Exploring critical factors related to reflection, engagement and self-directed learning

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***Abstract*— This research article describes the effectiveness of the GOAL Project platform in terms of the main critical success factors that have been detected in the literature. These critical success factors of educational platforms include elements such as Perceived Usefulness, Intention of behavior, Satisfaction, Enjoyment and Resource efficiency.**

Although there is a large amount of literature that has investigated these critical success factors, there is a limited number of articles that relate these factors to the development of other types of skills, such as the student's reflection on their own learning, student engagement and self -directed learning.

This paper also describes the relationship between critical success factors and the skills that are developed in students.

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

I. INTRODUCTION

At the beginning of each semester, it is quite evident that a significant number of students feel uncomfortable with traditional teaching methods [1]. Furthermore, the use of technology that only allows information transfer in one direction (from a teacher to a student) does not seem to provide students with a different experience [2].

Learning designs should have the capacity to provide students with a different new experience [3]. These designs should not only have the potential of improving student educational outcomes, but also promote skills that will become indispensable in the future [4, 5].

Among these abilities, self-guided learning (or the capacity of learning to learn) is, without doubt, one the abilities that will have strategic importance in individuals and organizations [6]. The speed at which changes take place, the continuous creation of new knowledge, and the increasing information access, make imperative the need to create learning strategies in individuals [7].

Although self-directed learning has several well-known characteristics, two of them are crucial: 1) to boost engagement to learning, which means that students develop the responsibility to act in relation to their learning effort, and 2) to provoke a continuous reflection on the way in which each student acquires his learning [8].

Based on this objective, in recent years, professors of the logistics area of our university have created a project called "GOAL Project" (Generating Opportunities for Learning in Logistics, by its acronym in Spanish), and have designed a learning online platform. On this platform we have placed a business game called "LOST" (an acronym for Logistic Simulator), and we have worked on the design and development of online learning units. These learning units contain videos, quizzes, teacher's notes, essays, and homework.

With this platform, we have explored the following elements:

- The ability to generate self-directed learning in students.
- The student engagement.
- The student's reflection on their own learning.

II. DESCRIPTION OF THE PLATFORM

The teaching of logistics faces major challenges; one the fiercest criticisms is that this knowledge field is fragmented. Most universities have organized their programs in such a way that they offer standalone topics in logistics such as forecasting, inventory control and production management, just to mention a few. However, there is an absence of scenarios in which students have the necessity to connect these topics. This way of teaching logistics has created fragmented visions of reality when this science should give a comprehensive vision [9].

Another criticism is that most of the used techniques and models need specialized knowledge of students that, for most of them, is an arid phase of learning in which the fundamental concepts and content of the course are difficult to absorb. The methodology of traditional teaching and subjects content are more focused in the solution methods (despite the enormous amount of software that has been developed for problem resolution), while the applications of those solutions are frequently ignored. Hence, students have huge difficulties to transfer this knowledge and visualize how and when these methods are relevant in their decision-making [10].

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The GOAL Project represents a new way of transmitting and generating logistics concepts. GOAL is an online platform where we have placed supports such as videos, notes and quizzes. These supports are linked to a game called LOST (an acronym for Logistic Simulator).

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

LOST is a video game that allows to students to develop logistical concepts and understand its interfaces, showing them the consequences of each decision they make and indicating how a decision in one department affects the performance of the overall system.

The first version of the game was designed in the 2013. It was created using Excel macros, and the game was used with a group of 20 industrial engineering students.

The pedagogical design has its foundation in a teaching technique denominated "gamification". In the literature, gamification it is described as an important instrument to develop engagement, as well as to motivate students to reproduce behaviors and achieve desirable results [11].

LOST is a business game where students are asked to be a member of a small company that is dedicated to the production and sale of different types of balls. A part of the tasks that students should carry out within the game is the forecast of demands of different products, select raw materials, choose suppliers, determine size of orders, design a production plan, select transport elements, among others. The directions for the game's objectives as well as how it operates are contained in the game itself.

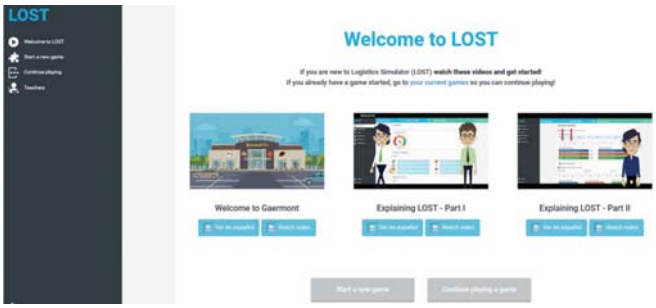

Fig. 2. Online Portal of LOST.

Students enter the program and receive a set of information generated randomly, but that is similar in their level of complexity. There are five different scenarios for the game (although in the courses the request is only to use a maximum of two of the scenarios) and each one has an objective to be achieved. Students can play the game as many times as they wish, but there is a deadline to overcome the stated goals.

Additionally, the game shows a set of key performance indicators for the company, this allows students to observe the consequences that their decisions have in different areas of the company. In this way, they can apply the different concepts they have studied in different logistics topics in a single scenario.

Fig. 3 Key Performance Indicators within the game.

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

When students have achieved their objectives in a scenario, they immediately get access to a new scenario that contains new variables or more complex situations in which they have to make a greater amount of decisions.

All scenarios contain problems related to logistical issues (e. g. forecasting, inventories level , transportation, production management) but the complexity of the situation they face and the goals to achieve are increasingly higher.

Each of the decisions made by the students is transferred and filed in a database so that the professor can trace the performance of his/her students and determine whether learning has been significant.

If a student does not get the minimum score on the deadline, he/she asks for an appointment with the professor and request advice on how to improve his/her performance.

Regularly, the student and the professor review each of the decisions made in the simulator. Assisted by the indicators shown in the game, the professor can quickly recognize the area in which the student is facing problems. For instance, in production or demand and supply planning.

An important indicator of the commitment is that even when students have achieved the minimum score, many of them (approximately 60%) play again the same scenarios with the intention of improving their results. For most of the students it is stimulating to see their names appearing at the top of the classification table.

One of the great difficulties that we had to face to generalize the use of this game is that LOST requires knowledge in various areas of the field of logistics. The professors argued that LOST demands more knowledge from those that were included in the syllabus corresponding to the topic they taught. This was the reason why we created a portal for the teaching logistics and the birth of the GOAL Project.

GOAL aims to provide support to students in different issues related to the decision-making process in the area of logistics. Undoubtedly, LOST is a fundamental part of the

portal, but there are other contents that we consider equally valuable.

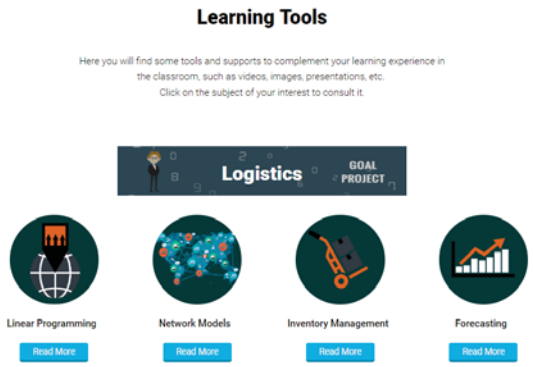

Fig. 4. Learning tools contained in the GOAL Project platform

A fundamental part of GOAL is the creation of a portal with learning tools of different logistics topics. This portal contains videos, quizzes, teacher notes and book chapters. In addition, with the intention of motivating students to consult supports from different subjects, GOAL has a reward system that motivates students to answer small questionnaires of different subjects. These rewards will have an effect within the game that allows the acquisition of certain privileges, such as increasing the size of a warehouse, increasing production efficiency, increasing demand, etc.

In this way, GOAL represents an innovative platform since it allows us to present to the students an integral set of knowledge. In the future, this online platform will have support materials on all issues related to logistics, but for now, the only fully developed topic is linear programming.

This document describes the first results of the surveys answered by the students who took the subject of Optimization Models (Linear Programming), and we have created some implications based on the results of these surveys.

III. Review of Literature

Self-directed learning is a critical skill in the labor markets of the future, the speed with which technological changes occur has caused a continuous change in the employer paradigms. Many companies and organizations have begun to demonstrate their preference for those workers who are able to manage their time and achieve results independently (without direction from supervisors, trainers, or educators). In summary, every day it is more important that people possess the quality of acquiring new skills and self-managing their performance [12].

This is the reason why Self-Directed learning has acquired enormous importance. Self-directed learning is recognized as a dynamic combination of attitudes and skills, which are indispensable to face the complexity of interactions that individuals face in all aspects of their lives in the modern world [13, 14].

The main role of the professor is to be a facilitator and cognitive coach, with the aim of maximizing and promoting the learning potential of the students. For their part, students must acquire the ability to determine what they want to learn and how to achieve this goal [15].

Self-directed learning consists of activities that are totally or partially under the control of the student. It consists of the design of tasks or events that are intended to achieve significant learning, may include class attendance, participate in a discussion, do homework, read or prepare for an exam. Self-directed learning is based on the behavior students choose to plan, manage or analyze different activities. In other words, self-directed learning seems to be directly linked to the student engagement [16].

Student engagement is defined as the active participation of a student, the degree of attention, interest and passion that they show when they participate in the learning process [17] [18]. Student commitment is beyond the grades that they obtain at the end of a course, it implies an effort of the student to understand the material and internalize it in order to apply it in their daily life. Without a doubt, achieving student commitment and participation represent the key factors to achieve an improvement in learning [19].

Although the commitment is defined around the academic, three dimensions are identified to observe the student's engagement [17]:

1. Behavioral Engagement. At this point, students are expected to comply with certain behavioral norms, such as attendance, participation, completion of their tasks, and demonstrate the absence of negative behaviors.
2. Emotional Engagement. Students are expected to be emotionally involved and to experience affective reactions such as interest or enjoyment of the class or some reading.
3. Cognitive engagement. Students are expected to invest time in their learning, seeking to go beyond the requirements, and show enthusiasm for the challenges.

On the other hand, converting available information into an organized and meaningful knowledge requires the ability to reflect, to create strategies to undertake the search for relevant information. Reflection is an important human activity, in which people "*recapture their experience, think about it, mull it over and evaluate it*". [20]

Reflecting on what has been learned helps students to understand the achievements and advances that have been presented during a course, helps to recognize what has been achieved, and to improve their practices. Reflection serves as a mechanism to convert the experience into knowledge, that is, it helps the students to recognize how they learns. The continuous use of the reflection process is essential to develop knowledge, to increase knowledge, and to develop the capacity of the person. It is around the reflection that students expand their learning capacity [21].

A fundamental task for the teaching activity is to involve the students completely in the process of "making sense". Education is not just about disseminating information; The pedagogical design must organize the instruction so that students can make sense of what they do. If the learning activity is meaningless, neither the learning outcomes nor the process can be valued by the students. This is why the reflective act is significantly important [22].

Finally, the use of learning portals has become an increasingly common practice in educational institutions, a large majority of universities have used this type of portals to place support materials for their students [23]. The widespread use of these platforms has generated a good part of the literature analyzing the critical success factors of them [24, 25]. Some of the key factors that have been common among the different studies carried out are the following: Perceived usefulness, Intention of Behavior, Student satisfaction, Enjoyment, Efficiency of the platform [26].

These new technological learning environments have opened a new paradigm in teaching methods, they are increasingly effective, comfortable and motivating. But the incorporation of new technologies in teaching must also aim to propose an active, responsible, constructive and reflective learning; generate a greater commitment to their own learning; and generate skills so that a greater number of students are able to self-regulate their learning.

IV. Research Questions

Our goal is to answer the following questions:

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

2) Is it possible to generate an improvement in student's engagement with this platform?

3) Is it possible to generate in the student a reflection on his learning?

4) Is it possible to promote self-directed learning elements in the student?

5) Which of the critical factors have greater influence in student engagement, in the reflection on the learning, and on the self-regulation of the students on their learning?

Based on these chosen constructs, we initiate the application of a survey to the students who have studied the topic of Optimization Models (Linear Programming).

V. Methodology

In the semester August-December 2018, January-May 2018, and August-December 2017, different types of supports have been placed in the course of Linear Programming: videos, notes with solved exercises, summative tasks, Quizzes (that offer immediate feedback of the results obtained by the students) and a business game that is available online.

All types of supports for the course have been placed on the network, but using different platforms. The notes, the videos and the game are placed on an open access educational platform called GOAL Project. We have also used the Blackboard Learn platform to assign students other tasks (such as discussion forums, quizzes and essays). We have also generated a YouTube channel that we have used to place videos.

Fig. 5. GOAL Project Channel on YouTube.

At the end of the semester two different types of surveys have been applied:

- A survey based on the critical success factors for e-learning [27], which aims to measure the different constructs such as:

S1. Perceived usefulness
S2. Behavioral intention
S3. Student satisfaction
S4. Enjoyment
S5. Resource Efficiency

- A survey with questions related to the following constructs:

S6. Student engagement
S7. Reflection on their learning
S8. Self-Directed Learning

The reliability and validity of the constructs were assessed by a pilot study.

Definition of each of the constructs contained in the survey, is described in Table I.

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 "Optimization Models" subject.

This questionnaire was applied 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.

A 1 to 7 likert scale was used, where 1 means "totally disagree" and 7 means "totally agree."

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. Behavioral intention	An individual's performing a conscious act, such as deciding to accept (or use) a technology
S3. Student satisfaction	The extent to which a user is pleased or contented with the supports.
S4. Enjoyment	The extent to which the activity of using a specific system is perceived to be enjoyable in its own right.
S5. Resource efficiency	Perception of whether the supports generate significant learning in the student
S6. Student engagement	Perception on whether the dynamics of the course and supports make the student more committed to their learning
S7. Reflection on their learning	Perception on whether the dynamics of the course and the supports make the student think about their learning style
S8. Self-Directed Learning	Perception of whether the course dynamics facilitate and promote self-learning

TABLE II CONSTRUCTS AND 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's 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 follow the activities found in the program of the subject. 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. Behavioral intention	1. I believe that in the future, the courses should contain games, videos and quizzes. 2. If I have access to other classes where the course is scheduled through games, videos and quizzes, I intend to enroll. 3. I think instructors should create games, videos and quizzes to incorporate their courses. 4. I think the University should promote this type of learning experience.
S3. Student satisfaction.	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 widely 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, it's nice for me. 2. The use of games, videos and quizzes seems to me an interesting activity.
S5. Resource efficiency	1. The act of "learning" using games, videos and quizzes is not a complicated activity. 2. I could complete the learning activities of this course using the game, videos and quizzes and having a teacher who could help me answer 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.
S6. Student engagement	1. The activities I do outside of the classroom, such as playing the simulator, watching the videos or solving 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 my own learning. 3. After having this course, where a part of its content depends on my own effort, I feel more committed to my performance and my learning.
S7. 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 didactic resources that cause me to improve my academic performance and obtain greater learning. 3. At the end of this course I can identify which resources facilitate my learning in a better way.
S8. Self-Directed Learning	1. When I watch a video, play the simulator, or solve 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-Directed Learning is a skill that I must develop because it will be very useful in the future.

VI. RESULTS

The averages and standard deviations of the opinions issued by the students on each of the constructs are shown in Table III.

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	5.858	1.122
S6	6.133	0.974
S7	6.151	1.042
S8	6.284	0.797

The averages and standard deviations of each of these constructs represent the average of the answers to each of the questions that are contained in this construct. For example, for the first construct 6,422 is the general average of the six questions that were asked to measure it.

As shown, the opinions of the students in relation to the GOAL Project platform are favorable. Seven of the eight constructs have an average equal to or greater than 6.

In the case of construct S5 (resource efficiency), the third question related to the qualification of this construct has an average opinion of 5.39. The average of the first two questions is equal to or greater than 6, but this last question decreases that average. The qualification that the students give to the third question reflects the fear of not having a teacher who can accompany them and solve their doubts.

TABLE IV
PERCENTAGE OF FAVORABLE OPINIONS

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

Table IV shows the percentage of students who have a favorable opinion with respect to each construct. We have considered that the students have a favorable opinion of a construct when the responses marked 6 or 7 on the Likert scale.

Table V shows a correlation study between each of the eight constructs. In most of the cases, the coefficients show a high correlation between the different constructs.

TABLE V

CORRELATION COEFFICIENTS

	S1	*S2*	*S3*	*S4*	*S5*	*S6*	*S7*	*S8*
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	0.547	0.671	0.632	0.623	1.000			
S6	0.636	0.545	0.700	0.753	0.504	1.000		
S7	0.702	0.610	0.725	0.649	0.535	0.583	1.000	
S8	0.605	0.601	0.685	0.647	0.565	0.661	0.619	1.000

Trying to explain the relationship between the critical factors (constructs S1-S5), and the constructs "Student engagement", "Reflection on their learning" and "Self-Directed Learning" (constructs S6-S8), a forward stepwise regression was carried out. To do this regression, we consider the averages of the opinions of each student in each of the constructs S1 to S5 (the averages of these constructs are equivalent to the independent variables), and a regression was made with respect to the dependent variables (represented by constructs S6, S7 and S8). Then we considered an alpha to enter = 0.25, and the runs were made using the Minitab software. The results for each of these runs are presented in Table VI, Table VII and Table VIII.

TABLE VI

FORWARD REGRESSION FOR STUDENT ENGAGEMENT

Regression Analysis: S6 versus S1; S2; S3; S4; S5

Forward Selection of Terms

α to enter = 0.25

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	35.276	17.6380	36.40	0.000
S3	1	5.245	5.2453	10.82	0.002
S4	1	2.327	2.3274	4.80	0.032
Error	72	34.891	0.4846		
Lack-of-Fit	65	32.474	0.4996	1.45	0.321
Pure Error	7	2.417	0.3452		
Total	74	70.167			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.696126	50.27%	48.89%	46.27%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.113	0.627	1.78	0.080	
S3	0.532	0.162	3.29	0.002	2.69
S4	0.266	0.121	2.19	0.032	2.69

Regression Equation

S6 = 1.113 + 0.532 S3 + 0.266 S4

TABLE VII

FORWARD REGRESSION FOR REFLECTION ON THEIR LEARNING

Regression Analysis: S7 versus S1; S2; S3; S4; S5

Forward Selection of Terms

α to enter = 0.25

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	47.073	23.5364	51.02	0.000
S1	1	4.808	4.8075	10.42	0.002
S4	1	8.700	8.6998	18.86	0.000
Error	72	33.215	0.4613		
Lack-of-Fit	65	28.015	0.4310	0.58	0.881
Pure Error	7	5.200	0.7429		
Total	74	80.287			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.679201	58.63%	57.48%	52.66%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.485	0.616	0.79	0.433	
S1	0.441	0.137	3.23	0.002	2.06
S4	0.450	0.104	4.34	0.000	2.06

Regression Equation

S7 = 0.485 + 0.441 S1 + 0.450 S4

TABLE VIII

FORWARD REGRESSION FOR SELF-DIRECTED LEARNING

Regression Analysis: S8 versus S1; S2; S3; S4; S5

Forward Selection of Terms

α to enter = 0.25

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	26.6368	8.8789	30.89	0.000
S1	1	2.0057	2.0057	6.98	0.010
S3	1	2.3128	2.3128	8.05	0.006
S5	1	0.5623	0.5623	1.96	0.166
Error	71	20.4062	0.2874		
Lack-of-Fit	64	15.1840	0.2372	0.32	0.994
Pure Error	7	5.2222	0.7460		
Total	74	47.0430			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.536107	56.62%	54.79%	50.04%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.308	0.524	2.50	0.015	
S1	0.312	0.118	2.64	0.010	2.47
S3	0.385	0.136	2.84	0.006	3.19
S5	0.0952	0.0681	1.40	0.166	1.50

Regression Equation

S8 = 1.308 + 0.312 S1 + 0.385 S3 + 0.0952 S5

As shown in these tables, “Student Engagement” is associated with the construct S3 (Student Satisfaction) and construct S4 (Enjoyment). But the one that has a greater influence is Student Satisfaction.

“Reflection on their learning” is associated with the construct S1 (Perceived Usefulness) and construct S4 (Enjoyment). But the one that has a greater influence is Enjoyment.

Finally, Self-Directed Learning is associated with the construct S1 (Perceived Usefulness), S3 (Student Satisfaction) and construct S5 (Resource Efficiency). But the one that has a greater influence is Student Satisfaction.

The following figure summarizes our findings.

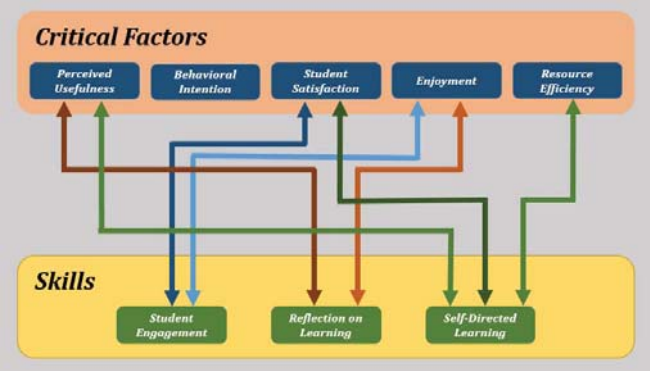

Fig. 6. Relationships between critical factors and skills.

Other important academic results are shown in the following table

TABLE IX

ANOTHER 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 Table IX are significant at 1%.

VII. CONCLUSIONS

The "GOAL Project" is an educational innovation in the area of teaching logistics, since it allows us to present a set of knowledge in an integral way, 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 has produced results significantly different from those we have had in traditional courses.

On the basis of the literature review, two types of surveys were designed and applied to the students. The first of them allows us to measure the critical factors related to the use of the platform; while the second survey provides information on the development of specific skills that will be fundamental for our students in the future.

The results show that both the critical factors and the perception of the development of certain skills are favorably evaluated by the students in this educational innovation.

A deeper analysis of the relationship between critical factors and developed skills allows us to conclude that "Student engagement" is associated with Student Satisfaction and Enjoyment; "Reflection on their learning" is associated with Perceived Usefulness and Enjoyment; finally, “Self-Directed Learning” is associated with Perceived Usefulness, Student Satisfaction and Resource Efficiency.

ACKNOWLEDGMENT

The authors would like to acknowledge the financial and the technical support of Writing Lab, TecLabs, and Tecnologico de Monterrey, Mexico, in the production of this work.

Finally, we would also like to thank the students who have participated in this project for their support in responding to the surveys and for the suggestions for improvements to the game, the quizzes, and the videos.

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