

## ENHANCING COOPERATIVE LEARNING AND STUDENT MOTIVATION WITH GAMIFICATION STRATEGIES: A CASE STUDY IN INDUSTRIAL ENGINEERING

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### Abstract

This contribution presents the pedagogical design of a subject through gamified activities supported by technological tools in which the integration of two key subjects of the Civil Industrial Engineering career were implemented, which are operational research and project evaluation. In addition, the results of the satisfaction and learning perception questionnaires administered at the end of the experience are presented. Gamification is planned and implemented as a collaborative learning strategy to relate knowledge and skills acquired in order to provide solutions to science-based engineering problems in the area of their profession. The experience has been developed with 10 students in the ninth semester of the 2017 generation of the career, dictated this semester. It should be noted that the course was planned to be taught in classroom mode, due to the COVID-19 pandemic, for both academics and students, it was a challenge and a learning achievement to teach the course online since the University of Antofagasta was not prepared to teach classes in virtual mode. Even though Chilean universities have used gamification in engineering, there have been no records of the existence of subjects integrated with the application of this tool.

The results obtained in this teaching innovation achieved motivation of our students, teamwork, learning to learn, good performance in the completion of academic activities and the satisfaction of students accredited through the survey.

**Keywords** – Gamification, Integration, Motivation, Learn to learn, Teamwork.

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## 1. Introduction

The advance in technology in society has generated important changes and education is no exception. In this regard, given the worldwide pandemic, the use of technology has accelerated, allowing us to satisfy basic needs, from acquiring food to taking classes online.

On the other hand, learning is an active process that requires motivation both to initiate and to persist in it. Learning requires interest and willingness of the learner for his own learning or for the activities that lead to it (motivation), the use of skills, actions and thoughts that take place during learning (strategies), and also what conception of learning the learner holds and how he approaches it (learning approaches) (Domínguez & Mora, 2014). In higher education, the motivation to learn can often be diminished, especially when, in contexts such as the pandemic, an element of self-direction and autonomy is required (OECD, 2000). It is necessary to use new educational teaching-learning strategies that, in addition to involving students, make their learning more meaningful (Muñoz-Moreno & Lluch-Molins, 2020).

In recent years, the term gamification is being frequently used to refer to different methodological resources applicable to various situations and disciplines (Martínez-Villalobos & Ríos-Herrera, 2019); (Domínguez & Mora, 2014). Gamification emerges as a tool for educational transformation (Landers & Callan, 2011; Muntean, 2011; Corchuelo-Rodríguez, 2018) since the term was coined by Pelling in 2002 for referring to the adaptation of gaming in education. In fact, both the Horizon Report on Higher Education, as well as the one on Early Childhood and Primary Education, published in 2014 already highlight gamification and game-based learning as trends of great impact in the educational field in the coming years. The use of games as a tool to enhance learning has been used at various educational levels, especially in early childhood, and primary and secondary education. However, at the university level, this strategy has not been developed in such a generalized way. As a result of the Teaching Innovation program in Engineering 2030 Consortium of Engineering Faculties of the Second Region of Antofagasta taught by the University of Barcelona, which was carried out promptly where we were able to learn various tools including participative evaluation strategies, cooperative learning, gamification, among others, provided us with knowledge and tools that were essential to address the current pandemic.

When gamification is described, it is referred to as “a system in which players engage in an abstract challenge, defined by rules, interactivity and feedback that results in a quantifiable outcome that often elicits an emotional reaction” (Kapp, 2012: page 7). The link between gamification and motivation has been long studied (Reyes-Cabrera & Quiñonez-Pech, 2020; Deterding, Dixon, Khaled & Nacke, 2011; Burke, 2011; Simões, Díaz Redondo & Fernández Vilas 2013; Hamar, Koivisto & Sarsa, 2014; Monguillot, González, Zurita, Almirall & Guitert, 2017; Contreras & Eguías, 2017). In fact, gamification is seen as an opportunity to address two problems in education: motivation and engagement (Lee, Ceyhan, Jordan-Cooley & Sung, 2013), however, “the success of a gamification strategy in higher education lies in the design” (Corchuelo-Rodríguez, 2018: page 39). Although numerous gamification experiences are currently available, they sometimes lack a didactic design and/or a clear connection with competencies, such as the transversal competencies of learning to learn and cooperative learning; hence, this proposal contemplates taking advantage of gamification as a collaborative strategy (Glover, 2013; Pineda, 2019; García, 2019) to motivate the student body and, thus, promote a meaningful type of learning. In this regard, we share a link where you will find examples of proposed methodologies for the application of gamification of the subject “Psychological intervention in learning disorders” belonging to the master’s degree in special education of the Faculty of Education – Teacher Training Center of the Complutense University of Madrid and the subject “Teaching-learning of natural sciences” belonging to the degree of early childhood education in the Faculty of Education Sciences of the University of Las Palmas de la Gran Canaria (<https://bit.ly/3hoWXQ3>).

Gamification promotes the assimilation of complex concepts in various areas, game-based learning is a tool that facilitates study in a motivating, participative and focused way, providing immediate feedback that allows participating students to visualize their progress and see their mistakes as an opportunity for improvement (Macho-González, Bastida, Sarriá-Ruiz & Sánchez-Muniz, 2021).

More and more teachers are adopting gamification practices in addition to the current trend given the Covid 19 contingency, which forced us to search for strategies on how to continue with the delivery of learning to students, processes that had great challenges since we were not trained and prepared to teach online. This event has been replicated all over the world, in the paper called “The Covid 19 pandemic and

blended learning in higher education and teacher training for remote university education: New opportunities in times of emergencies” describes the obstacles that teachers had to face due to the confinement and all the challenges that this implied (<http://www.scielo.org.ar/pdf/ritet/n28/n28a40.pdf> and <http://www.scielo.org.ar/pdf/ritet/n28/n28a28.pdf>). Today the use of educational platforms and learning management systems such as Moodle acronym for Modular Object-Oriented Dynamic Learning Environment (designed to provide educators, administrators and students with an integrated system to create personalized learning environments to suit individual needs), this virtual learning environment was used in this work in addition to Microsoft Teams (which is a Microsoft 365 chat-based workspace designed to improve communication and collaboration of work teams in organizations, reinforcing the collaborative functions of Microsoft’s cloud platform), in this case, used for interaction between teachers and students, during the teaching of the subject.

Part of the steps to design a reference model for gamification in education is presented below in Figure 1; it is worth mentioning the importance of generating competition for students that motivates them, paying attention to establishing levels of increasing difficulty (Galán-García, 2021).



Figure 1. Gamification steps

Among the gamification activities that were implemented in the subjects, the following were carried out: Escape room, QR code, concept map, one note, videos, Kahoot, Educaplay: crossword puzzle. While all these tools are aimed at motivating the students and their teamwork, the main innovation is the integration of two important disciplines in the Industrial Civil Engineering career, allowing them to simulate problems that they will face in their working life.

The main objectives of the development of this subject are related to the importance that once students have acquired a combination of knowledge, skills and abilities, they can be integrated allowing the evaluation of certain problems that they must face in their professional life. These objectives are shared in the subjects of “Operations Research and Project Evaluation” and that is why they have been integrated for the present proposed experience.

In this regard, in a publication, Rodríguez, Prades and Basart (2007) define professional competencies as the integration of knowledge, skills and attitudes that enable quality professional performance. From the academic point of view, they are the result of a learning process that should ensure that students are able to integrate the knowledge, skills, attitudes and responsibilities required by professional profiles. In an academic context, the contribution that a computer program can make is relevant, as it allows a more complete analysis of the problem in question, including a greater number of variables and restrictions that bring the students closer to a reality they will face in their professional life, given that the study of resource optimization is more complex than what a student can apply in the classroom. Although the current learning system provides the fundamentals of the subjects that allow understanding the concept, it only admits a reduced number of variables and restrictions, as is the case of operations research, which, using tableau makes the process slow, easy to make mistakes, laborious and restricted by the time available in the lectures. Although the existing software options for solving problems of great difficulty are varied, Solver is the most appropriate for its easy accessibility and use, being found as a complement in a spreadsheet as well-known as Microsoft Excel. The use and implementation of this type of tool allow solving problems such as inaccurate manual graphs or solving complex algorithms, leaving only the interpretation of results to the student.

The preparation and evaluation of projects have become an instrument of priority use among economic agents involved in any of the stages of resource allocation to implement investment initiatives, it is a technique that allows to collect, to create and to analyze in a systemic way of a set of economic

precedents that enables to judge qualitatively and quantitatively the advantages and disadvantages of allocating resources to a certain initiative, therefore, it is an important tool for decision making that our students must face shortly. Although there is software that allows the calculation of the cash flow spreadsheets, there is no license to use them; for this reason, the Excel tool is used, which is of massive use, allowing to automate the calculation of the cash flow spreadsheets, facilitating the sensitization of the variables.

The development of competencies in Civil Industrial Engineering in pandemic contexts with online teaching has had an impact on education, as there has been a massive closure of face-to-face activities in educational institutions in most countries of the world, including our country, in order to avoid contagion.

This led to a mobilization of the entire educational field to an online modality supported by various digital platforms that led to a series of agreements between students and institutions (in the following link <https://bit.ly/3stzh3m> you can see the agreement reached by the National University of Colombia). In the particular case of the Antofagasta University, one of the most relevant agreements was the right to privacy of the students, who could have the cameras turned off in the classes, not being obliged to attend them and, in addition, the request to record the sessions. Attached is a QR code where the agreements can be seen in Figure 2.



Figure 2. Agreements adopted at the negotiating table

The implementation of Competency-Based Assessment (CBA) practices, with complex, authentic tasks and in a real context, is still scarce. We can find reasons for this lack of alignment in (1) institutional impediments (e.g., in the process of establishing learning plans or in the lack of coordination of teaching teams) (Sánchez-Santamaría, 2011) and (2) different assessments of the concepts of evaluation (Baughan, 2020). If this was already problematic in face-to-face settings, the emergency changes forced during the first COVID-19 lockdown only emphasized these issues (García-Peñalvo, Corell, Abella-García & Grande, 2020).

All the above mentioned make it necessary to create instances that allow for greater participation and motivation of students in classes, favorable attitudes toward meaningful learning. Hence, the present proposal aims to relate knowledge and skills acquired in order to provide solutions to science-based engineering problems in the area of their profession, incorporating gamification as a strategy to help develop the crosscutting competencies of learning to learn and cooperative learning within the framework of the studies of Industrial Civil Engineering.

The COVID-19 pandemic, with the sudden closure of all face-to-face universities in Chile, created a new vital and professional scenario. Despite the advancement of the 21st century, many face-to-face universities had not fully implemented online teaching-learning practices by March 2020. University institutions and professionals had to switch to online teaching overnight and, in many cases, without the appropriate institutional conditions, nor the necessary training in line with a competency-based approach. However, despite the emergence of the pandemic situation, some faculties managed to design meaningful and authentic learning and assessment approaches to ensure student learning. In some cases, new practices may have been incorporated into regular higher education teaching after the closing semester.

## 2. Design/Methodology

The teaching innovation carried out deals with the application of gamification for an integrated subject, which is made up of two disciplines: operational research and project evaluation. This consists of 4 hours per week, it is the first time that it is dictated, being carried out in this opportunity this semester with a total of 10 students who will work in teams, it should be noted that the subject is consigned in the ninth

semester of the curriculum. The students belong to the 2017 generation of the redesigned curriculum of the Civil Industrial Engineering career, which is focused on student-based methodologies. For this, in the first instance, the concept and structure of a team are reinforced with the purpose that students make the document “Team Formation”, which contains the information of the members, name of the team, behaviors and general commitments, roles and rules established by each of them. The phases for the implementation of the experience are presented in Figure 3:

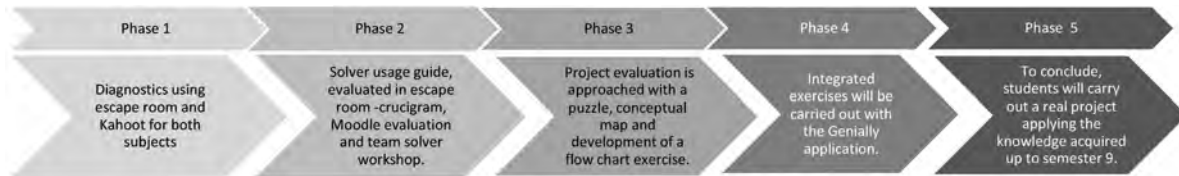


Figure 3. Stages of activities of the course

## 2.1. Diagnosis

We understand that evaluation is not only restricted to verifying the degree to which students have achieved the proposed learning objectives at a given time, but rather it is a continuous process in education that allows us to find out if the domains have been achieved in their totality, partially or not at all. Thus, students become aware of their status in relation to certain learning and what they need to learn; besides allowing feedback to the teacher that will help to improve what is being done in order to ensure the proposed learning from the diagnostic evaluation that allows the academic to formulate remedial alternatives as required.

For the implementation of the experience, first, a diagnostic evaluation has been carried out by applying gamification, specifically the escape room tool, in order to present the content in an attractive and motivating way. An educational escape room, also called breakOut, serious game, or escape game, corresponds to a methodology inserted in the gamification where a student or a group of them is challenged to get out of a room closed with a virtual padlock. The parts that must be followed in general for this type of educational experience are the welcome page to the activity, the context where the instructions are displayed, a series of challenges that are used to unlock the final virtual lock and finally the development of the virtual lock, at this stage the student must scan with a cell phone or other electronic device a QR code, which will redirect it to the lock, once in this place the student must enter the keys obtained in the challenge section; If they enter them correctly, they will be allowed to unlock the lock, otherwise the padlock will not open. In the diagnostic evaluation, there are two challenges, the first one corresponds to the subject of operational research 1 which deals with linear programming and the second one is about project evaluation, once the riddles are solved, they will find 5 digits that will allow them to open the virtual lock, having two attempts to do so. In the following link, you can access the activity and see the challenges. <https://bit.ly/3pnFpID>, which can be seen in Figure 4.



Figure 4. Diagnostic evaluation

Subsequently, a Kahoot is performed (Figure 5), this feedback will allow us to know how much the students know about the subject of Operations Research and project evaluation, defining if remedial work should be done in any of the disciplines. Link to the activity: <https://bit.ly/33XzHWa>.

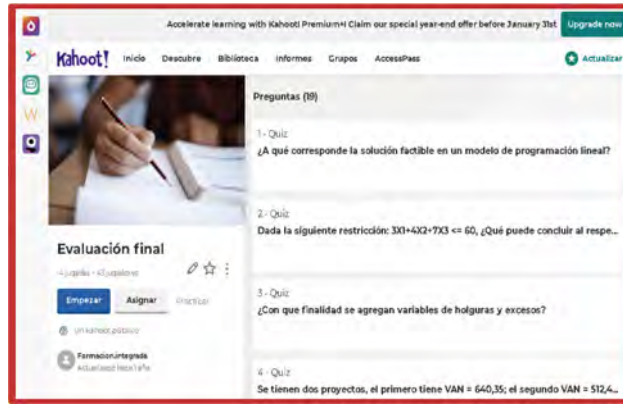


Figure 5. Linear Programming Kahoot with Solver and Project Evaluation

## 2.2. Modelling a Linear Programming Problem with the Solver Tool

To model linear programming problems we will use the Solver tool which is a Microsoft Excel add-in program used to carry out analysis, it is used to find an optimal value (minimum or maximum), for a cell, target cell, which is subject to restrictions or limitations on the values of other formula cells in a spreadsheet. After the model is captured in a spreadsheet, Solver must first be told which cells represent the objective function, the decision variables and the restrictions. In order to learn this tool, a user’s manual will be provided with an example exercise that will allow students to learn how to apply it.

To access Solver in Excel, go to the **Data** tab located on the toolbar and a parameter dialogue box will be displayed, as shown in Figures 6 and 7 respectively.

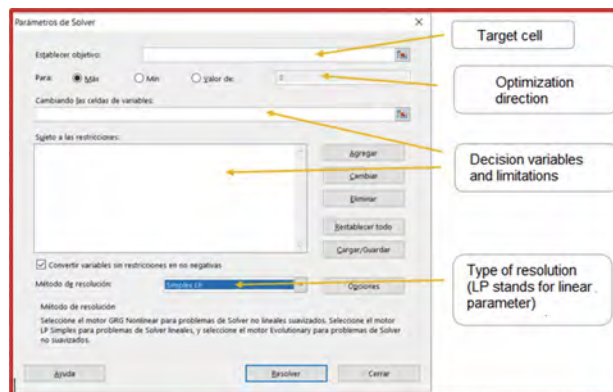


Figure 6. Solver User’s Guide

To access the user guide you must scan the following QR code.



Figure 7. User guide scanner

Escape Room and Operational Research and Solver crossword puzzle: Within the Escape Room in the challenge tab you will find a link to the crossword puzzle that students must develop with the instructions that will allow them to open the virtual padlock, which objective is to reinforce both tools, as shown in Figures 8, 9 and 10.

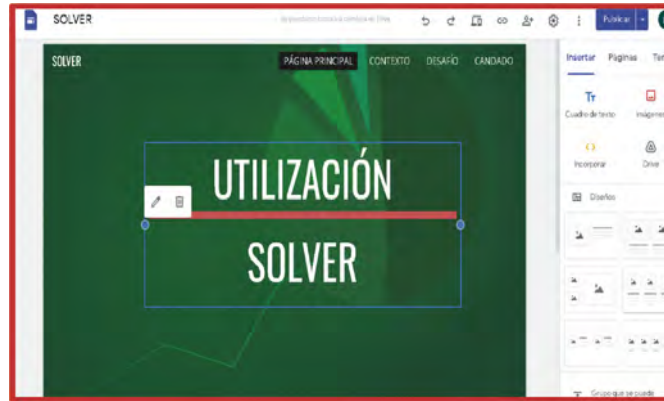


Figure 8. Scape Room of the use of Operations Research and Solver: <https://bit.ly/3IwHcm6>

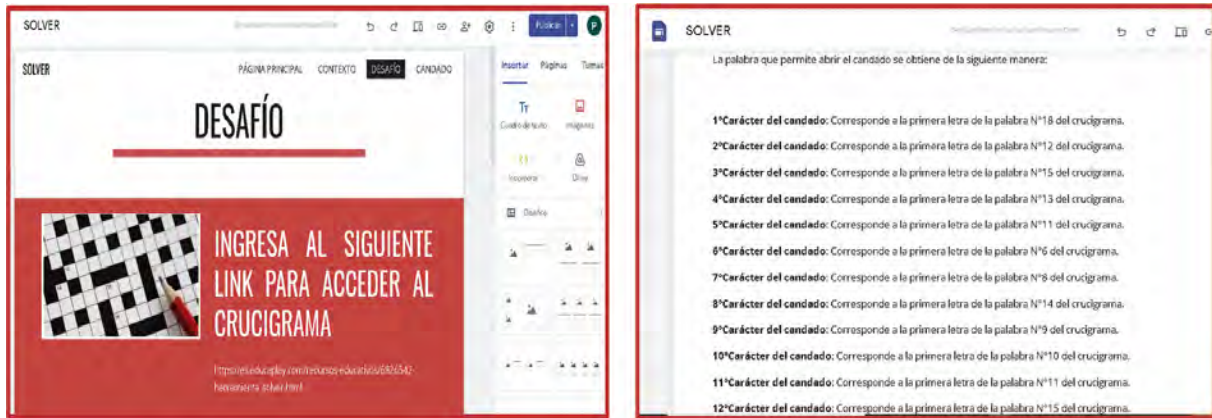


Figure 9. Crossword puzzle of the use of Operations Research and Solver <https://bit.ly/3IyCNyX>

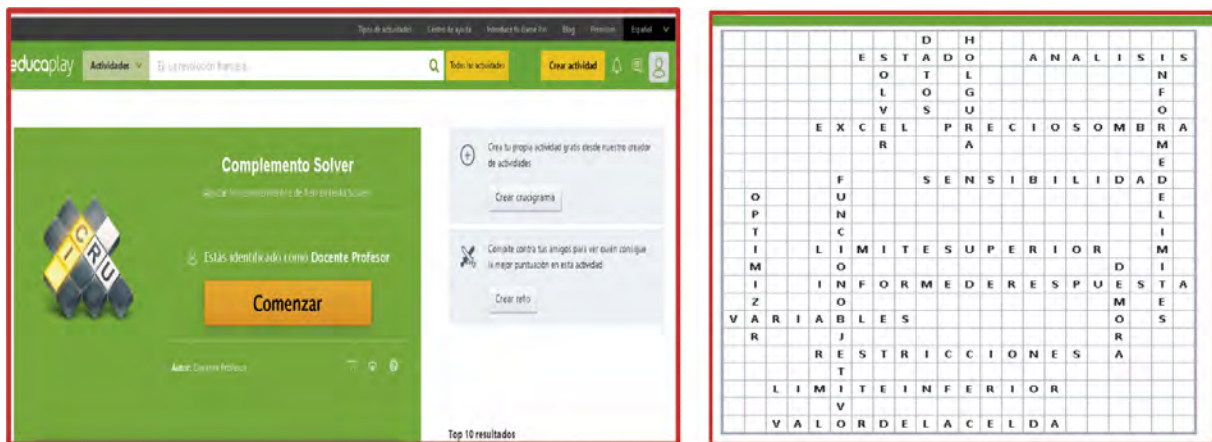


Figure 10. Solver crossword puzzle solution

To evaluate whether the students understood how to operate Solver, an evaluation was carried out on the Moodle platform, a workshop that is shown in Figure 11:

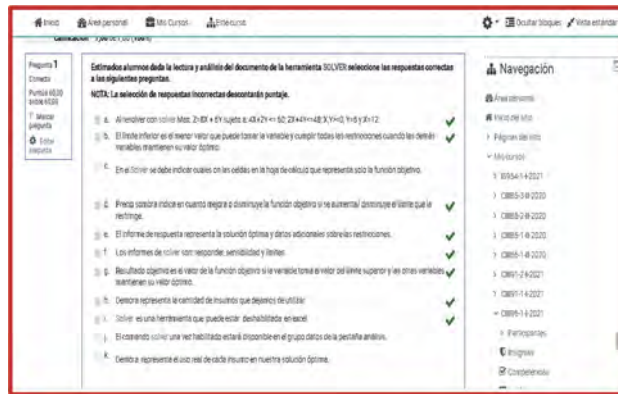


Figure 11. Solver evaluation in Moodle

The evaluation consists of conceptual questions and multiple-choice exercises, to be performed individually in a period of one and a half hours, from 8:30 to 10:00 a.m.

Once the crossword puzzle and workshop activities have been completed and internalized in the Moodle platform and escape room, the next step is the development of an operations research workshop using Solver, which must be solved by the students; the link indicated will allow seeing it: <https://bit.ly/3thWpB3>, as shown in Figure 12 and 13.



Figure 12. Moodle workshop on Operational Solver research exercise

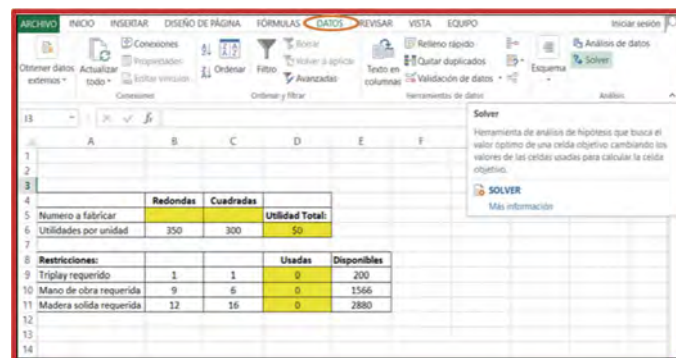


Figure 13. Solver Exercise



### 2.3. Project Evaluation

The objective of this part of the subject is for students to be able to carry out a cash flow study that represents the cash inflows and outflows generated by a project, investment or any economic activity, as well as the difference between the collections and payments made by a company in a given period. A user's manual containing the main elements of the preparation of a cash flow, both pure and financed, and the techniques of project evaluation NPV, IRR, etc., will be provided, for this, they will receive a manual to work with a puzzle as a team, the material is placed on the Teams platform, the activity lasts the 90 minutes of class in order to reinforce the concepts as shown in Figure 14.

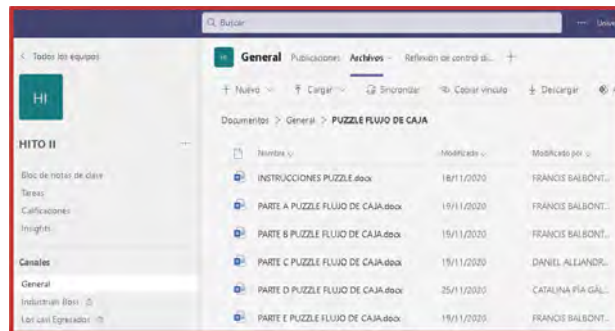


Figure 14. Cash Flow Puzzle

To access the manual you can access the following link: <https://bit.ly/3hrRgkq>.

Subsequently, an individual concept map is made, an activity in which the cash flow theme is analyzed and developed (Figure 15), in order to make a concept map video using Mindmeister. In the following link, you can watch one of the presentations of one of the students of the course: <https://bit.ly/3C3M5kk>.

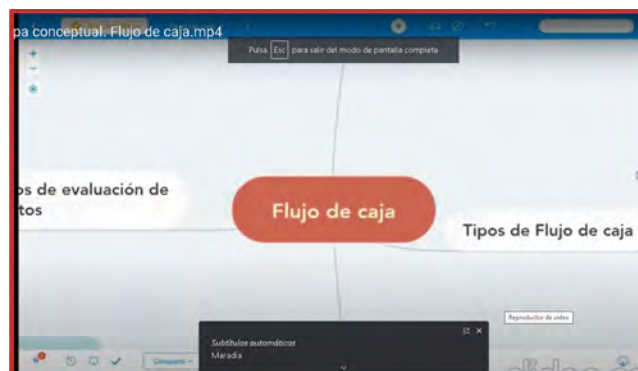


Figure 15. Cash Flow Conceptual Map

The last activity that students should develop as reinforcement of project evaluation is a cash flow exercise to be done in teams, which should be uploaded to the Moodle platform, as shown in Figure 16.



Figure 16. Cash Flow Exercise

In QR code you can find the workshop, as shown in Figure 17.



Figure 17. Workshop scanner

In the following link, you will find the result of the workshop: <https://bit.ly/3Hvoaer>.

## 2.4. Integrated Exercises

Once developed and learned the points of Operational research by applying Solver and project evaluation through Excel, the disciplines will be integrated through problems that should be analyzed as a team in order to simulate difficulties that could be faced in their professional practice, for this it is required to apply the skills acquired throughout the career, students will perform a puzzle activity with the Genially application, as shown in Figure 19.

In the following QR code you can see the solution to one of the integrated exercises, as shown in Figure 18.



Figure 18. Integrated exercise solution



Figure 19. Integrated Exercises

In the following link, you can access the exercise: <https://bit.ly/3K0Qffm>.

## 2.5. Final Project

Finally, the work teams that have been developing the different previous stages planned throughout the semester, must develop a real case by applying the knowledge acquired up to the ninth semester of the course to solve the problem, the structure of the report must contain: Definition of the problem, analysis of the literature review, project objectives (general and specific), scopes or scope of the project, methodological proposal, chronogram, bibliography, as shown in Figure 20.

The team's proposal to address the problem presented by the "Green Plastic" project of the Industrial Engineering Department of the Universidad de Antofagasta, whose requirement is to design a new plant to process PET1 plastic, which is used to generate plastic filament for 3D printers. It was delivered within the required deadlines, and the skills acquired in the subjects of operations research, Industrial Engineering and financial management were used, achieving the goal set.

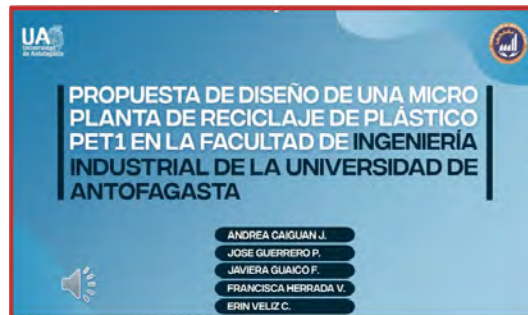


Figure 20. Final Projects (<https://bit.ly/3BZOxT>)

## 3. Presentation of Results

Regarding phase 1 diagnostic evaluation, the teams are asked to reflect and write down in one note their appraisals about the diagnosis, in general terms, the students have the following opinion:

*"We found the methodology of the activity interesting, didactic and innovative. Having to solve a problem to escape from the room makes us think about how to work and react to complex situations as a team, applying the knowledge we have acquired throughout the course."*

**The easiest part of the activity:** *the first part of the activity was less complex, since the knowledge in the area of operations research and optimization problems is solid at the team level, considering that we have recently taken courses where this knowledge is applied, which were much more present in our memory, therefore, it took us less time to solve the exercise. On the other hand, teamwork was easy for us, since we reacted immediately to the activities to be performed by each of the members, where we were able to delegate and prioritize tasks correctly to meet the objective of the diagnostic challenge, in addition to the communication and provision of information by the team members.*

**The most complex part of the activity:** *The second part of the evaluation, corresponding to cash flow, was more difficult since it required a more complex level of analysis and the knowledge in this area was not so strong at the team level, where the reactivation of the knowledge acquired in previous subjects was more complex. This may be because the subject referring to cash flow was taught several semesters ago and there was no reinforcement of it in recent subjects, so as a team we had to review and therefore, we had to invest more time to solve the problem, compared to the first exercise."*

From the reflection presented by the team, it can be seen that the experience was motivating for them, which is one of the objectives set and informs us that we should carry out remedial in project evaluation.

In phase 2, the students study the manual of the Solver tool that will allow them to develop linear programming exercises with more variables, different activities were carried out that allow us to give them feedback for its application, of the activities evaluated individually one is a control in Moodle (Figure 21), and a workshop with excellent results (graph 2), the average grades are very good considering not having used the tool before, these are a 7 and 6.6 respectively, on a scale where 7 is the maximum grade.

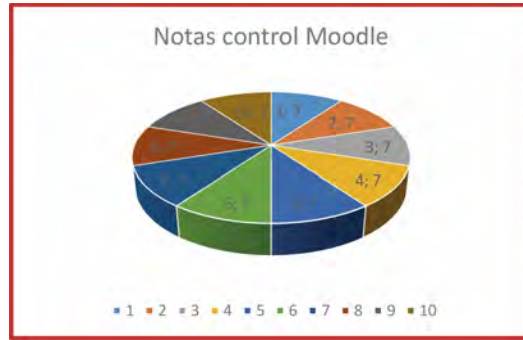


Figure 21. Moodle control grades (Where 1;7 stands for Student; Grade)

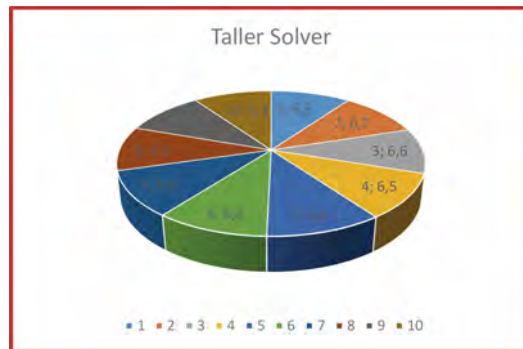


Figure 22. Solver workshop grades (Where 1; 6,7 means Student; Grade)

Regarding phase 3 project evaluation, in general terms, in the course, there were doubts in the completion of the exercises, since the students did not remember the sequence of the preparation of a cash flow, in its different formats, i.e., pure (with financing by the investor) or financed (with the participation of a third party as a financier, for example, a bank). To this end, they were given feedback reminding them of how cash flow was carried out and reviewing some concepts such as project evaluation techniques, among others. Finally, the students were able to correctly perform the exercises and activities related to the subject of project evaluation, this was measured and therefore, from the analysis of the individual workshop data, very good evaluations were obtained, with an average grade of 6.6 on a scale where the maximum grade is 7, as shown in Figure 23.



Figure 23. Project evaluation workshop grades of the 10 students (Where 1;6,6 means Student; Grade)

In phase 4 integrated evaluation, the students faced exercises that simulated problems that they could face in their professional life, these were analyzed in teams, and it was observed that it was not easy for them to develop these exercises, requiring support from the academics. For the students it was a first approach to what they could face in the work environment and even when they said that it was a complex activity, they were grateful for the instance of being able to apply the tools seen in the career until that semester, and to

know how they can be integrated for problem solving. The grades for one of these exercises in one team are 4.3 and the other 4.6.

Historically, mathematical modelling is one of the most difficult parts for students to understand the problem itself and translate it into a mathematical expression. In most cases, this is a problem of reading comprehension.

Finally, in phase 5 students developed a real case proposed by them, this was worked in a team, being one of the requirements to use different knowledge acquired through the curriculum of the career to solving the problem addressed, it is worth mentioning that this activity showed the academics pleasing results on how they managed to develop and show both teamwork and the correct application of the instruments acquired until the ninth semester, obtaining good grades. The grades of the project report, average of workshops are shown in Table 1 of the grades records of the Universidad de Antofagasta system:

RUT	Project report	Workshops	Presentation grades	Test 1	Test 2	Theory attendance	Final grade
19.320.689-1	6.5	6.2	6.3			100%	6.3
19.444.603-9	6.5	5.5	5.9			90%	5.9
18.054.642-1	6.5	6.5	6.3			100%	6.3
19.397.907-6	6.5	6.5	6.3			90%	6.3
19.565.194-9	6.5	6.5	6.3			100%	6.3
19.441.081-6	6.5	5.6	6.0			90%	6.0
19.098.522-9	6.5	5.6	6.0			90%	6.0
19.396.032-4	6.5	5.5	5.9			90%	5.9
19.180.766-9	6.5	5.6	6.0			90%	6.0
19.396.170-3	6.5	6.2	6.3			90%	6.3

Table 1. Record of grades (Grades system Universidad de Antofagasta)

#### 4. Satisfaction Evaluation

A student survey is conducted at the end of the course, the opinions and perceptions will allow us to make improvements in the course, all the students participated. Tables 2 and 3 contain the results of the survey.

Item	Completely disagree	Disagree	Agree	Completely agree
Tests and assignments reflect important aspects of their training			50%	50%
The subject presents clear objectives to be reached			70%	30%
The manuals and instructions provided in the course are clear and allow the development of digital technology tools			40%	60%
The activities done have improved general preparation in aspects such as oral and written expression, teamwork, use and processing of information, critical capacity			30%	70%
The course material is well prepared and helpful for learning			50%	50%
The subject has helped me to complete my professional training		10%	40%	50%
The evaluation criteria of the course are clearly defined		10%	50%	40%
The subject fully meets my expectations		10%	60%	30%

Table 2. Survey related to the subject matter

Item	Completely disagree	Disagree	Agree	Completely agree
The teacher demonstrates mastery of the contents covered in the subject			20%	80%
The teacher expresses him/herself clearly in his/her explanations and/or expressions			40%	60%
Responds clearly to doubts and/or queries raised by students			40%	60%
The way the professor teaches the classes motivates the student to attend the subject		10%	50%	40%
Uses methodologies to actively engage students in learning			40%	60%
Adequately meets deadlines for delivery of tests and/or results		20%	70%	10%
Employs a passive role in teaching, which is what the subject is aimed at		10%	60%	30%
Student participation is encouraged in the delivery of opinions and points of view in the different activities			40%	60%
The teacher is best suited to teach the subject.			40%	60%

Table 3. Teacher survey

The survey consists of two parts: firstly, questions referring to the course, where only one student thinks that the course has not helped him to complete his professional training, that there is no clarity in the evaluation criteria and that the course does not meet his expectations. As a whole, the students think that the assignments and evaluations are important for their training, the clarity of the objectives, the manuals provided are clear and allow the development of digital technology tools and they consider that both the material and the activities developed in the course were useful for their learning.

Regarding the second part of the survey, which is related to the evaluation of the academics who taught the subject, in general terms, the students are satisfied with the service provided in terms of mastery of the topics addressed, clarity in the feedback, in agreement with the learning methodologies used, and that the academics are adequate to teach the subject, except for two students who consider that the deadlines for the delivery of tests results were not timely, and one student believes that the didactic means did not facilitate learning and he was not motivated by them.

The following link will allow access to see the student survey: <https://bit.ly/3stqK0a>.

## 5. Conclusions

In this document, planning of an innovative proposal of a methodological change in an integral subject is carried out, where the results of implementation with a small sample are encouraging to continue with the proposed change, analyzing a larger sample and assessing the possible relevant modifications for improvement. It will be relevant to carry out a quantitative and/or qualitative study on the causal attribution made by the students regarding their competence development; as well as a study on the degree to which continuity in following courses and/or in different subjects generates improvements.

The objectives were achieved since it was observed that the students were motivated by the different gamification activities carried out in the course, we feel that this was a great achievement given the conditions in which we worked, since due to agreements between the students and the directors of the University, pacts were made to work in pandemic with cameras turned off so as not to violate the privacy of the students, which has meant in other subjects having to teach the classes without knowing if the students are actually paying attention, in addition to the fact that they are not obliged to attend the classes and the academics have to record them; all of the above was corrected thanks to the activities carried out and the motivation of the students.

The students expressed the importance of the integration of the subjects and valued the tools seen in class and their usefulness for their professional development.

Since the subject is taught for the first time this semester, we faced the inconvenience of having started it late, which required rescheduling the activities. Therefore, the delay in the implementation of it in the Moodle platform, the official site of the online academic activities, including the evaluations made by the students. This was evident in the results of the student surveys.

It should be noted that even though the subject was designed to be taught in person, it was adapted and managed to be done online, with all the difficulties that the pandemic has meant, the students were able to integrate the skills and knowledge acquired during the course of the career, in real problems, performing analysis and finding the best alternative solutions for decision making.

For the academics who taught this subject, the students' comments on the course were satisfactory, highlighting in the survey the teachers' mastery of the topics covered.

A work team is made up of people with different skills, who make relevant contributions to achieve the objectives that are set. At the beginning of the subject, some students took an individualistic attitude, this means a lack of commitment to the work team, which hinders learning, so a change of vision should be made, allowing to move from a personal approach to a group approach. However, the students generated a sense of ownership of the goals that the team established, understanding the importance of their contribution to the achievement of these goals.

Educational gamification can be a tool that allows the motivation of future professionals of the Civil Industrial Engineering career, thus improving academic performance.

The improvement points detected have implications for future teaching designs, as finding a way to implement a more technology-supported competency assessment remains a challenge for the future.

Pre- and post-test questionnaire. To have evaluation indicators. For example, in order to respond to the general objective defined, this project could evaluate the students' ability of learning to learn with the validated self-perception questionnaire Motivated Strategies for Learning Questionnaire (MSLQ), as a pre- and post-test, at the beginning and end of the course; from a positivist paradigm based on a hypothetical-deductive process.

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