade the others to adopt what they suppose to be the best decision.

Periodically, teams take time-out to reflect on what they did, how to explain the their results, discuss what they could do to improve their performance, and to plan what to do next. This game has a structure that can be used to apply strategies to improve the three principle practices of *Group Processing, Interpersonal and Social Skills* and *Face-to-Face Interaction*, but it also has intrinsic conditions that allow practicing the principles of *Positive Interdependence* and *Individual Accountability*. It is necessary to re-structure it to create the basic conditions in order to implement strategies to improve these last two principles.

In terms of engineering, the Gantt chart can help introduce students to such subjects as scheduling, cost, production systems, and introduce the main job-shop scheduling problems.

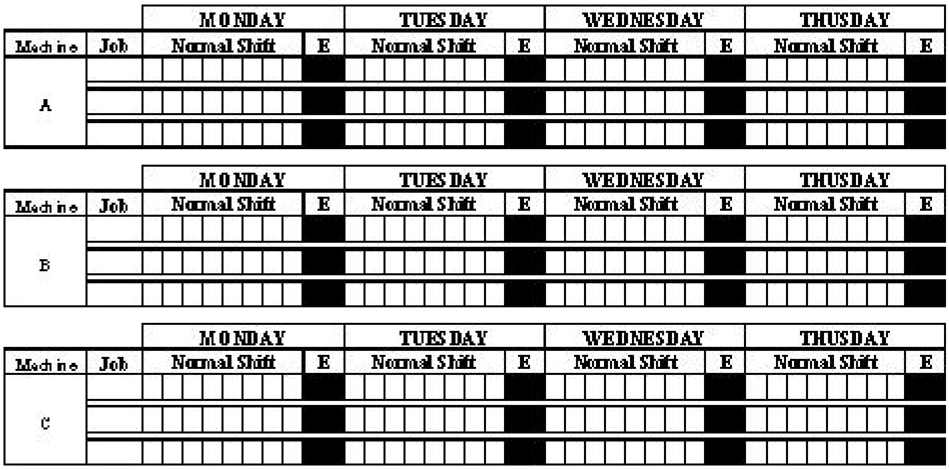

Figure 3: Gantt chart

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FINAL CONSIDERATIONS AND CONCLUSIONS

The Beer Game, in its original version, is played over 36 periods where orders are placed and received every period. The demand at the retailers is generated from a deck of cards. The demand in the first four periods is four units, after that, the demand jumps to eight and it remains eight. At the end of the game, the students are put together, and they are asked about the demand behavior. The participants, other than the retail position, often guess that demand was varying through out the experiment, and try to justify their bad performance through the demand behavior conjectured by them. After disclosing that demand was steady, the teacher tries to show them that the oscillation that caused a bad performance was a consequence of the interaction of the structure of the system and the decision process that the participants were involved in. Since the objective of this process is to show that the cause of the bad performance is not outside the system but inside of it, the participants cannot play the game again because they already know the final consumer demand.

To practice the active and cooperative learning, the game process was modified. Based on the Kolb's learning cycle, the students are involved in a concrete experience, playing the game in the same way as the original process. After that, the students are involved in a reflexion process. At that moment, they are put *face-to-face*, where they are encouraged to practice *Group Processing* and *Interpersonal and Social Skills.* They review what has been done and experienced; discuss their performance as a team, and they are motivated to identify subtle events and to communicate them clearly to others.

In the next step, after the reflexion, students are involved in a process of formation of abstract concepts and generalizations. The teams are invited to develop a "theory" or explanation about the phenomena identified. They have to use adequate terms and use all that they know to express their theory in appropriated terms.

The next step, which tests the implications of concepts and theory developed, each team is invited to develop a strategy, heuristic or algorithm to be applied in a new experience. They are arranged in the same initial way to play the game again for testing the knowledge developed. If necessary, this cycle must be repeted until the objective is achieved. This application this procedure to the beer game assures that the five active and cooperative principles and the Kolb's learning cycle are being contemplated.

In the original version of the Gantt Game, the students are arranged in teams. Each team is put in charge of programming the production of a job shop company in order to maximize its profit using a Gantt chart. The entire team members take all the decisions together. This configuration encourages *face-to-face interaction*, *permits group processin*g and develops *interpersonal and social skill*, but it does not offer an opportunity to practice the other principles. To practice the other active and cooperative principles, the game was modified as follows:

The students play the game for the first time in team but their member are distributed in different ways from the original. The decision making process of the game is simplified by factoring and creating a network of specialized functions. In such a network, information is distributed among the members of each team. Each team member or decision-maker receives only part of the available information flow. They receive an amount of information small enough to allow them process it appropriately and take decision. As part of this simplification, the game facilitator, as a central authority, attributes goals focalizing the decision-maker's attention to some specific obligation and specific measures of performance. For instance, the objective of the factory is to meet the shipping goals of the period. All must be done to reach this objective, regardless of the other consequences.

Under this configuration, the game is played several times interchanging the position of the decision-makers. In this stage, the students are involved in a Concrete Experience and practicing *Positive Interdependence* and *Individual Accountability.* After playing the game several times, they become aware of how positive interdependence can leverage the team performance, and begin to behave demonstrating mastery of the subject on an individual basis.

After that, the students play the game for the first time taking all decisions together. Now, the team works as the factory manager taking charge of all the decision from production to financial accounting. All team members have access to all available information and all decisions are taken in group. In this stage, the cooperative principles practiced most often are *face-to-face interaction*, *group processin*g and *interpersonal and social skills,* because they are distributed in the work table face-to-face and they have to communicate with each other clearly to chose the decision that they believe to be the best for the team. These alternative ways to play the game offer the opportunity to practice all the active and cooperative principles, to practice concepts of operation management already learned and to practice two different decision making processes.

After playing the game for several times under this configuration, the students are invited to reflect, in team, about its performance and write an explanation about how the two different ways of playing the game affect the results.

Finally, based on their explanation, each team develops a strategy and choses a team configuration to play the game again competing with the other teams. The Kolb's learning cycle can be repeted as much as necessary to help the students develop their own knowledge about the subject. At the and, the teacher as a specialist finalizes the learning process, and makes a lecture about the subject calling attention to the conclusions that can be generalized and the conclusion that can not be generalized.

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