GOAL: Generating Learning Opportunities in Logistics

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***Abstract*— "Generating learning opportunities in logistics" (GOAL Project, for its acronym in Spanish), represents the effort of a group of professors in the logistics area of Tecnologico de Monterrey (Mexico) to disseminate and make more fun the learning of logistical concepts. To do this, the group created an online consulting platform for students to find help in topics, exercises to practice and receive immediate feedback about their level of learning. Based on a business simulator called "LOST" (Logistic Simulator), students have been able to create strategies, manage interfaces and understand the constraints of different logistical systems. In the semester from August to December 2017, the Optimization Models course utilized this online platform. It was created with four main objectives: 1) explore new communication and information technologies that promote flexible, adaptable learning; 2) help students detect opportunities for improvement in their learning and skills; 3) motivate the students to commit themselves to their self-learning; and, 4) explore different support tools that help the students reflect on their learning process. After three semesters of using this online platform, the results are quite favorable: 1) a vast majority of students are satisfied with the various supports in the platform (98%); 2) a large percentage of students would like all logistics courses to include similar supportive material (92%); 3) the degree of student motivation increased when measured against traditional courses; 4) the average grades improved; 5) the percentage of students failing the subject decreased, and 6) students (mostly) felt more committed to their learning.**

Keywords*— *e-learning, Gamification; Hybrid models; Motivation; Flexible Learning, Engagement, Educational Innovation.

I. Introduction

Currently, one of the most prominent challenges teachers face is achieving a greater engagement of students, i.e., to get the student to commit to their learning. It is common for instructors to hear that their students are only interested in getting a passing grade with as little effort as possible. Undoubtedly, this complaint is worrisome, and teachers regularly attribute the lack of genuine interest in the subject to generational or internal problems in the students. Consequently, there is a prevalent feeling among teachers that they face a context in which they can do almost nothing to change this behavior.

Moreover, there are indications that the teaching of logistics faces serious challenges; one of the strongest criticisms is that this area of knowledge is functionally fragmented. The vast majority of universities have organized their programs in such a way that they offer topics in forecasts, inventories, and linear programming, for example, but there are no scenarios in which students need to manage the interfaces among them. [1].

Another criticism is that the vast majority of the techniques and models used demand specialized knowledge from the students, which for many of them means an arid phase of learning in which the content and fundamental concepts of the course are difficult to assimilate. The traditional teaching methodology and the content of the study programs are more focused on the teaching of the solution methods (despite the enormous amount of software that has been developed for problem-solving), while the applications of the solutions are frequently ignored [2]. Consequently, students have enormous difficulty in transferring this knowledge and visualizing how and when these methods are relevant in their decision-making.

Based on these observations, we have set up an educational innovation project specifically to explore the following:

- The use of games in the classroom
- The flexibility of learning
- The evaluation of learning

The idea that students do not learn because they are not motivated is not always correct; the implication could be in the opposite direction, that is, we might observe that students are not motivated because they do not perceive their learning [3].

Motivating the student through games, offering an integrating vision of the logistical decisions made in a company, and creating a different way to evaluate learning using new communication and information technologies were the main challenges we took on in this project.

II. Description of the Platform

While it is true that a large number of students seem to be uncomfortable with traditional teaching methods, the use of technology that only transfers information in one direction (from a teacher to students) does not provide a broad learning experience. Designs for learning must have the potential to improve student engagement and educational performance outcomes.

GOAL is a new vision for teaching and developing logistics concepts. GOAL is an online platform which includes helpful materials to students such as videos, notes, and quizzes. These supports are linked to a game called, "LOST" (an acronym for Logistic Simulator).

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Fig. 1 Online Portal of the GOAL Project platform (http://goalproject.co)

"LOST" is a video game in which students develop logistical concepts and understand their interfaces. It shows people the consequences of each decision they make and how a decision in one department affects the functioning of the overall system.

We designed the first version of the game using Excel macros. It was used for the first time in the August to December 2013 semester with a group of 20 industrial engineering students at the Tecnologico de Monterrey, campus in Mexico City.

The didactic technique, "gamification," supports the pedagogical design. In the literature, gamification is described as an essential instrument for developing commitment and motivation among students and the achieving of desired results.

LOST is a business game where students forecast the demands of the different products, make a production plan, select the raw materials they should use, choose suppliers and order sizes. In the game, students can observe the effects that their decisions have in different areas of the company. They observe multiple concepts that they have studied in various other subjects being applied to a single scenario in this simulator.

In order that they can visualize different strategies, the students must possess knowledge of essential topics such as production, inventories, forecasts, optimization, and transportation, for example.

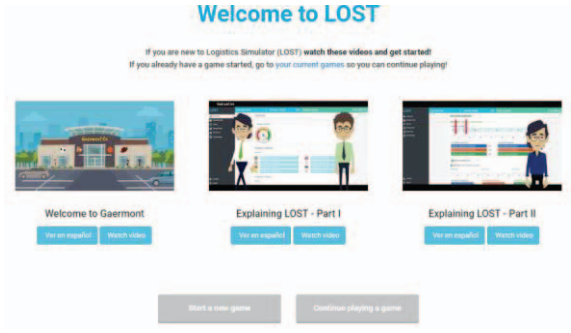

Fig. 2 Image of the video game LOST online platform.

In 2016, a videogame company was hired to make the game available for use through the internet, and the first version of the game became accessible in July 2017.

One of the initial difficulties to be overcome to gain acceptance of the game among some professors of logistics was their feeling that the game would require more knowledge than what would be taught according to the course syllabuses of the subjects they were teaching. That feedback led to the creation of the portal for teaching logistics that we call the GOAL Project.

The objective of GOAL is not only to provide students the use of this business simulator but also to give them support tools in different topics that relate to the decision making process.

In order to motivate students to consult and use the portal in different subjects, GOAL has a rewards system when students answer small questionnaires in different subjects. These rewards in the game allow the students to acquire certain privileges, such as increasing the size of a warehouse, increasing production efficiency, and increasing demand, for example.

GOAL is an innovative platform because it presents the students a cohesive set of knowledge instead of the fragmented offerings that many universities have put in their curricula.

In the future, this online platform will have support materials in all topics related to logistics. For the moment, the only fully developed topic is Linear Programming, although, partial progress in other subjects lets us visualize a much broader offering on this online platform.

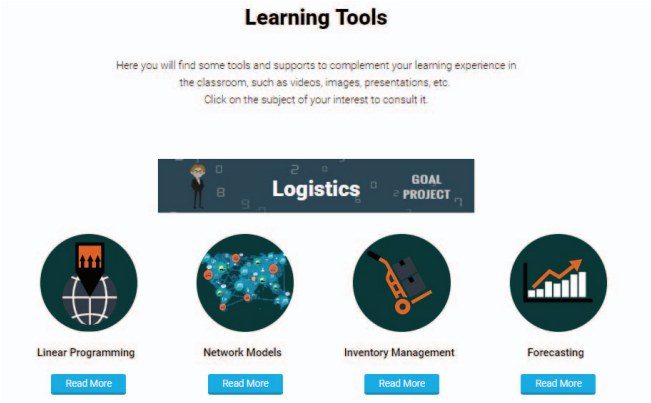

Fig. 3. Learning tools available on the GOAL Project platform

For example, LOST provides students reports with critical indicators that are useful in subjects such as Production, Transportation, and Forecasting. This use of the game in these subjects is helpful when the teachers want to illustrate some of the course contents. However, Linear Programming is the only subject currently having a set of videos that fully cover its curriculum.

Linear Programming is used within the game to optimize production costs, minimize the free time of machines and establish the restrictions associated with labor and product quality.

The GOAL Project platform is the most visible part of the project, but this educational innovation also includes a series of activities that are an important part of the logistics courses. These include essay exercises in which students reflect upon

their learning, information searches that give guidance on self-learning, and involvement with SMEs so that students develop a sense of social responsibility.

This document describes the first results of the surveys given to students who studied the subject of Optimization Models (Linear Programming) and some implications based on the results of these surveys.

Students responded favorably in the first surveys. They appreciated the effort behind the support materials provided and the creation of the business game used in the course.

III. Review of Literature

The technological revolution is transforming the entire society, and this directly affects the educational system. In 1998, UNESCO stated that "*rapid advances in information and communication technologies modify the way knowledge is developed, acquired and transmitted*."

There is no gain in supposing that this represents a threat; on the contrary, education must welcome the opportunities opened by the advance of technologies and embrace the challenges this poses to improve the way we produce, organize, disseminate and access knowledge.

Moreover, we must generate equitable processes of access to these technologies at all levels of education. Education is fundamental for the construction of a more equitable society, particularly when the future is based on knowledge, learning, and information. The technologies promise "*the progressive disappearance of space and time restrictions in teaching and the adoption of a more student-centered learning model.*"[4]

Selim (2007) defines electronic learning (e-learning) as "*the use of modern information and communication technology (ICT) and computers to provide instruction, information and learning content*." [5] According to this author, online learning systems provide multiple benefits to their users, such as greater accessibility to information, better content delivery, content standardization, responsibility, flexibility, interactivity, trust, and greater convenience.

During the last years, many researchers have examined various elements of e-learning in both developed and developing countries, such as student attitudes, quality of information, satisfaction of students and teachers, the effectiveness of e-learning, the interaction of the participants and the student's experience [6], [7], [8].

The e-learning literature indicates that both external sources (social, environmental) and internal sources (individual characteristics) are crucial for e-learning implementation [9].

Also, it is possible to obtain from the literature a large number of critical success factors for e-learning, for example, intrinsic motivations [10] and extrinsic motivations [11], perceived usefulness, perceived ease of use, behavioral intention, enjoyment, and satisfaction, among others.

Perhaps, one of the most significant changes in the field of education is the paradigm shift from teacher-centered education to student-centered education. The emergence of e-learning has further facilitated the widespread adoption of student-centered education and other changes in educational practices [12].

The use of educational platforms has brought to the forefront of discussion a crucial idea; namely, characterizing learning as a product and trying to conceive what happens in the learning process. [13]. The act of learning does not occur in a vacuum; its achievement is based on pre-existing knowledge, skills, and strategies to attain the objectives set at the beginning of the learning process.

Nuñez [14] points out that in the past, learning research focused on the cognitive side, but currently, studies examine the relationship that exists between cognition and motivation. This line of research has differentiated the way we conceive learning. According to Nuñez, it is not only essential to discover the capacity to learn that one possesses but also the way in one applies the learning and highlighting how to bring this knowledge to practice.

Students will value neither the process of learning nor the results if the learning task given to them has no relevance. The commitment of the student will be null if the course contents lack meaning. Observing the learning process from this perspective leads to thinking about motivational elements and predispositions that make the development of our abilities conditional. The achievement of learning is very much dependent upon motivation, engagement, retention, transfer, and applicability of knowledge. These make possible changes in individual behavior.

Finally, a fundamental element for successful student learning outcomes is to get the students to reflect upon their learning process. Reflection is a distinguishing human activity in which people recapture their experiences, think about them, and evaluate their relevance. [15]

Reflecting on what has been learned helps students to know and improve their practices. Reflection serves as a mechanism to convert the experience into knowledge about their learning. The continuous use of reflection is essential for them to develop knowledge and increase the capacity to learn [16].

A fundamental task for teachers is to engage students fully in the process of "making sense." Pedagogy is not just about disseminating information; instead, the pedagogical design should organize instruction so that students are producers, not just consumers, of knowledge [17].

Our review of the literature exposed considerations not yet incorporated into e-learning. Specifically, our interest turned to the impact of self-learning and reflection on the obtaining of knowledge. Therefore, we designed an educational innovation in e-learning to include two necessary actions:

- Promote the motivation of student reflection on how he/she obtains knowledge.
- Promote and expand the self-learning capacity of the student.

IV. Research Questions

Recent advances in information technologies and learning management systems have played an essential role in the provision of educational resources. The successful use of these systems in higher education is critical for the implementation, management and continuous improvement of e-learning services to increase the quality of learning.

This research model considers some of the critical success factors that we found in the literature (perceived usefulness, the intention of behavior, satisfaction, and enjoyment, for example). We added in the model the factors of amotivation and extrinsic and intrinsic motivation. Finally, we attached other constructs that would be desirable in an educational platform such as resource efficiency, commitment to self-learning, and reflection on their learning.

Our goal was to answer the following questions:

1) Which of the critical factors are satisfied by this educational innovation?

2) What kind of motivation is generated in the students when using our supports?

3) Is it possible to generate within students a higher commitment to their learning?

4) Is it possible to get students to reflect on their learning?

5) Is it possible to promote self-learning in the students?

6) Are these elements related to the students' final grades?

We decided on the constructs to be in the model, and we initiated the application of a survey to the students who studied the subject of "Models of Optimization (Linear Programming."

V. Methodology

In the semesters August-December 2017, January-May 2018, and August-December 2018, various types of support materials were placed in the courses taught at the Mexico City campus of Tecnologico de Monterrey. These included videos, notes with solved exercises, summative tasks, pop quizzes that offered immediate feedback results and a business game that is available online.

All the support for the course were placed on different platforms of the network. The notes, the videos, and the game are placed on an open-access-educational platform called GOAL Project (http://goalproject.co). We also used the Blackboard Learn platform to assign students other tasks (such as discussion forums, quizzes, and essays). We generated a YouTube channel that hosts the videos.

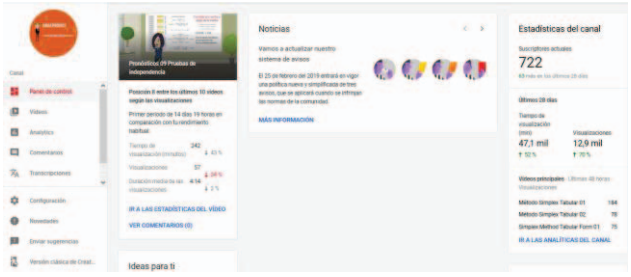

Fig. 4. GOAL Project Channel on YouTube.

The platform allows students to choose the percentages of each activity they will do to satisfy each partial evaluation (within specified ranges). For instance, in the first partial evaluation, there are three types of activities: quizzes, homework, and test. The quizzes could weight 20% to 35% of their grade, the homework could weight 10% to 20%, and the test could weight 50% to 70%. Each student can choose the desired percentage within these predetermined ranges, but the sum of these weights must be 100%. Students choose these percentages before starting their activities.

At the end of the semester, three different types of surveys were applied:

- A survey based on the critical success factors for e-learning [18], designed to measure different constructs such as perceived usefulness, intention of behavior, satisfaction with the provided supports, and enjoyment
- A motivational survey based on behavioral studies [19] that assessed amotivation, intrinsic motivation, and extrinsic motivation.
- A survey with questions related to the following constructs: resource efficiency, commitment to self-learning, reflection on learning, self-learning, and preference of tools used.

A definition of each of the constructs contained in the survey is described in Table I.

TABLE I. Model Constructs and Definitions

Model Construct	Definitions
S1. Perceived Usefulness	The degree to which a person believes that using a particular system would enhance his or her job performance.
S2. Intention of behavior	An individual performing a conscious act, such as deciding to accept (or use) a technology.
S3. Satisfaction with the provided supports.	The extent to which a user is pleased with the support materials.
S4. Enjoyment	The extent to which the use of the system itself is perceived to be enjoyable.
S5. Amotivation	Represents the total lack of motivation, where the individual experiences incompetence and lack of control.
S6. Intrinsic motivation	It is a sign of self-determination.
S7. Extrinsic motivation	It refers to participation in an activity in order to get rewards or recognition.
S8. Resource efficiency	Perception of whether the support materials generate significant student learning.
S9. Commitment to their learning	Perception of whether the dynamics of the course and supporting materials make the student more committed to their learning.
S10. Reflection on their learning	Perception of whether the dynamics of the course and the supporting materials make the student think about his/her learning style.
S11. Self-learning	Perception of whether the course dynamics facilitate and promote self-learning.
S12. Preference of the tools used	Perception of the student about the usefulness of the different tools used.

Table II shows the questions that were included in the measurement of each of the constructs. The questions used are based on the studies cited above.

As mentioned earlier, the survey was given to students during three semesters who studied the subject of "Optimization Models" at the Tecnologico de Monterrey campus in Mexico City.

This questionnaire went to 89 students (41.6% female and 58.4% male), all of whom are in the industrial engineering curriculum. The course is taught in the fifth semester of the industrial engineering program.

The scale used in the first eleven constructs was from 1 to 7, where 1 means "totally disagree" and 7 means "totally agree."

TABLE II CONSTRUCTS AND QUESTIONNAIRE ITEMS

Model Construct	Items
S1. Perceived Usefulness	1. I think the use of games, videos, and quizzes improves my performance in the courses 2. I think it is quite useful to take courses where games, videos, and quizzes are used. 3. The games, videos, and quizzes help me efficiently carry out my learning activities. 4. The games, videos, and quizzes are useful to support the activities found in the program of the course 5. The use of games, videos, and quizzes offers several advantages in terms of solving problems related to time and location. 6. The use of games, videos, and quizzes improve my success in the courses.
S2. Intention of behavior	1. I believe that in the future, the courses should contain games, videos, and quizzes. 2. If I have access to other classes that include games, videos, and quizzes, I intend to enroll. 3. I think instructors should incorporate games, videos, and quizzes in their courses. 4. I think the University should promote this type of learning experience.
S3. Satisfaction with the provided supports.	1. I'm satisfied with the help that the game, videos, and quizzes have given me in this course. 2.. I think I feel satisfied with the achievement I have obtained in this course. 3. The tools provided by the platform are very satisfactory. 4. The game, videos, and quizzes seem like a satisfactory system for self-learning activities.
S4. Enjoyment	1. Using games, videos, and quizzes for learning this subject is a pleasant experience. 2. The use of games, videos, and quizzes seems an interesting activity.
S5. Amotiva-tion	1. When I'm playing the game or watching a video or taking a quiz, I have the impression that I'm wasting my time. 2. I can not understand why playing the game or watching a video or taking a quiz is important for this class. 3. I can not understand why playing the game or watching the videos or solving a quiz should be a task that must be done.
S6. Intrinsic motivation	1. I like to play the simulator, watch the videos or take a quiz because they present new information or make me reflect on essential aspects of my career. 2. I like to play the simulator, watch the videos, or take a quiz because they present me with new information on a topic that I enjoy. 3. I like to play the simulator, watch the videos, or take a quiz because they allow me to continue learning subjects that are interesting to me. 4. I like to play the simulator, watch the videos, or take a quiz, because of the challenge of learning things on my own.
S7. Extrinsic motivation	1. I like to play the simulator, watch the videos, or take a quiz because the information can help me eliminate some of the questions that I had in the classroom. 2. I think playing the simulator, watching the videos, or taking a quiz can help me improve my grades in this subject. 3. I like to play the simulator, watch the videos, or take a quiz because they allow me to learn some subjects that are relevant to my career. 4. I like to play the simulator, watch the videos, or take a quiz because it helps me to have better preparation for when I will look for some work opportunity.
S8. Resource efficiency	1. The act of "learning" to use games, videos and quizzes is not a challenging activity. 2. I could complete the learning activities of this course using the game, videos, and quizzes and having a teacher who answers my questions. 3. I could complete the learning activities of this course using the game, videos, and quizzes even if I could not call anyone for help.
S9. Commitme nt to learning	1. The activities I do outside of the classroom, such as playing the simulator, watching the videos or taking a quiz, make me feel more committed to my own learning. 2. Having a course with complementary activities outside the classroom generates in me a greater commitment to learning. 3. After taking this course, where a part of its content depends on my effort, I feel more committed to my performance and my learning.
S10. Reflection on their learning	1. This course has caused me to reflect on the way I learn. 2. This course has caused me to reflect on those educational resources that cause me to improve my academic performance and obtain higher learning. 3. At the end of this course, I can identify which resources facilitate my learning better.
S11. Self-learning	1. When I watch a video, play the simulator, or take the quizzes of this subject, I have the impression that I can learn subjects on my own. 2. The use of games, videos, and quizzes improves my self-learning skills. 3. I believe that self-learning is a skill that I must develop because it will be advantageous in the future.
S12. Preference of the tools used	1. The use of this resource is fundamental in the development of the course: Simulator, Videos, Quizzes, Teacher notes, Homework. 2. Which of the resources used in this course I believe has helped me achieve greater learning: Simulator, Videos, Quizzes, Teacher notes, Homework 3. On a scale of 1 to 10, rate the academic quality of the resource: Simulator, Videos, Quizzes, Teacher notes, Homeworks

In addition to the measurement of these constructs in our study, we included the final grade (FG) of the course obtained by the students. The final grade is a number that ranges from 0 to 100, where 100 represents the maximum. The passing grade for the course is 70 or higher.

VI. RESULTS

The averages and standard deviations of each of these constructs and final grade appear in Table III, except for S12, which is described and measured differently.

TABLE III

MEANS AND STANDARD DEVIATIONS OF EACH CONSTRUCT

	Mean	St. Dev.
S1	6.422	0.831
S2	6.020	1.040
S3	6.285	0.820
S4	6.293	1.094
S5	2.418	1.887
S6	6.133	0.974
S7	6.340	0.789
S8	5.858	1.122
S9	6.249	0.952
S10	6.151	1.042
S11	6.284	0.797
FG	79.834	8.774

As shown, the means of the opinions of the students about each construct are favorable for the evaluation of this educational innovation.

Nine of the eleven constructs evaluated have an average score equal to or greater than 6. In the case of the S5 construct (amotivation), it is desirable that the average of that evaluation be equal to or less than 2.

In the case of construct S8 (resource efficiency), the third question has an average opinion of 5.39. The averages of the first two questions are equal to or greater than 6, but this last question decreased the total average, meaning that students reflect a particular fear of not having a teacher who can answer their questions.

In the case of the S5 construct, we have certain doubts about the students' answers, since it is the only question in which we would like the student to disagree with the phrases related to his lack of motivation. Also, the standard deviation of the answers is the highest compared to all other constructs.

TABLE IV

PERCENTAGE OF FAVORABLE OPINIONS

	% of favorable opinions
S1	0.843
S2	0.663
S3	0.742
S4	0.831
S5	0.933
S6	0.730
S7	0.843
S8	0.618
S9	0.787
S10	0.697
S11	0.809

Table IV shows the percentage of favorable opinions of each of the constructs. We consider that the students have a favorable opinion of a construct when the average of the questions related to the constructs is greater than or equal to 6, except for the construct S5 (amotivation), where we expect that an opinion is favorable if the average of the questions related to it is less than or equal to 2 (this is because we consider it desirable to decrease the lack of motivation perceived in the student).

In the previous table, we see that the percentage of favorable opinions in each of the constructs is quite high. An important observation is that construct S5 has the highest percentage of favorable opinions. This observation increases the doubts about the answers of the students about this construct.

Table V shows a correlation study between each of the first eleven constructs that were in the survey. In most cases, the coefficients show a high correlation among the different constructs. The exceptions are constructs S5 and S8, which, as mentioned previously, are the constructs that have the lowest evaluations by students.

A more detailed discussion of this table is presented in the next section.

TABLE V

CORRELATION COEFFICIENTS

	S1	*S2*	*S3*	*S4*	*S5*	*S6*	*S7*	*S8*	*S9*	*S10*	*S11*	*FG*
S1	1.000											
S2	0.629	1.000										
S3	0.775	0.709	1.000									
S4	0.688	0.773	0.831	1.000								
S5	-0.341	-0.127	-0.256	-0.284	1.000							
S6	0.516	0.540	0.685	0.621	-0.140	1.000						
S7	0.699	0.649	0.809	0.843	-0.268	0.688	1.000					
S8	0.547	0.671	0.632	0.623	-0.005	0.452	0.548	1.000				
S9	0.636	0.545	0.700	0.753	-0.249	0.630	0.782	0.504	1.000			
S10	0.702	0.610	0.725	0.649	-0.203	0.667	0.643	0.535	0.583	1.000		
S11	0.605	0.601	0.685	0.647	-0.180	0.630	0.644	0.565	0.661	0.619	1.000	
FG	-0.133	-0.318	-0.155	-0.225	0.076	-0.114	-0.120	-0.335	-0.235	-0.071	-0.267	1.000

Fig. 5, Fig. 6 and Fig. 7 show the results of the survey about S12.

In the first two questions about S12, students could only choose one of the options. In the third question, the scale used was from 1 to 10 because that is the scale used in the grade assignments throughout their courses.

Fig. 5 shows the results of resources that the students consider essential in the course. We believe that the reason the students selected the videos to be the most fundamental to performance in this innovation is that a high percentage of the final grade comes from the quizzes, exams, and tasks, which depend on the explanations that we have placed in the videos.

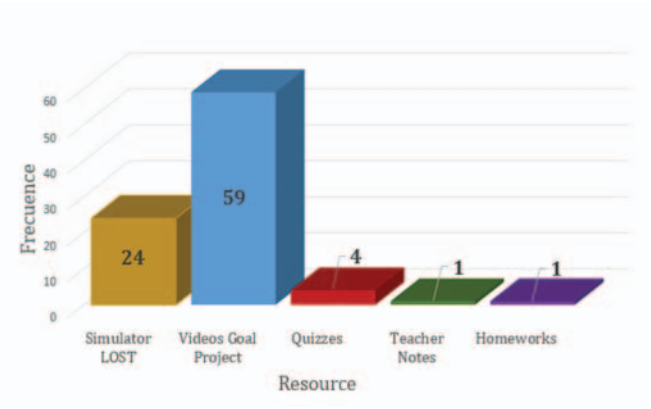

Fig. 5 The use of this resource is fundamental in the course.

However, in the next question, the students responded that the support that helped them learn the most is the business game, LOST (See Fig. 6).

Although there is no official measurement of the degree of enthusiasm of the students when playing this game, many of them asked the teacher if other friends and family could have access to this simulator.

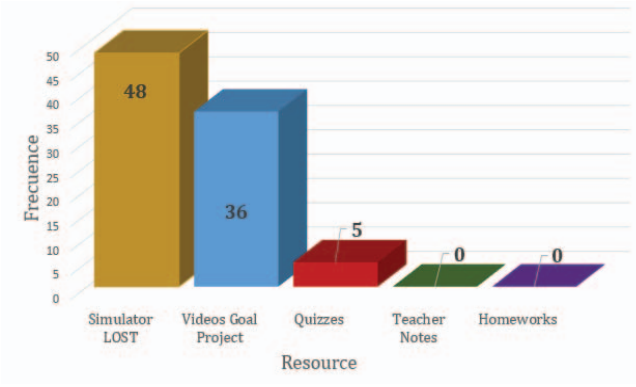

Fig. 6 The use of this resource has caused me greater learning.

LOST is a business game that is available within the online platform. Within the game, there are videos where the objectives of the game and the operation of the program are explained to the students.

Students enter the program and receive sets of randomly generated data that are similar in their degree of difficulty.

There are five different scenarios for the game (although in the course only two of these scenarios are required to play), and each scenario has a goal to achieve. Students can play the game as many times as they wish, but there is a deadline to attain the stated goals.

Each of the decisions made by the students is transferred and stored in a database, so the teacher can observe the performance of the students and determine if there is significant learning as shown by key indicators of the game.

Also, the game contains a "table of positions" that allows students to identify their performance compared to other members of the group.

When students have achieved the objectives of a scenario, they immediately have access to a new scenario that contains new variables or more complex situations in which they must make a higher number of decisions.

All scenarios contain problems related to logistical issues, such as forecasts, inventories, transportation, production management, and selection of suppliers, for example, but the complexity of the situations to face and the goals to reach become increasingly more difficult.

An important indicator of engagement is that even when the students have managed to overcome the minimum score, many of them (approximately 60%) return to play the same scenarios. They intend to improve their results to obtain a better place in the standings, because, for a vast majority of students, it is very gratifying to see their names appearing at the top of the leaderboard.

If a student does not reach the minimum score by the deadline, he or she can request an appointment with the teacher and ask for advice on how to improve their performance.

Regularly, the student and the teacher review each of the decisions made in the simulator. Helped by the indicators shown in the game, the teacher can quickly recognize the area in which the student is having problems (for example, in production, demand planning, or supply).

On the other hand, we also observe that students have a very apparent preference for the use of novel resources that are possible in the project thanks to the availability of new information and communication technologies.

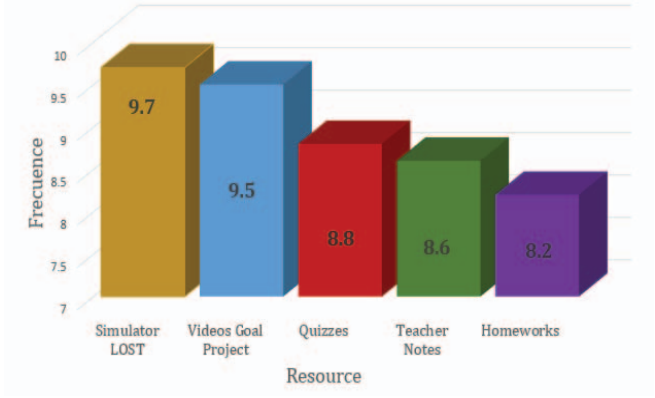

Fig. 7 On a scale from 1 to 10, rate the academic quality of the resource.

Fig. 7 confirms that the students consider that the resources used in this project contain a high academic quality.

VII. Discussion

As we can see in the statistics presented in the figures and tables above, the results of this innovation are encouraging. Students perceive high usefulness when they work with the games (or simulators), videos, quizzes, and traditional tools (such as teacher's notes and homework) that are available in the course.

Indeed, the item most highly rated is the usefulness of the tools that support the course. This utility perceived by the students impacts their degree of satisfaction with the subject and the enjoyment of the support materials. The results show that the higher the perception of utility by the students, the more they are motivated in the course. Additionally, this perceived utility also seems to increase student reflection on their learning and impacts self-learning positively.

Analysis of Correlation Coefficients (See Table V)

The construct, “Intention of behavior” (S2), strongly correlates to student satisfaction level and the efficiency of resources, the latter being an extrinsic motivator.

The satisfaction experienced by the student in the use of the support tools is linked to the enjoyment of the learning experience, intrinsic motivation, extrinsic motivation, reflection on their learning, and the student's perception of self-learning.

The enjoyment of learning activities correlates highly with extrinsic motivation and reflection on their learning.

Intrinsic motivation, besides being linked to student satisfaction and enjoyment of learning activities, correlates with extrinsic motivation, reflection on their learning, and self-learning.

Extrinsic motivation strongly correlates to the commitment that the student makes to their learning and the reflection on their learning processes.

The efficiency of the resource is strongly linked to the intention of behavior.

As we mentioned earlier, the student's commitment to their learning is affected by satisfaction and extrinsic motivation.

The student's reflection on their learning links to the usefulness of the support materials, their satisfaction, the enjoyment of the learning activity and their intrinsic motivation.

Finally, the student's perception of the achievement of self-learning correlates to the utility of the resources, their satisfaction, enjoyment, intrinsic motivation, and their extrinsic motivation.

The last row of Table V, showing the correlation coefficients of the final grades, is perhaps much more significant than all the previous ones. Curiously, it seems that the final grade of the course is not significantly linked to any of the previous constructs, and all the correlation coefficients of final grade seem to be negative, except the one that is linked to amotivation.

This is a very surprising result because we expect that those students who express a positive perception of the usefulness of the support tools would also obtain the highest grades of the course. However, interestingly, those who value most the whole set of support tools are those students who have the lowest grades of the course. We have interpreted this fact arguing the hypothesis that students who have a higher difficulty to assimilate and use mathematical tools are those who most value the set of support materials that we have placed on this platform.

Fig. 8 pulls together the strong relationships that exist among the different constructs.

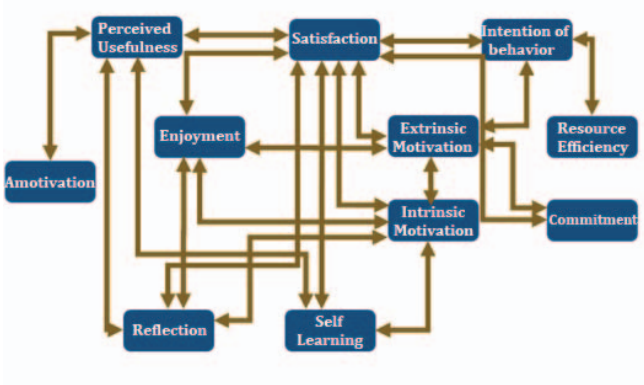

Fig. 8 Strong relations among the different constructs.

Satisfaction and extrinsic motivation are the elements that have the strongest relationships with the rest of the constructs, while amotivation and the efficiency of the resources seem not to have too much correlation with the other constructs analyzed in the study.

On the other hand, when trying to conduct a regression model that explains the final grades of the student, the correlations do not have a high significance, so these constructs do not seem to explain the final grade of the student.

We consider that this fact is a favorable result for this educational innovation because it tells us that regardless of the final grade of the student, they perceive the value contained in the group of support materials that have been placed in the platform for this subject.

Table VI shows other important academic information related to this project.

TABLE VI

OTHER IMPORTANT ACADEMIC RESULTS

Optimization Models

	Jan-May 2014 Jan- May 2017	Aug-Dec 2017 Aug-Dec 2018
Registered students	194	89
Total casualties (%)	7.7	2.9
Efficiency rate (%)	76.8	84.2
Average final grades	73.89	79.17

All the results shown in the previous table are significant at 1%.

Some students complained that the frequency of the quizzes was high and that the explanatory videos of the game needed more detail. Noteworthy, the poor online data network and internet-related issues could result in low scores in the activities associated with the quizzes.

VIII. CONCLUSIONS

The "GOAL Project" is an educational innovation that allows us to present a set of knowledge cohesively, breaking with the fragmented scheme that most universities have adopted in their curricula. GOAL contemplates the construction of an online platform in which we have created games, tests, videos, exercises, and notes, and it has produced results significantly different from those we have had in traditional courses.

Based on the review of the literature, we applied a set of surveys to students to measure different constructs related to the use of the platform and the students' perceptions of motivation and satisfaction with the course.

The results show that the critical factors indicated in the literature are favorably evaluated by the students in this educational innovation.

The resources that students evaluate best are those novel supports (the game and the videos) whose use is possible due to the new information and communication technologies.

The design of this course generates a more significant commitment of the students to their learning. Also, through different elements placed in the course, it is possible to motivate students to reflect upon their learning and develop self-learning skills.

The perception of the usefulness of this innovation is independent of the student's final grade.

We believe that the set of support tools used in this project can make possible new ways to teach students logistical concepts in a cohesive, not fragmented, manner.

We must emphasize that the academic indicators that have been observed are significantly improved when compared to traditionally taught courses.

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