Learning Skills Development Through the Usage of Simulators

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Abstract— The phenomenon of globalization has resulted in an increase in importance of economic and commercial practices. In this environment in order to increase company competitiveness it is critical to improve logistic activities at all levels of the organization.

The main mission of these activities is to place the right products (goods and services) in the right place, at the right time, with the desired conditions, and at the lowest cost. In summary, the objective of logistics is to guarantee customer satisfaction by achieving the best cost, quality and service conditions.

Unfortunately, the goal of building a systemic vision of logistics achieved by the coordination of different processes not been achieved through traditional teaching methods. In addition, the number of academic simulators in this discipline is very low. This is why the professors of the logistics area of Tecnologico de Monterrey have been designing and testing a business game with a focus on logistics decision making. Logistic Simulator (LOST) is a thorough game that allows students to develop and apply logistics concepts in a fast and fun way to learn. Thus allowing to understand the interfaces of different logistic topics. The game shows the participants the consequences of the different decisions that are made through a series of key performance indicators, thus promoting the identification of the main variables that should be evaluated when making each decision. LOST represents a new way of learning and managing logistic concepts. In addition, LOST triggers in students the development of various skills such as Self-regulated learning, Student Engagement and Reflection on their learning.

This article aims to describe the design of this simulator, the strategies we have followed to provoke learning in our students, and show the main results that have been obtained in the development of the aforementioned skills.

Keywords— *Educational Innovation, Self-directed learning, Gamification, Student Engagement, Reflection on learning.*

I. INTRODUCTION

The globalization of international markets and cost reduction are among the drivers of greater interest in logistics activities worldwide [1, 2, 3]. This is why all universities and companies recognize the strategic importance of logistics [4, 5]. One of the biggest problems facing companies today is recruiting people with experience in decision making in this area, or with specialized knowledge in this area.

In the great majority of Universities, the teaching of this topic faces serious difficulties. Traditional teaching methods in logistics allow students to understand the concepts of proper operations management; however, through these methods, students lack the skills to put these concepts into practice.

Among the strongest criticisms of teaching in this area, we can cite the following:

• Fragmented view of logistic concepts: a large majority of universities have organized their logistics curricula in such a way that subjects such as forecasting, optimization models, transportation techniques, inventory management are taught in a fragmented way. However, there are a limited number of experiences that connect all these contents. Consequently, this approach has created a fragmented view of the logistics reality [6].

• The techniques and tools are complicated and arid: an important part of the logistics tools and techniques require specialized knowledge with great mathematical content, which represents a great effort for the majority of students [7, 8].

• Lack of a systemic vision: even when students are able to handle the different numerical techniques, they are unable to understand the implications that a logistics related decision has in the different areas of a company. This means that traditional education has privileged the fragmentation of knowledge instead of promoting an integral vision of logistics. [9].

Today it is quite evident that a significant number of students feel uncomfortable with traditional teaching methods [10]. An important task for teachers is to transform this teaching into meaningful experiences in which students can observe the importance of the tools they are learning. We must formulate new learning designs that have the ability to provide students with a different new experience [11]. These designs should not only have the potential to improve the acquisition of knowledge in students, but also promote skills that will be indispensable in the future [12,13].

Among these skills, the ability to "learn to learn" is undoubtedly one of the skills that will have strategic importance in individuals and organizations [14]. The creation of new knowledge, the amount of information that appears daily on the world wide web, and the speed at which changes in organizations take place make it essential to develop this skill among students [15].

In order for students to be interested in developing their ability to "learn to learn", it is essential to develop in them a commitment to their own learning [16]. And after they are exposed to different pedagogical designs, we consider it desirable that they have the time to reflect on their experiences, their achievements, and their mistakes. That is, they must have a moment reflect on their learning.

Based on this objective, in recent years, professors in the logistics area of our university have created a business game called "LOST" (acronym for Logistic Simulator), and we have worked on the design and development of "learning units" online. These learning units contain videos, quizzes, teacher notes and exercises

Based on these tools we have explored the following elements:

• The ability to generate self-directed learning in students.

• Student commitment.

• The student's reflection on their own learning.

II. LOST

LOST is a business game whose objective is to recreate the operation of a small supply chain. The game consists of simulating a company dedicated to the production of balls used for different sports games. The game is placed within an online platform called "Goal Project" (https://goalproject.co). This online platform aims to promote the learning of logistic concepts and contains various types of materials and supports.
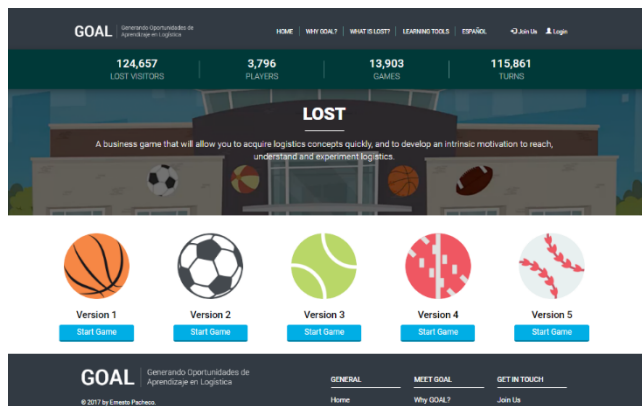
Upon entering the game, each player receives a randomly generated demand database, so each player will have a different game, but with a similar degree of difficulty. The game can be played individually or as a team and we have designed five different scenarios, each scenario has a different degree of difficulty.

The first scenario simulates a small company that operates two facilities: a factory and a store. In the factory all the balls are produced, while the store is dedicated to the retailing of this type of balls.

Players must make decisions about the number of the different balls that will be produced, the raw materials that will be used (these raw materials have different costs and different degrees of quality) and the orders that will be made to the

different suppliers. At the end of each turn, the balls produced must be sent from the factory to the store and the player must decide the quantities to be sent considering the cost of transportation.

Each turn of the game represents an opportunity for the student to put into practice their logistic decisions, and in each turn it is necessary for the player to observe important details such as the demand behavior of each item, the production capacity of the company, the availability of raw materials, the delivery time of the suppliers, the quality of the product, the inventory of the finished product, the level of pollutants that are emitted, among others.

In the first scenario the production capacity is quite adjusted with respect to the demand, so the student must be very careful to choose the type of products to produce. However, this scenario only has one factory and one store, the capacity of the warehouse is unlimited, there are no defective products due to the quality of the raw material, the delivery times of the suppliers are fixed. All these assumptions are modified in the subsequent scenarios.

Characteristics	Game Scenarios				
	1	2	3	4	5
Number of Factories	1	1	1	1	2
Number of Stores	1	1	3	3	4
Discounts		✓	✓	✓	✓
Large transportation vehicles	✓	✓	✓	✓	✓
Small transportation vehicles		✓	✓	✓	✓
A single transportation route	✓	✓			
Multiple transportation routes			✓	✓	✓
Defective production		✓	✓	✓	✓
Possibility to accquire new machinery			✓	✓	✓
Possibility to accquire new improved machinery				✓	✓
Usage of time of new improved machinery				✓	✓
Variable prices of raw materials					✓
Machine breakdowns					✓
Change of price of finished products					✓
Contracts					✓
Notifications					✓

Fig. 2.   Description of each game scenario characteristic.

The game offers graphics on a series of key performance indicators that help players improve their decision making. These indicators also allow teachers to quickly identify areas of improvement for students and strengthen their knowledge in logistic topics.
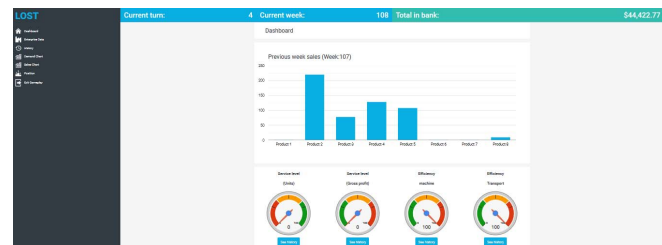

Fig. 3.   Main key performance indicators of the first game scenario.

In addition, the game provides a scoring system, which allows players to know their level of performance compared to other players.

In addition, the game provides a scoring system based on the company's profits. This scoring system is incorporated into a table of positions that allows students to know their

performance and compare themselves with other group members.

When students have reached a specific goal set by their teacher, they gain access to a new scenario that contains more complex characteristics and in which they regularly have to make a greater number of decisions. If a student fails to reach the established goals, the student may request help from the teacher or other group members.

Each of the decisions made by the students is transferred and filed in a database so that the teacher can track the performance of their students and determine if the performance is satisfactory and the learning has been significant.

One of the most important indicators of the motivation that the game has aroused in the students lies in the fact that even when the students have reached the score requested by their teacher, many of them (approximately 60%) replay the same scenarios with the intention of improving their results. It is motivating for most students to see their name appear at the top of the scoreboard.

III. LITERATURE REVIEW

The enormous amount of knowledge that is generated daily has changed the paradigm of employers. Having people who have the ability to "learn to learn" is essential to face the complexity of the interactions that companies face frequently [17]. That is why many companies prefer to hire workers who can manage their time and achieve results independently (without the direction of supervisors, trainers or educators). Every day it is more important that people possess the ability of acquiring new skills, new knowledge and self-management [18].

The paradigm shift has also become a great challenge for educational institutions, and in particular, for universities. The development of these skills and attitudes that support the self-management of knowledge has become a fundamental part of its objectives and goals. For universities, it is important to develop in the student the ability to develop critical thinking; conduct research, propose new methods of solving problems, and improve their communication skills [19].

The teacher must become a facilitator and promote the learning potential of students through the use of new tools, new strategies and new pedagogical designs. For the teacher it has become essential to use methods that make the knowledge meaningful to the student.

To achieve this goal, it is essential to have the collaboration of the student and its commitment to develop and manage its own learning. The student's engagement goes beyond the grades obtained at the end of a course, it implies an effort by the student to understand the material and internalize it to apply it in their daily life. Undoubtedly, achieving student engagement and participation represent the key factor in achieving an improvement in learning [20].

It is important to mention that it is possible to identify three different dimensions to observe the student's commitment [21]:

1. Behavioral engagement. Ability of the student to meet certain standards of behavior (attendance, participation, completion of their homework and to demonstrate the absence of negative behaviors).

2. Emotional engagement. Students are expected to experience emotional reactions such as interest or enjoyment of the class or some reading.

3. Cognitive engagement. Students are expected to invest time in their learning (go beyond the requirements and show enthusiasm for the challenges).

One of the ways to achieve student engagement is to design activities where they enjoy what they are doing, so that they are motivated with the task to be done.

Gamification is a technique which has the potential foster interest, motivation and enjoyment in the student, and through these elements it is possible to build the student's commitment to their learning [22]. The games represent a combination of fantasy, challenge and curiosity, plus a level of commitment where users are not distracted, this is why gamification represents an excellent technique to apply in the classroom, especially when the game represent a challenge for students [23].

Finally, an important part of this pedagogical design is that the student has a clear awareness of what he has learned playing the game. Reflecting on what has been learned helps students understand their achievements and progress, helps to recognize what has been achieved and improve their practices. The reflection process is essential to recognize what has been advanced and what we need to improve, understand what we know and what we do not know. It is around the reflection that students expand their learning capacity [24].

Reflection is an important human activity, in which people "*recover their experience, think about it, mull it over and evaluate it*" [25].

The teaching activity should be considered with the perspective of involving students in the process of "making sense". Education is not just about disseminating information; The pedagogical design should organize instruction so that students can understand what they do. If the learning activity is meaningless, neither the learning outcomes nor the process can be valued by the students. That is why the reflexive act is significantly important [26].

IV. RESEARCH QUESTIONS

The research we have done aims to answer the following questions:

- What is the student's evaluation of LOST?

- Is it possible to modify in the student the ability to "learn to learn"?

- Does the simulator have the ability to arouse interest, enjoyment and concentration in the student, and also increase their knowledge in this area?

- What are the main reflections that students make about their learning?

V. Methodology

A logistics course was offered to the students of the university and the pedagogical design had the LOST business game as its main tool. The students enrolled in the course were 72 students (50% female and 50% male), all students are undergraduate students and belong to careers in business and engineering.

In order to measure their opinion on self-directed learning before taking the course, students were asked to complete a survey that is based on the work of Fisher, King and Tague [27]. At the end of the course, the same survey was applied to them in order to know if their opinion on self-directed learning had changed throughout the course.

On the other hand, a survey on enjoyment was applied to measure the degree of student commitment. The survey is based on the works of Fu, Su and Yu [28]. Annex to this survey we ask students to rate the game on a scale from 1 to 10 (where 1 means lousy and 10 means excellent).

At the beginning of the course they were asked to answer a survey that was intended to get their opinion on self-directed learning, and at the end of the course they were asked to take this survey again.

Finally, as the final project of the course, we ask the students to carry out an essay where they will reflect on what they learned during the course.

VI. Results

The game was well accepted by the students. The average rating that the players gave to LOST was $\bar{x} = 8.64$ with a standard deviation $s = 1.80$. If we consider as a good evaluation those that are greater than 7, then 92% of the players had a good experience with this simulator.
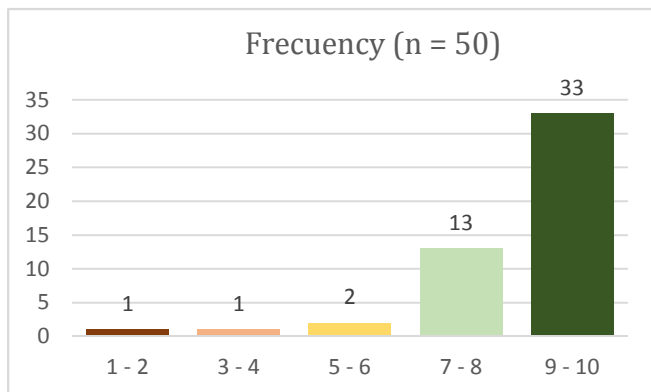

Fig. 4.   Student opinion about LOST.

On the other hand, the survey used to measure self-directed learning was developed by Fisher, King and Tague in 2001 [27], and is the most widely used scale to measure this construct. A Likert 5 scale was used to answer this questionnaire. The questionnaire consists of 56 questions , and we divide this questionnaire into the following parts:

M. Self-management

I. Independence

C. Curiosity

O. Open Mind

P. Personal characteristics that favor self-learning

E. Enjoy learning

S. Self control

Table I shows the average of each of these factors in each of the two surveys.

TABLE I.

Means of each Factors from the surveys of self-directed learning.

	First Survey	Second Survey
M	3.97	4.10
I	4.07	4.21
C	4.12	4.27
O	4.51	4.41
P	4.31	4.38
E	4.41	4.31
S	4.29	4.31

Each survey was answered by 56 students, and we apply the t-test to determine if there are significant differences in each of these constructs. It was found that Self-Management, Independence and Curiosity show significant differences with $\alpha = 0.05$. This shows that the pedagogical design carried out promotes some areas of self-directed learning.

To investigate the degree of student enjoyment in the game, we have used the scale proposed by Fu, Su and Yu [28]. This scale is designed to measure student enjoyment in e-learning games and has been widely used in the literature. This scale contains 56 questions and has eight different factors that are analyzed:

C. Concentration

G. Goal Clarity

F. Feedback

Ch. Challenge

A. Autonomy

I. Immersion

S. Social interaction

K. Knowledge Improvement

The survey was applied to the 72 students and 52 responses were obtained. The scale applied was a Likert 7,

and the score obtained per student in each of the factors evaluated represents the average of the opinions of the students in each question that belongs to this factor. For example, Concentration contains eight questions related to it, the average of these eight questions was taken to determine the degree of student concentration in the game.

Table 2 shows the mean and standard deviation of each factor.

TABLE II.

MEANS AND STANDARD DEVIATION OF EACH FACTOR

	Mean	Standard Deviation
Concentration	5.640	1.219
Goal Clarity	5.960	1.365
Feedback	5.293	1.636
Challenge	5.757	1.340
Autonomy	6.027	0.989
Inmersion	5.423	1.523
Social Interaction	5.850	1.283
Knowledge Improvement	6.076	1.227

Table III shows the percentage of favorable opinions of each factor. We have considered that the students have a favorable opinion of a factor when the average of the questions related to this factor is greater than or equal to 5.

TABLE III.

PERCENTAGE OF FAVORABLE OPINIONS OF EACH FACTOR

	% of favorable opinions
Concentration	78.85
Goal Clarity	84.62
Feedback	61.54
Challenge	78.85
Autonomy	84.62
Inmersion	73.08
Social Interaction	80.77
Knowledge Improvement	88.46

As can be seen from Table II and Table III, the factor that is best qualified is "Knowledge Improvement", and the item with the greatest area of improvement in the simulator is Feedback. However, all the averages of the opinion of the students in each factor is greater than 5, and the percentage of favorable opinions in each factor is greater than 70% (except for Feedback).

Table IV shows a correlation table between the different factors of this survey. From this table we only want to underline that the improvement of knowledge seems to be highly correlated with the challenge, autonomy and social interaction.

TABLE IV.

CORRELATIONS COEFFICIENTS

	C	GC	F	Ch	A	I	SI	KI
C	1.000							
GC	0.758	1.000						
F	0.651	0.632	1.000					
Ch	0.770	0.709	0.767	1.000				
A	0.687	0.627	0.711	0.919	1.000			
I	0.876	0.729	0.629	0.818	0.743	1.000		
SI	0.598	0.521	0.497	0.753	0.745	0.632	1.000	
KI	0.694	0.680	0.600	0.866	0.824	0.728	0.834	1.000

Finally, at the end of the course the students were asked to reflect on what they had learned, they were asked to reflect on those academic aspects that they had incorporated into their knowledge, but they were also asked to reflect on what they had learned in relation to in his own way of learning. The essay had a completely free format.

The comments that appeared most frequently were the following.

Academic elements

- To learn how to make forecasts

- To understand that every production system has capacity constraints,

- To learn how to calculate the quantity of order from their suppliers,

- To learn how calculate the profits of each product.

Non-academic elements

- To discover the difficulties they face when making decisions in complex systems.

- To discover that they like working in a team.

- To learn how to find relevantinformation.

- To discover it is possible to learn through a gameTo discover that it is possible to learn through online videos and notes.

VII. CONCLUSIONS

LOST is a business game designed to support the teaching of logistic concepts. LOST allows students to develop a greater commitment to their learning and allows them to explore the search for new solutions and strategies that lead them to optimize logistics performance. The game allows students to give greater meaning to their learning, which results in them developing more motivation, generating greater commitment and promoting student reflection.

The opinion of the students about this game is very favorable. In particular, some attributes of the game, such as the level of the challenge, social interaction and autonomy to advance at their own pace, favor the perception of improved knowledge in students.

Some other elements of the pedagogical design implemented in the courses where this simulator is used promote different types of skills, including self-directed learning and reflection.

Although we have designed five different scenarios for the game, we could still expand the number of scenarios by incorporating expertise in the areas of finance, marketing and supply chain to help us think and design new challenges.

In the same way, we aim to build a larger results database that will allow us to understand what are the main mistakes that students make when playing with the simulator; what variables consider important; what variables go unnoticed; what are the most successful strategies; how they apply prior knowledge. Based on these results, one of the objectives is to design a series of support materials (exercises, videos, readings) that will offer useful advice to strengthen student abilities.

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REFERENCES

[1] Kherbach, O.; Mocan, M. (2016). The importance of logistics and supply chain management in the enhancement of Romanian SMEs. Procedia-Social &Behavioral Sciences, 221, 405-413.

[2] Ballou, R. (1997). Business logistics: importance and some research opportunities. Gestão & Produção. 4. 117-129. 10.1590/S0104-530X1997000200001.

[3] Lee, H. Y., Seo, Y. J., & Dinwoodie, J. (2016). Supply chain integration and logistics performance: the role of supply chain dynamism. The International Journal of Logistics Management, 27(3), 668-685.

[4] Daud, D. (2011). A Qualitative Study on Logistics Educational Needs in Malaysian Higher Education Institutions: A Perspective from Logistics Practitioners. International Journal of Human Resources Studies. 1. 52.

[5] Karatas-Cetin, C., & Denktas-Sakar, G. (2013). Logistics research beyond 2000: theory, method and relevance. The Asian Journal of Shipping and Logistics, 29(2), 125-144.

[6] Pacheco-Velazquez, Ernesto. (2015). The use of bussines simulators in teaching logistics. 57-60. 10.1109/ICBL.2015.7387634.

[7] Espinosa, E.; Pacheco, Ernesto. (2007) "Online Simulation for Logistics and Decision Making," Service Operations and Logistics, and Informatics. SOLI 2007.

[8] Lander, R. (2016). Addressing The Challenges Of Logistics And Supply Chain Education: A Case Study Of Programme Development In The Uk. Business Logistics in Modern Management, 16, 39-50.

[9] Lancioni, R.; Forman, H.; Smith, M. (2001). Logistics and supply chain education: Roadblocks and challenges. International Journal of Physical Distribution & Logistics Management. 31. 733-745. 10.1108/EUM0000000006287.

[10] Lee, J., & Hammer, J. (2011). Gamification in education: What, how, why bother? Academic Exchange Quarterly, 15(2), 146.

[11] O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: A scoping review. The internet and higher education, 25, 85-95.

[12] Bricall J., (2000) Conferencia de Rectores de las Universidades españolas (CRUE) Informe Universidad 2000 Organización de Estados Iberoamericanos Biblioteca Digital de la OEI disponible en http://www.campus-oei.org/oeivirt/bricall.htm.

[13] Tumino, M. C., & Bournissen, J. M. (2016). Conectivismo: hacia el nuevo paradigma de la enseñanza por competencias. European Scientific Journal, ESJ, 12(10), 112.

[14] Klimenko, O.; Alvares, J. (2009) Aprender cómo aprendo: la enseñanza de estrategias metacognitivas. Educación y Educadores [en linea] 2009, 12 (Agosto-Sin mes) pp. 11-28 Universidad de La Sabana Colombia. ISSN 0123-1294.

[15] Hiemstra, R. (1994). Self-directed learning. In T. Husen & T. N. Postlethwaite (Eds.), The International Encyclopedia of Education (second edition), Oxford: Pergamon Press.

[16] Zimmerman, B. (1990) Self-Regulated Learning and Academic Achievement: An Overview, Educational Psychologist, 25:1, 3-17, DOI: 10.1207/s15326985ep2501_2

[17] Guglielmino, L.; Long H. (2011) "The International Self-Directed Learning Symposium: A 25-Year Perspective", International Journal of Self-Directed Learning, pp. 1 – 6

[18] Gureckis, T. M.; Markant D.B. (2012) Self-Directed Learning: A Cognitive and Computational Perspective. Perspectives on Psychological Science; 7 (5): 464 DOI: 10.1177/1745691612454304

[19] Andrew B. Artis & Eric G. Harris (2007) Self-Directed Learning and Sales Force Performance: An Integrated Framework, Journal of Personal Selling & Sales Management, 27:1, 9-24, DOI: 10.2753/PSS0885-3134270101

[20] Fredricks, J.A., Blumenfeld, P.C. and Paris, A.H. (2004) School Engagement: Potential of the Concept, State of the Evidence. Review of Educational Research. 74 (1), pp. 59–109.

[21] Trowler, V. (2010). Student engagement literature review. The Higher Education Academy, 11, 1-15.

[22] Simoes, J., Redondo, R., & Vilas, A. (2012). A social gamification framework for a K-6 learning platform. Computers in Human Behavior, 29(2013), 345e353.

[23] Kirriemuir, J., & McFarlane, A. (2004). Literature review in games and learning.

[24] Claxton, G., Expanding the Capacity to Learn: A new end for education? British Educational Research Association Annual Conference 6 September 2006 Warwick University, 2006

[25] Boud, D., Keogh, R., & Walker, D. (1985). Reflection, turning experience into learning. London, Kogan Page

[26] Costa, Arthur and Bena Kallick. Learning And Leading with Habits of Mind: 16 Essential Characteristics for Success. Alexandria, VA: ASCD, 2008. Print.

[27] Fisher, M., King, J., & Tague, G. (2001). Development of a self-directed learning readiness scale for nursing education. *Nurse education today*, 21(7), 516-525.

[28] Fu, F.L., Su, R.C. & Yu, S.C. (2009). EGameFlow: A scale to measure learners' enjoyment of e-learning games. Computers & Education, 52(1), 101-112. Elsevier Ltd. Retrieved November 14, 2019 from https://www.learntechlib.org/p/67125/.