The effect of problem-based learning supported on flipped classroom approach in the student´s learning of Economic Engineering course

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This dissertation is dedicated to my daughter María Camila for allowing me to know how a moment of happiness makes time stop, and Salvador De La Torre her father.

To my parents Blancamar y Rafael, my brothers Ricardo y Jorge, and my sister Diana for being an example of strength and hope.

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List of Abbreviations

ABET	Accreditation Board for Engineering and Technology Inc.
ASEE	American Society for Engineering Education
CFT	Theory of Cognitive Flexibility
FPBL	Problem-Based Learning support on Flipped Classroom
IBM	International Business Machines Corporation
MEN	Ministry of National Education of Colombia
PBL	Problem-Based Learning
Q1	Questionnaire 1
q1	question 1
Q2	Questionnaire 2
Q3	Questionnaire 3
RC	Recovery Capital
RQ1	Research Question 1
RQa	Secondary Research Question a
RQb	Secondary Research Question b
RQc	Secondary Research Question c
S1	Section 1
S2	Section 2
SPSS	Statistical Package for the Social Sciences
TBL	Team Based Learning
UNC	National University of Colombia

Summary

This dissertation presents the integration of the problem-based learning supported on flipped classroom approach FPBL in engineering education, in particular the design and intervention of this approach is carried out in the course of Economic Engineering of the National University of Colombia, the main objective is to determine the effect of problem-based learning supported on flipped classroom approach FPBL in the student's learning of Economic Engineering course. FPBL is a hybrid Problem Based Learning PBL model (Barrows H. S., 1986) whose framework is the PBL combined with Flipped Classroom learning approach. FPBL approach design is based on the principles of the problem-based learning approach Kolmos and De Graaff (De Graaff & Kolmos, 2003) and Flipped Classroom is used for the formulation and design of learning activities.

The design of learning activities is sustained in the Theory of Cognitive Flexibility, as well as relevant aspects for the formulation of real problems stated by Andrade and Coutinho (2016). The Research method is Mixed (Qualitative and Quantitative), the research design is quasi-experimental, the data collection technique used is the survey and the instruments for data collection are three questionnaires. This dissertation allows to recognize significant changes in the learning processes of students, both, at the level of knowledge of Economic Engineering, as well as in the perception of students regarding the development of their teamwork skills, self-directed learning. Also describe aspects relevant to the students' perception of the effectiveness of the teacher's role within the FPBL approach.

Key words: Problem-Based Learning PBL, Problem-Based Learning support on Flipped Classroom FPBL, Economic Engineering.

Introduction

This dissertation is motivated by the need for innovation in engineering education, in the need to strengthen the connection between learning and skills that students achieve during their academic training process, and the real problems that they will have to solve during their professional performance. Innovation requires that: the teaching and learning processes are focused on the student, real engineering problems are formulated, and situations based on the context are solved. On the other hand, self-directed learning and teamwork must be promoted and the role of the teacher facilitate the design of dynamic classes.

The implementation of the FPBL approach in the Economic Engineering course at the National University of Colombia is proposed as an initial change from a course whose methodology is based on lectures towards an innovative teaching-learning methodology. The PBL approach is used because the theories that support them, the principles and the teaching and learning strategies, give answers to the innovation needs for the Economic Engineering course, and the flipped classroom learning approach is used for the design of teaching and learning activities.

The problem-based learning approach PBL is mainly supported by the different learning theories: constructivism, humanistic sociology, experiential pedagogy, philosophy of science, cognitive psychology, as well as, the learning principles: Learning based on the formulation of a problem, Learning based on an activity, Interdisciplinary, Exemplariness (Popper, 1962) (Bechtel, Abrahamsen, & Graham, 2001) (Dewey, 1993) (Kolb, 1984) (Kolmos A. , 1996) (Schmidt, 1993). Learning based on group work it allows the student to achieve their learning objectives by solving real-life problems. It includes a series of teaching and learning strategies that facilitate collaborative and cooperative work among students (Kolmos A. , 2004). PBL facilitates the acquisition of knowledge and skills in Engineering students such as self-direction, collaboration, creativity and innovation, as it emphasizes students' independence and research skills, and focuses on students working in groups to find solutions to real-life problems. (El Mawas, Bradfor, Andrews, Pathak, & Mantean, 2018).

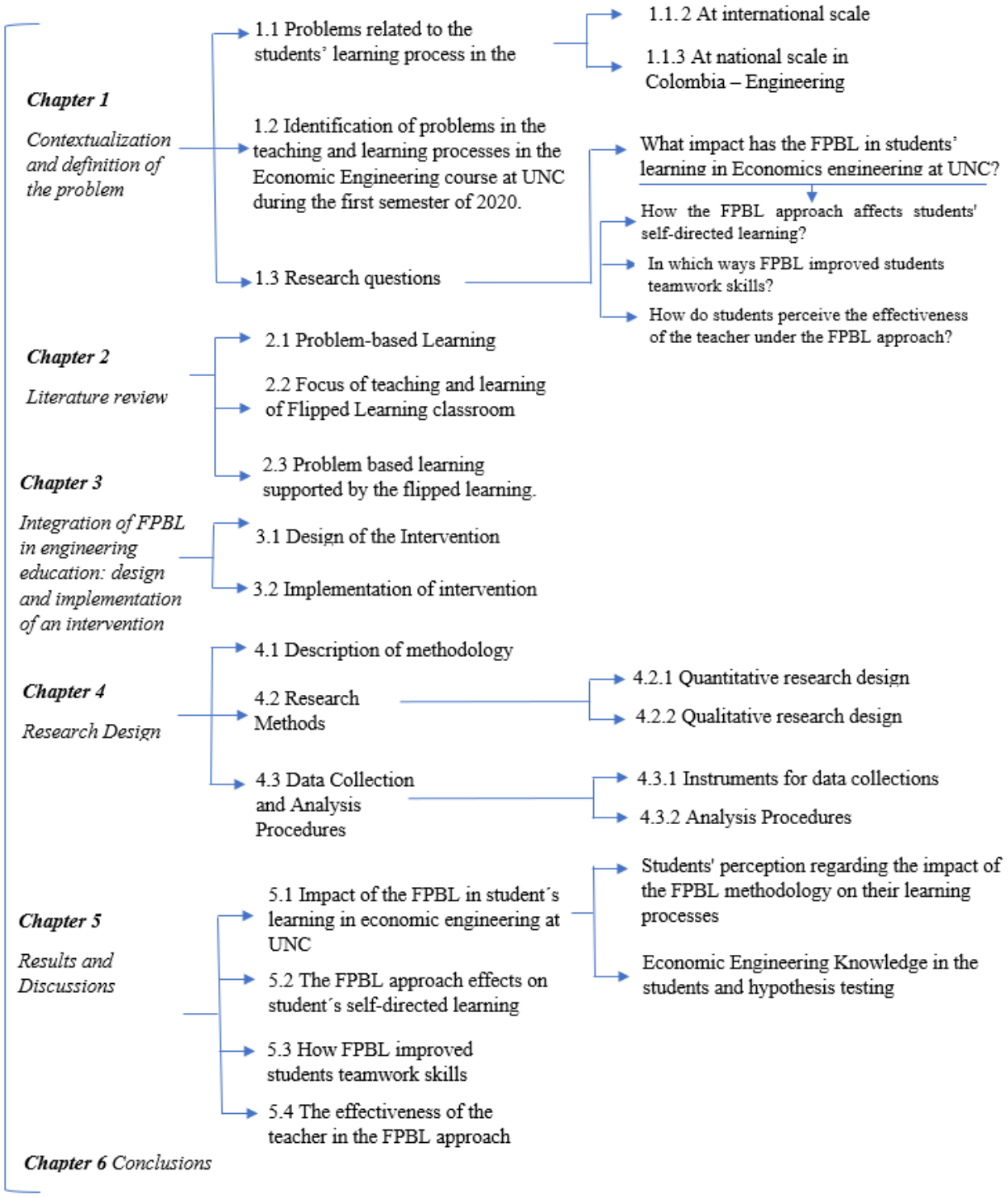
Flipped learning classroom refers to a learning model where learners study instructional material prior the physical and virtual class (such as readings of topics from the corresponding specific knowledge area of the course, videos, online lectures) and apply the knowledge acquired

out of class, through synchronous and asynchronous interaction using information and communication technology tools. Flipped learning classroom is a mean to increase the interaction and personalized contact time between teacher and students. It creates an environment where students assume the responsibility of their own learning process and generates a classroom where the teacher's role is the one of a guide and counselor; it is the combination of direct teaching and constructivist learning (Fonseca , Moura, & Fonseca, 2015).

The FPBL proposed in this dissertation incorporates these important aspects of problem-based learning, this dissertation incorporates teaching strategies based on authentic contexts, where the students' learning is based on the experience and in a specific domain (Bellan, French, & Ertmer, 2009). The PBL approach includes real life problems that have different limitations, perspectives, and alternative solutions (Lazonder, 2014), which give the student the opportunity to carry out a work of synthesis, analysis, formulation and design of alternatives to solve the problem. Regarding flipped learning this dissertation incorporate: i) identifying distance learning activities (virtual activities carried out by the student in different time from the class session) and ii) the definition of teaching and learning activities to be carried out during the virtual meeting between students and teachers, it means, the virtual class (it implies personalized attention by the teacher in his role as a counsellor towards students, analysis and discussion between groups of students about the work done in group) (Andrade & Continho, 2016).

In implementing this approach, real-life problems are assigned to the students to be solved, students are responsible for their own learning (self-directed learning), students work collaboratively in groups, the instructor acts as a facilitator, and students reflect upon the problem and the solution (Eseryel, Ifenthaler, & Ge, 2013) (Hung, Jonassen, & Liu, 2008) (Ertmer, 2005) (Ge & Land, 2003) (Barrows H. , 1996). This dissertation identifies the differential effects on students' learning by including characteristics of the FPBL's instructional design, such as collaborative work in large and small groups to carry out the formulation and solution of real-life problems, through prior reading of documents related to the topics, group tasks, lecture activities and the development of a final project. This dissertation is presented in five chapters as indicated in the following figure 1.

Figure 1. Content Scheme



1. Contextualization and definition of the problem

Three challenges are detected in the discipline of Economic Engineering, which are: 1) students learning and conceptualize the content of the course; 2) development of self-learning skills, and 3) development of teamwork skills. These three challenges are formulated from the identification of problems related to the learning process of students in economic engineering courses, both, internationally and at the National University of Colombia. The first challenge is established from the international study presented by Noble, Meyers and Schmahl (2000), the other two challenges from the resolutions issued by the MEN as results of the evaluation of the undergraduate engineering programs of the UNC (2021).

Literature shows that PBL and flipped classroom are suitable methodologies to address the aforementioned challenge. In one hand the FPBL approach is used to meet these challenges for the following reasons: PBL problem-based learning allows meaningful learning through which the student incorporates new knowledge and experiences to find a solution to real problems; it provides the student the possibility of organize and build their own learning process. Also, it is an approach that facilitates the process decision making, perform analysis and detect learning needs and objectives, develop self-learning skills, promote teamwork, and allow structuring of learning activities. teaching and learning within the main aspects. On the other, flipped learning is used to structure teaching and learning activities, mainly because this theory takes into account the work rhythms of students, the selection of resources and tools so that they are available at any time for students, promotes interaction between students for problem solving.

This chapter elaborates on the challenges observed in the discipline of economic engineering at an international and national context (sub-chapter 1.1). Based on discussion of such challenges, a problem is identified and argued for (sub-chapter 1.2) leading to the formulation of four research questions (sub-chapter 1.3).

1.1 Problems related to the students' learning process in the Economics Engineering Course

From the review of literature related to the identification of problems that arise in the teaching and learning processes of the economic engineering course, the most relevant aspects

mentioned by the authors of international scale in the conferences of the American Society for Engineering Education ASEE are described. On the other hand, at national scale, in the economic engineering course of the Faculty of Engineering of the UNC the identification of problems is carried out based on the results of the teacher performance perception survey that students responded to in the "Edificando" system Annex 1 (UNC, 2021).

1.1.1 At international scale

The first challenge that is formulated is that students can learn and conceptualize the content of the course, this challenge is associated with a first problem that consists in that the guide texts of Economic Engineering focus more on the formulation of problems with emphasis on the economic component with respect to the Engineering component and the lack of implementation of a teaching-learning approach that involves active learning.

The foregoing is supported by the review of the following international topics. Economic engineering addresses specific issues of economics and calculations and principles, from engineering perspective. This area of knowledge is required for the projection and execution of engineering projects. In the United States, engineering schools have integrated courses in engineering economics for their students, the purpose of which is that students at the end of the course obtain knowledge and skills to optimize profits, minimize costs, analyze various scenarios, predict fluctuations in economic cycles, among other aspects. The course offered is called economic engineering (Zoghi, 2015).

According to the results of a survey applied to collect data on the ways and means in which the economics of engineering is taught in universities in the United States, it is indicated that despite the importance of the economic engineering course, universities were not able to effectively teach economic engineering concepts to students in ways they could understand. Also, "IE faculty do not incorporate some of the more popular active learning techniques (see Smith, 1989) such as groups and case studies into their engineering economy course as frequently as compared to Non-IE faculty.". (Umphred, Needy, & Lavelle, 1997).

In a study carried out to classify the problems that are included in the final chapters of three reference texts of economic engineering in relation to the level and type of engineering content, namely Economic Analysis written by Newnan and Lavelle (Newnan & Lavelle, Engineering

Economic Analysis, 1998) , Engineering Economy written by Degarmo, Sullivan, and Bontadelli (Sullivan, Wicks, & Bontadelli, Engineering Economy, 1999), and Engineering Economy, written by Blank and Tarquin (Blank & Tarquin, 1998) cited in (Noble, Meyers, & Schmahl, 2000), it was established that the problems related to decision-making in engineering projects are fewer, in number, than the problems related to the area of economics.

The above is due to the lack of intervention of Engineers in the formulation of engineering problems, so that these problems are included in the texts of Economic Engineering. In this sense, it could be stated that it is necessary the formulation of real-life problems of engineering projects to be included in the courses. Literally in the study it is stated that "Engineering economics courses should provide an approach to engineering decisions more than what is emphasized in the texts" (Noble, Meyers, & Schmahl, 2000) this quote is reaffirmed by several publications of the Division of Engineering Economics in the ASEE National Conference. (Hartman, 1998) (Wells, 1998) (Mallik & Sarin, 1996).

On the other hand, it is mentioned that the historical trend and the texts of the Economic Engineering course did not vary much from 1975 to 2002. It was established that there were some minor changes in books related to the order and combination of the chapters, which is evident in relation to the slow development of the course from the 70s to the 90s. (Eschenbach, 2002). Esto implica que no se ha realizado una actualización del contenido de los textos relacionado con problemas reales de la actualidad.

ABET's approach for the 2000s included aspects in engineering education such as continuous improvement, customer engagement, and measurement of achievement, which could strengthen engineering economics, accounting, and cost estimation. In this vein, it was projected that for the 2020 economic engineering course, it would include aspects such as: distance education, asynchronous work related to the topics of financial mathematics, with generation of problems, solution and correction of errors, face-to-face classes on campus, as well as off-campus asynchronous delivery, texts in CDs or web support. (Eschenbach, 2002).

A recent study related to the application of the PBL, indicates that maintaining high levels of participation and the interest of students is a challenge for the economic engineering course. To address this challenge, the Baylor Engineering School of Computer Science designed a series of homework directed to students, which were supported by problem-based learning methodology

that obtained good results based on student engagement measured by class attendance, completion rate of the tasks and statistics of the evaluation of the course (Donndelinger, 2019).

1.1.2 At national scale in Colombia – Engineering Faculty of the National University of Colombia

The National University of Colombia establishes academic excellence as one of its principles; this principle indicates that "academic processes will be developed within the highest quality parameters, and with pedagogical models, methods and methodologies that contribute and facilitate training in the undergraduate and graduate professions and disciplines The academic community will incorporate the advances in teaching into its work and will strive for the permanent improvement of the training given at the University" (UNC, 2005).

Economic engineering has its origin in the need to create engineering projects that have high profitability, in which strong quality work is carried out, but at the same time costs are reduced. In Colombia, the first training program in engineering to include aspects related to this area of knowledge was the civil engineering program of the school of mines in Medellín in 1911. Since the creation of the undergraduate program, it was desired that the study plan could be dynamic and adapted to the needs of that time, such as the construction of roads and rail lines in the department of Antioquia. Given the importance of this subject, it was considered that it should be included within the foundation component of the study plans of the Faculty of Engineering of the National University of Colombia, keeping as a reference the study texts written by Newnan, Eschenbach and Lavelle (Newnan, Eschbach, & Lavelle, Engineering Economic Analysis, 2004); Degarmo, Sullivan, and Bontadelli y Blank (Sullivan, Wicks, & Koelling, Engineering Economy, 2020) and Tarquin (Blank & Tarquin, 2002).

According to the reports of the Academic Information System DININFO of the National University of Colombia, in the last three years 2017-2019 in the Faculty of Engineering of the Bogota campus, 2,790 students enrolled in the economic engineering course. All the programs have the course as compulsory (UNCa, 2021).

As a result of the evaluation process carried out by the Ministry of National Education MEN to the Engineering programs, this entity issues a series of recommendations related to the weaknesses that appear in each of the undergraduate and graduate programs, so that the UNC

executes improvement actions, once these documents were reviewed, an important challenge was identified which corresponds to the implementation of innovative teaching-learning methodologies, since the traditional teaching approach still predominates at the UNC. (UNCb, 2021)

1.2 Identification of problems in the teaching and learning processes in the Economic Engineering course at UNC during the first semester of 2020

As a result of the perception survey of teaching performance directed at UNC students in the "Edificando" system for the Economic Engineering course of the first semester of 2020 Annex 1 (UNC, 2021), it is evident that there are difficulties related to: i) activities that facilitate students to find connections of the topics covered with other contexts or contents of their study plans. ii) Lack of motivation in students to promote critical argumentation and interest in the topics addressed in the course content. iii) The allocation of time or adaptation of activities to provide advice with the purpose of solving doubts. iv) Absence of a plan to change or modify teaching methods according to the learning needs of students.

Therefore, the challenge at the level of the Economic Engineering course is the adoption of a teaching and learning approach whose framework facilitates the design of teaching-learning activities so that students improve the learning process and develop self-directed learning and teamwork skills.

1.3 Research questions

To face the challenges required to improve education in Economic Engineering at the national university, the FPBL approach implementation is proposed. because it includes problem-based learning, self-directed learning, teamwork, also the teacher has an important role as a guide in the student's learning process. This approach uses the flipped classroom for the design and implementation of teaching-learning activities. Consequently, it is necessary to determine the impact of implementing the FPBL approach and identify the changes associated with the learning that students are intended to achieve during the course. For this, the following research questions are formulated.

RQ1 What impact has the FPBL in students' learning in Economics engineering at UNC?

RQa. How the FPBL approach affects students' self-directed learning?

RQb. In which ways FPBL improved students' teamwork skills?

RQc. How do students perceive the effectiveness of the teacher under the FPBL approach?

Synthesis

This chapter identifies an educational problem in the discipline of economic engineering. The problem is defined based on challenges reported at international level (Hartman, 1998) (Noble, Meyers, & Schmahl, 2000) (Umphred, Needy, & Lavelle, 1997) (Zoghi, 2015) and national level (UNC, 2021) (UNCb, 2021), which relate with students' difficulties in conceptualizing the discipline content, the development of self-directed learning and teamwork skills. Based on these the following research questions are formulated: What impact has the FPBL in students' learning in Economics engineering at UNC?, How the FPBL approach affects students' self-directed learning?, In which ways FPBL improved students' teamwork skills?, And How do students perceive the effectiveness of the teacher under the FPBL approach?.

2 Literature review

This chapter presents the state of the art regarding Problem-based Learning PBL, flipped classroom, and include the Comparison between the traditional learning approach and flipped classroom, through a literature review. Additionally, the chapter also provides an overview of pedagogical theories and frameworks to design a FPBL intervention to address the challenges identified for the economic engineering course.

2.1 Problem-based Learning PBL

PBL is defined through its learning principles, which are: Problem-based learning, this means that learning is organized around problems. Self-directed learning indicates ownership of the learning process and especially the formulation of the problem. Experience learning in which promotes the students' motivation and comprehension. Activity-based learning, Interdisciplinary learning relates to the dimension of knowledge as the solution to the problem formulation, Exemplary practice this principle bridges the gap between the acquisition of theoretical knowledge and professional skills., where the students learn to relate the concrete or empirical experience with the theoretical one., and Group-based learning is presented here as the last principle by which most learning processes take place in groups and teams. (Kolmos, Flemming K, & Long, 2006).

PBL allows students to acquire knowledge and key skills through the development of projects that respond to real-life problems. The objective of this approach is to promote autonomy in students, so that each of them is the protagonist of their own learning process. Within the framework of this approach, students plan, structure, execute and present a project that answers the main research question which solves a real problem. Teachers play a facilitator role and have the responsibility to guide and support students throughout the entire project. PBL didactics defines different steps in the learning process. McMasters' original approach established a three-step model. Later, the term "Seven Jump" has been coined to indicate an extended process model developed at the University of Maastricht. This term has gained much interest and widespread use (Albanese & Mitchell, 1993) (Boud & Feletti, 1997).

Maastricht's approach begins with the presentation of the case. The PBL process, then, follows seven steps: (1) clarification of terms and concepts, (2) definition of the problem, (3)

analysis and compilation of the problem, (4) construction of a systematic inventory of ideas, (5) formulation of the learning objectives, (6) self-directed study and (7) synthesis and discussion (Schmidt, Problem-based learning: rationale and description, 1983). PBL is based on working in small groups of students guided by a tutor. Steps 1 to 5 are carried out during a first meeting of a group of students and their tutor. After a few days of self-directed study, the group of students and the teacher meet again for a presentation and final discussion. Students decide what information is needed and what learning objectives are important in understanding and solving the problem. Therefore, PBL strengthens the ability to acquire facts and use these facts to solve problems (Barrows & Tamblyn, 1980). Students are in an active environment (Schmidt, Problem-based learning: rationale and description, 1983) (Hoffman & Ritchie, 1997), where they need to identify problems and problem-solving skills on their own, allowing them to acquire skills and dispositions for lifelong learning (Hoffman & Ritchie, 1997).

According to Kolmos and De Graaff (De Graaff & Kolmos, 2003), PBL learning principles that are used in different studies are: Problem-based learning, as the beginning of the learning process. The learning process is led by participants because students are the owners of their learning, that is, learning is centered on the student, in experiencing learning because students use their own experiences and specific and particular interests. Learning is based in activities because this approach requires them to investigate, make decisions and write about them. The interdisciplinary learning, learning through exemplary practice so that the results show the benefits of solving a specific problem and group learning considering that students learn in groups. The following elements are considered as key benefits of PBL: it stimulates students to solve realistic problems, to work cooperatively, to activate higher cognitive levels, and to organize their own learning process.

2.2 Focus of teaching and learning of Flipped Learning classroom

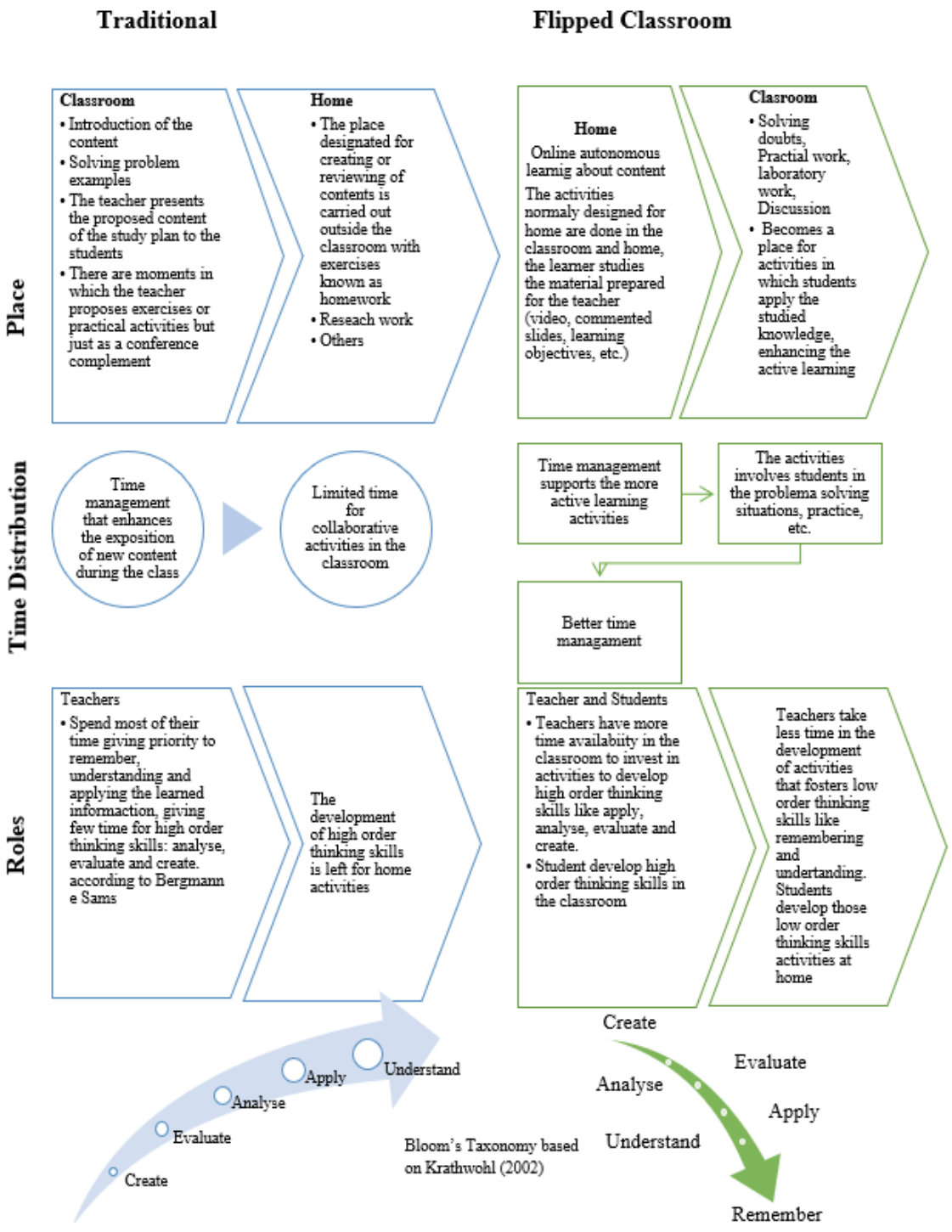
The university teaching approach of flipped learning class receives this name because it reverses the traditional higher education learning sequence of teaching, study and evaluation, by the study sequence (self, per, hetero), evaluation and teaching. It involves an intentional displacement outside the classroom of certain parts of the subject's content. (Iborra, Ramirez, Badia, Bringué, & Tejeiro, 2017). Through guided activities and certain technological resources,

which are transferred outside the classroom with the purpose of freeing class time in which the presence of the teacher is required to facilitate the learning process. Some of the activities correspond to: validation of learning, correction or specification or deepening of the understandings that students have obtained from the previous study activity, the promotion of soft skills and superior thinking, or the transfer and application of the contents to situations similar to professional practice. This approach seeks to maximize the understanding of the concepts and theories on the disciplinary areas, applied to specific problems and not memorization, under a flexible learning environment (Iborra, Ramirez, Badia, Bringué, & Tejeiro, 2017).

Through collaborative activities, the reflection, analysis and discussions are developed by the student. This methodology is consistent with what is established at the institutional level at the National University of Colombia based on the time allocated for the student's autonomous learning. This approach has three elements that can be focused on: Peer Instruction, that consists of preparing the student to learn outside of class, doing pre-class readings and answering questions about the readings using the method (Manzur, 1997) Just in Time Teaching which consists of the feedback between classroom activities and the work that students do in their time outside the classroom in order to maximize the learning process in the classroom, improve student motivation and facilitate the teacher to properly manage the class. (Cashman & Eschenbach, 2003) and Team Based Learning TBL el cual se basa en la interacción de los estudiantes en grupos pequeños, los estudiantes realizan actividades diseñadas para mejorar su capacidad de estudio, un periodo de tiempo de la clase es asignado para el desarrollo de la actividad y promover el desarrollo de aprendizajes autogestionados (Michaelsen & Sweet, 2008) (Robinson & Franchini, 2014).

Under this approach, the university professors have the role of facilitator of student learning. He defines study activities that are relevant for the student and he is a manager of study activities According to Andrade and Coutinho (2012), some of the flipped learning classroom characteristics are: greater interaction and personalized contact time between students and teachers, autonomous learning, the teacher is the "counsellor", absent students are not left behind, the content of the class is permanently stored for review or correction. Andrade and Coutinho point out that the flipped classroom implies a series of “investments”: investments of place, time, roles, and learning objectives. Which are shown in Figure 2 .

Figure 2. Comparison between the traditional learning approach and flipped classroom.



Schneider, Suhr, Rolon and Almeida (2013) propose a flipped classroom model aimed at distance education. They use the inverted Bloom Taxonomy to guide the structure of the model that points to an organization of education in time and place, seeking a greater role for the student. Some assumptions of the model are student-centered learning; access to knowledge and technologies through physical and digital means; the student must develop self-study and autonomy in the construction of knowledge; the teaching and learning strategies are oriented to the acquisition and creation of knowledge; the didactic sequences of activities presented in both the classroom and at a distance learning. On the other hand, problem-based learning didactics places the student at the center of learning process so that they can solve problems autonomously.

The taxonomy of Educational Objectives was proposed by Bloom and later revised by Krathwohl et al (Krathwohl, 2002). It has six categories: knowledge, understanding, applying, analysis, synthesis, and evaluation. All categories have subcategories, except for evaluation, and are organized hierarchically and cumulatively. To master one of these levels, it is necessary to have mastered the previous levels. According to the latest revision of the taxonomy by Krathwohl (Krathwohl, 2002) through which he adjusts nouns to verbs, the categories are: remember, understand, apply, analyze, evaluate and create.

Assumptions of the flipped learning classroom model are student-centered learning, access to knowledge and technologies through digital means, the student must develop self-study and autonomy in the construction of knowledge, teaching and learning strategies are oriented to acquisition and creation of knowledge and there must be a didactic sequence of activities presented in both class and at home. (Andrade & Continho, 2016). Andrade and Coutinho propose a flipped learning classroom model based on the theory of cognitive flexibility CFT which purpose is that the student can acquire an advanced level of knowledge in poorly structured domains and facilitate the transfer of knowledge to new situations. The characteristic of a poorly structured domain is that there are no general rules that apply to all cases (problems or situations), each case has its hierarchical conceptual framework, and the use of prototypes induces errors, the meaning of the concepts depends on the context and what makes this particular cases is the relationships between the various concepts involved.

The approach taken by CFT is focused on the case. Each case should be made up of mini cases that will be analyzed according to different topics, principles, concepts, points of view or

perspectives. This process of analysis is called deconstruction. Another process of extreme importance in the theory is the predefined topic crossovers. Each crossing of topic presents a topics or combination of topics for the mini cases of different cases so that the learner understands that the same topic can be present in very different situations. The processes to develop cognitive flexibility while learning a particular topic are deconstruction of mini cases through different points of view and establishing relationships between mini cases of different cases (topic crossovers).

As the flipped learning classroom is based on the interaction between distance and face-to-face activities, the processes recommended by CFT are divided into activities outside the classroom (online) and in the classroom (face-to-face), through chats, forums, questionnaires and others. it can keep the student more active (Andrade & Continho, 2016). Within the framework of this methodology, there are two moments: "Distance" moments and "Face to face" moments. In the first moment, the steps that are carried out are: Step: 1. Students reading of the cases, mini cases and topics provided by the teacher. 2. Instruct the students to carry out the deconstructions of mini cases according to topics. Sharing tools such as Google Drive or OneDrive are used. It is important that the teachers have record of the thematic comments of the students to identify their difficulties and better plan the activities.

In the second moment, the following phases are executed: collective discussion of the deconstructions and development of "topic comments" from the discussion, topic crossings and creation of new cases: in the form of questions, challenges, problems and other active learning activities for students to analyze, implement and evaluate the issues through the various mini cases and discussion and elaboration of topic consensus comments (Andrade & Continho, 2016).

On the other hand, a study carried out by VanWyk (Van Wyk, 2018) shows how a change was made in economics class, in a teacher training course, and it shows an exploration of the performance of future teachers using flipped learning classroom pedagogy in the University of South Africa. The main results reported are that the group of students that used the flipped learning classroom approach surpassed the group of direct institution (direct instruction). In final exam scores, better performance and perceptions were observed of economics students, and the interaction and collaboration between students and teachers was fostered. It was established that the role of the teacher is crucial for optimal student learning, and it is stated the possible use of the

flipped learning classroom approach as an alternative assessment strategy in higher educational institutions; specifically, in teacher training programs (Van Wyk, 2018). The model proposed by Lo and Hew (Lo & Hew, 2017), is included by VanWyk (Van Wyk, 2018) as a global framework in their study, to understand how the flipped learning classroom approach is used in distance education. This model is supported on the premise that the flipped classroom environment is an approach that facilitates teaching and learning in environments in which students and teachers are physically and socially distanced (Long, 1998).

The model has two phases: phase one: Classroom learning tasks (demonstration and application) this phase includes three steps: 1) Start by providing a topic for active discussion, 2) Demonstrate how to use knowledge and skills, and 3) apply the knowledge and skills acquired in the tasks. Phase two corresponds to the execution of learning tasks outside of class (problem solving and critical thinking) and includes the following steps 4) Activate through an active discussion of the topic during the session outside of class. 5) Apply the knowledge and skills acquired in tasks individually or in groups for class sessions and 6) Integrate the application of the knowledge and skills learned in the learning unit, either individually or in groups (Van Wyk, 2018).

2.3 Problem based learning supported by the flipped learning

According to Barrow's taxonomy (1986) one of the six PBL models is the Hybrid PBL, this model is characterized by:

i). The format is pure PBL supplemented with a few lectures. ii) Regarding PBL processes: the problem-solving reasoning led by the learner, the content knowledge acquisition is learning self-acquired with minimal assistance from the instructor on integration of content knowledge, the timing of knowledge acquisition and application is simultaneously, the problem-solving process is an inquiry process, the content contextualization is very high. iii) The problem characteristics is Highly ill-structured. iv) The Impact on learning outcomes (theoretically) related to la efficiency of content knowledge acquisition/coverage is medium to high, knowledge application and transfer, problem-solving and reasoning skills, Self-directed learning skills, and ability to cope with uncertainty are very high (Hung W. , 2011).

According to Tawfik and Lilly (Tawfik & Lilly, 2015) to meet the main objective of education is increasingly relevant for managers and teachers in universities. This main objective is to prepare students to build solutions by carrying out practices, challenges, limitations and perspectives that are found outside of academic spaces knowing that those are the ones they will face in their professional lives; allowing them to participate actively in obtaining their own knowledge.

To meet this objective, the principle of self-learning plays a relevant role. One of the alternatives in the generation of this self-directed learning is the creation of new spaces and approaches that are based on the use of digital technologies. As is the case of the "Flipped Learning classroom" as mentioned by Davies et al (Davies, Dean, & Ball, 2013), this is a model that uses videos and multimedia resources, based on the belief that these effectively replace the assignments that may be left in class, since they become a way to reinforce self-directed learning and a way for students to acquire what is necessary to solve real-life problems.

Tawfik and Lilly (2015) conducted a study to understand how the flipped learning classroom intervened in student learning process in a 16-week psychological statistics course supported by problem-based learning PBL for example Lazonder (2014) ensure that knowledge is better obtained through experience since, it motivates students to carry out independent investigations.

This allows them to have different perspectives on the problem to be solved; thus, positioning the PBL methodology in one of the most brilliant ones in regard to the management of poorly structured problems, autonomous learning and the problem-solution reflections that may arise in each of the students when it is applied (Tawfik & Lilly, 2015). Specifically, the flipped learning approach, as mentioned above, allows the classroom to be an efficient place of knowledge. It seeks to encourage students to find their own learning pace and prevents the learning process to only take place inside the classroom. This approach helps replacing the assignments with online videos tasks and helps devoting class time to problem solving. This method is also advantageous because it allows students to access the videos and they have interacted with the material, generating engagement and motivation as mentioned by Davies et al. (Davies, Dean, & Ball, 2013).

3 Integration of FPBL in engineering education: design and implementation of an intervention

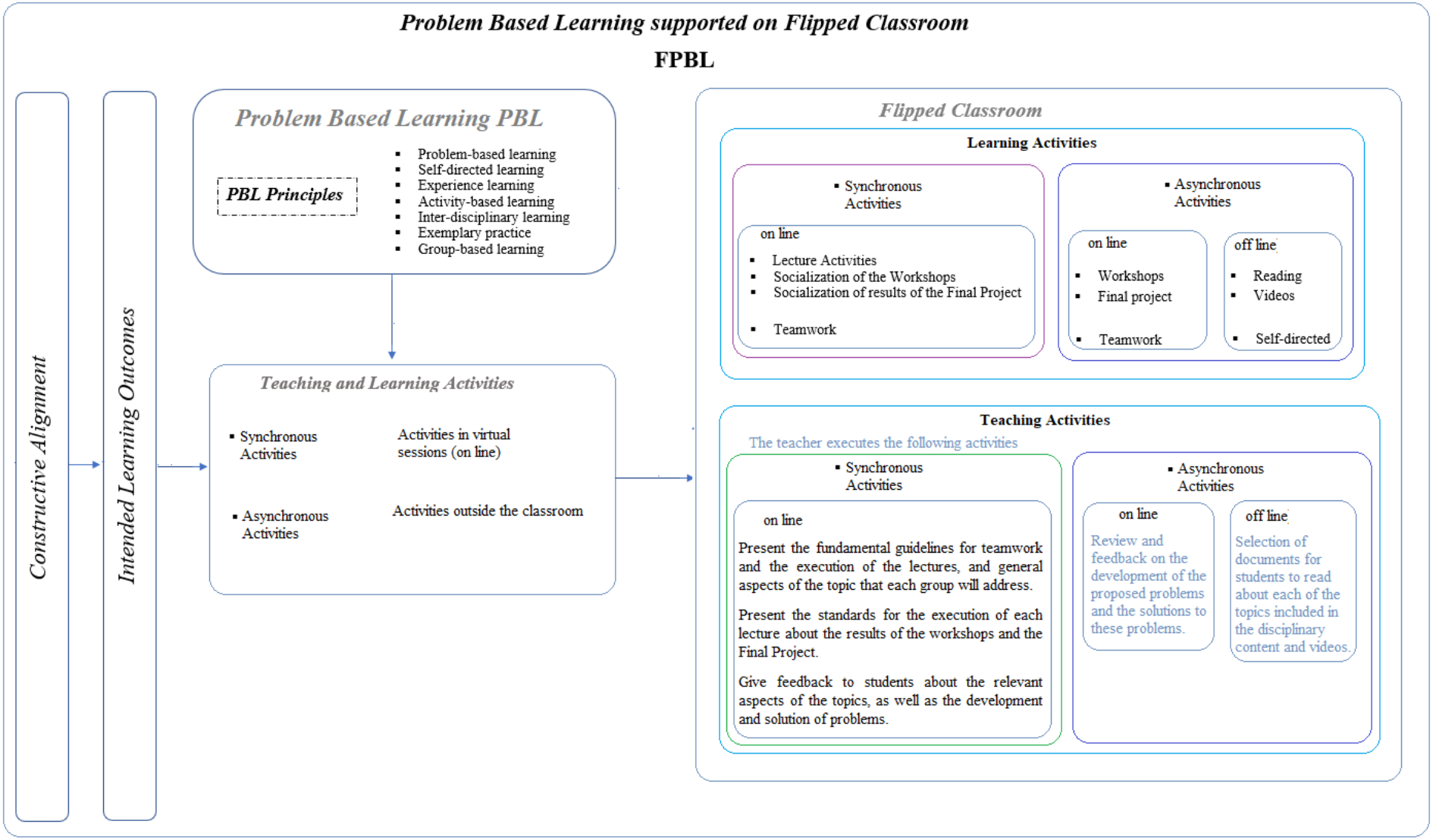
This chapter describes the integration of the FPBL approach in Engineering education, which is done through the design and implementation of an intervention. In the first subchapter *Design of the Intervention*, the FPBL model is presented, which includes a detailed description of the intended learning outcomes, the Economic Engineering content, and the teaching and learning activities that must be carried out to meet the objectives. In the second subchapter, *Implementation of the Intervention*, it presents the scheme of activities that are carried out during the intervention.

3.1 Design of the Intervention

FPBL is a Hybrid PBL model (Barrows H. S., 1986) whose framework is the PBL combined with Flipped Classroom learning approach. FPBL approach design is based on the principles of the problem-based learning approach described by Kolmos and De Graaff (De Graaff & Kolmos, 2003) whereas Flipped Classroom is used for the formulation and design of learning activities.

The design considers the constructive alignment so that learning activities, learning objectives, and assessment activities can be aligned (Biggs, 1999), the definition of the intended learning outcomes for the course and for each of the topic modules of the subject, the specification of teaching and learning strategies where the selection of online distance learning activities and learning activities are presented during virtual sessions with teacher guidance and techniques for the assessment of student learning and evaluation. The design of the teaching and learning strategy is based on the model presented by Andrade and Coutinho (Andrade & Continho, 2016) which takes into account the revision of Bloom's Taxonomy carried out by Krathwohl et al (Krathwohl, 2002) for the definition of the Intended learning outcomes supported by the theory of cognitive flexibility. It is also supported by the activities proposed in the study by Tawfik and Lilly (Tawfik & Lilly, 2015). Figure 3 presents the FPBL model, it is relevant to highlight the following classification of activities: synchronous, which are those that are carried out during the virtual sessions of the course and where the student interacts with their classmates and the teacher and the asynchronous activities that are executed in any other time than the virtual sessions.

Figure 3. FPBL Model



Intended learning outcomes

The intended learning outcomes were studied and redefined for each module, based on the review of the objectives formulated in the study guide texts, based on the review of the objectives presented in Bloom's Taxonomy carried out by Krathwohl et al (Krathwohl, 2002)

Teaching and learning activities

Activities outside the classroom (online) and in the virtual classroom (virtual session guided by the teacher) are described below: it is divided into two steps. The firsts activities are intended for students to read the selected material about each of the module topics, as well as the problems to solve that are the cases which are provided by the teacher. After reading, students are instructed to carry out case deconstructions according to predefined themes in the second stage.

The virtual learning environment facilitates this process, the selected environment domain is Google classroom, For the final reports' official deliveries, the emails were used, and shared resources such as Google Drive. Google questionnaires were used to consolidate the comments about the perception of the FPBL methodology. The activities that were established in the online framework are: i) readings of the topics contained in each of the chapters. ii) review of the videos on each topic. iii) the solution of exercises (simple problems - simple cases). iv) development of the workshops. and v) development of the final project (online work).

Activities in virtual sessions: Class time is divided into two phases. Once in possession of the deconstructions produced by each student. The first step is to discuss the deconstructions collectively and then developing a thematic comment that emerges from the discussion. This is the moment of the debate of meanings between the different answers given by the students and the teacher. In other words, the goal is to discuss the various deconstructions and find a thematic comment that can synthesize the range of ideas produced by the students. The second step is for thematic crossovers and the creation of new cases. In this model, thematic crossovers can be solved in the form of questions, challenges, problems; it means active learning activities for students to analyze, implement, and evaluate the topics through the various cases. In this step, students are also required to create new cases according to the topics proposed by the teacher, considering the proposal of Andrade and Coutinho (Andrade & Continho, 2016).

The Activities that were established during the virtual sessions with the teacher's guidance are: i) Reading Controls, consists of discussion and reflection on each of the topics by the students, motivated by questions based on cases of the real context formulated by the teacher or at times by the students. ii) Control over the use of the videos, from the discussion and reflection on each video´s topics, starting with questions formulated by the teacher or questions that arise from the student´s doubts. iii) Control of the solution of exercises, consists of the socialization of the solution of the problems both of simple tasks and in the workshops (problems with a medium degree of complexity) carried out by each group of students. The feedback from both the students as well as the teacher. iv) Socialization of results of the final project, consists of the presentation of each advance of the development of the final project, presentation of the problem and solution, and vii) Lecture Activities, and viii) Socialization of the workshop results. The general design is presented in Annex 2, the detail description of the teaching and learning activities is presented in Annex 3 and Annex 4.

3.2 Implementation of the intervention

The National University of Colombia UNC is an entity of a national order, (Bill Law 1210/93, art.1). The University can create and organize campuses. The legal address and the main headquarters of the University are located in Bogotá D.C. (MEN, 1993).

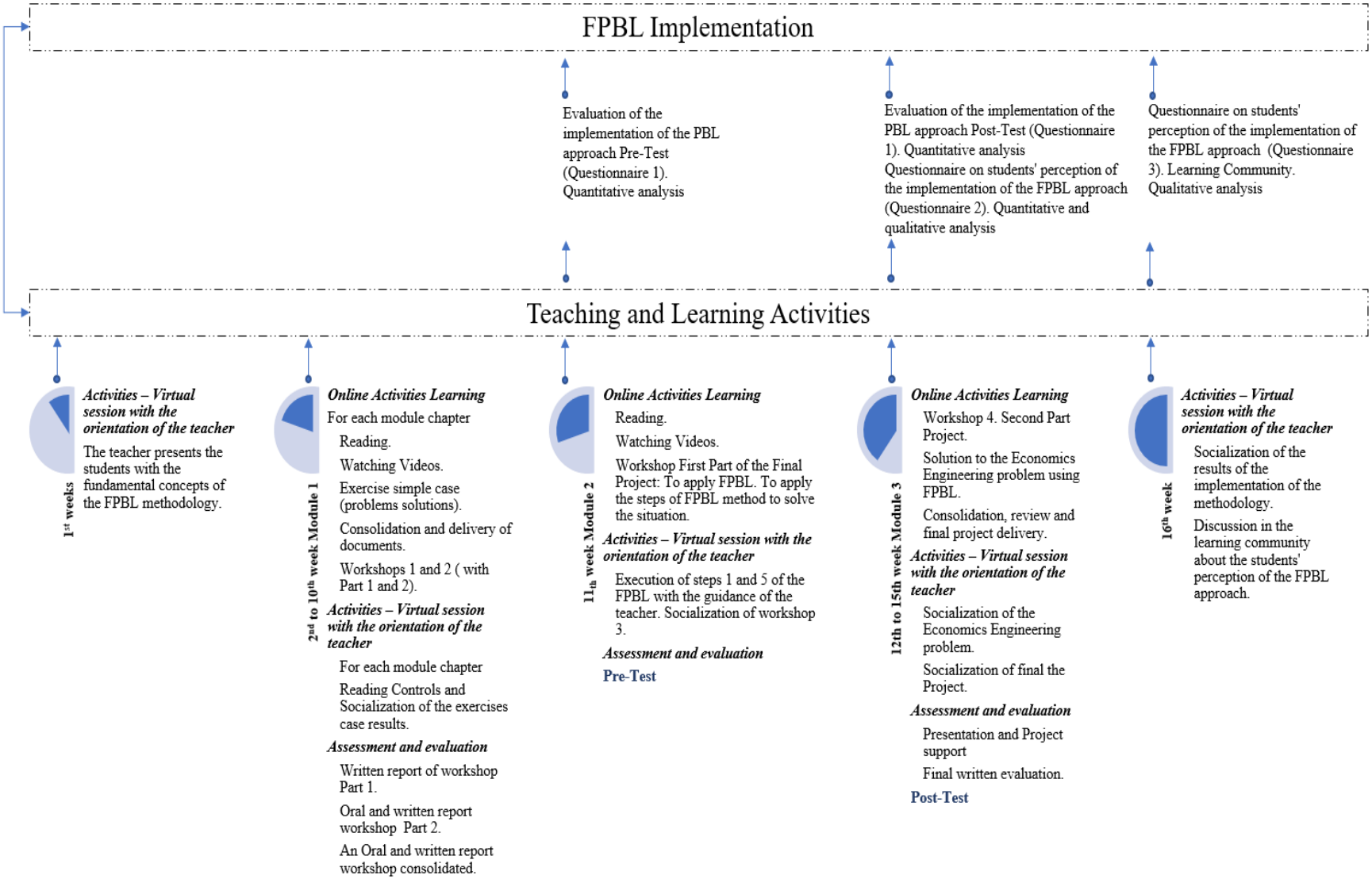
In the first semester of 2019, the Bogota campus registered 32,087 enrolled students, 25,569 in undergraduate studies and 6,518 in postgraduate studies. The Faculty of Engineering of this campus was created in 1861, it has nine undergraduate programs in Engineering and 27 registered post-graduate programs. 6,464 students are enrolled in undergraduate programs and 944 post-graduate students in the period 2019-1. The average number of students who have enrolled in the Economic Engineering course during the last six semesters (2017-1 to 2019-2) is 466, with an average of 11 groups per semester with 44 students enrolled per group (UNCa, 2021).

This master's dissertation will consider the FPBL in two groups of the Economic Engineering course G_4 and G_{10} denominates G_1 and G_2 respectively. The focus should be also state that implementation of PBL and active learning is part of faculty and university strategic plan, or vision. For the implementation of the FPBL approach in the Economic Engineering course in the two groups, in the first place, direct communication was established with the only professor who

expressed interest in implementing PBL approach combined whit flipped classroom in his group. In second place, the design of the FPBL approach was showed to the teacher of G_1. In thirdly place, the period of duration of the implementation and each of the stages was established with the teacher and finally the students were made aware of the content and focus.

The FPBL approach was considered convenient due to the following circumstances: i) The online course must be implemented, in compliance with the standards issued by the UNC. ii) The UNC requires its teachers to implement and adopt innovative teaching and learning approaches such as problem-based learning. iii) The UNC provides the information and communications technology resources to implement online courses (Google accounts, Google Drive storage service for large volumes of information and Google Meeting, Google Classroom service). iv) It is an intervention that can be carried out in phases and gradually. v) The management committee of the department and the curriculum committee of the program that provide the service of this subject to the entire Faculty of Engineering granted the endorsement for the intervention. And vi) Willingness in students to adopt the approach and participate in the study.

Figure 4. Implementation scheme of the FPBL approach



The duration of the implementation is 16 weeks. It will take place in three stages. preparation 1st week, implementation and validation 3rd week to 16th week and analysis of results 10th to 16th week. The implementation scheme of the FPBL approach is presented in the Figure 4. it describes when the teaching-learning activities are executed. It also indicates when the online activities are carried out, as well as the virtual activities with the teacher's guidance, and the moments in which the assessment and evaluations of the students are carried out. Likewise, this scheme shows the moments in which the knowledge and perception surveys are applied to the students to evaluate the implementation, as well as the methods that are used for the analysis of the students' responses.

Synthesis

This chapter presents the framework where the impact of the implementation of the FPBL approach on student learning is evaluated. Also, the scaffolding on which the Economic Engineering course is designed. It describes how to integrate the PBL approach with the flipped classroom in the FPBL model. In the same way, the design of teaching and learning activities, specifying which of these activities are synchronous and asynchronous.

The design specifies the activities that are focused on improving the academic performance of students in connection with professional performance, and on promoting the development of self-directed learning skills and teamwork. It also includes the activities carried out by the teacher in the role as facilitator and guide of the students' learning process. Finally, It is built the implementation scheme which shows the sequence of the activities.

The following chapter describes the research design which includes the evaluation of the intervention and the impact of FPBL on student learning during the Economic Engineering course.

4 Research Design

The research design used in this study is Mixed Model (Quantitative and Qualitative), The study is quasi-experimental, the method used for data collection is the questionnaire which are of two types, one with closed responses and two surveys about students' perception of the implementation of the FPBL approach that containing open and closed questions. Questionnaire 1 contains closed questions in which case information is obtained to perform a quantitative analysis Annex 7 and Annex 8.

Regarding the Questionnaires 2 and 3, the Questionnaire 2 contains closed and open questions (Annex 9 and Annex 10); this implies carrying out quantitative and qualitative analysis respectively on the information collected. And Questionnaire 3 contains open questions which implies a qualitative analysis on the information obtained when asking the questions (Annex 11). The detailed description is presented in the following literals.

4.1 Description of the methodology

The design proposed for this research corresponds to a quasi-experimental study. The quasi-experimental design is defined as a work plan with which it is intended to study the impact of the treatments and the change processes, in situations where the subjects or observation units have not been assigned according to a random criterion (Arnau, 1995), In this quasi-experimental design there is no control group, this method is used to estimate the causal impact of an intervention, the FPBL intervention. The design scheme is show in Figure 5. In this study, the quasi-experimental design is used for the application of the PBL approach supported by flipped classroom FPBL in students of the economic engineering course in the period 2020-03 from the Faculty of Engineering of the National University of Colombia.

Table 1. *Basic quasi-experimental research scheme of the study*

Experimental Group	O_1: Observations and measurements at the beginning of the study Pre-Test (Questionnaire 1)	X: independent variable (treatment)	O_2: Observations and measurements at the end of the study. Post-Test (Questionnaire 1). Perception FPBL Survey (Questionnaire 2 and 3)	No control group and no random selection

Participants

This dissertation has the participation of n = 66 students enrolled in the undergraduate course of Economic Engineering of the Faculty of Engineering of the National University of Colombia in the Bogotá campus during the second semester of the year 2020. The selection of the target population is made in a non-random manner; 33 students from G1 and 33 students of the group G2, of the total number of students, 77.27% of them enrolled the subject with the compulsory foundation typology, while for the rest the subject corresponded to the elective component. All students enrolled in this course are part of the Faculty of Engineering of the National University of Colombia. The students enrolled in the course corresponded to people who entered their degree from 2015-2 to 2020-1. Annex 6 include the summary of the population description. Students were informed that the courses were part of the investigation of the implementation of the problem-based learning approach supported by flipped learning classroom.

Variables

The problem-based learning approach supported by flipped classroom FPBL is established as an independent variable for both the quantitative and qualitative study, since it corresponds to the variable that is controlled or changed to determine the effects on the learning of students in the Economic Engineering course. On the other hand, Self-Directed Learning, Teamwork, Teaching-learning Activities are established as dependent variables.

4.2 Research Methods

The Quantitative research design is supported by post positivism, which examines the cause and how different causes interact and influence the results. The approach is typically deductive, where most ideas or concepts are reduced to variables, and the relationships between them are tested (Creswell J. W., 2009).

Qualitative research is defined by Creswell (1994) as the type of research that is "explaining phenomena through the collection of numerical data that are analyzed using methods based on mathematics, specifically statistics." Within the types of quantitative research are the following: survey, correlational, experimental, and causal-comparative research. (Creswell J. W., 1994).

Mixed research designs are defined by Johnson and Onwuegbuzie (2004, pág. 7) as "the type of study where the researcher mixes or combines research techniques, methods, approaches, concepts, or quantitative or qualitative language in a single study." On the other hand, Creswell (2009) who argues that "mixed research allows integrating, in the same study, quantitative and qualitative methodologies in order to have a better understanding of the object of study."

According to Rocco et al. (2003), mixed designs can be of two types, with a mixed model or a mixed method. With a mixed method, quantitative methods are used in one stage or phase of the investigation and qualitative methods in another. With a mixed model, they are those that combine both, quantitative and qualitative methods in the same stage of the investigation.

According to the above, the design in this study corresponds to a mixed model, there is simultaneity in the application of the methods and none of them is prioritized over the other, only the order in terms of sequentiality varies. It corresponds to a type VII; simultaneous investigation, exploratory investigation. Quantitative and qualitative data with quantitative and qualitative analysis.

The initial stage of research design includes data collection from Questionnaire 1 and quantitative analysis. Through this analysis, it is desired to establish whether the students reached the intended learning outcomes, related to the fundamental knowledge of economic engineering, and it is also sought to establish a causal effect between the variables. In addition, it is identified if there is a change in the student's perception before and after the implementation of the FPBL methodology.

The final stage of the research includes the collection of data from questionnaire 2 and the qualitative and quantitative analysis, according to the organization of mixed designs proposed by Creswell (2009). At this stage, the explanatory sequential strategy is used, where the qualitative results are used to explain quantitative results, the order is quantitative qualitative, the emphasis is to explain and interpret relationships.

In the same way, it is carried out with the data collected from questionnaire 3, where a qualitative analysis is carried out for the resulting data.

4.2.1 Quantitative research design

Quantitative Research in education can be used to give a numerical response to change, for example, regarding the academic performance of students. It allows quantify opinions, attitudes, and behavior, and discover how a group of population feels about a certain topic. Based on these aspects, it is possible make a descriptive analysis, for represent and characterize certain situations and additionally is used descriptive statistics for data analysis. On the other hand, quantitative research is used to explain some phenomena and to execute the hypothesis test, in this case the inferential analysis is used to explain the phenomenon and describe it. (Sukamolson, 2007)

The quantitative analysis is used in this study to establish the difference between the knowledge that economic engineering students possess before starting the final project of the course compared to the knowledge acquired at the end of the final project. Additionally, it helps to establish if there is any change in the student's perception regarding the implementation of the PBL approach. In particular, the quantitative analysis is used to analyze the information collected in Questionnaire 1, as well as in the analysis of the information of close questions in Questionnaire 2.

4.2.2 Qualitative research design

Qualitative research design is based on the natural paradigm. The focus of the study is inductive and begins with the assumption that reality is subjective. Generally, qualitative design is presented as the first option, when little is known about a certain phenomenon, experience, or concept. A qualitative research is dedicated more to qualitative aspects of reality (Creswell J. W., 2009).

The purpose of qualitative research is to make sense of large volumes of data in a process defined by the reduction of information, the definition of meaningful patterns, and the construction of a framework that allows communicating what the data reveals (Patton, 1990).The above to understand opinions or experiences and deepen about a problem. Qualitative Research is used when the interpretation of data is required by identifying and codifying the topics, concepts, processes, or contexts to build theories, supporting these theories, or putting them to the test

(Lewins & Silver, 2009). This research involves the use of methods for data collection, among which are: observation, interview, surveys.

Among the techniques to perform the qualitative analysis of texts and documents is the qualitative content analysis. This analysis is defined as "A set of communication analysis techniques aimed at obtaining indicators by systematic and objective procedures for describing the content of the messages, allowing the inference of knowledge regarding the conditions of production/reception of these messages" (Bardin, 2002, pág. 32), the purpose of content analysis is to verify the presence of themes, words or concepts in content and their meaning within a text in a context (Arbeláez & Onrubia, 2014).

Rojas's coding technique was used to treat open questions present in each of the questionnaires 2 and 3 (Rojas, 1981). In this analysis, it is used to know the student's perception about the implementation of the FPBL approach, especially in aspects related to self-directed learning, teamwork, the development of the final project and the efficiency of the teacher's role.

4.3 Data collection and Analysis Procedures

This sub-chapter specifies the quantitative and qualitative research method used in this study. It describes each instrument used for data collection, and the sections that compose it and their characteristics, and informs about the research question that will be answered with the collection. and subsequent data analysis. It also includes information about the software used for both, quantitative and qualitative data analysis.

4.3.1 Instruments for data collection

To carry out the study, first, a pre and post-test design was used. This test corresponds to Questionnaire 1 and it is divided into two sections, the first section – Q_1S_1 - is used to know the perception of students about the methodology before and after the final project's execution using the FPBL methodology, this section includes eight open questions numbered $Q_1S_1Q_1$ through $Q_1S_1Q_8$. The second section – Q_1S_2 – is used to compare the knowledge acquired by the students before the execution of the final project in which they use the method of the seven steps for the solution of the problem which corresponds to a specific case, with the knowledge acquired at the end of the final project to obtain the answer to question **RQ1** (The final project corresponds to the

solution of a problem proposed by the teacher). A controlled and moderate class test scored out of 100 points is used as a pre-and post-test. The controlled trial was based on contemporary economic problems. The questionnaire is developed online. This test assesses the academic performance of students, and the result is part of the evaluation score for module 3.

The section – Q_1S_2 – contains a total of 24 questions divided into eight subsections that correspond to each of the topics covered in the course. The analysis and description of each of the questions is presented in Annex 7. After analysing the results of the questions for each of the subtopics, a comparative descriptive analysis will be made of the main measures of central tendency and dispersion between the results obtained globally between the pre and post-tests.

The Characteristics of the question in Section 2 of Questionnaire 1 are presented in Annex 8. For these questions, the statistical analysis includes the following calculations: of measures of central tendency and dispersion. It also includes a comparative descriptive analysis between the pre and post-test scores. Finally, a hypothesis test is carried out, which indicates the difference between the measurements. Each analysis is performed for each subsection. Second, a questionnaire of the FPBL approach is used in the classroom, questionnaire 2 - Q2- is taken online, it is structured and closed, and uses a Likert scale, to collect data to explore students' perceptions of the usefulness of the strategy. As well as, questionnaire include open questions, this questionnaire required to answer the research questions **RQa to RQc**, uses Google formats for design of the questionnaire, and the questionnaire is available for the student to answer it at the end of the course. The characteristics of the questions in of Questionnaire 2 are presented in Annex 9.

Finally, the publications in the learning community of the economics engineering course are downloaded, analysed and encoded in topics, where three open questions were formulated to initiate the discussion. Its questions are including in the Questionnaire 3. This questionnaire answer question **RQc**. Specific questions are related to FPBL are asked in the Engineering Economics course learning community. The characteristics of the questions in of Questionnaire 3 are presented in Annex 10.

4.3.2 Analysis Procedures

The information for the analysis is extracted from the instruments (Questionnaires 1 to 3). The software tools used for information processing are Microsoft Office Excel, IBM SPSS Statistics 23 and statistical software R version 4.0.2. From the results is made triangulation and generalization. The quantitative analysis of this dissertation took place in two moments: in the first, descriptive resources of the two groups were used, through the Excel program in its 2016 version, in which the data were organized with the help of a matrix that allowed observe the frequency of the data consulted; From there, a graphic representation was obtained that would allow know the distribution and grouping the data. In a second moment, it was possible to analyze the information comparatively through the IBM SPSS Statistics 23 program. Frequency analysis is made regarding the Likert scale questions present in each of the three Questionnaire under consideration. Cronbach's alpha is calculated to assess the different sections' reliability evaluated with the Likert scale (Conbranch, 1951).

For the analysis of the quantitative responses, was used the statistical software R version 4.0.2 is used. For Questionnaire 1, in first instance will be carried out an analysis of the primary measures of central tendency and dispersion (mean, median, mode, standard deviation, and variance). In addition to this, a hypothesis test will be carried out for the mean whit the purpose to find a statistical difference between the results obtained in the pre-test and the post-test. To know quantitative results obtained by the Likert scale questions, the data are transformed to a numerical scale. The collection of data to perform the quantitative analysis, which answers are given to research questions, the pre-test is carried out in week 11 and the post-test in week 14. An analysis of the information provided by the students of the open questions about their perception of the methodology implemented in the course was carried out through the discourse analysis methodology. Then, this information was entered into the Atlas.TI program (Penalva, 2003). Based on these data, the students' discourse's central ideas are extracted, creating codes linked to each other and generating nodes, which are representations, concepts, or discrete approaches around a specific topic (Questionnaires 2). Data collection for qualitative analysis was carried out to answer question RQa to RQc. The perception questionnaire is applied in week 14. Particularly, data collection for qualitative analysis was carried out to answer question RQa to RQc. In the learning community, it takes place during the week 15-16. The constant comparison data analysis

method will be used to identify the topics that are stated by students in the learning community (Questionnaire 3).

Table 2. Research Methods

Research methodolgy	Data collection (instruments)	Data analysis	Example of questions
Quantitative	Questionnaire with close questions Questionnaire 1 Questionnaire 2 ($Q2q_1$ to Q2q8, $Q2q_{14}$, $Q2q_{42}$, $Q2q_{45,}$, $Q2q_{47}$)	Descriptive statistics	Questionnaire 1. Q1q13 The question includes four answer options the student must select the correct option. The question corresponds to a simple case of a real problem that the student must solve.. Two locations are under consideration to build a bridge that crosses a river in the department of Meta. The first option will alleviate local vehicular traffic; the disadvantages of this site are that the bridge would do little to ease local traffic congestion during rush hours, and that it would have to span from hill to hill and would have to be a suspension bridge. The second option will require a much shorter journey, thus allowing the construction of a propped bridge, but would require construction of new roads. The suspension bridge will cost $ 50 million with annual inspection and maintenance costs of $ 35,000. Additionally, the concrete deck will have to be renewed every 10 years at a cost of $ 100,000. The propped bridge and nearby roads are expected to have a cost of $ 25 million and annual maintenance cost of $ 20,000. The bridge will need to be painted every 3 years at a cost of $ 40,000. It will also need to be sandblasted every 10 years at a cost of $ 190,000. Purchase cost right-of-way is expected to be $ 2 million for the suspension bridge and $ 15 million for the propped bridge. If the interest rate is 6% per annum. For the propped bridge: The capitalized cost of the initial cost CC1; the recurring operating cost of the A1 propped bridge, the A2 annual painting cost, the A3 sandblasting annual cost, the CC2 recurring cost capitalized cost and the CCPA propped bridge capitalized cost will be respectively. Questionnaire 2. Q2q2. To what extent do you agree or disagree that the following activities were helpful in the FPBL strategy to support your self-study? Very important, Important Moderately important Reading of book chapters or articles on each of the Economic Engineering topics Simple problem solving corresponding to case studies Observation and analysis of concepts through videos-podcast with specific topics Multiple-choice questions Solution of preparatory tests for the mid-term that include simple case studies of Economic Engineering Workshops with economic engineering problems- mini case studies to solve them Student presentations on topics of interest - student's lecture activity Formulation and solution of the Final Work
Qualitative	Questionnaire with open questions Questionnaire 2 ($Q2q_6$ $Q2q_9$ to $Q2q_{13}$, $Q2q_{15}$ to $Q2q_{41,}$ $Q2q_{43}$, $Q2q_{44}$, $Q2q_{46}$) Questionnaire 3 (Q_3q_1 to $Q_3q_{3)}$	Content analysis	Q_2q_{18} How did the final project affect your acquisition of skills to solve real economic engineering problems? Q_3q_3. In what sense has the problem-focused learning methodology supported by the flipped learning classroom allowed you to develop your self-directed learning?

5 Results and Discussions

This chapter presents the results and discussions about the impact on student learning by implementing the FPBL approach in the engineering economics course.

The subchapter 5.1 presents the general framework of results of the implementation of the FPBL approach. Literal 5.1.1, as well as the results regarding student learning from the pretest and posttest, the results of students' perception regarding learning activities are also included, the above based on the results of the quantitative analysis of the data collected from the questionnaire 1. Also, it includes the students' perception regarding the final project and the use of the videos, and the results about the acquisition of knowledge from the qualitative analysis of the data collected from the questionnaire 2. Likewise, subchapter 5.2 presents the FPBL approach effects on students' self-directed learning from the qualitative analysis of the data collected in questionnaire 2. Subchapter 5.3 describes How FPBL improved student's teamwork skills from the quantitative analysis of the data collected in questionnaire 1 and the quantitative analysis of the data collected from questionnaire 2. Finally, the subchapter 5.4 presents the results of the students' perception about the effectiveness of the teacher's role in the framework of the FPBL approach based on the qualitative analysis of the results collected from questionnaire 3.

5.1 Impact of the FPBL in students' learning in economics engineering at UNC

This section presents the descriptive statistical analysis of section 1 of questionnaire 1. This section of the questionnaire contains questions about the student's perception of the FPBL methodology of both the pre test and the post test.

5.1.1 Students' perception regarding the impact of the FPBL on their learning processes

This section of the questionnaire proposes 6 axes of inquiry about the use of the FPBL methodology, these axes are: Impact of the FPBL methodology on students' learning processes, the efficiency of the methodology in promoting self-directed learning, the performance was made by the teacher to promote the development of teamwork to prepare the correct preparation of the

final project, Importance of each student having a work plan for the final project, collaborative work as a fundamental element for optimal professional and personal development, and usefulness of examples of everyday situations to expose class topics. Table 3 shows the quantitative - comparative analysis of the results for each of the axes of inquiry before and after the implementation of the FPBL approach for the execution of the final project (**Q1S1**).

The Microsoft Office Excel program is used for the analysis. The number of students who answered the questionnaire is n = 57. From group 4 (G_1) the number of students is n_1 = 27 and from group 10 (G_2) the number of students n_2 = 30.

Table 3. Pre-Test and Post -Test Results Questionnaire 1 – Section 1 -

	Pre-Test	***Post-Test***
Impact of the FPBL methodology on students' learning processes	After executing the final project, a significant change is evidenced in the increase in the percentage of students who fully agree with the phrase "I like working with classmates because in this process there is an exchange of ideas that are mutually complementary" (G_1=33%, G_2=22%), consequently, the decrease in the percentage of students who agree (G_1=30%, G_2=44%).	Regarding the percentage of students who expressed their degree of affiliation neither agree nor disagree, a clear difference is observed between the two groups, in group 1 the percentage of students increases, while in group two the percentage decreases regarding their perception before executing the final project (G_1=27%, G_2=26%). On the other hand, in the two groups, the percentage of students who disagree is maintained (G_1=10%, G_2=7%), and none of the students expressed being in total disagreement.
The efficiency of the methodology in promoting self-directed learning	When asking the student how much the FPBL methodology used in class would be useful to promote their autonomy for the development of the final project, it is observed that the highest percentage of students consider that it would be very useful (G_1=22%, G_2=37%), and completely useful (G_1=56%, G_2=30%). On the other hand, to a lesser extent a percentage of students consider it to be neutral (G_1=22%, G_2=30%), and a minimum percentage of students consider it not very useful (G_1 = 3%, G_2=0%).	Once the project is finished, a change is observed in the perception of students about the usefulness of the methodology to promote their autonomy, an increase in the percentage of students who considered it completely useful (G_1=33%, G_2=46%), as well as in the percentage of students who considered it very useful (G_1=47%, G_2=42%), and a decrease in the students considered it to be neutral (G_1=17%, G_2=12%), it did not show changes in the students who considered it not very useful (G_1=0%, G_2=3%), and no student considered it not useful.
The performance was made by the teacher to promote the development	Regarding the role played by the teacher to promote the development of teamwork with a view to the correct execution of the final project, the highest percentage of students indicates that the teacher role was useful (G_1=56%, G_2=40%), followed by the percentage the students consider that the role played by the teacher was neutral	Once the final project is finished, a change is observed in the perception of the students, since the highest percentage of students consider that the role played by the teacher was completely useful (G_1=40%, G_2=37%), followed by the percentage of students who consider that the role of the

of teamwork to prepare the correct preparation of the final project	(G_1=7%, G_2=33%), A significant percentage of students that consider it to be completely useful (G_1=22%, G_2=10%), as well as the percentage of students who consider that the role was slightly useful (G_1=11%, G_2=13%), and a smaller percentage consider that the role of the teacher was not very useful (G_1=4%, G_2=3%).	teacher was useful (G_1=40%, G_2=30%) and the percentage of students who consider that the role of the teacher was neutral (G_1=20%, G_2=30%). On the other hand, the percentage of students who consider a role to be slightly useful is minimal (G_1=0%, G_2=4%).
Importance of each student having a work plan for the final project	Regarding the importance of each student having a work plan for the preparation of the final project, the highest percentage of students indicates it is very important (G_1=56%, G_2 = 30%), followed by the percentage students consider which is completely important (G_1= 22%, G_2=37%), a significant percentage of students who consider it to be neutral (G_1=22%, G2 = 30%). On the other hand, to a lesser extent, the percentage of students that is considered unimportant (G_1 = 0%, G_2 = 3%).	Once the final project is finished, a change in the perception of the students is observed, an increase in the percentage of the students consider that it is completely important that each student has a work plan for the elaboration of the final project (G_1=33% , G_2=46%), an increase in the percentage of students who consider it to be very important (G_1=47%, G_2=42%), consequently a decrease in the percentage of students who consider it to be neutral (G_1=20 %, G_2=30%). On the other hand, there are no changes in the percentage of students who consider that the importance is little (G_1=3%, G_2=0%) and no student considers that it is not important at all.
Collaborative work as a fundamental element for optimal professional and personal development	When asking students about their degree of affiliation with the phrase "collaborative work is a crucial element for optimal professional and personal development because in this space each person manages to form favourable skills. The highest percentage of students declared to be in complete agreement (G_1= 48%, G_2=47%), followed by a percentage of students who declared to be in agreement (G_1=33%, G_2=43%). On the other hand, a percentage of students stated that they did not agree or disagree (G_1=15%, G_2=10%), and no student expressed disagreement.	After executing the final project, it is evident that the percentage of students who completely agree with the phrase "I like working with classmates because in this process there is an exchange of ideas that complement each other" is still the highest (G_1=33%, G_2=22%), followed by the percentage of students who consider that they agree (G_1=33%, G2=33%). However, a change is observed in the increase in the percentage of students who do not agree. agree or disagree (G_1 =33%, G_2 =43%).
Usefulness of examples of everyday situations to expose class topics.	Considering how useful it is for students that teachers use everyday examples to present class topics, the highest percentage of students (G_1=85%, G_2=73%). A significant percentage of students consider it useful (G_1=11%, G_2=20%). On the other hand, a small percentage of them consider it neutral (G_1=11%, G_2= 20%) and none of the students consider it slightly useful or not very useful.	Once the final project is completed, a change in the perception of the students is observed, an increase in the percentage of students who consider that teachers use everyday examples to present class topics, the highest percentage of students is completely useful (G_1=83%, G_2=81%), consequently, a lower percentage of students who consider it useful (G_1= 13%, G_2=11%).

In accordance with the results described in Table 3, it is important to note that once the intervention is completed, the percentages of students who highly value each of the axes (Impact of the FPBL methodology on students' learning processes, The efficiency of the methodology in promoting self-directed learning, The performance was made by the teacher to promote the development of teamwork to prepare the correct preparation of the final project, Importance of

each student having a work plan for the final project, Collaborative work as a fundamental element for optimal professional and personal development, Usefulness of examples of everyday situations to expose class topics) is increased. Therefore, it can be stated that students consider that the FPBL methodology improves their learning process.

5.1.2 Economic Engineering Knowledge in the students and hypothesis testing

This literal presents the analysis of results, based on the consolidation of the information of the results for the pre-test and post-test included in Annexes 7 and 8, respectively.

The following table shows the eight subsections of section 2 questionnaire 1. Each correspond to the results obtained of the specific assessment topics after applying the pre-test and post-test. The Table 4 includes the consolidated information corresponding to the average score value obtained by the students in each group, the average value of the total score, and the maximum possible score. As can be seen in the Table 4, the lowest total score averages were obtained by students in the following topics: the present value of bonds, inflation, and annual value analysis.

Table 4. Pre-Test and Post -Test Results Questionnaire 1 – Section 2 -

Subsection	**Score average Group 1 G_1**		**Score average Group 2 G_2**		**Total score average**		**Maximum possible score**
	Pre-Test	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**	
Present Value Analysis	19,15	23,38	20,37	27,30	19,77	25,38	36
Future Value Analysis	5,42	6,42	5,26	7,33	5,34	6,89	9
Capitalized Cost Analysis	5,54	5,62	4,74	6,30	5,13	5,96	9
Analysis of the Payback Period	7,77	9,00	8,37	10,11	8,08	9,57	11
Life Cycle Cost	7,54	9,00	7,26	10,37	7,40	9,70	11
Bonus Present Value	0,92	1,23	1,04	5,22	0,98	3,26	13
Annual Value Analysis	3,04	3,81	2,78	4,26	2,91	4,04	6
Inflation	1,54	3,12	1,11	3,52	1,32	3,32	5

Likewise, in Table 4 the results obtained in the post-test are higher for each subsection in each of the groups and in the total.

Furthermore, for the section on the Bonus Present Value, where the score average obtained by the students is 0.98 and 3.26 out of 13 possible for the pre-test and post-test respectively, it is observed that the results are particularly low.

Additionally, a comparative analysis is performed using the Chi-Square test for each pre-test and post-test question. Annex 16.

Hypothesis testing

In order to compare the results obtained before and after the final project, the following hypothesis test is proposed:

$$H_0: \mu_A \leq \mu_B$$

$$H_a: \mu_A > \mu_B$$

$$where \quad H_0 = the\ null\ hypothesis$$

$$H_0 = the\ average\ of\ the\ post\_test\ results\ is\ less\ than\ or\ equal\ to\ the\ average\ of\ the\ pre\_test\ results.$$

$$where \quad H_a = alternative\ hypothesis$$

$$Ha = the\ average\ of\ the\ post\_test\ results\ \ is\ greater\ than\ the\ average\ of\ the\ pre\_test\ results.$$

Where μ_A is the scores average obtained by the students after the final project, and μ_B is the average obtained by the students before the final project.

The level of significance is $= 0.05$, that is, a confidence level of 95%.

Note: For the mean difference hypothesis test, a non-parametric alternative to the t-test is used, this is the Mann-Whitney-Wilcoxon test because the data do not come from a normal distribution.

The increase in the means of both groups and the total, the value of the *W* statistic and the *p-value* associated with the hypothesis test are shown in Table 5. Since the *p-value* in the three cases considered is less than α, it is possible to conclude that there are clear differences against the null hypothesis, that is, and that the results obtained by the students after the final project are significantly higher than the results obtained before the final project, which gives us a clear indication that the final project developed with the FPBL approach is an effective learning activity.

Table 5. Pre-Test and Post -Test Results Statistical Analysis

Groups	N	Pre-test		Post-test		Mean difference	W	p-value
		Mean	SD	Mean	SD			
G1	26	55,46	9,13	68,96	14,27	13,50	154,5	0,0004037
G2	27	54,66	9,91	81,7	13,04	27,04	47	<0,000***
Total	53	55,06	9,45	75,45	14,98	20,39	402,5	<0,000***

According to the consolidated results in Table 5, it is also evident that the averages of the scores obtained by the students in the pre-test are quite similar, since the average of G_1 is 55.46 and that of G_2 is 54, 66 and its standard deviations are very close.

Also, it is evident that the average results after the final project in both cases improved, as well as a clear difference between the average of both groups where this parameter for G_2 corresponds to 81.7 and for G_1 it is 68.96. The difference in means between the pre-test and the post-test are 13.50, 27.04 for G_1 and G_2 respectively and 20.39 in the total, which supports the efficiency of the final project as a learning activity.

5.1.3 Results of the student´s perceptions regarding learning activities.

Reliability is understood to be the degree of stability, precision or consistency manifested by the test as a measuring instrument for a certain trait, and in order to evaluate this characteristic of the test, Cronbach's Alpha is applied. The results are present in the Table 6.

Table 6. Quantitative Statistical Analysis Questionnaire 2. Section 1 close question

Section	Cronbach's alpha
Self-directed learning in students	0,73
Perception regarding the development of the final project	0,83
Importance of the learning activities developed in the course	0,81
Teacher's role in the course	0,76
Contribution of learning activities for the development of knowledge	0,78
Teamwork during the development of the final project	0,93
Teamwork during the course development	0,78

It can be seen in the Table 6 that all values for Cronbach's Alpha are greater than 0.7, which shows the quality of the instrument to measure these traits.

In order to have a better idea of the students' perception regarding each of the sections presented in the test, a linear transformation is applied in order to scale the data from 0 to 100. The results can be observed in the Table 7.

Table 7. Quantitative Statistical Analysis Questionnaire 2 Section 1 close question

Section	**Score**
Self-directed learning in students	80,01
Perception regarding the development of the final project	80,39
Importance of the learning activities developed in the course	81,59
Teacher's role in the course	82,97
Contribution of learning activities for the development of knowledge	81,16
Teamwork during the development of the final project	81,34
Teamwork during the course development	60,02

As a result of the consolidation of information regarding the perception that students have about self-directed learning, the development of the final project, the importance of the learning activities developed in the course, the role of the teacher in the course, the contribution of learning activities for the development of knowledge and teamwork during the development of the final project; it is obtained that the score is high, since each value for each section is above 80 points out of 100, which would imply that it is good. On the other hand, it is observed that teamwork during the development in the course generally obtained a score of 60 out of 100, which would imply that it is acceptable.

Otherwise, considering the study by Van Wyk (Van Wyk, 2018) where he performs a pre-test and post-test to two groups of students, one that is the direct instruction group and the other that is the group where flipped classroom was implemented, where comparing the results obtained from each of them, it turned out that the difference between the final exam scores is significant. It is possible to affirm that for this study the result is similar to the result obtained by Van Wyk, this is evidenced in the consolidated results in the Table 5, where the difference from the average of the students in the pre-test and post-test turns out to be significant.

Student´s perception regarding the Final Project and the use of the videos

This section presents the summary of the results of the qualitative analysis of questionnaire 2 section 2 which corresponds to the open questions asked to the students about the students' perception regarding the final project and the use of the videos, the details are included in the annexes where the network of codes generated by the Atlas TI software are presented and the consolidation of information, respectively.

i) Final Project: The students indicate that the development of the final project is an activity that promotes self-learning, the solution of real problems of Economic Engineering allows them to obtain a better understanding of the class topics through practical exercises, strengthens the learning of the concepts through its practical application and motivated them to research specific topics. Likewise, they express that the methodology for the development of the project manages to attract the attention of the students by encouraging them to tackle different problems of economic engineering, they indicate that the pedagogical relationship between theory and practice gives rise to the growth of their interest and motivation.

ii) Use of the videos: Regarding the effect of the use of videos on students' self-learning, they consider that they contribute to meeting the project objectives, problems are developed with greater understanding and in less time, they allow greater autonomy in the learning process. In the same way because it allows to link practice with theory, and the study of previous topics is required for the development of the project. It also allows you to resolve doubts that the readings may not address. When the study sources are reliable, the acquired learning is more robust, as in this case. In consideration of the effect of the use of videos for the acquisition and application of knowledge, students indicate that the change can be observed in that knowledge is acquired more easily, a representative change is presented because audiovisual tools help to understand more easily the themes because they are made from the everyday context.

Student´s perception regarding the FBPL methodology affects the appropriation of economic engineering knowledge

Regarding how the final project within the framework of the FBPL methodology affects the appropriation of economic engineering knowledge in students, the resulting information is divided into two categories : *Professional Performance*: where students state that “the final project

had a profound impact because it generated a space for practice and evidence of the knowledge acquired during the course", they pointed out that "the decisions are more correct as long as the based on theoretical criteria", and *Academic performance:* the students state that "the execution of the project demands the study of the topics in greater depth and in it consolidates what has been learned throughout the semester", "Greater understanding of the issues was obtained". Also, that "the project brings them closer to the research field", "there is greater diversification and appropriation of the topics because information has to be consulted in different source" (Annex 17. Figure 24. Q2q17).

When consulting the students about how the final project affects the acquisition of skills in the students, the information is divided into two categories, in the same way as the information resulting from the previous answer: *Professional Performance:* It stands out among their appreciations that the project has a positive effect on the development of their abilities. The students state that the final project "provide a better approach to real problems" and "provides tools for problem solving", "it is useful for the understanding of problems of the profession". and "promotes the development of academic and professional autonomy", Likewise, the students indicate that by executing the final project affects the acquisition of skills because "development of groups skills such as and individual responsibility", "It´s important for making decisions" and contribute to teamwork". *Academic Performance:* The resulting information has an important characteristic regarding the help provided by the development of the project in terms of understanding and knowledge. Students state that "Helps to consolidate the knowledge acquired in class." and "It helps to understand with more clarify the class´s problem." (Annex 17. Figure 25 Q2q18). However, a new category emerges that is named *Recommendations,* the improvement opportunities are identified by the students "Some of the issues and problems were dealt with in a hurry, therefore they could not be put to better use".

About of the effect on the learning the fundamental concepts of Economic Engineering. The information is including in three categories: The *Academic Performance* category: the students expressed that the main contributions when developing the project are "it allows them to consolidate the specific knowledge of each topic", to "develop scientific criteria", "to link between theory and practice" and *Professional Performance* category: The students state that "It presents

the possibility of the solving problems in a long time", and "Encourages the development of academic skills". According to the data provided by the students, it is possible to notice that the information of some central categories is shared, from which it is useful to affirm that there is a close link between them. In this case, it is evident that in the category named *Contributions* the students affirm that "strengthens skills through problem solving", "There are greater clarity and understanding of the issues", and "contributes to making decisions" (Annex 17. Figure 26. Q2q19).

Similarly, regarding the effect of the Project on the acquisition and application of knowledge. The information is including in three categories: *Academic Performance*: students consider that "It is good because it contributed a lot to the development of knowledge", "Contributes to the development of investigative skills", "Complements what was learned in class", and "Knowledge is consolidates". Likewise, *Professional Performance* the student state that "It generate a change because the problems are based on everyday aspects". *Recommendations*: Students consider that "It is recognized that there are favourable changes, but it is highlighted that there are complementary elements to be addressed" (Annex 17. Figure 29. Q2q22).

The previous results of the qualitative analysis are coherent with the results of the quantitative analysis regarding the perception of the students regarding the importance of the final project, whose score is 80.39 (Table 7).

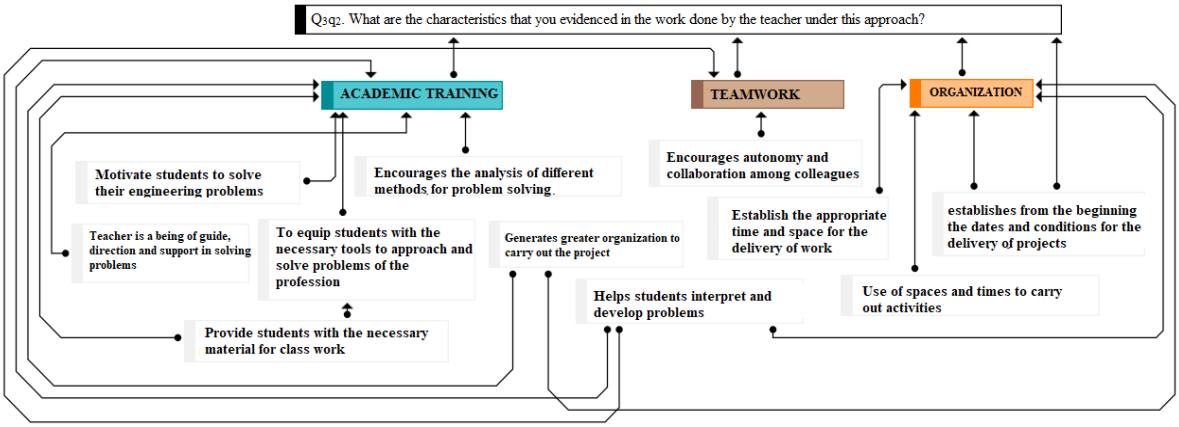
5.2 The FPBL approach effects on students' self-directed learning

In the second research question RQa, a query is made about the relationship between the implemented methodology and self-directed learning, resulting in information that can be classified under the four central categories. These categories emerge of the content analysis and they are as follows:

i) Organization of time: this information is aimed at the correct distribution of spaces and times for carrying out some academic activities; from this it is possible to see its connection with future professional life.

ii) Self-directed learning: refers to those skills and qualities that students acquire in the face of the acquisition of knowledge; it is closely related to the category of academic performance.
iii) Academic performance: this information is related to what is stated in the category of self-directed learning, in which it is also possible to see that a position of greater autonomy is acquired.
iv) Teamwork: includes information that links the relationship between colleagues and that helps their correct performance in both professional and student life, in which it is highlighted that students develop a posture of greater ownership of their academic training.

Figure 5. Q3q3 Questionnaire 3 Question 3 Code Network – Self-directed learning



5.3 How FPBL improved students teamwork skills

In the third research question RQb, a query is made about the relationship between the implemented methodology and the development of teamwork skills, resulting in information that is shown below.

The positive or negative tendency of students to work in a team.

For question Q2q8 which corresponds to the questionnaire designed to establish the tendency (positive or negative) of students to work in a team, based on the questionnaire designed by Trechera (2003), the results are consolidated in the Tables 6 and 7. The quantitative analysis for this question is presented below. The total number of students who answered questionnaire 2

in section 2 is 43 students, in particular in the section called "Attitude of students towards teamwork during the course." For the analysis of results, in the first instance a score of 1 to 5 is assigned to each of the responses given by the students, where 5 corresponds to the highest degree of positive attitude and 1 corresponds to the lowest degree of this. Then a descriptive analysis was carried out with the mean and the deviation of the data in each of the thirty questions, later the questions with the greatest positive attitude were selected (the results are presented in the Table 6, and the questions with the greatest negative attitude the results are presented in the Table 7.

Table 8 shows that students have a fairly positive attitude towards communication and listening skills to function well in the team. They also tend to feel that with the union of its members, they can achieve great goals. They also express the importance of good weather in the group, that each of the members is comfortable belonging to it, as this would help the group function better.

Table 8. Positive Attitude of students towards teamwork during the course

Item	mean	Standard deviation
Communicating and knowing how to listen is essential for good team functioning.	4,3023	0,9888638
If the members of a team are united, they are able to achieve any type of objective.	4,2093	0,9650596
If there are good group climate and people are comfortable in the team, people will get involved and function better.	4,1860	1,006072

The Table 9 Students can communicate to reach agreements with their colleagues who think differently, and they also show disagreement that the members of each organization do not know the objectives, means, and actions of this. Additionally, the students' abstinence is seen regarding the expulsion of the students while they generate disagreement in the group.

Table 9. Negative Attitude of students towards teamwork during the course

Item	mean	Standard deviation
If there is conflict in the team it is best to expel the discordant members.	2	0,8164966
It is not important that the members of an organization have to know the objectives, means and actions of this.	2	0,9759001
It is impossible to communicate and be able to reach agreements with people who think differently.	2,139535	0,8885889

Students' perception regarding the effects of the teamwork during the course and the final project.

This section presents the summary of the results of the qualitative analysis of questionnaire 2 section 2 which corresponds to the open questions asked to the students about the students' perception regarding the effects of the teamwork during the course and the final project.

i) Teamwork: Related to the actions established by the students during teamwork, they indicated that the designation of responsibilities was made for all members of the group, given the parameters that had to be met, such as work delivery dates. In some cases, individual tasks were assigned to contribute to the development of the project. They also mentioned that teamwork motivates the generation of knowledge because each person can contribute different ideas to the group, because of the cooperation between colleagues and because of the debate of ideas, finally they indicated with respect to decision making that dialogue is the key resource for mutual understanding, this dialogue is characterized by the fact that each student made their contributions and the corresponding feedback was given between all, options were proposed, analyzed and submitted to consensus.

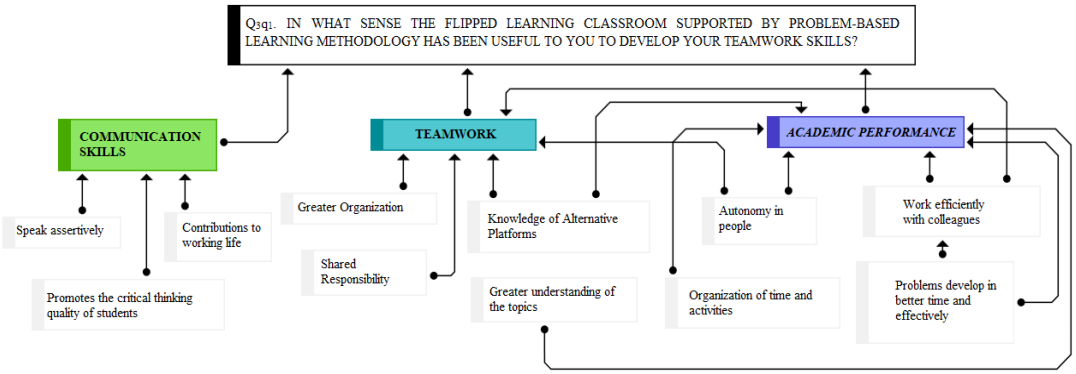
ii) Regarding teamwork during the completion of the final project: the students indicate that the contributions in their academic performance are different perspectives are shared regarding the solution of problems, the need to work as a team is present to resolve doubts, the participation of students is very active during the virtual class sessions, a responsible and collaborative work was carried out, the commitment of each student in front of the group was high. The students also consider that communication is a relevant factor, and communication was maintained between the members of the group under parameters of respect and cordiality, the communication was carried out mainly by email and WhatsApp.

Student´s perception about effect of FPBL approach to develop teamwork skills.

The qualitative analysis corresponding to the students' responses to the questions published in the learning community is presented. In the first question, students are asked about the usefulness of the methodology implemented in class compared to teamwork, on which information is distributed in three central categories, distributed as presented below. *i) Communication skills:*

talk about critical qualities and assertiveness that are generated in students. *ii) Teamwork*: includes key processes such as responsibility, understanding of issues and organization of time. *iii) Academic performance*: refers to those behavioural changes that students have and have favoured their performance in class, such as efficiency, autonomy and organization of time and activities.

Figure 6. Q3q1 Questionnaire 3 Question 1 - Code Network -Teamwork skills



Regarding Teamwork carried out under the FPBL approach. As a result of the qualitative analysis regarding the student's participation in the work team, the information is classified into two categories: *Academic Performance:* in this category, the students affirmed that their participation was "Responsible and collaborative work was done" and "Participated actively in-class activities." *Professional Performance:* the students stated that "We worked with mean commitment with colleagues and with our training" and "It was valuable to work in this way because it allowed me to share points of view with colleagues". (Annex 17. Q2q44). The previous results are supported with the information that results from the qualitative analysis when asking the students about their main contribution of teamwork in their learning process. The information is classified into two categories: *Academic Performance:* students report that "Help solve class doubts" and "Improve communications with other people". *Professional Performance:* students affirm that "Strengthen responsibility and collaboration skills among colleagues" and "Interacting with other colleagues is useful to clarify doubts and have more ideas to develop in the project"(Annex 17. Figure 17. Q2q6). Students' attitude towards teamwork during the development of the course shows a greater positive attitude (Q2q8). Table 8. These results are consistent with the results obtained described in the previous paragraphs.

5.4 The effectiveness of the teacher under the FPBL approach

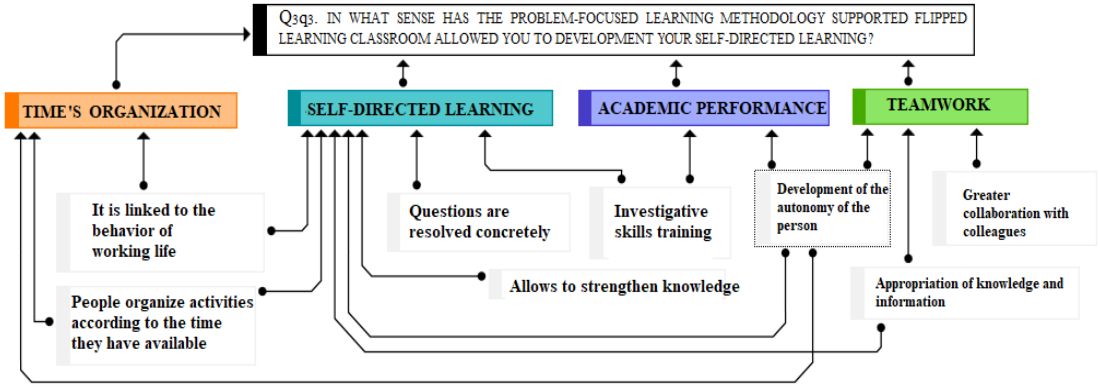
In the fourth research question RQc, a query is made about the relationship between the implemented methodology and the efficiency of the teacher's work using this methodology, resulting in information that is shown below.

Student´s perception about effect effectiveness of the teacher under the FPBL approach

The qualitative analysis corresponding to the students' responses to the questions published in the learning community is presented. The third question inquires about the characteristics evidenced by the students in the work carried out by the teacher with this approach, by means of which information is found that is organized into three central categories that are shown below.

The role of the teacher in FPBL classroom used in the course: The students perceived that the role of the teacher allows them to improve their academic performance since it facilitates them to understand that "knowledge has significance beyond the academic", encourages autonomous work, teamwork and contributes to the appropriation of knowledge. The teacher's guide contributes to the research development, the concepts are better understood when they are applied. They also perceive that it will contribute to their professional performance since doubts are solved by the teacher more precisely "when they are contextualized in an environment of problems typical of the career". They indicated that the role of the teacher in FPBL "is friendlier with the students in the virtual mode."

Figure 7. Q3q2 Questionnaire 3 Question 2 Code Network – teacher characteristics



i) Academic training: in this case it is named that the teacher is the person who knows the class topics, so he performs functions such as guiding students in solving doubts, at the same time that he manages to motivate them in the search for a solution to problems. All this becomes relevant and useful because it manages to equip students with the necessary tools for their optimal performance in their study and future profession. *ii) Organization:* at this point, favourable aspects of the teacher are highlighted in relation to the distribution of time, such as setting the parameters and conditions of delivery of the works, with enough anticipation, since this allows students to distribute their activities according to the time that have to perform. *iii) Teamwork:* in this category the qualities that students develop in this opportunity are named, which becomes important as it is one of the central objectives of the flipped classroom work methodology.

Finally, according to the data provided by the students in the three previous questions, it is possible to notice that the information of some central themes or categories is shared, from which it is useful to affirm that there is a close link between them, even when inquire about different content; This possibly allows us to identify that, both in the analysis of the participants' discourse and in the formulation of the questions, a proximity is established that is manifested on this occasion.

Regarding the effectiveness of the teacher under the FPBL approach: The students consider that the work carried out by the teacher was good because the professors support was permanent and they were interested in the students understanding the topics that were developed in class, solving doubts that the students may have in the process. It serves as a guide and orientation for the students, also because of its commitment, organization, and the tools provided. The students consider that the teacher's main contribution during the development of the final project was their orientation for the development of the formulated problems. The students considered that these problems are very good because they manage the concepts seen in class, and the best are those that link theory with practice in the same analysis.

6 Conclusions

- The impact of the implementation of the FPBL approach on student learning becomes evident in relation to the appropriation of disciplinary knowledge of economic engineering, for each of the assessed topics a significant change is evidenced in the results of the test of knowledge, where it is evidenced that the students achieved the expected learning objectives in the topics of Present Value Analysis, Future Value Analysis, Capitalized Cost Analysis, Analysis of the Payback Period, Life Cycle Cost, Annual Value Analysis, Inflation, however You should work on the inclusion of real problems for the topic of, Bonus Present Value because although the score achieved by the students improves at the end of the project, this score is far from the maximum score that the student should obtain.

- Regarding the development of self-directed learning ability, the implementation of this approach guarantees that the student reflects on the importance of her responsibility in the execution of their learning activities.

- The implementation of the FPBL approach promotes the performance of activities within the framework of teamwork, generates in students a positive attitude towards carrying out activities with colleagues, in the same way it promotes collaborative work within the framework of cordiality and the respect.

- In relation to the efficiency of the teacher's role under this approach, it is important to highlight two fundamental aspects on which the students consider as main contributions the organization of the activities in the course and the formulation of real problems that facilitate the connection of the theoretical aspects with their professional performance.

- As future work based on the results of this intervention, this study will be presented to the academic committee as the initial step for the adoption of this approach for all the economic engineering groups of the National University of Colombia.

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Annex 1. Teaching performance perception survey result 2020-1 Engineering Economic.

Table 10. Teaching performance perception survey result 2020-1 Engineering Economic.

Economic Engineering Course First Semester 2020-1		
	Improvement Actions	Number of students 13
Question Number of survey original	It is required to undertake improvement actions in the teaching processes in teachers and learning in students in the following aspects	Aspect
4	Organization of time for consultancies	53.85% of your students consider that always, and 15.38% consider that frequently, you dedicated enough or adequate time to advise them, guide them and clarify doubts.
5	Problem formulation to find connections of course topics with other contexts	76.92% of your students consider that you enabled them to find connections of the topics covered with other contexts or with other contents of their study plans.
7	Promote critical argumentation	69.23% of your students consider that you promoted argumentation or critical reflection in them.
9	Motivate interest in course topics	69.23% of your students consider that you inspired or motivated interest in the topics covered.
12	Adjust teaching methods according to student learning rates	38.46% of your students consider that always, and 38.46% consider that frequently, you adapted or modified your teaching methods according to their needs.
15	Design of assessments aimed at improving student learning	61.54% of its students consider that they always, and 15.38% consider that frequently, their evaluations led them to improve their learning.
17	Transformation of thinking, feeling or acting	69.23% of your students consider that you transformed the way they think, feel or act

Annex 2. Redesign of the content of the course of Economic Engineering for UNC

Identification of the course

The course is identified within the System of Information of the university as follow. Code: course 2015703. Name of the course Engineering Economics. Faculty: Engineering. Leve: Undergraduate. The length of the course is 16 weeks and in the following chart it is specified the number of study hours; on-line and face to face. The total hours of academic periods is 144, and the number of credits per subject is 3.

Objectives of the course

By the end of the course students should have the ability to:

- Understand the different situations that arise in relation to the concept of the value of money over time.
- Analyse, manage, and decide on the different investment opportunities to define strategies, identify and select the best alternative solution to economic engineering problems.

Content of the course

Detailed content

The selection of the topics was made from the guidelines established by the curricular committee of the undergraduate program of economic engineering and approved by the Office of Academic Management of the UNC.

The committee establishes the topics to be addressed in the course, however, within the framework of the University regulations, the professor is given the freedom to include specific subjects and to specify some of the topics, as well as to include additional themes, provided that

each of the previously established general topics is addressed. For the inclusion of each of the topics, a review of the economic engineering books that have been used as study guide texts (Blank & Tarquin, 2002) (Newnan & Lavelle, Engineering Economic Analysis, 1998) (Sullivan, Wicks, & Koelling, Engineering Economy, 2020)

The content was classified into three modules. The first module includes two chapters: these are: i) Financial statements, it includes five main topics: fundamentals of economic engineering, factors such as time and interest affect money, combinations of factors, nominal and effective interest rates. ii) Tools for evaluating of alternatives, including six main topics: present value analysis, annual value analysis, single alternative rate of return analysis, alternative rate of return analysis multiple, benefit / cost analysis and economics of the public sector and decision-making method MARR and multiple attributes.

The second module corresponds to the topic of Decision Making in Real Projects which the solution is focused on the of economic engineering problems.

Finally, the third module corresponds to the Integration of Studies and includes the topic of inflation effects.

Table 11. Redesign of the content of the course of Economic Engineering for UNC- Source: content redesigned based on the selection and revision and formulated objective and established objective present in the Engineering Economics text guide (Blank & Tarquin, 2002) (Newnan, Eschbach, & Lavelle, 2004) (Sullivan, Wicks, & Koelling, 2020).

Basic Content Detail Content	**Date**	**Online Activities (distance assignments)**	**Activities – Virtual session with the orientation of the teacher**	**Intended Learning Outcomes**	**Scoring/ Evaluation**
MODULE 1. Chapter 1. Introduction to financial statements (08/25/2020 -09/24/2020)					
1.1. Introduction	08/25/2020 to 08/27/2020 (1st week)	Activity 1. Readings 1 and 2 + videos	Reading control	1. To know the types of questions that economics engineering answers. 2. To identify the necessary elements to successfully carry out an economics engineering study.	Written report of workshop #1 Part A

1.2. Fundamentals of Economic Engineering	09/01/2020 to 09/10/2020 (2nd -3rd week)	Activity 2. Workshop # 1 Part A	Reading control and videos. 09/15/2020	3. To do calculation of interest rate and return rate. 4. To describe the significance of the economic terms equivalence. 5. To calculate the simple interest and compound interest for one or more interest periods. 6. To identify and apply the terminology and symbiology of the economics engineering. 7. To identify the most common functions of the Excel© spreadsheet to solve problems. 8. To understand the meaning and to apply the concept of Minimum Acceptable Rate of return (MARR). 9. To understand the concept of cashflow and its estimation and graphic representation.	10/09/2020
1.3. Factors like time and interest affect money	10/09/2020 to 14/09/2020	Activity 3. Reading 3 and 4. Exercise + videos September 1-10	Socialization of exercises cases (problems) 09/22-29/2020	1. To use compound quantity factors and present value for unique payment. 2. To apply factors of present value and uniform series capital recovery. 3. To use factors of compound quantity and sinking fund in a uniform series. 4. To linear interpolate to calculate the value of a factor. 5. To apply formulas of the geometric gradient. 6. To calculate the interest rate (return rate) of a sequence of cashflow. 7. To create a spreadsheet to do an analysis of the basic sensibility by using the functions of the spreadsheet.	Oral and written reports of worksho p 1-part B 09/24/2020 Oral and written report of the worksho p 1 consolid ated 29/09/2020 Test 1 written report 10/1/2020 (6th week)
1.4. Combination of factors	14/09/2020 to 25/09/2020			1. To determine P, F or A of a uniform series that starts in a different moment to the period 1. 2. To calculate P, F or A of unique quantities place at random and quantities of uniform series. 3. To do calculus of equivalence for cashflow that involves geometric gradients or deferred arithmetic. 4. To do calculus of equivalence for cashflow that implies decreasing arithmetic gradients. 5. To show the different functions of a spreadsheet and to compare by-hand solutions to computer solutions.	
1.5 Effective and nominal interest rate	28/09/2020 to 01/10/2020	Activity 3. Reading. Homework + video Activity 4 and 5. Consolidat		1. To understand the formulas for rate of nominal and effective interest. 2. To deduce and apply the formula for the effective annual rate interest. 3. To calculate the effective interest rate for any period.	

		ion and delivery of documents		4. To determine the correct method to do the equivalence calculation for different periods of payment and capitalization. 5. To do equivalence calculation for periods of payments that are equal or mayor than period of capitalization when unique quantities are presented. 6. To do equivalence calculation when a uniform or series gradient is presented for periods equal or mayor than capitalization period. 7. To do equivalence calculation of period that are minor than the capitalization period. 8. To calculate and use an effective interest rate for the ongoing capitalization. 9. To consider interest rate that vary with time when equivalence calculation is being carried out.	
Chapter 2. Tools for the evaluation of alternatives 6/10/2020 (7th week -10th week)					
2.1 Introduction	06/10/2020	Activity 6 – Reading 5 and 6 + videos and exercises Workshop 2 Part A	Socialization of the case exercises (problems)	1. To Identify the mutually independent and exclusive projects. 2. To distinguish the income and service alternative. 3. To select the best same lives alternatives using the present value analysis. 4. To choose the best different lives alternative using the present value analysis. 5. To choose the best alternative using the future value analysis. 6. To choose the best alternative using the calculation of the capitalized cost 7. To determine the recovery period used i = 0% e i > 0% and to point put the deficiency of the recovery time analysis 8. To do an analysis of the life-spam cost for the acquisition phase and the alternative operation phase (system) 9. To calculate the present value of an investment bonus 10. To create spreadsheets that use the P analysis and its extensions using the recovery period	Written and oral report of the results from the workshop 2 Part A 29/10/2020
2.2 Analysis of the present value	13/10/2020				
2.3 Analysis of the annual value	15/10/2020			1. To demonstrate that the AV needs to be calculated only during one life cycle. 2. To calculate the recovery capital RC and the AV using two methods. 3. To choose the best alterative using AV analysis.	

				4. To calculate the AV of permanent investment.	
2.4 Analysis of the unique alternative rate of return	19/10/2020	Activity 7 – Reading 7 and 8 + videos and exercises	Socialization of the result of the workshop 2 Part A	1. To explain the meaning of return rate. 2. To calculate the return rate using an equation of present value or annual value 3. To identify the difficulties of using a RR method in comparison with me PV and AV methods 4. To calculate the maximum possible RR for a cashflow series 5. To calculate the compound return rate using the determined reinvestment rate 6. To calculate the nominal and effective interest rate for a bonus investment	
2.5. Analysis of multiple alternative return rate	27/10/2020	Activity 8. Reading 9 and 10 and exercises workshop 2 Part B	Socialization of results of workshop 2 Part B	1. To explain why it is necessary an increasing analysis to compare alternative with the RR method. 2. To do an increasing cashflow tabulation for two alterative. 3. To interpret the meaning of the RR over initial increment investment 4. To choose the best between two alternatives using the analysis of equilibrium or increasing RR considering the present value 5. To choose the best between two alternatives using the analysis of RR considering the annual value 6. To choose the best between two alternatives using an increasing RR analysis. 7. Create a spreadsheet that includes the PV, AV and RR for multiple alternatives of different lives	
2.6 Cost/benefit analysis and the public sector economy	29/10/2020			1. To identify the main differences between the economic alternatives of the private and public sector. 2. Use the cost benefit ratio for the evaluation of one project. 3. To choose the best between two alternatives using the increasing C/B ratio method. 4. To choose the best option between the multiple alternatives using the increasing C/B ratio method	Written and oral report of the results of Workshop 2 Part B 03/11/2020
2.7 Makes decisions based on MARR method and multiple attributes.				1. To choose the suitable method to compare mutually exclusive alternatives. 2. Represent the cost of capital and its relation to MARR 3. To describe the proper capital-debt mix and calculate the weighted average cost of capital (WACC) 4. To estimate the cost of debt capital 5. To calculate the own capital cost and to explain how this cost is compared to the WACC & MARR	Test 2 written evaluation 05/11/2020

				6. To explain the risks for companies to mix own capital-debt 7. To identify and develop weighted factors for the multiple attributes used in the election of alternatives 8. To apply the weighted attributes method to make decisions on the multiple attributes	
MODULE 2. Chapter 3. Decision making of real projects					
3.1 Problem solving of Economics Engineering	10/11/2020 to 14/11/2020	Activity 12. Workshop 3 First Part of the Project: To apply FPBL. To apply the steps of FPBL method to solve the situation.	Execution of steps 1 and 5 of the FPBL with the guidance of the teacher. Socialization of workshop 3	1. To analyze the problem of Engineering Economics 2. To set the expected learning objectives 3. To identify alternative for solution 4. To propose different alternative for solution 5. To select the most suitable solution alternative 6. To apply the solution alternative	Pre-Test 10/11/2020
MODULE 3. Chapter 4. Studio Integration					
4.1 Introduction	17/11/2020	Activity 13. Workshop 4. Second Part Project Solution to the Economics Engineering problem using FPBL. 26/11 Activity 14. Consolidation, review and final project delivery. 01/12/2020	Socialization of the Economics Engineering problem 26/11/2020	1. To determine the difference effect of inflation between the money now and the money in the future 2. To calculate the present value with the adjustment on the inflation 3. To determine the real interest rate and calculate the future value with adjustment on the inflation. 4. To calculate the amount of annual money in future dollars that is equivalent to a future or present determined sum.	Presentation and Project support 01/12/2020
4.2 Effects of the inflation	19/11/2020		Socialization of final the project 3/12/2020		Final written evaluation. Post-Test 09/12/2020

Annex 3 Detail Description of the Teaching and learning activities.

Reading about Economic Engineering topics

This activity is included for students to develop the ability to understand and reflect on each of the topics covered in the course based on their personal reasoning and their own experiences.
The documents that the student must read correspond to specific chapters of the course guide textbooks. This implies for the student the analysis, synthesis, integration and interpretation of the fundamental concepts of Economic Engineering relevant to each topic.
Associated with this activity, the reading control is carried out. The teacher plays an essential role since he asks questions to establishing a dialogue between students about the subject. These questions are about the meaning and application of each concept. The students deliver the summary of the text and concept maps as a product of this activity, which they present to their classmates during the virtual session.

Videos

Using the videos for individual learning and as a complement to online learning is included in the design of this course. During the virtual sessions, the videos that were selected are intended to interest the student in the subject that the video addresses and support specific content learning. The student synthesizes of the information presented in the video with the aspects that he considers relevant, then shares this information with classmates during the virtual session. The videos are considered an essentials educational didactic material in the teaching-learning process; That is why there are different studies to estimate the efficiency of the video format in learning activities and to know its impact as a source of information for students (Silveira, Chigami, Matushima, & Ruggiero, 2015) (Van Wyk, 2018).

Workshops

Four workshops that were designed within this intervention to be carried out in work teams by the students. The actions are directed towards "knowing how to do". These workshops are built on the following principles of the PBL (De Graaff & Kolmos, 2003), problem-based, activity-based, interdisciplinary and group-based learning. The teacher proposed problems and are simple cases of the real context, and the student takes the problem as the starting point of their learning process. The Workshops have the following characteristics:
Self-directed learning
1) The student must carry out a preliminary investigation about the topics covered by the workshop. (Autonomous work).
2) From each of the proposed economic engineering problems, which correspond to simple cases, each student inquiries about the concepts required to solve the problem and identifies the methods, they can use to obtain the optimal solution. (Autonomous work).

Teamwork

3) Each student shares the findings with the other group members and presents their alternative solution. (Teamwork online).
4) Then the students consolidate the workshop´s written report, including the procedure and the mathematical solution of the problem as the solution that is generated when using the economic formulas of the Excel software. (Teamwork on-line - They share a document in Word and another in Excel with the members of the work team through Google Drive).
5) Each work team socializes the results of the workshop with all the students in the group during the virtual session with the teacher's guidance (Teamwork during the virtual session).
6) Each work team makes the corrections or adjustments that are required to find the precise solution to the problem and consolidates the information in the final report. (Teamwork online).
The role of the teacher

7) The teacher formulates reflective questions on the subject and solves doubts that the students express during the virtual session.

Workshop 1:

This workshop has two parts: A and B, for Workshop 1A the teacher formulates cases of medium complexity, for each case the student applies the fundamental concepts of economic engineering (interest rates and rates of return, equivalence in economic terms, simple interest and compound interest for one or more interest periods, minimum attractive rate of return MARR to find the solution. Similarly, for Workshop 1B the teacher formulates cases of medium complexity for the topics; Factors like time and interest affect money, combinations of factors, and nominal and effective interest rates.

Workshop 2:

This workshop has two parts A and B, for Workshop 2A the students solve cases of medium complexity, for each case the student applies the concepts and methods of Present Value Analysis and Analysis of the annual value as appropriate for each case, students calculate the optimal solution to the problem. In Workshop 2B students solve each case in which is required the Single or multiple alternative rate of return analysis is required.

Workshops 3 and 4	are a fundamental part for the development of the Final Project, these workshops were designed from the following principles of problem-based learning; i) specific activities formulated that involve research, ii) decision-making and the writing of documents, iii) interdisciplinary learning, since the analysis and understanding of the cases requires knowledge of each discipline such as civil, industrial, chemical, electrical, electronic and mechanical engineering.
Final project	The final project of the course corresponds to the final activity within the framework of the student's learning process. The duration of the final project is 2 weeks. The project has the following general characteristics: i) it must be developed under the problem-based learning approach supported by an invested class. ii) it addresses the contents of Annual Value Analysis, Present Value Analysis, and inflation. iii) the student applies in an integrated way the knowledge and skills acquired during the course development, by solving real problems (cases of medium complexity) iv) defines activities that must be carried out by the student independently and online, as well as group learning activities during virtual sessions. v) It must be developed and presented in a group of students. vi) It has the support of the teacher in his role as a facilitator of the students' learning process. At the end of the project, the student is expected to improve their self-learning and teamwork skills. Concerning Knowledge, it is expected that at the end of the project the student will be able to include inflation in the analysis of real problems of economic engineering, this analysis includes the measurement of the impact of inflation and the calculations of the present value values VP with inflation, future value FV with inflation and AV value with inflation and meets the expected learning objectives described in table 3 module 3.

Annex 4 Detail Description of the Evaluation and assessment

Written test	Students take three written tests that assess the knowledge acquired by students about each of the topics in each module.
Post-Test and Pre-Test	Corresponds to a specific knowledge test Annex 3 Section**.**
Socialization of the Workshops	Students present a written and oral report of the results of the workshops.
Socialization of results of the Final Project	Students delivers the final report of the project and makes an oral presentation, also presents the specific Post-Test.
Lecture Activities	It corresponds to the oral presentation of a specific topic previously selected from the content of the subject that is assigned to a group made up of students. Teams are formed in the first-class. The students of the group are the speakers, the other students reflect on the topic and answer the questions posed by each speaker. The presentation is made during the virtual online session, with an exposure time of 20 minutes and a time of 10 minutes for the solution of questions or doubts that arise in students. It aims to motivate students to participate in the class session, provide key ideas on the topic being addressed, and ensure that students understand key ideas.

Table 12. Evaluations and evaluations of the students' work in the course

Activity	Percentage value	Interaction	Specification
Written test 1 Written test 2 & Specific Post-Test	20% First 10% second & third	Individual	Written evaluation that includes topics covered in class and activities analysis.
Workshops (4)	5% each	Group	Problems based on simple cases context)
Final project	20%	Group	To present a practical workshop of the real problem
Reading check and exercises Lecture activities	10% 10%	Group Group	Readings and model. homework with simple cases Reading of the thematic modules. Homework exercises simple cases. Students presentation, analysis and discussion about the topic

Annex 6. Characterization of the population Economic Engineering Course 2008-2019

	Absolute frequency		
Semester in which the student enrols to the university	G1	G2	Total
2013-1S	0	1	1
2015-1S	1	0	1
2015-2S	1	1	2
2016-1S	1	0	1
2016-2S	4	1	5
2017-1S	4	1	5
2017-2S	2	9	11
2018-1S	4	6	10
2018-2S	5	6	11
2019-1S	6	8	14
2019-2S	3	0	3
2020-1S	2	0	2
Total	33	33	66

Typology	G1	G 2	Total
Rationale - Mandatory	26	25	51
Rationale - Optional	7	8	15
Total	33	33	66

Undergraduate	Absolute frequency		
	G 1	G2	Total
Agricultural Engineering	1	7	8
Civil Engineering	10	4	14
Computer and Systems Engineering	7	8	15
Electric Engineering	3	2	5
Electronic Engineering	3	2	5
Mechanical Engineering	6	4	10
Mechatronics Engineering	2	1	3
Chemical Engineering	1	5	6
Total	33	33	66

Annex 7. Questionnaire 1 – Q1 – Student´s perception of methodology and Post-Test and Pre-Test Knowledge

Section 1. Questions about the student's perception of the methodology

$QS_1Q_{1..}$ In which of the following fields do you consider that the methodology carried out in class will have a greater impact on the development of the final project?

a. Autonomy because the methodology leads the student to adopt a position where he formulates and solves questions derived from the topics discussed, at the same time that he delves into what is of interest to him.

b. Teamwork because when questions that students cannot solve appear, they can ask for help to their classmates for the questions to be solved or clarified.

c. Appropriation of knowledge because the way in which the classes are carried out allows contextualizing the theoretical content to its proper development in the daily life.

d. Greater organization of time and learning spaces by the student

$QS_1Q_{2.}$ What aspects or elements of your training do you consider should be reviewed before carrying out the final project?

a. Preparation of group work that promotes interaction with colleagues.

b. Realization of problems that relate the information and topics that are used in the classes and are contextualized by their application in real situations.

c. Development of autonomous work activities in which the knowledge of each student is strengthened

QS_1Q_3. Based on your experience so far in this class, express the degree of affiliation with the following phrase: "I like working with colleagues because in this process there is an exchange of ideas that complement each other". Scale from 1 to 5 where 1. Completely disagree and 5. Completely agree.

QS_1Q_4. How useful do you consider the methodology used in class is to promote autonomy for the development of the final project? Scale from 1 to 5 where 1. Nothing and 5. Completely.

QS_1Q_5. Based on your experience so far in this class. To what degree do you consider that the role carried out by the teacher was useful to promote the development of teamwork with a view to the correct preparation of the final project? Scale from 1 to 5 where 1. Not very useful and 5. Completely useful.

QS_1Q_6. According to your performance so far in class activities. How important do you think it is that each student has a work plan for the preparation of the final project? Scale from 1 to 5 where 1. Not at all important and 5. Absolutely important.

QS_1Q_7. For the completion of the final project, indicate the degree to which you agree with this phrase: "Collaborative work is a crucial element for optimal professional and personal development, because in this space each person manages to form favourable skills". Scale from 1 to 5 where 1. Strongly disagree and 5. Strongly agree.

QS_1Q_8. For preparation prior to the final project, how useful is it for you that teachers use everyday examples to present class topics? Scale from 1 to 5 where 1. Not very useful and 5. Completely useful.

Section 2. Questions Specific Knowledge

The questions formulated based on the information present in the Engineering Economics text guide (Blank & Tarquin, 2002) (Newnan, Eschbach, & Lavelle, 2004) (Sullivan, Wicks, & Koelling, 2020).

Present Value Analysis – Formulation of Mutually Exclusive Alternatives

$Q_1q_{1.}$ Fundamental Concepts

$Q_1q_{2.}$ Projects (Blank & Tarquin, 2002)

Analysis of the Present Value with Equal Life

$Q_1q_{3.}$ Analysis of present value.

$Q_1q_{4..}$ Present value analysis when a series of mutually exclusive alternatives are presented.

$Q_1q_{5.}$ Analysis of present value, guide that is applied for one or more alternatives when the projects are independent.

$Q_1q_{6.}$ Analysis of present value and Safe value.

Present Value Analysis with different lives.

$Q_1q_{7.}$ The present value analysis with different lives

$Q_1q_{8.}$ The analysis of present value with different lives and conditions required

$Q_1q_{9.}$ The analysis of present value of multiples alternatives

Future Value Analysis

$Q_1q_{10.}$ The analysis of future value fundamental concepts

$Q_1q_{11.}$ MARR

Capitalized Cost Analysis

$Q_1q_{12.}$ Fundamental Concepts

$Q_1q_{13.}$ Capitalized Cost Analysis exercise 1

$Q_1q_{14.}$ Capitalized Cost Analysis exercise 2

Analysis of the Payback Period

$Q_1q_{15.}$ Fundamental Concepts of Life Cycle Cost

$Q_1q_{16.}$ Fundamental Concepts of Life Cycle Cost

$Q_1q_{17.}$ Classify the activities according to acquisition or operation

Bonus Present Value

$Q_1q_{18.}$ Identify of the entity that issues bonus; government or company and its classification (Treasury, Municipal, Mortgage, Debt Securities)

Annual Value Analysis

$Q_1q_{19.}$ Fundamental Concepts

$Q_1q_{20.}$ Selection of Project engineer Alternative

Inflation

Source: Questions Asked by Blank and Tarquin (Blank & Tarquin, 2002)

Q_1q_{21}. Present value

Q_1q_{22}. Conversion of dollars of constant value to inflated dollars.

Q_1q_{23}. Convert inflated dollars into dollars of constant value

Q_1q_{24}. Interest rate and real interest rate

Q_1q_{25}. Future dollars

Annex 8. Characteristics of the questions in Section 2 of questionnaire 1.

Table 13 shows the subtopic, the numbering of the question, the type of competence that is evaluated and the description of the question methodology, as well as the type of statistical analysis to be carried out. The Type of skill to evaluate TSE correspond to Interpretative (I), Argumentative (A) and Propositional (P).

Table 13. Characteristics of the questions in Section 2 of Questionnaire 1.

Subtopic	Questions	TSE	Description of the question methodology
Present Value Analysis – Formulation of Mutually Exclusive Alternatives	$Q1_{q1}$	I	The question includes nineteen statements in which the student must answer for each one of them if it is true or false
	$Q1q_2$, Q1q3 $Q1q_4$, $Q1q_5$ $Q1q_6$, $Q1q_2$, and $Q1q_9$,	A	Each question ($Q1q_2$ to $Q1q_7$, and $Q1q_9$) has four answer options where only one of the answers is correct. $Q1q_9$, corresponds to a simple case of a real problem that the student must solve.
	$Q1q_8$	A	The question presents four situations in which the student must answer whether or not. A present value analysis is required, depending on the case. Only one of the answer options is true
Future Value Analysis	$Q1q_{10}$	I	Includes seven statements for each of them the student must answer if it is true or false
	$Q1q_{11}$	A	It includes four answer options where the student must select the correct option. The question corresponds to a simple case of a real problem that the student must solve.
Capitalized Cost Analysis	$Q1q_{12}$	I	Includes five statements for each of them the student must answer if it is true or false
	$Q1q_{13}$	P	The question includes four answer options the student must select the correct option. The question corresponds to a simple case of a real problem that the student must solve.
	$Q1q_{14}$	P	The question includes four answer options the student must select the correct option. The question corresponds to a simple case of a real problem that the student must solve.
Analysis of the Payback Period	$Q1q_{15}$	I	Includes eleven statements for each of them the student must answer if it is true or false
Life Cycle Cost	$Q1q_{16}$	I	$Q1q_{15}$ Includes five statements for each of them the student must answer if it is true or false
	$Q1q_{17}$	A	This question contains five activities, the student must classify each activity in the acquisition phase or operations phase as appropriate
Bonus Present Value	$Q1q_{18}$	A	$Q1q_{17}$ includes thirteen examples of vouchers, the student must specify which is the entity that issues each voucher (government and state are the response option) and the classification of each one.
Annual Value Analysis	$Q1q_{19}$ and $Q1q_{20}$	I	Each question has four answer options where only one of them is correct. $Q1q_{19}$ corresponds to a simple case of a real problem that the student must solve.
Inflation	$Q1q_{21}$, $Q1q_{22}$, $Q1q_{23}$, $Q1q_{24}$ and $Q1q_{25}$	P	Each of the questions has four answer options where only one of them is correct

Annex 9. Characteristics of the questions of Questionnaire 2.

Table 14. Characteristics of the questions of Questionnaire 2 – Q2 -

Variables	Questions	Description of the question methodology
Self-directed Learning in students	$Q2q_1$	This question includes eight statements related to the functionality of the FPBL methodology. The student must express whether they agree or disagree on a four-level Likert scale. The response options are strongly agree, agree, strongly disagree, and disagree
Importance of the learning activities developed in the course	$Q2q_2$	This question includes eight types of activities developed in the course. The student must classify the importance of each activity for him on a three-level Likert scale. The answer options are moderately important, important, and very important.
Teacher's role in the course	$Q2q_3$	This question includes seven statements in which the student must express his positive or negative attitude about the role of the teacher in the course on a four-level Likert scale. The response options are strongly agree, agree, disagree, and strongly disagree
	$Q2q_4$	This question is open, when answering it the student expresses his perception regarding the role of the teacher in the framework of the applied methodology
Learning Activities during the development of the course	$Q2q_5$	This question lists the eight activities in which the student must express perception about the extent to which each activity developed during the course was useful to support their self-learning. The response options are on a five-level Likert scale (very high, high, intermediate, low, and very low)
Teamwork during the development of the course	$Q2q_6$	This question is open, the student expresses the main contribution of teamwork during their learning process.
	$Q2q_7$	This question is structured and closed on a Likert scale. The scale has five levels. When answering it, the student classifies how good was her attitude to work in a team.
	$Q2q_8$	This question contains 30 statements about the teamwork circumstances, for each circumstance, the student expresses his degree of agreement according to his own perspective or experience. The response options are on a five-level Likert scale, where 1 totally disagrees and 5 totally agrees. The questionnaire was developed by Trechera (Trechera, 2003)
	$Q2q_9$, $Q2q_{10}$, $Q2q_{11}$, $Q2q_{12}$ and $Q2q_{13}$	These correspond to open questions, when answering them the student expresses his perception of teamwork during the development of the course. Question $Q2q_9$ asks about the actions that were established for teamwork. $Q2q_{10}$ about how decisions are made, $Q2q_{11}$ about the delegation of a leader in the team, $Q2q_{12}$ about the commitment and responsibility of the student for the execution of activities in the course, and $Q2q_{13}$ about how teamwork motivates and creates knowledge during the development of the activities in the course.
Perception regarding the development of the final project	$Q2q_{14}$	It contains 12 statements in which the student must express their degree of agreement regarding the development of the final project. The answer options are on a five-level Likert scale. (Strongly agree, Agree, Disagree Strongly disagree,
	$Q2q_{15}$, $Q2q_{16}$, $Q2q_{17}$, $Q2q_{18}$, $Q2q_{19}$, $Q2q_{20}$,	These questions correspond to open questions related to the student's perception regarding the development of the final project. Q2q15 inquiries about the perception of the use of the FPBL methodology in the execution

	$Q2q_{21}$, $Q2q_{22}$, $Q2q_{23}$ and $Q2q_{24}$	of the final project. $Q2q_{16}$, $Q2q_{17}$, and $Q2q_{18}$ inquire about how the final project supported, influenced, and affected self-directed learning, the acquisition of knowledge, and the development of the ability to solve problems respectively in the student.
Perception regarding the use of videos	$Q2q_{25}$, $Q2q_{26}$, $Q2q_{27}$, $Q2q_{28}$, $Q2q_{29}$, $Q2q_{30}$, $Q2q_{31}$, $Q2q_{32}$, $Q2q_{33}$, $Q2q_{34}$, $Q2q_{35}$, $Q2q_{36}$, $Q2q_{37}$ and $Q2q_{38}$	These are open questions that respond to the student's perception regarding the use of videos.
The role of the teacher in the student's learning in the project	$Q2q_{39}$, $Q2q_{40}$ and $Q2q_{41}$	these are open questions; the student describes his perception regarding the role of the teacher in the student's learning in the project.
Teamwork during the final project	$Q2q_{42}$	It is a question with a single answer. The student expresses what his role was in the work team during the final project.
	$Q2q_{43}$, $Q2q_{44}$ and $Q2q_{46}$	These are open questions about the student's perception of teamwork during the final project
	$Q2q_{45}$	It is a question with multiple answers. The student reports what communication tools she used in her work team during the development of the final project.
	$Q2q_{47}$	This question includes 20 situations, for each situation the student expresses to what extent problem-based learning allowed him to develop teamwork skills during the development of the final project. The response options are on a four-level Likert scale (Always, Frequently, Sometimes, Never)

Annex 10. Questionnaire 2 – Q2 – Student Perception Test about the methodology used in the course and the Project

- ***Self-directed learning in students***

Q_2q_1. To what extent do you agree or disagree that the functionality of the FPBL flipped learning classroom supported by problem-based learning approach is important for improving self-directed learning?	Strongly agree	Agree	Disagree	Strongly Agree
It promotes an environment that increases interaction between students and teachers outside of class.				
Engages students in the learning process by applying and practicing the content learned.				
It uses a student-centered approach as it focuses on increasing student learning.				
It promotes more responsibility to learn more about students, while giving them greater momentum and more room to experiment.				
Enhance active learning activities such as inquiry, learning, problem-based learning, and peer collaboration to achieve learning outcomes				
Create something that is individualized and applies to students' everyday lives as it extends beyond the lesson.				
It requires careful preparation and there is an urgency regarding the amount of time and effort that the instructor must put in.				
The process to implement the FPBL is time consuming and creates additional work and may require new skills from the teacher.				

- ***Importance of the learning activities developed in the course***

Q_2q_2. To what extent do you agree or disagree that the following activities were helpful in the FPBL strategy to support your self-study?	Very important	Important	Moderately important
Reading of book chapters or articles on each of the Economic Engineering topics			
Simple problem solving corresponding to case studies			
Observation and analysis of concepts through videos-podcast with specific topics			
Multiple-choice questions			
Solution of preparatory tests for the mid-term that include simple case studies of Economic Engineering			
Workshops with economic engineering problems-case studies to solve them			
Student presentations on topics of interest - student's lecture activity			
Formulation and solution of the Final Work			

- ***Teacher's role in the course***

Q_2q_3 To what extent do you agree or disagree that the teacher played a crucial role in ensuring that the FPBL strategy could be used to improve student learning?	**Strongly agree**	**Agree**	**Disagree**	**Strongly disagree**
The teacher can cover more material and allow students to see how the material can be used in authentic problem-solving activities.				
The teacher provides students with simulations and hands-on activities.				
The teacher becomes a facilitator of the learning process, being available to help and support students throughout the whole process.				
The teacher must design Problem Based Learning processes supported by FPBL flipped learning classroom to develop high-level and engaging questions that serve to deepen students' thinking and clarify misconceptions in the lesson.				
The teacher plans activities outside of class for class discussion that can be led by students to enhance learning				
The teacher should design FPBL processes to develop engaging, high-level questions that serve to deepen students' thinking and clarify misconceptions in the lesson.				
The teacher must decide which elements inside and outside of class should be carefully integrated so that students understand the strategy and are motivated to prepare for class.				

Q_2q_4 To what extent do you consider that each of the designed learning activities contributed to the development of your knowledge?	**Very High**	**High**	**Medium**	**Low**	**Very Low**
Reading of book chapters or articles on each of the Economic Engineering topics					
Simple problem-solving corresponding to case studies					
Observation and analysis of concepts through videos-podcast with specific topics					
Multiple-choice questions					
Solution of preparatory tests for the midterm that include simple case studies of Economic Engineering					
Workshops with economic engineering problems-case studies to solve them					
Student presentations on topics of interest - student's lecture activity					
Formulation and solution of the Final Work					

Q_2q_5. What was your perception of the role of the teacher in the Problem Based Learning methodology supported by flipped learning classroom used in the course?

- ***Teamwork during the course development***

Q_2q_6. What do you think was the main contribution of teamwork in your learning process during the course?

Q_2q_7. What do you consider to be your attitude towards teamwork during the course, from 1 to 5, with 1 being a very bad attitude and 5 being a very good one?

Q_2q_8. To what extent do you agree or disagree with the following group situations?	**Totally Disagree**	**Disagree**	**I have doubts**	**Agree**	**Totally agree**
1. The human being tends to conform and to be influenced by others.					
2. It is more profitable to work alone than in a team.					
3. To be operative in decision-making, decisions must be imposed by majority.					
4. The ideal of any organization is that you think, feel and act in the same way as everybody.					
5. If there is conflict in the team, it is best to expel the discordant members.					
6. If the members of a team work together, they are able to achieve any type of objective.					
7. In general, team members work with less effort than the ones working individually.					
8. It is not important that the members of an organization have to know the objectives, means and actions of this.					
9. In teams, it is easier to pressure some members so that a few of them achieve the desired results.					
10. To maintain the identity of a team, it is preferable to isolate itself from external influences.					
11. For a leader to be impartial, it is better not to get emotionally involved with the members.					
12. It is preferable that the members are homogeneous.					
13. It is important to be functional that the rules in a team are already given and are clear so that no time is wasted in organizing or having to elaborate them.					
14. In a team, individual interests must always be subordinate to those of the team.					
15. Many people do not discover their capabilities until they are part of a team.					
16. Authoritarian leadership is preferable to make quick decisions and avoid conflicts					
17. The fundamental thing for a team is to be effective and meet the objectives that have been set.					
18. Teamwork is slower and less effective.					
19. Teams must form and evolve spontaneously.					
20. It is impossible to communicate and be able to come to agreements with people who think differently.					
21. Teams uniformize students					

22. Communicating and knowing how to listen is essential for good team functioning.						
23. The ability to work in a team is innate to each person.						
24. The team can make individuals try less or get carried away.						
25. It is more effective for the team to make decisions by consensus.						
26. Having information is having power, hence, to lead a team you don't have to communicate things.						
27. It is more effective to work according to the number of team members than to make all team members work.						
28. It is preferable to maintain the activities that are already mastered than to open up to new experiments.						
29. If there is a good group climate and people are comfortable in the team, people will get involved and work better.						
30. In order not to waste time on teamwork, directive leadership is more effective.						

Source: (Trechera, 2003)

Q_2q_9 During the development of the learning activities in the course, in your work team, were actions established to achieve the objectives (individual responsibilities, rules or precise tasks for each of the members)?

Q_2q_{10} How were decisions made in your work team during the course?

Q_2q_{11} Did you identify a leader or leaders in your work team during the development of the learning activities in the course?

Q_2q_{12} How did you demonstrate your commitment and responsibility to your work team during the development of the learning activities in the course?

Q_2q_{13} How did teamwork motivate you to create knowledge during the development of activities in the course?

- ***Perception regarding the development of the final Project***

Q_2q_{14} To what extent do you agree or disagree that flipped learning classroom pedagogy could be used to enhance your learning during the completion of the final project?	**Strongly agree**	**Agree**	**Disagree**	**Strongly disagree**
Enhance student learning process by engaging in dialogue and reflecting on how they experience the course.				
Helps students develop individual strategies to use information effectively to achieve results.				
It forces students to take responsibility for their own learning.				
It uses meta-cognitive thinking, where students must discern whether or not they have mastered the concepts.				
It helps when students are confused about part of the lesson as they can revisit course content anytime, anywhere.				
It promotes interactive relationships between the student communities and the teacher.				
Direct students to learn more and gain in-depth knowledge of material outside of class.				
Help students move through content faster with additional time to participate in independent research on the topic.				
It creates a space for communication among students that becomes the determining dynamic of a session dedicated to learning through practical work.				
Help students demonstrate what they have learned and apply the material in a way that makes sense to them.				
Engagement increases as more students enjoy virtual session activities and they benefit from watching lecture videos outside of virtual sessions.				

Q_2q_{15} What is your perception regarding the completion of the Final Project using the problem-based learning approach?

Q_2q_{16} How did the final project support self-directed learning when solving real-world Economic Engineering problems?

Q_2q_{17} How did the final project affect your knowledge of engineering economics?

Q_2q_{18} How did the final project affect your acquisition of skills to solve real economic engineering problems?

Q_2q_{19} Did the development of the final project allow you to gain a greater command of the fundamental concepts of economic engineering?

Q_2q_{20} Did the development of the final project allow you to know concepts of Economic Engineering and apply them in real problems?

Q_2q_{21} Did the development of the final project increase your interest in finding a solution to the problems?

Q_2q_{22} When developing the final project, do you consider that you achieved a conceptual change (an improvement in the acquisition and application of knowledge)?

Q_2q_{23} Do you think that you could monitor your own building of knowledge when developing the final project to address new gaps in knowledge?

Q_2q_{24} Did the assigned readings allow you to answer specific questions about the concepts required to solve the problems?

- ***Perception regarding the use of videos***

$Q_2q_{25.}$ What aspects of the videos impacted self-directed learning?

$Q_2q_{26.}$ Did you see improvements in your learning process by accessing the videos?

$Q_2q_{27.}$ Do you feel confident about learning the fundamental concepts and applying them to real problems?

$Q_2q_{28.}$ Did the videos give descriptive examples of the exercises to be performed?

$Q_2q_{29.}$ How did the videos support self-directed learning when solving real-world Economic Engineering problems?

$Q_2q_{30.}$ How did the videos affect your acquisition of knowledge about engineering economics topics?

$Q_2q_{31.}$ How did the videos affect your acquisition of skills to solve real economic engineering problems?

$Q_2q_{32.}$ How did the videos help you gain a better understanding of the fundamentals of engineering economics?

$Q_2q_{33.}$ How did the videos allow you to learn about Economic Engineering concepts and apply them to real problems?

Q_2q_{34} Did the videos increase your interest in finding solutions to problems?

Q_2q_{35} Did you access the video several times to use its content to solve the problem, as questions arose on the subject?

Q_2q_{36} How, when using videos, did you see that you achieved a conceptual change? (Improved the acquisition and application of knowledge)?

$Q_2q_{37.}$ Do you think you can monitor your own building of knowledge by re-accessing videos to address new gaps in knowledge?

Q_2q_{38} Did the videos allow you to answer specific questions about the concepts required to solve the real problem?

- ***The role of the teacher in the student's learning in the project***

$Q_2q_{39.}$ What was the main contribution of the teacher in the development of the final project?

$Q_2q_{40.}$ What aspects do you consider to be relevant regarding the formulation of the problems selected by the teacher for the final project?

$Q_2q_{41.}$ How did the new role of the teacher influence your learning process?

- ***Teamwork during the final project***

$Q_2q_{42.}$ What was your role on your team during the final project?

a. Leader (Team Brain)
b. Coordinator (Clarifies the goal to be reached and promotes decision-making)
c. Monitor-Evaluator (Analyzer of all options, strategizes and judges with accuracy)
d. Implementer (Efficient, transform ideas into actions)
e. Finisher (Look for omissions and carry out tasks within the established deadlines)
f. Researcher (Look for new opportunities and information)
g. Driver (Has initiative and courage to overcome new obstacles)
h. Cohesioner (Listen and prevent clashes, unite the team)
i. Specialist (Provides on particular knowledge)
j. Other. Which ones?

$Q_2q_{43.}$ How did the problem-based approach allow you to interact with the other members of your team during the final project?

$Q_2q_{44.}$ How do you consider your participation was in solving the problems formulated in the final project?

$Q_2q_{45.}$ What communication tools did you use in your teamwork during the development of the final project?

a. Email
b. Audio conferencing, video conferencing and instant messaging.
c. Skype
d. Google Talk
e. Windows Live Messenger
f. WhatsApp
g. Communication by direct cellular call

$Q_2q_{46,}$ How was the communication between the members of your work team during the final project?

I_2Q_{47} To what extent did problem-based learning allow you to develop teamwork skills during the development of the final project?	**Always**	**Frequently**	**Sometimes**	**Never**
The objectives of the teamwork were clear and accepted by each of the members				
Clear rules and tasks were established for each of the members of the work team				
A group leader was identified and accepted by the other members				
The actions were clearly defined to achieve the objectives				
Each of the student members of the work team was clear about their responsibilities				
Mechanisms were established to determine if the objectives of the work team are met				
Communication and participation of each student within the work team was facilitated				
Communication among students was clear and fluent				
The opinions of each one were heard among the team members.				
The decisions of the work team were made by consensus.				
When the decision was not taken by consensus, it is accepted by all students				
Alternative solutions to problems were generated				
The possible consequence of each alternative is analyzed.				
The analysis of the alternatives is carried out to select the optimal one				
Alternative work plans were developed.				
The climate for the development of activities is pleasant.				
Team members accept criticism positively				
Students accept suggestions or criticism in a positive way.				
Students express their conflicts openly and discussing differences.				
The conflicts focus on ideas and methods, not on people				

Annex 11. Questionnaire 3 – Q3 – for Perception of the usefulness of the FPBL approach in the course. Questions in the learning community

- ***Teamwork***

Q_3q_1. In what sense the flipped learning classroom supported by problem-based learning methodology has been useful to you to develop your teamwork skills?

- ***The role of the teacher in the FPBL approach, the main role is that of a tutor who facilitates and encourages reflection activities in the student.***

Q_3q_2. What are the characteristics that you evidenced in the work done by the teacher under this approach?

- ***Self-directed learning***

Q_3q_3. In what sense has the problem-focused learning methodology supported by the flipped learning classroom allowed you to develop your self-directed learning?

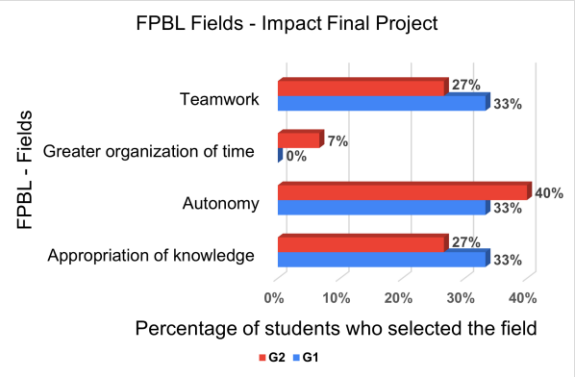
Annex 12. Questionnaire 1 Section 1 Results

This annex presents the descriptive statistical analysis corresponding to section 1 of questionnaire 1. The corresponding section contains questions about the student's perception of the FPBL methodology.

The Microsoft Office Excel program is used for the analysis. The number of students who answered the questionnaire is n=57; n_1 = 27 from group 4 (G_1) and n_2= 30 from group 10 (G_2).

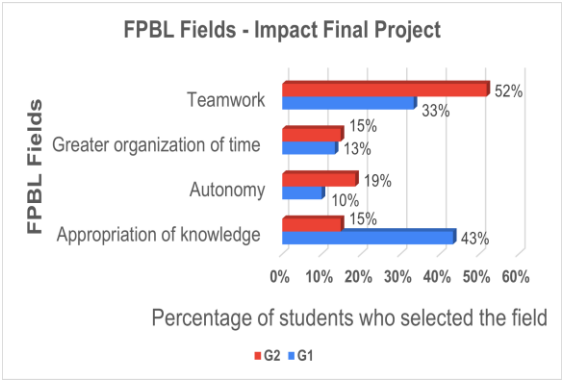
Figure 8. QS_1Q_1. In which of the following fields do you consider that the methodology carried out in class will have a greater impact on the development of the final project?

Pre-Test



FPBL fields	G_1	G_2
Appropriation of knowledge	33%	27%
Autonomy	33%	40%
Greater organization of time	0%	7%
Teamwork	33%	27%
Total	100%	100%

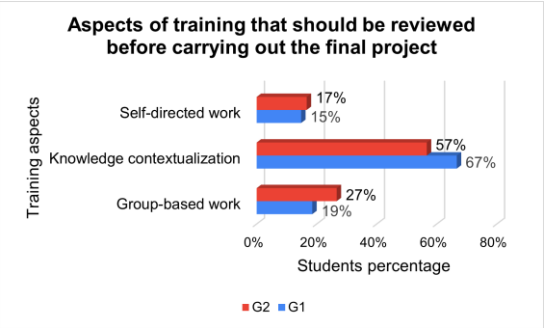
Post-Test



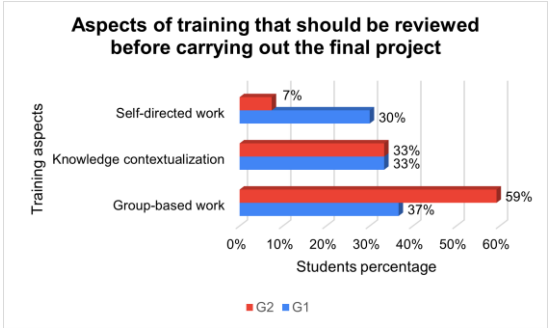
FPBL fields	G1	G2
Appropriation of knowledge	43%	15%
Autonomy	10%	19%
Greater organization of time	13%	15%
Teamwork	33%	52%
Total	100%	100%

Figure 9. QS_1Q_2. What aspects or elements of your training do you consider should be reviewed before carrying out the final project?

Pre-Test



Post-Test



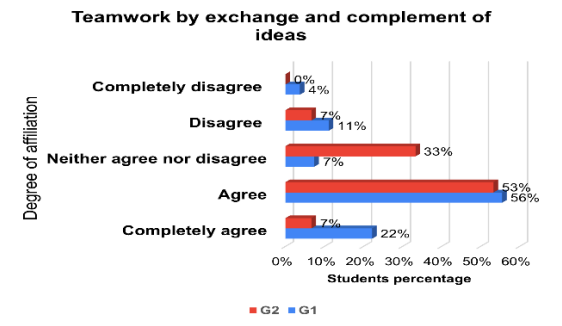
Training Aspect	**G1**	**G2**
Group-based work	19%	27%
Knowledge contextualization	67%	57%
Self-directed work	15%	17%
Total	100%	100%

Training Aspects	G1	G2
Group-based work	37%	59%
Knowledge contextualization	33%	33%
Self-directed work	30%	7%
Total	100%	100%

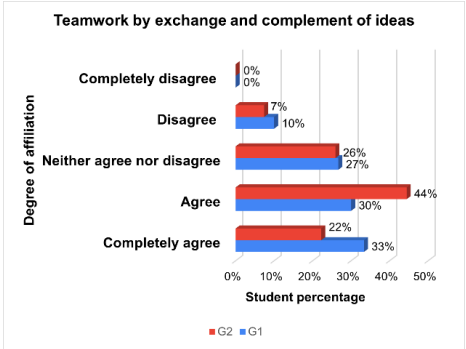
QS_1Q_3. Based on your experience so far in this class, express the degree of affiliation with the following phrase: "I like working with colleagues because in this process there is an exchange of ideas that complement each other". Scale from 1 to 5 where 1. Completely disagree and 5. Completely agree.

Figure 10. QS_1Q_3. Teamwork

Pre-Test



Post-Test



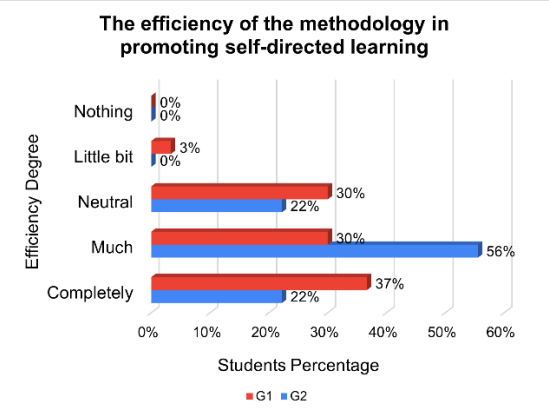
Degree of affiliation	G1	G2
Completely agree	22%	7%
Agree	56%	53%
Neither agree nor disagree	7%	33%
Disagree	11%	7%
Completely disagree	4%	0%
Total	100%	100%

Degree of affiliation	G1	G2
Completely agree	33%	22%
Agree	30%	44%
Neither agree nor disagree	27%	26%
Disagree	10%	7%
Completely disagree	0%	0%
Total	100%	100%

QS_1Q_4. How useful do you consider the methodology used in class is to promote autonomy for the development of the final project? Scale from 1 to 5 where 1. Nothing and 5. Completely.

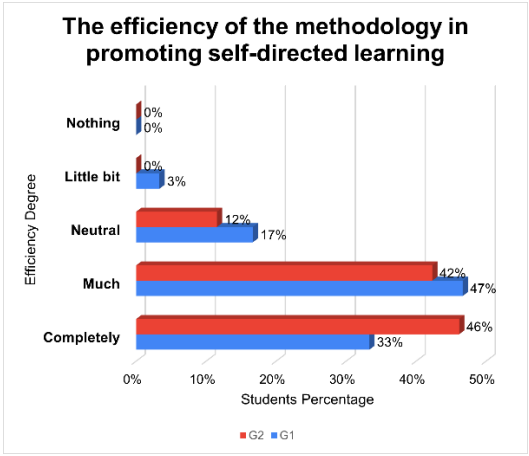
Figure 11. QS_1Q_4. Self-directed learning

Pre-Test



Efficiency Degree	G1	G2
Completely	22%	37%
Much	56%	30%
Neutral	22%	30%
Little bit	0%	3%
Nothing	0%	0%
Total	100%	100%

Post-Test



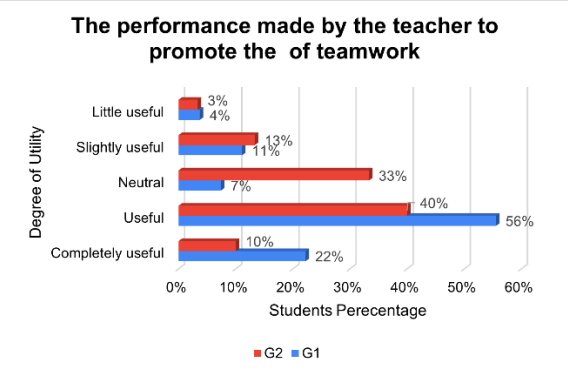
Efficiency Degree	G1	G2
Completely	33%	46%
Much	47%	42%
Neutral	17%	12%
Little bit	3%	0%
Nothing	0%	0%
Total	100%	100%

QS_1Q_5. Based on your experience so far in this class. To what degree do you consider that the role carried out by the teacher was useful to promote the development of teamwork with a view to the correct preparation of the final project? Scale from 1 to 5 where 1. Not very useful and 5. Completely useful.

The performance was made by the teacher to promote the development of teamwork to prepare the correct preparation of the final project.

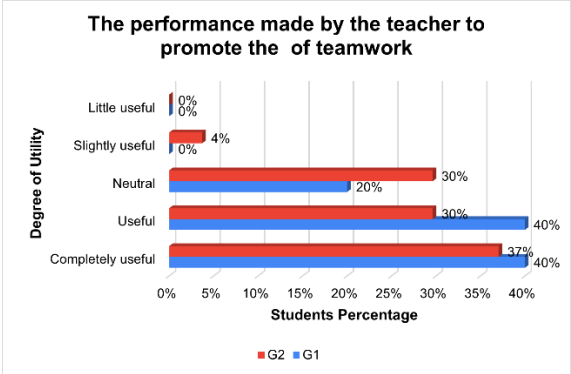
Figure 12. QS_1Q_5. The teacher role and teamwork

Pre-Test



Degree of Utility	G1	G2
Completely useful	22%	10%
Useful	56%	40%
Neutral	7%	33%
Slightly useful	11%	13%
Little useful	4%	3%
Total	100%	100%

Post-Test

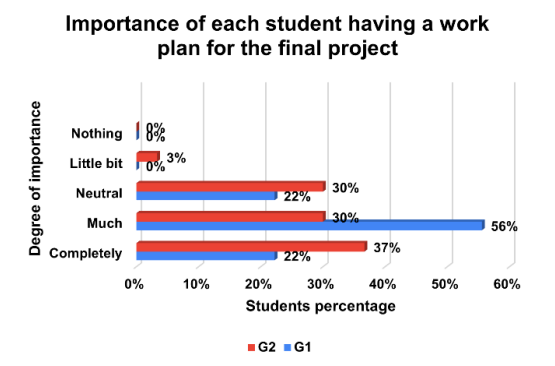


Degree of Utility	G1	G2
Completely useful	40%	37%
Useful	40%	30%
Neutral	20%	30%
Slightly useful	0%	4%
Little useful	0%	0%
Total	100%	100%

QS_1Q_6. According to your performance so far in class activities. How important do you think it is that each student has a work plan for the preparation of the final project? Scale from 1 to 5 where 1. Not at all important and 5. Absolutely important.

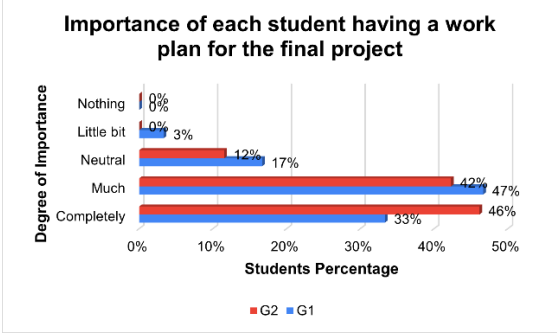
Figure 13. QS_1Q_6. work plan

Pre-Test



Degree of Utility	G1	G2
Completely useful	22%	10%
Useful	56%	40%
Neutral	7%	33%
Slightly useful	11%	13%
Little useful	4%	3%
Total	100%	100%

Post-Test

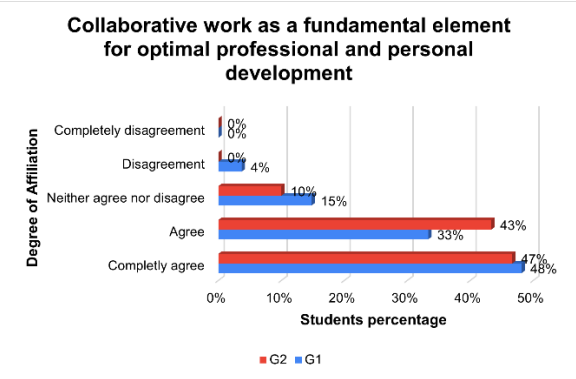


Degree of Importance	G1	G2
Completely	33%	46%
Much	47%	42%
Neutral	17%	12%
Little bit	3%	0%
Nothing	0%	0%
Total	100%	100%

QS_1Q_7. For the completion of the final project, indicate the degree to which you agree with this phrase: "Collaborative work is a crucial element for optimal professional and personal development, because in this space each person manages to form favourable skills". Scale from 1 to 5 where 1. Strongly disagree and 5. Strongly agree.

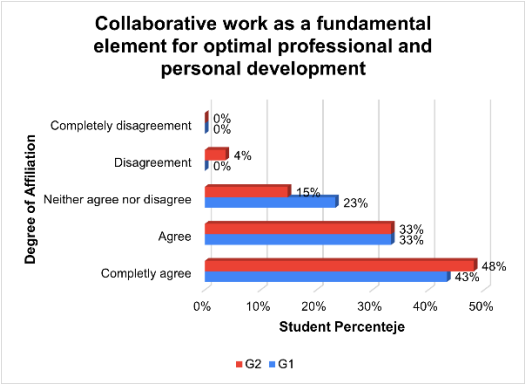
Figure 14. QS_1Q_7. Collaborativework

Pre-Test



Degree of Affiliation	G1	G2
Completly agree	48%	47%
Agree	33%	43%
Neither agree nor disagree	15%	10%
Disagreement	4%	0%
Completely disagreement	0%	0%
Total	100%	100%

Post-Test

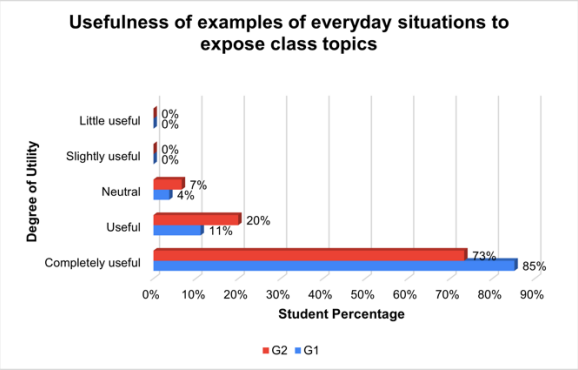


Degree of Affiliation	G1	G2
Completly agree	43%	48%
Agree	33%	33%
Neither agree nor disagree	23%	15%
Disagreement	0%	4%
Completely disagreement	0%	0%
Total	100 %	100%

QS_1Q_8. For preparation prior to the final project, how useful is it for you that teachers use everyday examples to present class topics? Scale from 1 to 5 where 1. Not very useful and 5. Completely useful.

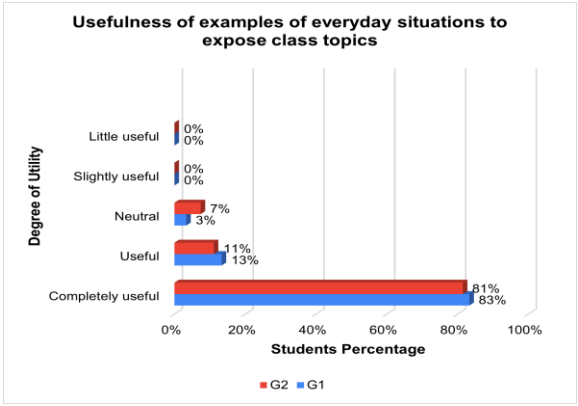
Figure 15. QS_1Q_8. Usefulness of examples of everyday situations

Pre-Test



Degree of Utility	G1	G2
Completely useful	85%	73%
Useful	11%	20%
Neutral	4%	7%
Slightly useful	0%	0%
Little useful	0%	0%
Total	100%	100%

Post-Test



Degree of Utility	G1	G2
Completely useful	83%	81%
Useful	13%	11%
Neutral	3%	7%
Slightly useful	0%	0%
Little useful	0%	0%
Total	100%	100%

Annex 13. Questionnaire 1 Section 2 Results – Pre Test

The following table shows the detail of the results obtained by the students once the pre-test was applied. The Table 15 shows the eight subsections corresponding to each topic, the typification of the question and the score assigned to each correct answer, the absolute frequency of students with correct answers for each group, and the total. As well as the corresponding percentage of students with correct answers.

Table 15. Results Quantitative Analysis Questionnaire 1 Section 2 pre-test

Subsection	Question	Correct answer score	Absolute Frequency of students with correct answers			Student percentage with correct answer		
			G_1	G_2	Total	G_1	G_2	Total
Present Value Analysis	1.1	1	19	24	43	73,1%	88,9%	81,1%
	1.2	1	8	11	19	30,8%	40,7%	35,8%
	1.3	1	17	17	34	65,4%	63,0%	64,2%
	1.4	1	18	18	36	69,2%	66,7%	67,9%
	1.5	1	21	26	47	80,8%	96,3%	88,7%
	1.6	1	21	23	44	80,8%	85,2%	83,0%
	1.7	1	17	10	27	65,4%	37,0%	50,9%
	1.8	1	20	27	47	76,9%	100,0%	88,7%
	1.9	1	14	15	29	53,8%	55,6%	54,7%
	1.10	1	18	15	33	69,2%	55,6%	62,3%
	1.11	1	7	8	15	26,9%	29,6%	28,3%
	1.12	1	22	22	44	84,6%	81,5%	83,0%
	1.13	1	22	25	47	84,6%	92,6%	88,7%
	1.14	1	18	21	39	69,2%	77,8%	73,6%
	1.15	1	14	21	35	53,8%	77,8%	66,0%
	1.16	1	19	22	41	73,1%	81,5%	77,4%
	1.17	1	13	16	29	50,0%	59,3%	54,7%
	1.18	1	15	22	37	57,7%	81,5%	69,8%
	1.19	1	21	23	44	80,8%	85,2%	83,0%
	2	2	13	20	33	50,0%	74,1%	62,3%
	3	2	15	12	27	57,7%	44,4%	50,9%
	4	1	17	14	31	65,4%	51,9%	58,5%
	5	2	17	14	31	65,4%	51,9%	58,5%
	6	2	17	11	28	65,4%	40,7%	52,8%
	7	2	6	16	22	23,1%	59,3%	41,5%
	8.1	1	26	27	53	100,0%	100,0%	100,0%
	8.2	1	20	23	43	76,9%	85,2%	81,1%
	8.3	1	18	15	33	69,2%	55,6%	62,3%
	8.4	1	16	20	36	61,5%	74,1%	67,9%
	9	2	9	12	21	34,6%	44,4%	39,6%

Subsection	Question	Correct answer score	Absolute Frequency of students with correct answers			Student percentage with correct answer		
			G_1	G_2	Total	G_1	G_2	Total
Future Value Analysis	10.1	1	26	25	51	100,0%	92,6%	96,2%
	10.2	1	22	20	42	84,6%	74,1%	79,2%
	10.3	1	19	26	45	73,1%	96,3%	84,9%
	10.4	1	17	20	37	65,4%	74,1%	69,8%
	10.5	1	15	8	23	57,7%	29,6%	43,4%
	10.6	1	21	22	43	80,8%	81,5%	81,1%
	10.7	1	13	11	24	50,0%	40,7%	45,3%
	11	2	8	10	18	30,8%	37,0%	34,0%
Capitalized Cost Analysis	12.1	1	24	26	50	92,3%	96,3%	94,3%
	12.2	1	22	24	46	84,6%	88,9%	86,8%
	12.3	1	25	20	45	96,2%	74,1%	84,9%
	12.4	1	21	22	43	80,8%	81,5%	81,1%
	12.5	1	23	21	44	88,5%	77,8%	83,0%
	13	2	13	8	21	50,0%	29,6%	39,6%
	14	2	16	7	23	61,5%	25,9%	43,4%
Analysis of the Payback Period	15.1	1	21	23	44	80,8%	85,2%	83,0%
	15.2	1	21	22	43	80,8%	81,5%	81,1%
	15.3	1	21	15	36	80,8%	55,6%	67,9%
	15.4	1	17	22	39	65,4%	81,5%	73,6%
	15.5	0	19	22	41	73,1%	81,5%	77,4%
	15.6	1	22	21	43	84,6%	77,8%	81,1%
	15.7	1	21	24	45	80,8%	88,9%	84,9%
	15.8	1	15	24	39	57,7%	88,9%	73,6%
	15.9	1	18	19	37	69,2%	70,4%	69,8%
	15.10	1	18	22	40	69,2%	81,5%	75,5%
	15.11	1	9	12	21	34,6%	44,4%	39,6%
Life Cycle Cost	16.1	1	22	26	48	84,6%	96,3%	90,6%
	16.2	1	18	7	25	69,2%	25,9%	47,2%
	16.3	1	21	19	40	80,8%	70,4%	75,5%
	16.4	1	9	10	19	34,6%	37,0%	35,8%
	16.5	1	20	23	43	76,9%	85,2%	81,1%
	17.1	1	24	23	47	92,3%	85,2%	88,7%
	17.2	1	9	10	19	34,6%	37,0%	35,8%
	17.3	1	17	19	36	65,4%	70,4%	67,9%
	17.4	1	22	20	42	84,6%	74,1%	79,2%
	17.5	1	17	19	36	65,4%	70,4%	67,9%
	17.6	1	17	20	37	65,4%	74,1%	69,8%
Bonus Present Value	18.1	1	1	4	5	3,8%	14,8%	9,4%
	18.2	1	0	2	2	0,0%	7,4%	3,8%

Subsection	Question	Correct answer score	Absolute Frequency of students with correct answers			Student percentage with correct answer		
			G_1	G_2	Total	G_1	G_2	Total
	18.3	1	9	5	14	34,6%	18,5%	26,4%
	18.4	1	3	5	8	11,5%	18,5%	15,1%
	18.5	1	2	4	6	7,7%	14,8%	11,3%
	18.6	1	5	3	8	19,2%	11,1%	15,1%
	18.7	1	2	1	3	7,7%	3,7%	5,7%
	18.8	1	1	0	1	3,8%	0,0%	1,9%
	18.9	1	0	0	0	0,0%	0,0%	0,0%
	18.10	1	0	2	2	0,0%	7,4%	3,8%
	18.11	1	0	0	0	0,0%	0,0%	0,0%
	18.12	1	0	2	2	0,0%	7,4%	3,8%
	18.13	1	1	0	1	3,8%	0,0%	1,9%
Annual Value Analysis	19.1	1	20	20	40	76,9%	74,1%	75,5%
	19.2	1	22	23	45	84,6%	85,2%	84,9%
	19.3	1	16	19	35	61,5%	70,4%	66,0%
	19.4	1	11	5	16	42,3%	18,5%	30,2%
	20	3	10	8	18	38,5%	29,6%	34,0%
Inflation	21	1	1	1	2	3,8%	3,7%	3,8%
	22	1	11	9	20	42,3%	33,3%	37,7%
	23	1	11	9	20	42,3%	33,3%	37,7%
	24	1	6	5	11	23,1%	18,5%	20,8%
	25	1	11	6	17	42,3%	22,2%	32,1%

Table 16. Questionnaire 1 Section 2 Pre-Test Average Scores by Section

Subsection	Score average G_1	Score average G_2	Total score average	Maximum possible score
Present Value Analysis	19,15	20,37	19,77	36
Future Value Analysis	5,42	5,26	5,34	9
Capitalized Cost Analysis	5,54	4,74	5,13	9
Analysis of the Payback Period	7,77	8,37	8,08	11
Life Cycle Cost	7,54	7,26	7,40	11
Bonus Present Value	0,92	1,04	0,98	13
Annual Value Analysis	3,04	2,78	2,91	6
Inflation	1,54	1,11	1,32	5

Annex 14. Questionnaire 1 Section 2 Results – Post Test

The following table shows the detail of the results obtained by the students once the post-test was applied. The Table 17 shows the eight subsections corresponding to each topic, the typification of the question and the score assigned to each correct answer, the absolute frequency of students with correct answers for each group, and the total. As well as the corresponding percentage of students with correct answers.

Table 17. Results Quantitative Analysis Questionnaire 1 Section 2 post-test

Subsection	Question	Correct answer score	Absolute Frequency of students with correct answers			Student percentage with correct answer		
			G_1	G_2	Total	G_1	G_2	Total
Present Value Analysis	1.1	1	23	27	50	88,5%	100,0%	94,3%
	1.2	1	22	26	48	84,6%	96,3%	90,6%
	1.3	1	21	25	46	80,8%	92,6%	86,8%
	1.4	1	19	23	42	73,1%	85,2%	79,2%
	1.5	1	24	27	51	92,3%	100,0%	96,2%
	1.6	1	23	26	49	88,5%	96,3%	92,5%
	1.7	1	21	20	41	80,8%	74,1%	77,4%
	1.8	1	22	26	48	84,6%	96,3%	90,6%
	1.9	1	24	26	50	92,3%	96,3%	94,3%
	1.10	1	13	24	37	50,0%	88,9%	69,8%
	1.11	1	11	20	31	42,3%	74,1%	58,5%
	1.12	1	21	27	48	80,8%	100,0%	90,6%
	1.13	1	25	25	50	96,2%	92,6%	94,3%
	1.14	1	20	25	45	76,9%	92,6%	84,9%
	1.15	1	19	25	44	73,1%	92,6%	83,0%
	1.16	1	23	27	50	88,5%	100,0%	94,3%
	1.17	1	18	26	44	69,2%	96,3%	83,0%
	1.18	1	20	26	46	76,9%	96,3%	86,8%
	1.19	1	22	25	47	84,6%	92,6%	88,7%
	2	2	14	25	39	53,8%	92,6%	73,6%
	3	2	23	23	46	88,5%	85,2%	86,8%
	4	1	21	24	45	80,8%	88,9%	84,9%
	5	2	20	23	43	76,9%	85,2%	81,1%
	6	2	17	20	37	65,4%	74,1%	69,8%
	7	2	13	25	38	50,0%	92,6%	71,7%
	8.1	1	26	26	52	100,0%	96,3%	98,1%
	8.2	1	23	26	49	88,5%	96,3%	92,5%
	8.3	1	23	24	47	88,5%	88,9%	88,7%
	8.4	1	20	23	43	76,9%	85,2%	81,1%
	9	2	17	22	39	65,4%	81,5%	73,6%

Subsection	Question	Correct answer score	Absolute Frequency of students with correct answers			Student percentage with correct answer		
			G_1	G_2	Total	G_1	G_2	Total
Future Value Analysis	10.1	1	24	26	50	92,3%	96,3%	94,3%
	10.2	1	26	26	52	100,0%	96,3%	98,1%
	10.3	1	23	27	50	88,5%	100,0%	94,3%
	10.4	1	23	26	49	88,5%	96,3%	92,5%
	10.5	1	13	21	34	50,0%	77,8%	64,2%
	10.6	1	25	26	51	96,2%	96,3%	96,2%
	10.7	1	17	22	39	65,4%	81,5%	73,6%
	11	2	16	24	40	61,5%	88,9%	75,5%
Capitalized Cost Analysis	12.1	1	24	26	50	92,3%	96,3%	94,3%
	12.2	1	25	27	52	96,2%	100,0%	98,1%
	12.3	1	25	27	52	96,2%	100,0%	98,1%
	12.4	1	20	24	44	76,9%	88,9%	83,0%
	12.5	1	23	26	49	88,5%	96,3%	92,5%
	13	2	14	22	36	53,8%	81,5%	67,9%
	14	2	15	18	33	57,7%	66,7%	62,3%
Analysis of the Payback Period	15.1	1	25	27	52	96,2%	100,0%	98,1%
	15.2	1	24	26	50	92,3%	96,3%	94,3%
	15.3	1	21	26	47	80,8%	96,3%	88,7%
	15.4	1	20	27	47	76,9%	100,0%	88,7%
	15.5	0	18	14	32	69,2%	51,9%	60,4%
	15.6	1	24	27	51	92,3%	100,0%	96,2%
	15.7	1	20	25	45	76,9%	92,6%	84,9%
	15.8	1	21	26	47	80,8%	96,3%	88,7%
	15.9	1	24	26	50	92,3%	96,3%	94,3%
	15.10	1	20	27	47	76,9%	100,0%	88,7%
	15.11	1	17	22	39	65,4%	81,5%	73,6%
Life Cycle Cost	16.1	1	26	26	52	100,0%	96,3%	98,1%
	16.2	1	15	23	38	57,7%	85,2%	71,7%
	16.3	1	23	27	50	88,5%	100,0%	94,3%
	16.4	1	16	25	41	61,5%	92,6%	77,4%
	16.5	1	22	27	49	84,6%	100,0%	92,5%
	17.1	1	24	26	50	92,3%	96,3%	94,3%
	17.2	1	18	22	40	69,2%	81,5%	75,5%
	17.3	1	22	26	48	84,6%	96,3%	90,6%
	17.4	1	24	26	50	92,3%	96,3%	94,3%
	17.5	1	22	27	49	84,6%	100,0%	92,5%
	17.6	1	22	25	47	84,6%	92,6%	88,7%
Bonus Present Value	18.1	1	2	16	18	7,7%	59,3%	34,0%
	18.2	1	2	16	18	7,7%	59,3%	34,0%

Subsection	Question	Correct answer score	Absolute Frequency of students with correct answers			Student percentage with correct answer		
			G_1	G_2	Total	G_1	G_2	Total
	18.3	1	5	18	23	19,2%	66,7%	43,4%
	18.4	1	4	20	24	15,4%	74,1%	45,3%
	18.5	1	2	16	18	7,7%	59,3%	34,0%
	18.6	1	3	15	18	11,5%	55,6%	34,0%
	18.7	1	2	15	17	7,7%	55,6%	32,1%
	18.8	1	1	3	4	3,8%	11,1%	7,5%
	18.9	1	1	2	3	3,8%	7,4%	5,7%
	18.10	1	0	5	5	0,0%	18,5%	9,4%
	18.11	1	3	4	7	11,5%	14,8%	13,2%
	18.12	1	2	6	8	7,7%	22,2%	15,1%
	18.13	1	5	5	10	19,2%	18,5%	18,9%
Annual Value Analysis	19.1	1	25	27	52	96,2%	100,0%	98,1%
	19.2	1	25	25	50	96,2%	92,6%	94,3%
	19.3	1	17	26	43	65,4%	96,3%	81,1%
	19.4	1	14	20	34	53,8%	74,1%	64,2%
	20	3	18	17	35	69,2%	63,0%	66,0%
Inflation	21	1	16	12	28	61,5%	44,4%	52,8%
	22	1	16	22	38	61,5%	81,5%	71,7%
	23	1	15	22	37	57,7%	81,5%	69,8%
	24	1	17	22	39	65,4%	81,5%	73,6%
	25	1	17	17	34	65,4%	63,0%	64,2%

Table 18. Questionnaire 1 Section 2 Post-Test Average Scores by Section

Subsection	Score average G_1	Score average G_2	Total score average	Maximum possible score
Present Value Analysis	23,38	27,30	25,38	36
Future Value Analysis	6,42	7,33	6,89	9
Capitalized Cost Analysis	5,62	6,30	5,96	9
Analysis of the Payback Period	9,00	10,11	9,57	11
Life Cycle Cost	9,00	10,37	9,70	11
Bonus Present Value	1,23	5,22	3,26	13
Annual Value Analysis	3,81	4,26	4,04	6
Inflation	3,12	3,52	3,32	5

Annex 15. Quantitative analysis code R - Questionnaire 1- Section 2

```
library(readxl)#Library used to load data from excel file
library(nortest)#library used for normality tests
ph <- read_excel("Prof Sandra Ing/ph.xlsx")#Loading data
ph<-data.frame(ph)
shapiro.test(ph$PreTest)
shapiro.test(ph$PostTest)
lillie.test(ph$PreTest)
lillie.test(ph$PostTest)
#The data do not come from a normal distribution
#Analysis for the total data
sd(ph$PreTest)
sd(ph$PostTest)
mean(ph$PreTest)
mean(ph$PostTest)
wilcox.test(ph$PreTest,ph$PostTest,alternative="less")
#Analysis for group 4
sd(ph[ph$Grupo=="Grupo 1",]$PreTest)
sd(ph[ph$Grupo=="Grupo 1",]$PostTest)
mean(ph[ph$Grupo=="Grupo 1",]$PreTest)
mean(ph[ph$Grupo=="Grupo 1",]$PostTest)
wilcox.test(ph[ph$Grupo=="Grupo 1",]$PreTest,ph[ph$Grupo=="Grupo
4",]$PostTest,alternative="less")
#Analysis for group 10
sd(ph[ph$Grupo=="Grupo 2",]$PreTest)
sd(ph[ph$Grupo=="Grupo 2",]$PostTest)
mean(ph[ph$Grupo=="Grupo 2",]$PreTest)
mean(ph[ph$Grupo=="Grupo 2",]$PostTest)
wilcox.test(ph[ph$Grupo=="Grupo 2",]$PreTest,ph[ph$Grupo=="Grupo
10",]$PostTest,alternative="less")
```

Annex 16. Comparative Analysis

Questionnaire 1- Section 1.

Table 19. Comparative Analysis - Significance

Q1q1	Value	gl	Asymptotic significance (bilateral)	Description
Pearson's Chi-square	9,193[a]	3	0, 027	It show a value of Pearson's Chi-square statistic is shown, whose value is 9.193 with three degrees of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.027 which is less than 0.05, which allows to conclude that there is enough evidence to suggest that the responses to question 1 have a significant change compared to the pre and post moments of the test; In this question, students are asked to choose from a group of options on the methodology carried out in class, which is the one that will have the greatest impact on the development of the final project. Based on this, the alternative hypothesis that describes that, between the pre and post time of the test there will be significant differences is accepted. in the same way, the null hypothesis is rejected since there is a significant relationship between the variables with respect to the two moments evaluated.a. 0 cells (0.0%) have expected a count less than 5. The minimum expected count is 5.00
Likelihood ratio	9,583	3	0,022	
N of valid cases	114			
Q1q2	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Description**
Pearson's Chi-square	9,841a	2	0, 007	It show a value Pearson Chi-square statistic whose value is 9.841 with two degrees of freedom is shown, presenting a p value (asymptotic (bilateral) significance) of 0.007 that is less than 0.05, with which it is possible note that there is evidence that allows us to state that the answers to question 2 have a significant change compared to the pre and post moments of the test; In this question, students are asked to choose from a group of options regarding the completion of the final project which is the one that should be reviewed during the training process. Based on the above, the null hypothesis is rejected since there is a significant relationship between the responses to the question regarding the two moments evaluated. a. 0 cells (0.0%) have expected a count less than 5. The minimum expected count is 5.00
Likelihood ratio	10,018	2	0,007	
N of valid cases	114			
Q1q3	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Description**
Pearson's Chi-square	5,923[a]	4	0, 205	It shows a value of Pearson's Chi-square statistic whose value is 5.923 with four degrees of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.205 that is greater than 0.05, with which is possible to point out that there is not enough evidence to suggest that the answers to question 3 have a significant change compared to the pre and post moments of the test; In this question, students are asked to use their experience in class to select from a Likert-type scale the option that allows them to express the degree of affiliation with the following phrase: “I like working with classmates because in this process there are exchange of ideas that complement each other "
Likelihood ratio	6,374	4	0, 173	
N of valid cases	114			

				Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Q1q4	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Description**
Pearson's Chi-square	2,161[a]	3	2,161	It shows a value of the Pearson Chi-square statistic whose value is 2.161 with three degrees of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.540 that is greater than 0.05, with which it is possible to point out that there is not enough evidence to suggest that the answers to question 4 have a significant change compared to the pre and post moments of the test; In this question, students are asked to use their experience in class to select from a Likert-type scale that option that allows expressing the degree that each person considers that the methodology used in class is useful to promote autonomy for development of the final project. Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Likelihood ratio	2,179	3	2,179	
N of valid cases	114			
Q1q5	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Description**
Pearson's Chi-square	13,148a	4	0,11	It shows a value of the Pearson Chi-square statistic whose value is 13.148 with four degrees of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.011 which is less than 0.05, whit which allows to conclude that there is enough evidence to suggest that the answers to question 5 have a significant change compared to the pre and post moments of the test; In this question, the students are asked, according to their experience in the class, to choose on a Likert- type scale to what degree they consider that the role carried out by the teacher was useful to promote the development of teamwork with a view to the correct elaboration of the final project. Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Likelihood ratio	14,659	4	0,005	
N of valid cases	114			
Q1q6	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Description**
Pearson's Chi-square	4,28	3	0,233	It shows a value of Pearson's Chi-square statistic whose value is 4.280 with three degrees of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.233 that is greater than 0.05, with which it is possible to point out that there is not enough evidence to suggest that the responses to question 6 have a significant change compared to the pre and post moments of the test; In this question, students are asked to use their experience in class to select from a Likert-type scale that option that, according to their performance in class activities, allows them to know how important they consider it to be that each student has a work plan for the development of the final project. Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Likelihood ratio	4.725	3	0,193	
N of valid cases	114			

Q1q7	Value	gl	Asymptotic significance (bilateral)	Description
Pearson's Chi-square	0,293[a]	2	0,864	It shows a value of the Pearson Chi-square statistic whose value is 0.293 with two degrees of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.864 that is greater than 0.05, with which it is possible to point out that there is not enough evidence to suggest that the answers to question 8 have a significant change compared to the pre and post moments of the test; In this question, students are asked to use their experience in class to select from a Likert-type scale the option that indicates how useful it is for teachers to use everyday examples to present class topics, compared to the preparation prior to the final project. Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Likelihood ratio	0,293	2	0,863	
N of valid cases	114			
Q1q8	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Description**
Pearson's Chi-square	0,293[a]	2	0,864	It shows a value of the Pearson Chi-square statistic whose value is 0.293 with two degrees of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.864 that is greater than 0.05, with which it is possible to point out that there is not enough evidence to suggest that the answers to question 8 have a significant change compared to the pre and post moments of the test; In this question, students are asked to use their experience in class to select from a Likert-type scale the option that indicates how useful it is for teachers to use everyday examples to present class topics, compared to the preparation prior to the final project. Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Likelihood ratio	0,294	2	0,863	
N of valid cases	114			

Questionnaire 1- Section 2.

Q1q9	Value	gl	Asymptotic significance (bilateral)	Exact significance (bilateral)	Exact significance (on-sided)	Description
Pearson's Chi-square	5.211[a]	1	0,22			It shows a value of the Pearson Chi-square statistic whose value is 5.211 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.022 which is less than 0.05, whit which allows to conclude that there is enough evidence to suggest that the answers to question 9 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "A future amount of money converted to its equivalent value now has a present value (PV) amount that is always less than the actual cash flow, due to because for any interest rate greater than zero, all P / F factors have a present value of less than 1.0.] " Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Continuity Correction	3,990[b]	1	0,46			
Likelihood ratio	5.501	1	0,19			
Fisher´s exact test				0,43	0,21	
N of valid cases	114					

Q1q10	Value	gl	Asymptotic significance (bilateral)	Exact significance (bilateral)	Exact significance (on-sided)	Description
Pearson's Chi-square	35,884a	1	0			It shows a value of Pearson's Chi-square statistic whose value is 35.884 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.00 which is less than 0.05 , which allows us to conclude that there is enough evidence to suggest that the answers to question 10 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "It is common for the calculation of present value (PV) to be called discounted cash flow (FDE)." Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Continuity Correction	33,606[b]	1	0			
Likelihood ratio	38,858	1	0			
Fisher´s exact test				0	0	
N of valid cases	114					
Q1q11	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	16,765[a]	1	0			It shows a value of the Pearson Chi-square statistic whose value is 16,765 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.000 which is less than 0.05, whit which allows to conclude that there is enough evidence to suggest that the answers to question 11 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "The interest rate used in the calculation of present value analysis problems can also be called the discount rate." Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Continuity Correction	15,130[b]	1	0			
Likelihood ratio	17,613	1	0			
Fisher´s exact test				0	0	
N of valid cases	114					
Q1q12	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	22,626[a]	1	0			It shows a value of Pearson's Chi-square statistic whose value is 22.626 with a degree of freedom, presenting a p-value (asymptotic (bilateral) significance) of 0.000 which is less than 0.05, whit which allows us to conclude that there is enough evidence to suggest that the answers to question 12 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: “the economic evaluation of an alternative does not require an estimated cash flow during a specific period of time and a criterion for choosing the best alternative, the alternative proposals to achieve a specific purpose, some projects not economically viable and others not ”. Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Continuity Correction	20,852[b]	1	0			
Likelihood ratio	23,567	1	0			
Fisher´s exact test				0	0	
N of valid cases	114					

Q1q13	Value	gl	Asymptotic significance (bilateral)	Exact significance (bilateral)	Exact significance (on-sided)	Description
Pearson's Chi-square	3,805[a]	1	0,051			It shows a value of Pearson's Chi-square statistic whose value is 3.805 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.051 that is greater than 0.05, with which is possible to point out that there is not enough evidence to suggest that the answers to question 13 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: ”projects can be categorized as mutually exclusive, which implies that only one of the viable projects can be selected through an economic analysis and each viable project is an alternative or independent more than one viable project can be selected through an economic analysis ”. Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Continuity Correction	2,435[b]	1	0,119			
Likelihood ratio	4,196	1	0,041			
Fisher´s exact test				0,113	0,057	
N of valid cases	114					
Q1q14	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	2,171 [a]	1	0,141			It shows a value of the Pearson Chi-square statistic whose value is 2.171 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.141 that is greater than 0.05, with which is possible to point out that there is not enough evidence to suggest that the answers to question 14 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: ”when evaluating alternatives, the option of not doing NH refers to the fact that the current approach is maintained, something new is not started; no new costs, income or savings are generated by said NH alternative. If a mutually exclusive alternative is not considered economically acceptable, it is possible to reject all the alternatives and accept (by elimination) the “don't” alternative. Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Continuity Correction	1,389[b]	1	0,239			
Likelihood ratio	2,221	1	0,136			
Fisher´s exact test				0,238	0,119	
N of valid cases	114					
Q1q15	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	7,389 [a]	1	0,007			It shows a value of the Pearson Chi-square statistic whose value is 7.389 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.000 which is less than 0.05, whit which allows to conclude that there is enough evidence to suggest that the answers to question 15 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: “mutually exclusive alternatives imply that each project is evaluated separately and the comparison is between one project at a
Continuity Correction	6,371[b]	1	0,012			
Likelihood ratio	7,497	1	0,006			

Fisher´s exact test				0,011	0,006	time and the alternative of doing nothing, while independent projects compete with each other during the evaluation ". Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
N of valid cases	114					
Q1q16	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	22,626 [a]	1	0,222			It shows a value of Pearson's Chi-square statistic whose value is 1.490 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.222 that is greater than 0.05, with which is possible to point out that there is not enough evidence to suggest that the answers to question 16 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "in real life there are restrictions on projects, such as the budget limit that eliminates some of the alternatives, independent projects with budget limits are known as "Capital Budget Problems." Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Continuity Correction	20,852 [b]	1	0,36			
Likelihood ratio	23.567	1	0,218			
Fisher´s exact test				0,361	0,18	
N of valid cases	114					
Q1q17	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	18,937 [a]	1	0			It shows a value of the Pearson Chi-square statistic whose value is 18.937 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.000 which is less than 0.05, whit which allows to conclude that there is enough evidence to suggest that the responses to question 17 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "the nature or type of alternative is determined by the cash flow which is based on income or service, all alternatives evaluated in a particular study of economic engineering they must be of the same type ". Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Continuity Correction	17,091[b]	1	0			
Likelihood ratio	20,544	1	0			
Fisher´s exact test				0	0	
N of valid cases	114					
Q1q18	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	0,351 [a]	1	0,554			It shows a value of Pearson's Chi-square statistic whose value is 0.351 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.554 that is greater than 0.05, with which is possible to indicate that there is not enough evidence that allows to state that the answers to question 18 have a significant change compared
Continuity Correction	0,156 [b]	1	0,693			

Likelihood ratio	0.351	1	0,554			to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: ”for the“ income ”alternatives, each alternative has only estimated costs in cash flow. Income or savings are not dependent on the selected alternative, so these cash flows will be considered the same, as in the case of public sector (government) initiatives ”.Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Fisher´s exact test				0,693	0,347	
N of valid cases	114					
Q1q19	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	10,344 [a]	1	0,001			It shows a value of Pearson's Chi-square statistic whose value is 10.344 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.001 which is less than 0.05, whit which allows to conclude that there is enough evidence to suggest that the answers to question 19 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: “for the“ service ”alternatives, each alternative generates a cost or disbursement and income or input, estimated in cash flow and possible savings. The income depends on the alternative you selected. These alternatives usually include new systems, products and those that require investment capital to generate income and / or savings. The acquisition of new equipment to increase productivity and sales is an income alternative”. Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Continuity Correction	9,163 [b]	1	0,002			
Likelihood ratio	10,521	1	0,001			
Fisher´s exact test				0,002	0,001	
N of valid cases	114					
Q1q20	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	1,303 [a]	1	0,254			It shows a value of Pearson's Chi-square statistic whose value is 1.303 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.254 that is greater than 0.05, with which it is possible to point out that there is not enough evidence to suggest that the answers to question 20 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "In the analysis of the present value, PV is calculated from the minimum attractive rate of return for each alternative." Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Continuity Correction	0,733 [b]	1	0,392			
Likelihood ratio	1,319	1	0,251			
Fisher´s exact test				0,393	0,196	
N of valid cases	114					
Q1q21	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	2,151 [a]	1	0,142			It shows a value of the Pearson Chi-square statistic whose value is 2.151 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.142 that is

Continuity Correction	1,210 [b]	1	0,271			greater than 0.05, with which is possible to indicate that there is not enough evidence that allows to state that the answers to question 21 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "In the present value analysis, expenses or income are transformed into equivalent current pesos. In other words, all future cash flows associated with an alternative are converted into present pesos". Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Likelihood ratio	2,244	1	0,134			
Fisher´s exact test				0,271	0,136	
N of valid cases	114					
Q1q22	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	2,669[a]	1	0,102			It shows a value of the Pearson Chi-square statistic whose value is 2.669 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.102 that is greater than 0.05, with which is possible to point out that there is not enough evidence to suggest that the answers to question 22 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "in the value analysis present the comparison of alternatives with equal lives using both alternatives in identical capacities for the same period of time, these are called of "equal service alternatives. "Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Continuity Correction	1,961[b]	1	0,161			
Likelihood ratio	2,704	1	0,1			
Fisher´s exact test				0,161	0,08	
N of valid cases	114					
Q1q23	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	4,150 [a]	1	0,042			It shows a value of the Pearson Chi-square statistic whose value is 4.150 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.042 which is less than 0.05, whit which allows to conclude that there is enough evidence to suggest that the answers to question 23 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "in the analysis of present value when with a different life the same criteria are used as for the same life, but it is required that the VP be compared with the same number of years, which implies calculating the equivalent present value for future cash flows in each alternative. A fair comparison can be made only when PV values represent costs (and revenues) associated with the same service." Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Continuity Correction	3,279 [b]	1	0,07			
Likelihood ratio	4,226	1	0,04			
Fisher´s exact test				0,069	0,034	
N of valid cases	114					
Q1q24	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**

Pearson's Chi-square	7,270 [a]	1	0,007			It shows a value of the Pearson Chi-square statistic whose value is 7.270 with a degree of freedom, presenting a p value (asymptotic significance (bilateral)) of 0.007 which is less than 0.05, whit which allows us to conclude that there is enough evidence to suggest that the answers to question 24 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "The equal service requirement for present value analysis with different lives can be satisfied by either of the following two approaches. Compare the alternatives over a period of time equal to the least common multiple (LCM) of their lives and Compare the alternatives using a study period of n number of years, which does not necessarily take into account the useful lives of the alternatives; this method is known as the planning horizon approach". Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Continuity Correction	5,889[b]	1	0,015			
Likelihood ratio	7,76	1	0,005			
Fisher´s exact test				0,013	0,007	
N of valid cases	114					
Q1q25	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	8,215 [a]	1	0,004			It shows a value of the Pearson Chi-square statistic whose value is 7.270 with a degree of freedom, presenting a p value (asymptotic significance (bilateral)) of 0.007 which is less than 0.05, whit which allows to conclude that there is enough evidence to suggest that the answers to question 25 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "In the analysis of present value with different lives, If the cash flows are expected to vary by any other index, then the PV analysis should be conducted using a constant value in dollars, which takes into account inflation ". Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Continuity Correction	7,083 [b]	1	0,008			
Likelihood ratio	8,402	1	0,004			
Fisher´s exact test				0,007	0,004	
N of valid cases	114					
Q1q26	**Value**	**gl**	**Asymptotic significance (bilateral)**	**Exact significance (bilateral)**	**Exact significance (on-sided)**	**Description**
Pearson's Chi-square	6,200 [a]	1	0,013			It shows a value of Pearson's Chi-square statistic whose value is 6.200 with a degree of freedom, presenting a p- value (asymptotic (bilateral) significance) of 0.013 which is less than 0.05, whit which allows to conclude that there is enough evidence to suggest that the responses to question 26 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "in the analysis of present value with different lives, a study period analysis is necessary if the first assumption about the amount of time of alternatives ".Based on this, the alternative hypothesis is accepted, which describes that there will be significant differences between the pre and post time of the test.
Continuity Correction	5,124 [b]	1	0,024			
Likelihood ratio	6,373	1	0,012			
Fisher´s exact test				0,022	0,011	
N of valid cases	114					

Q1q27	Value	gl	Asymptotic significance (bilateral)	Exact significance (bilateral)	Exact significance (on-sided)	Description
Pearson's Chi-square	0,691 [a]	1	0,406			It shows a value of Pearson's Chi-square statistic whose value is 0.691 with a degree of freedom, presenting a p value (asymptotic (bilateral) significance) of 0.406 that is greater than 0.05, with which it is possible to point out that there is not enough evidence to suggest that the answers to question 27 have a significant change compared to the pre and post moments of the test; In this question, students are asked to indicate whether the following statement is true or false: "A present value analysis on the MCM requires that the estimated salvage value be included in each life cycle." Based on the above, the alternative hypothesis is rejected since there is no significant relationship between the responses to the question compared to the two moments evaluated.
Continuity Correction	0,307 [b]	1	0,579			
Likelihood ratio	0,695	1	0,404			
Fisher´s exact test				0,581	0,29	
N of valid cases	114					

Annex 17. Qualitative Analysis Atlas TI- Questionnaire 2- Section 2.

This section presents the qualitative analysis results of questionnaire 2 section 2 which corresponds to the open questions asked to the students about the students' perception regarding the effects of the learning activities of the final project, the use of the videos, teamwork during the course and the final project, and the teacher's performance within the framework of the FPBL included in the network of codes generated by the Atlas TI software.

Figure 16. Q2q5. What was your perception of the teacher's role in the Problem Based Learning methodology supported by flipped learning classroom used in the course?

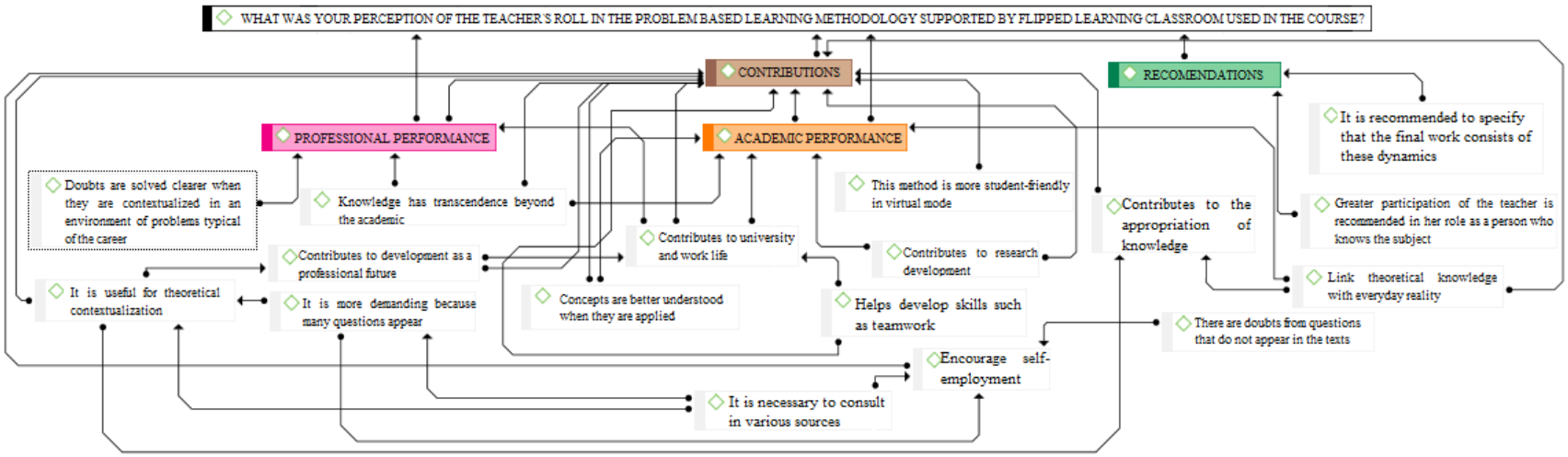


Figure 17. Q2q6. What do you think was the main contribution of teamwork in your learning process during the course?

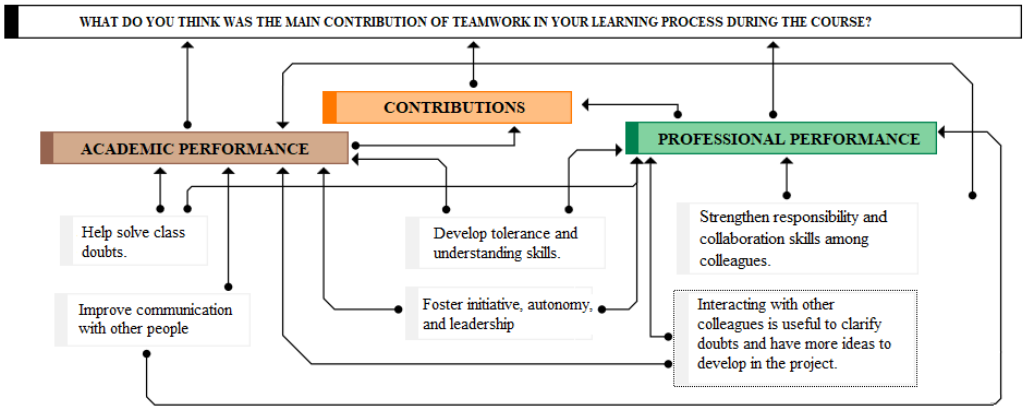


Figure 18. Q2q9 During the development of the course's learning activities, in your work team, were actions established to achieve the objectives (individual responsibilities, rules, or precise tasks for each of the members)?

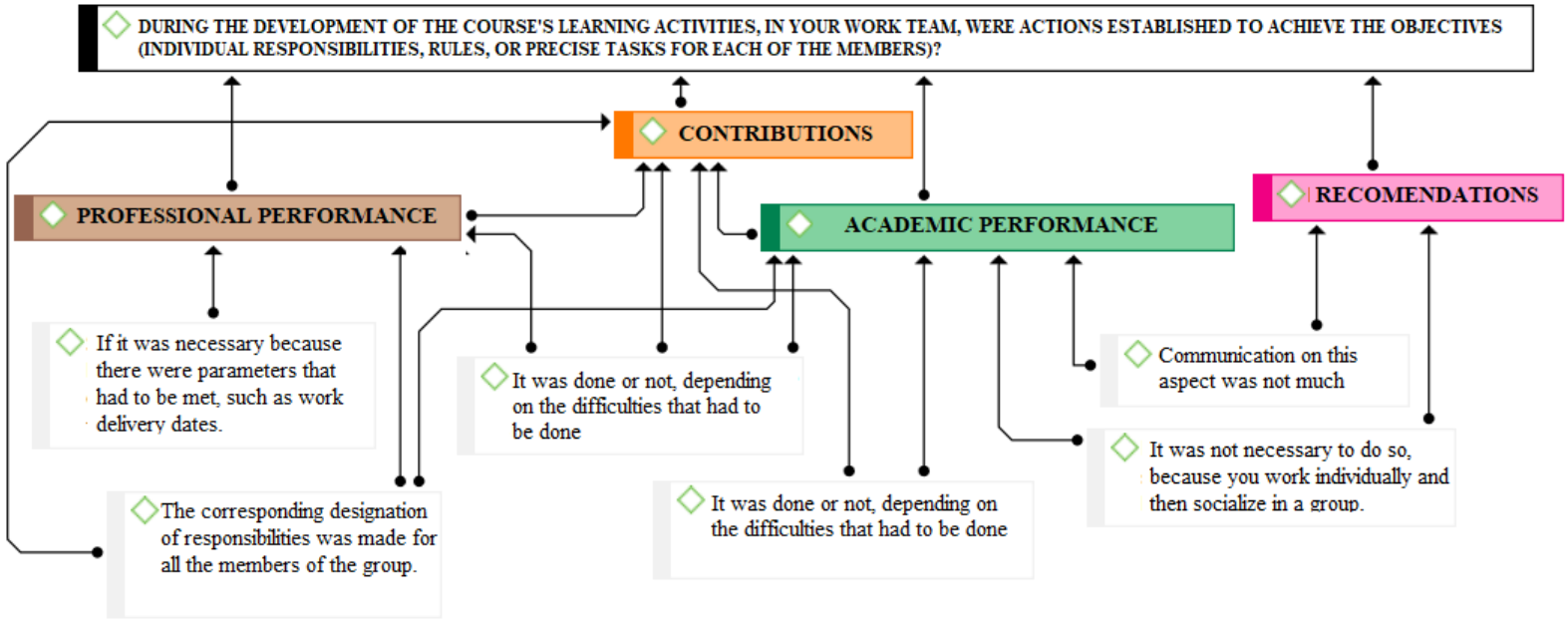


Figure 19. Q2q10 How were decisions made in your work team during the course?

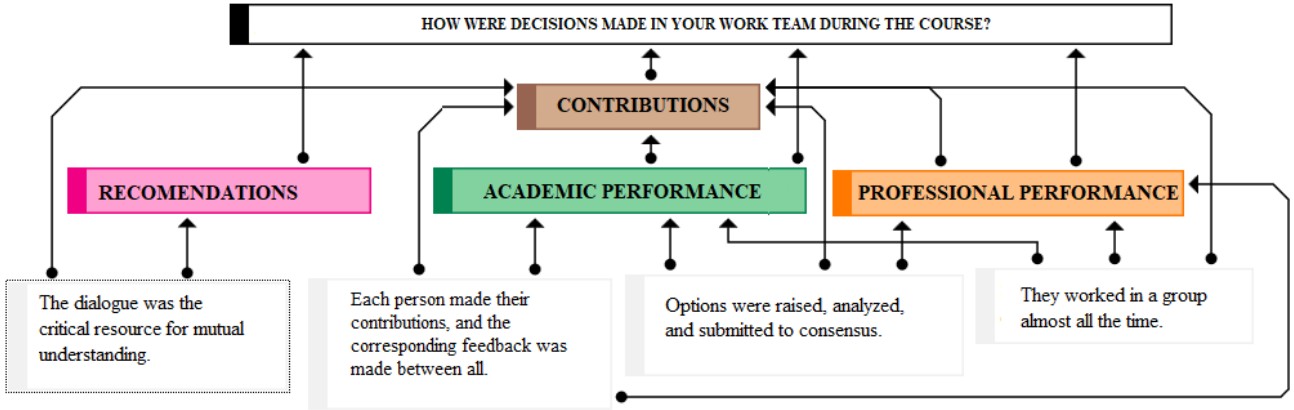


Figure 20. Q2q11 Did you identify a leader or leaders in your work team during the development of the course's learning activities?

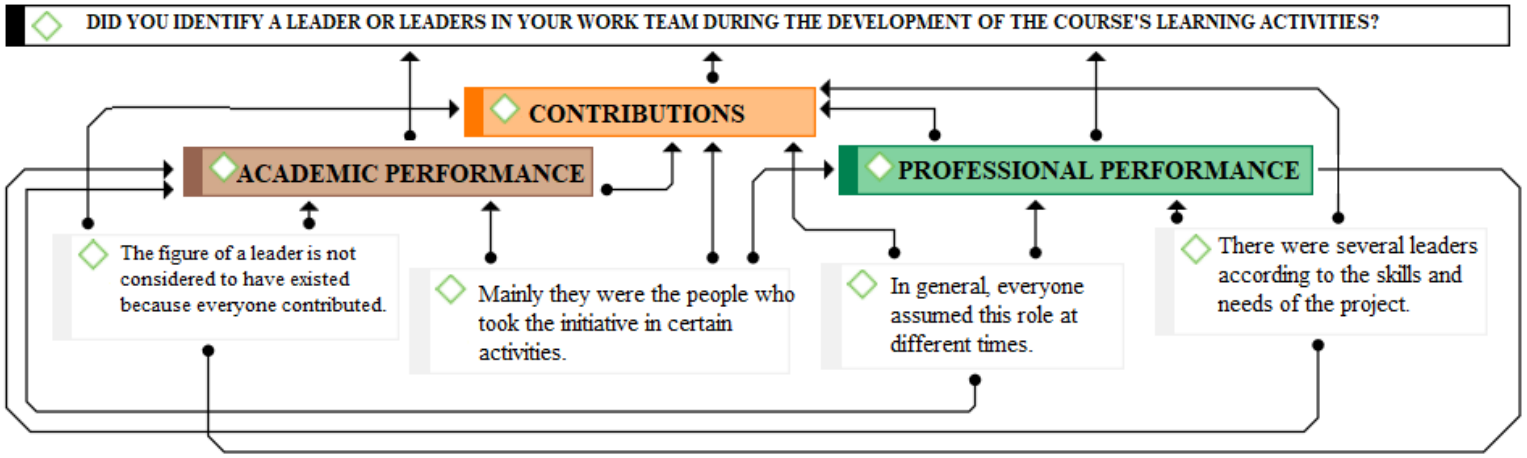


Figure 21. Q2q12 How did you demonstrate your commitment and responsibility to your work team during the development of the course's learning activities?

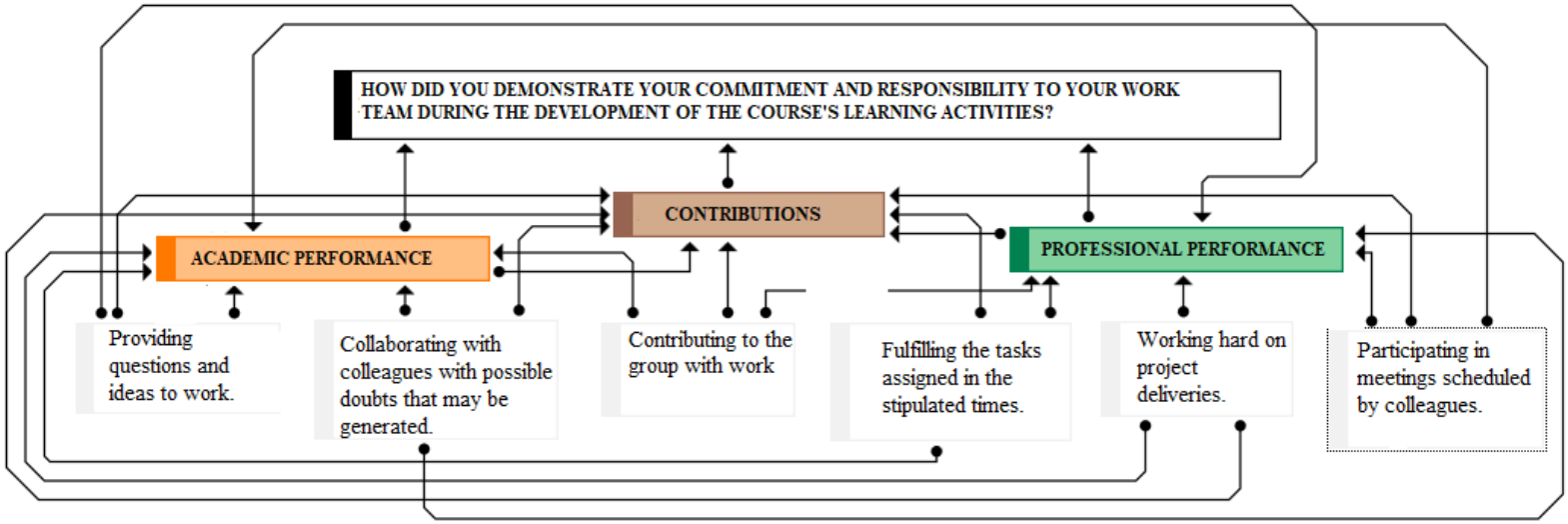


Figure 22. Q2q13 How did teamwork motivate you to create knowledge during the development of activities in the course?

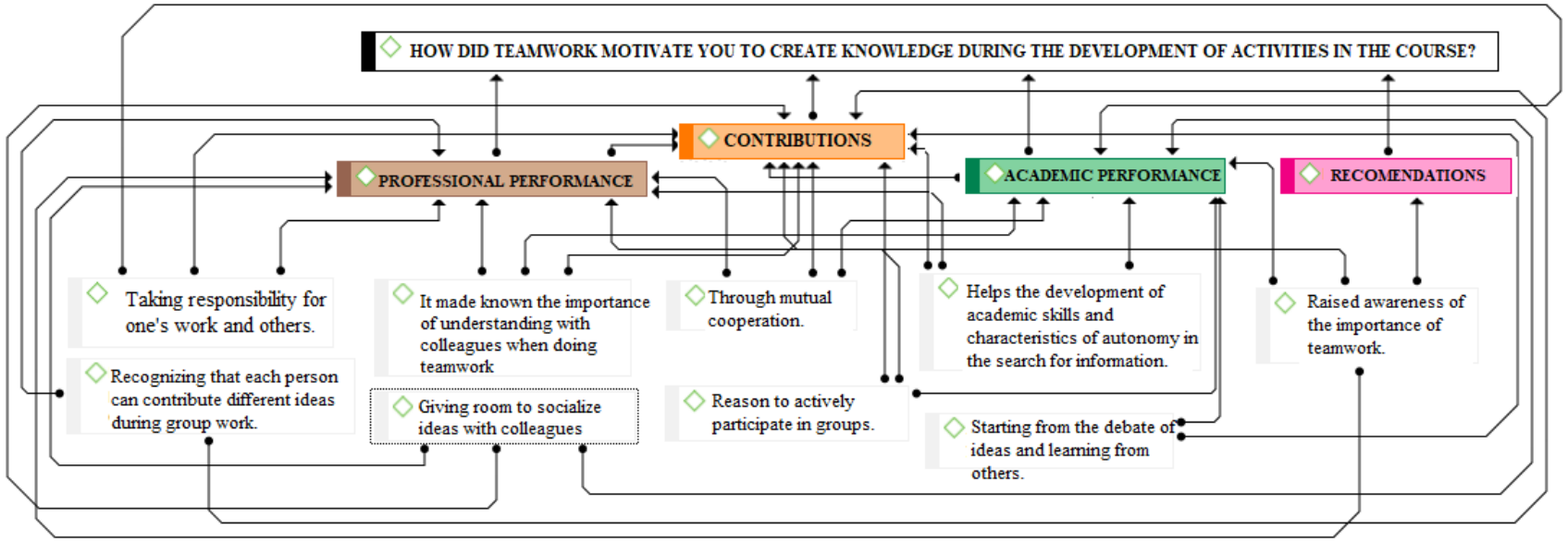


Figure 23. Q2q16 How did the final project support self-directed learning when solving real-world Economic Engineering problems?

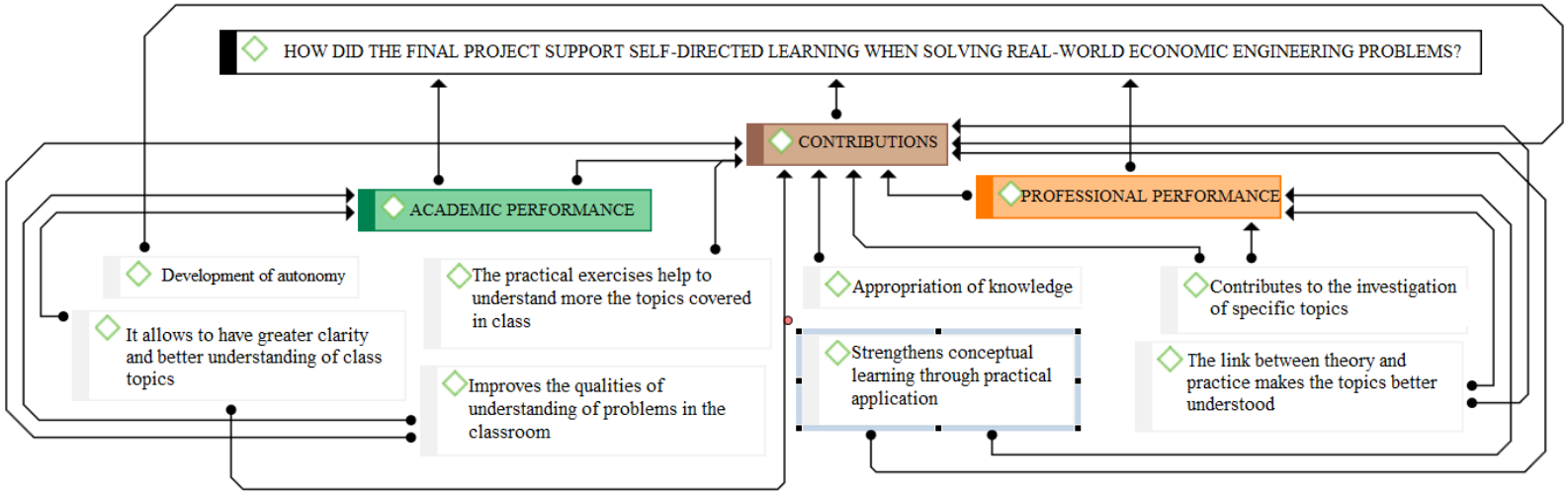


Figure 24. Q2q17 How did the final project affect your knowledge of engineering economics?

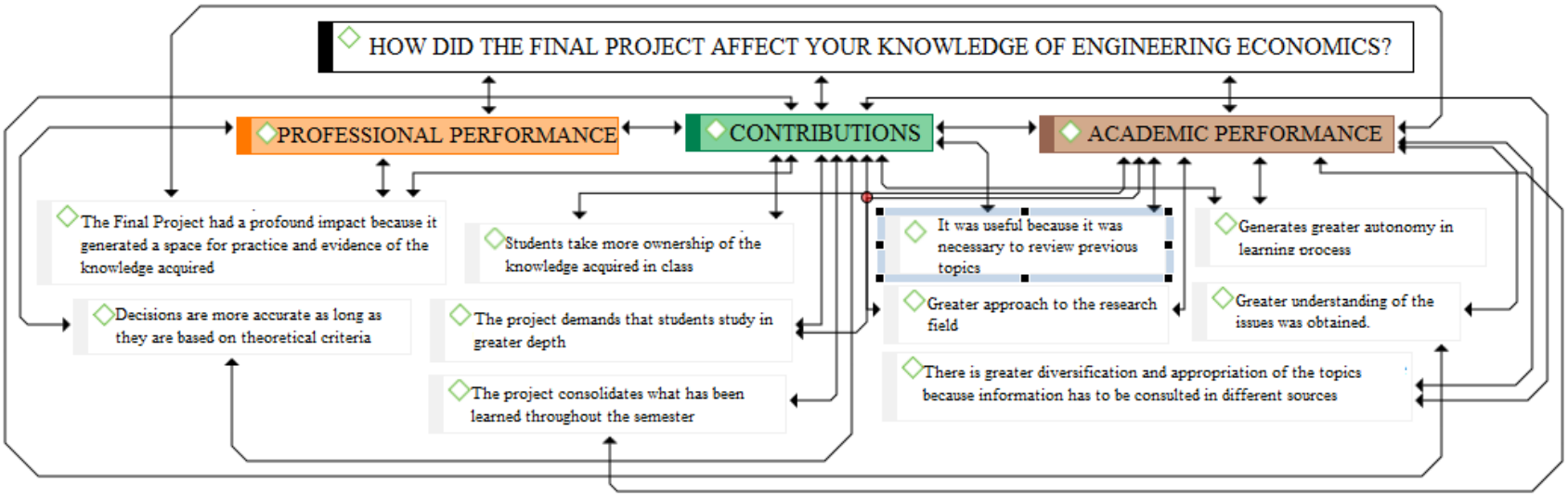


Figure 25. Q2q18 How did the final project affect your acquisition of skills to solve real economic engineering problems?

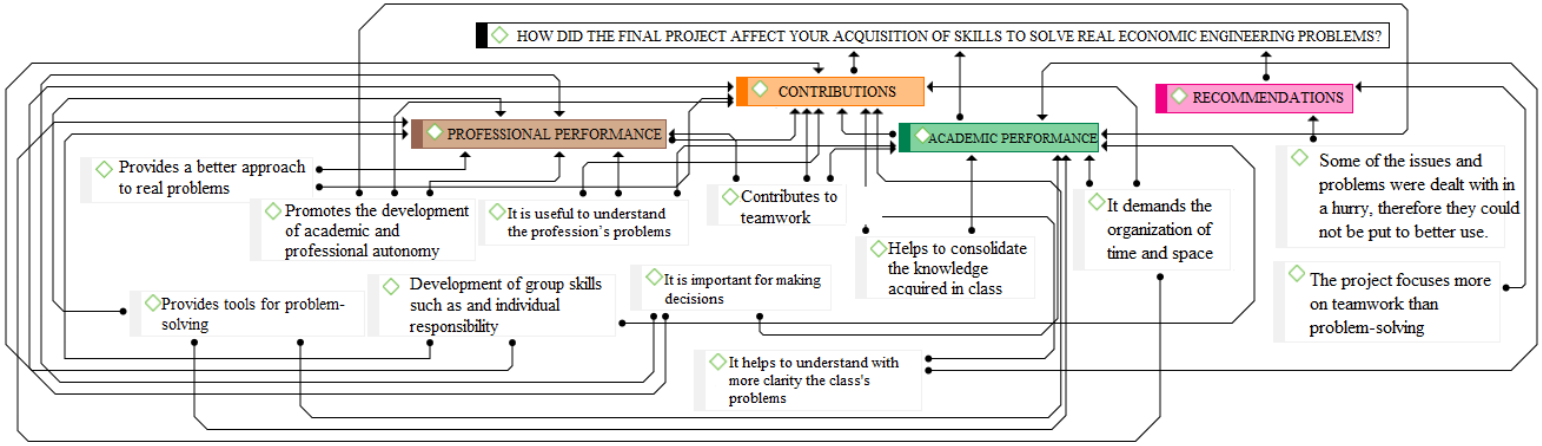


Figure 26. Q2q19 Did the development of the final project allow you to gain a greater command of economic engineering's fundamental concepts?

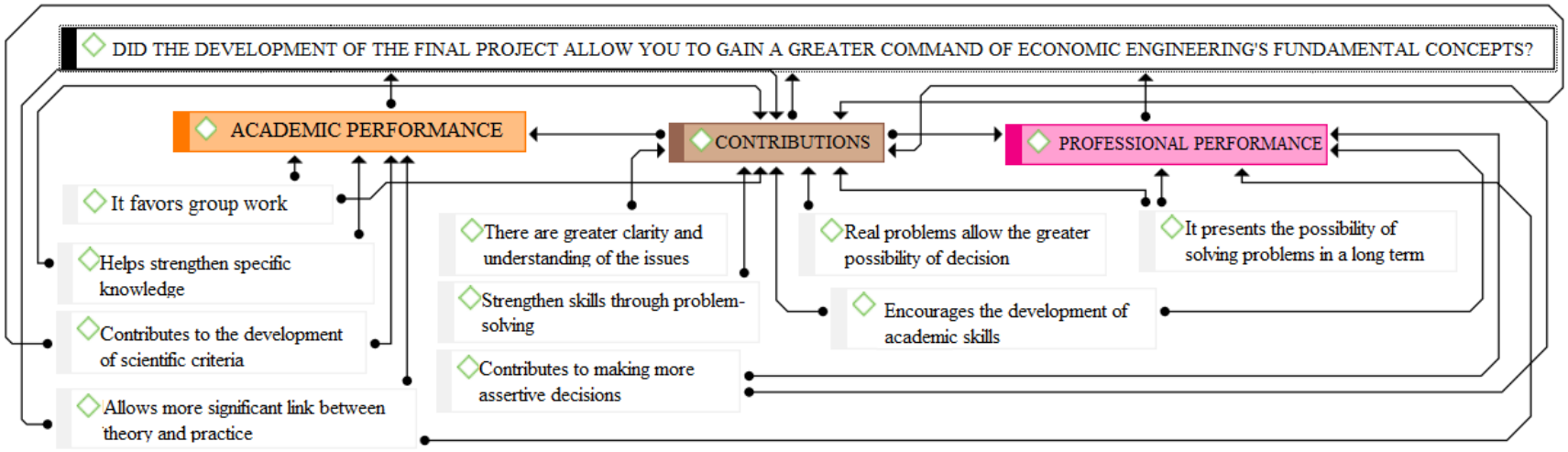


Figure 27. Q2q20 Did the final project's development allow you to know concepts of economic engineering and apply them in real problems?

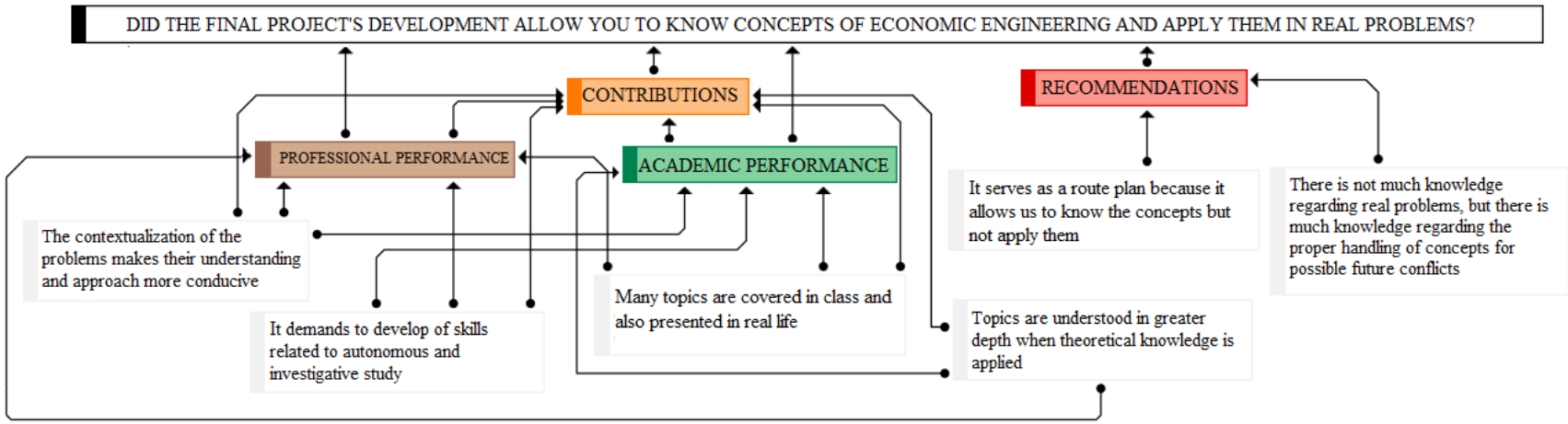


Figure 28. Q2q21 Did the development of the final project increase your interest in finding a solution to the problems?

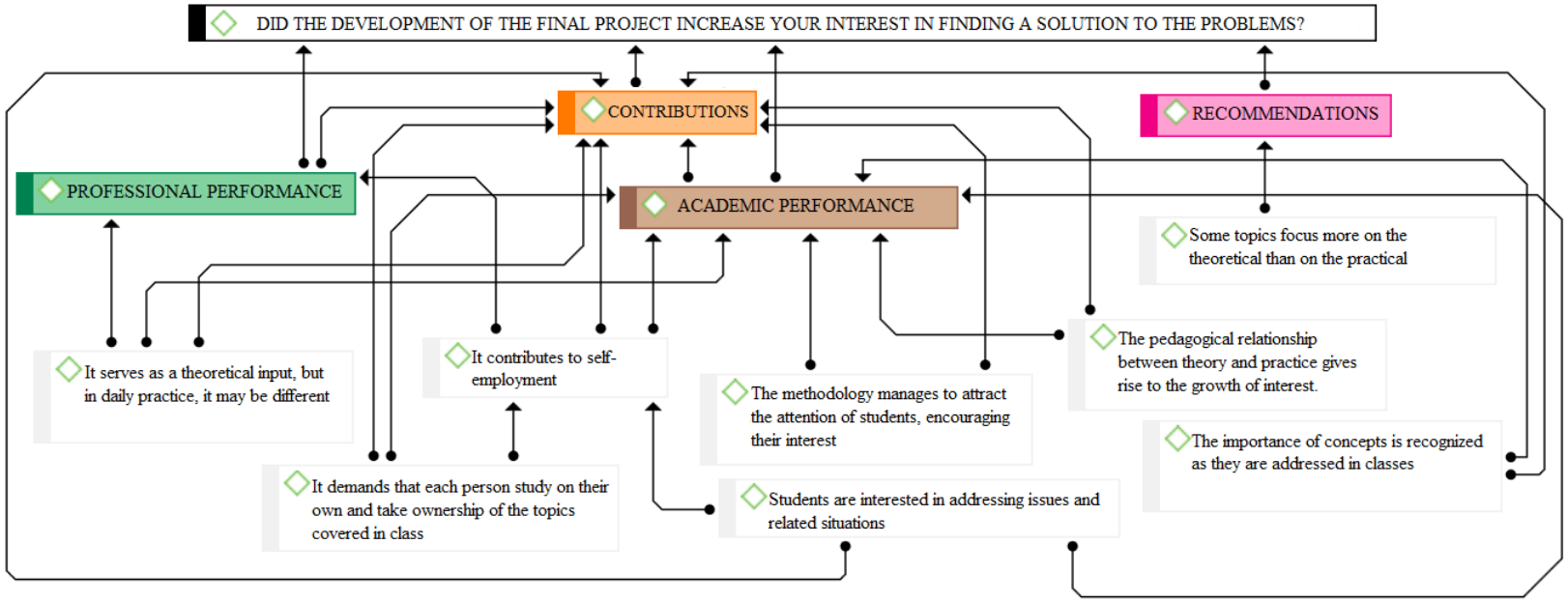


Figure 29. Q2q22 When developing the final project, do you consider that you achieved a conceptual change (an improvement in the acquisition and application of knowledge)?

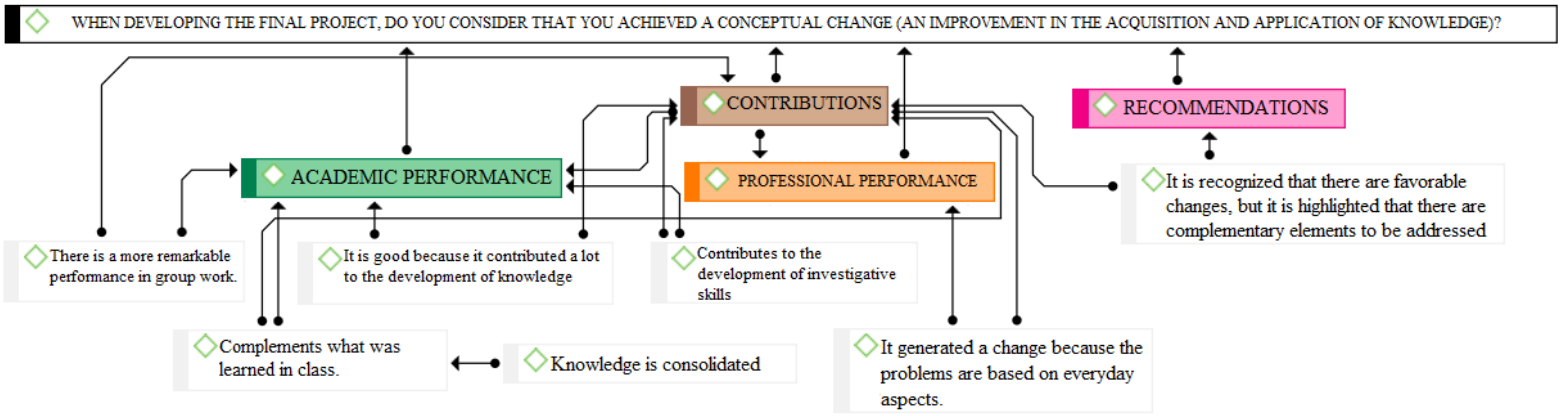


Figure 30. Q2q23 Do you think you could monitor your own building of knowledge when developing the final project to address new knowledge gaps?

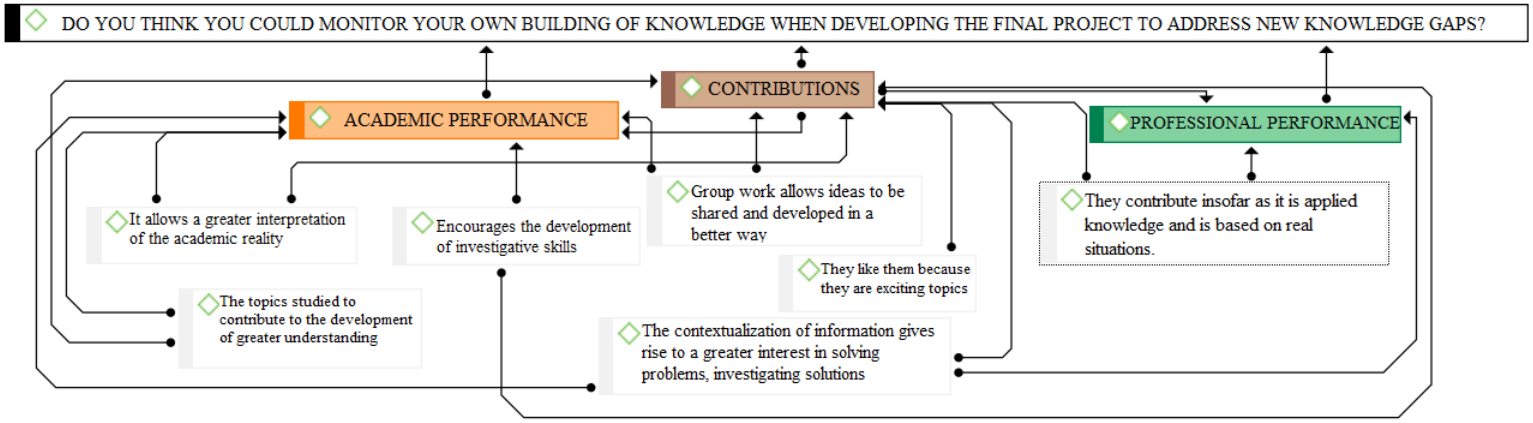


Figure 31. Q2q24 Did the assigned readings allow you to answer specific questions about the concepts required to solve the problems?

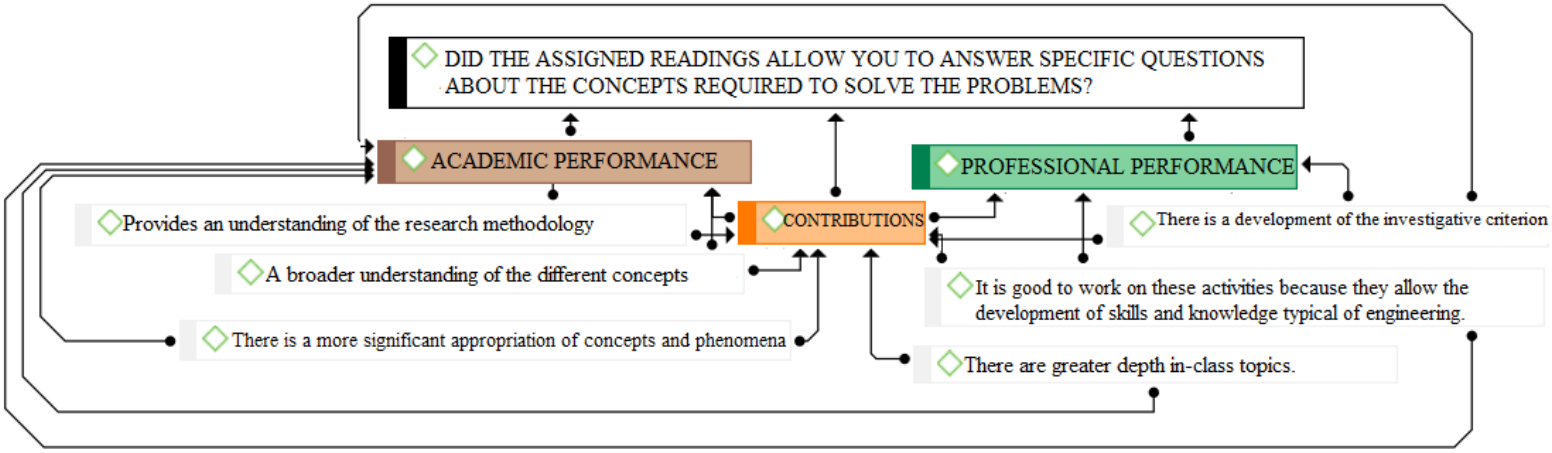


Figure 32. Q2q25. What aspects of the videos impacted self-directed learning?

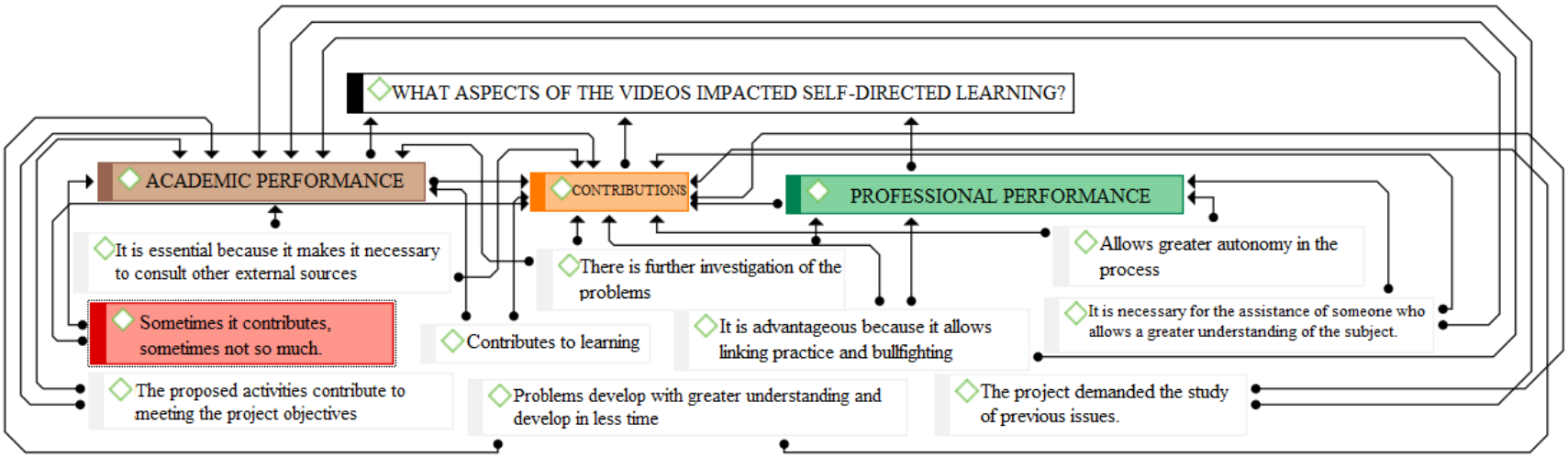


Figure 33. Q2q26. Did you see improvements in your learning process by accessing the videos?

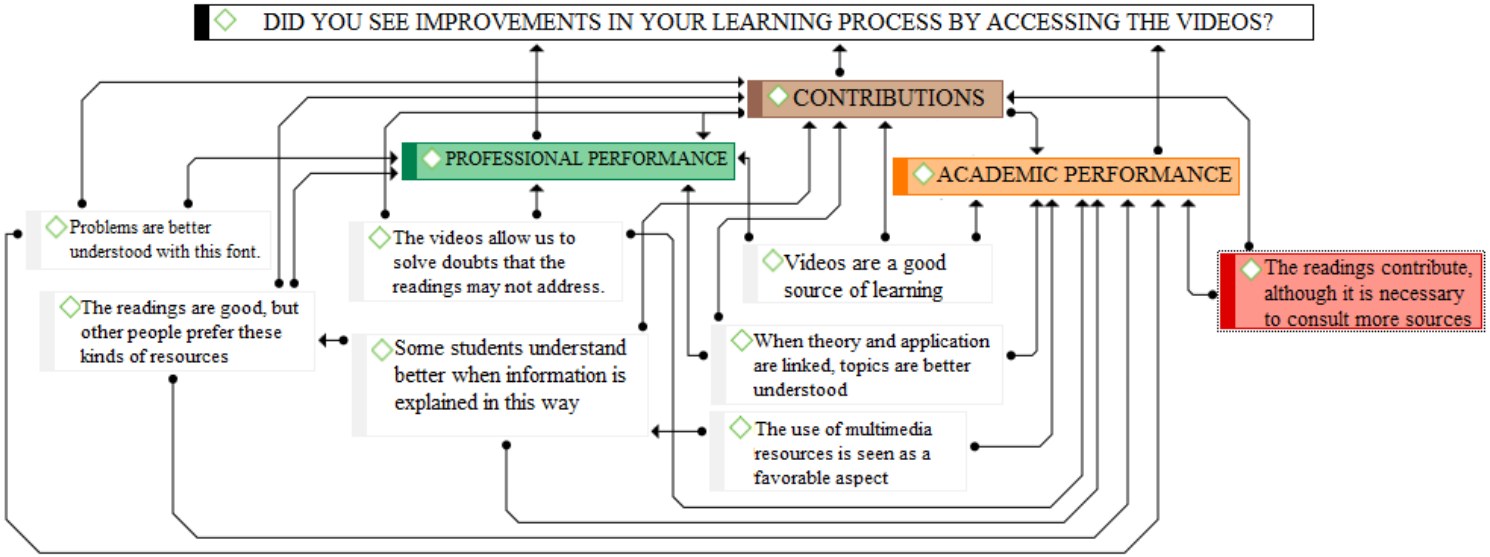


Figure 34. Q2q27. Do you feel confident about learning the fundamental concepts and applying them to real problems?

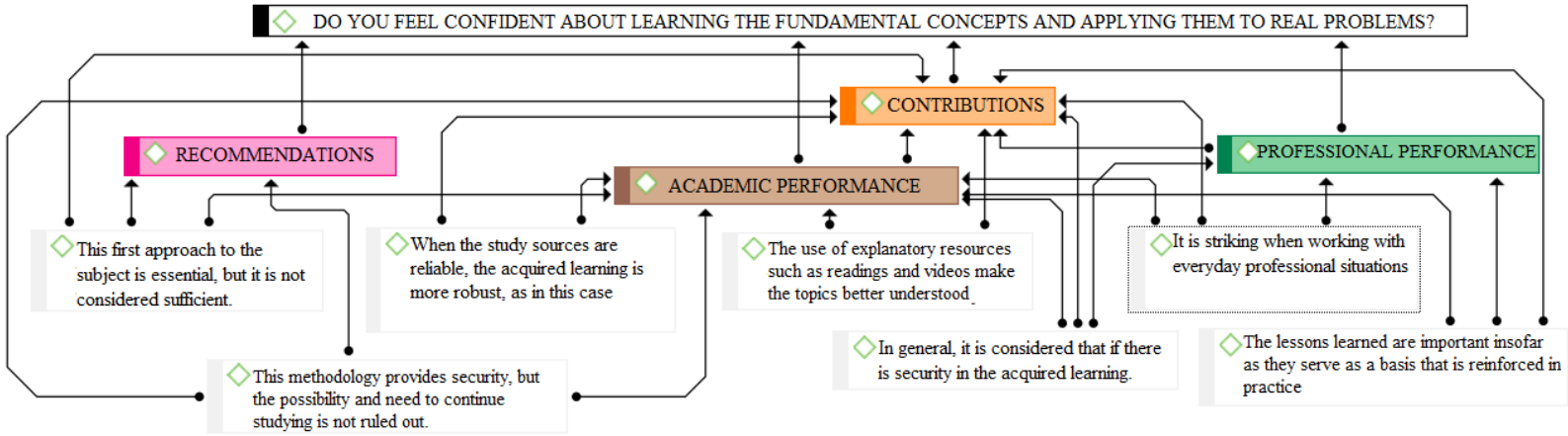


Figure 35. Q2q28 Did the videos give descriptive examples of the exercises to be performed?

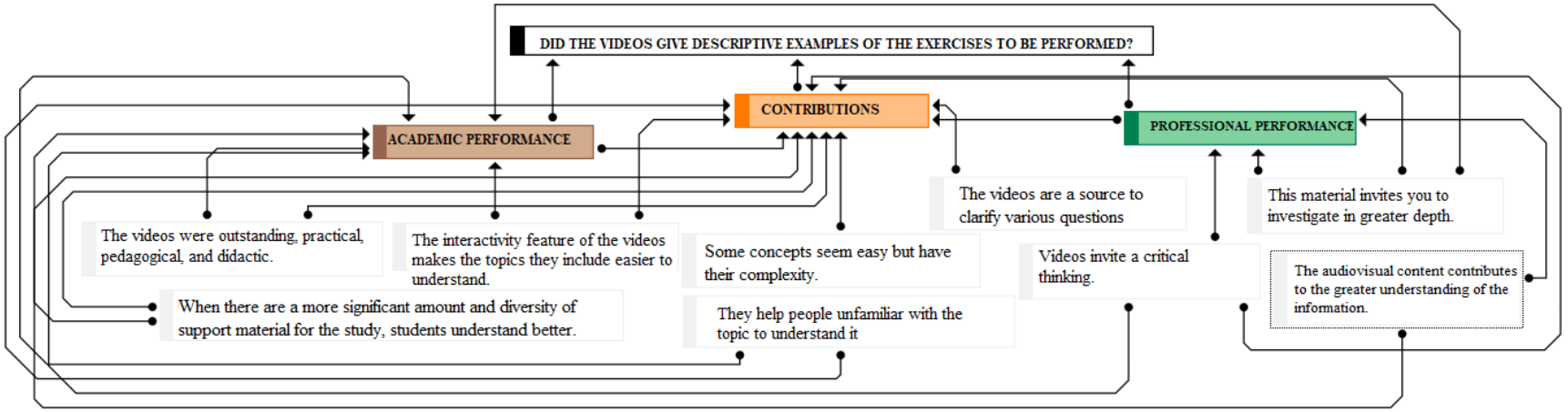


Figure 36. Q2q29. How did the videos support self-directed learning when solving real-world Economic Engineering problems

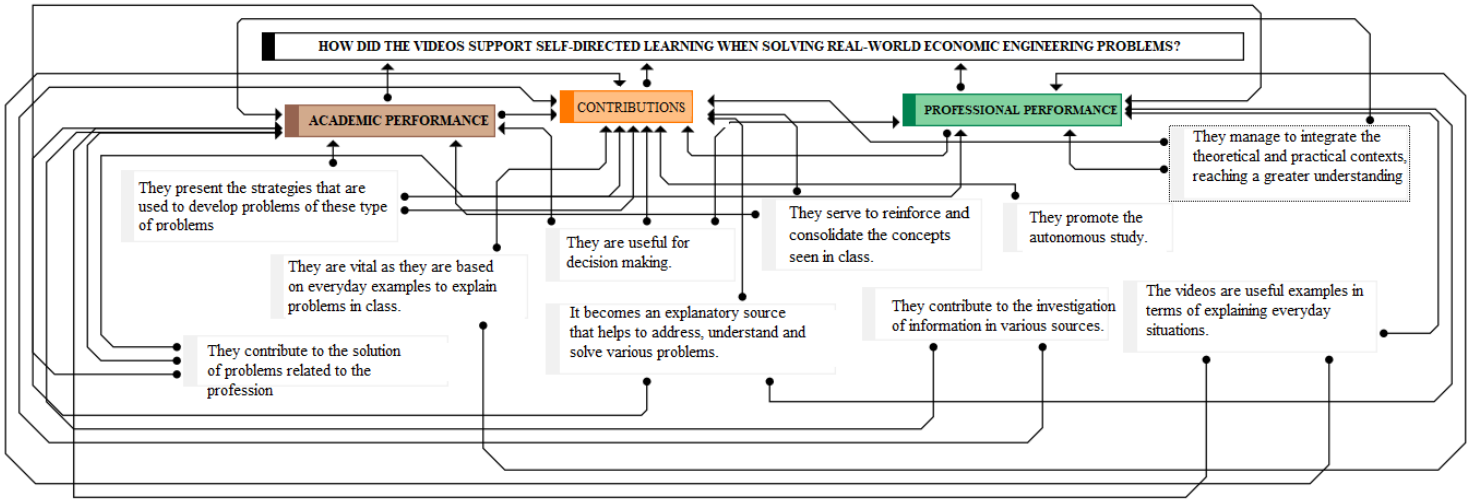


Figure 37. Q2q30. How did the videos affect your acquisition of knowledge about engineering economics topics?

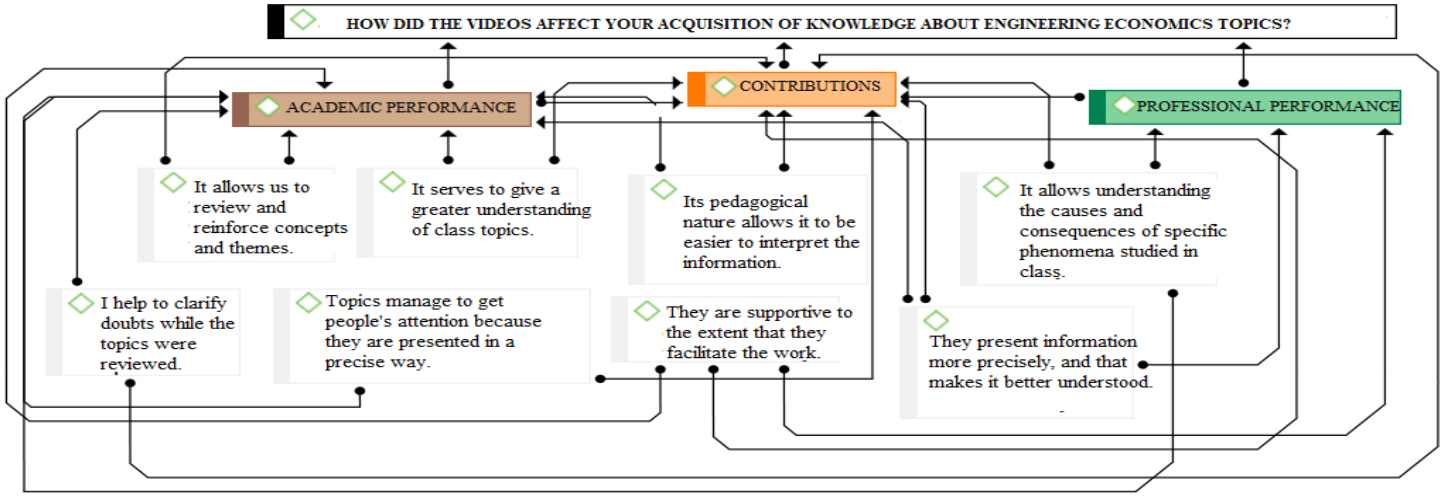


Figure 38. Q2q31. How did the videos affect your acquisition of skills to solve real economic engineering problems?

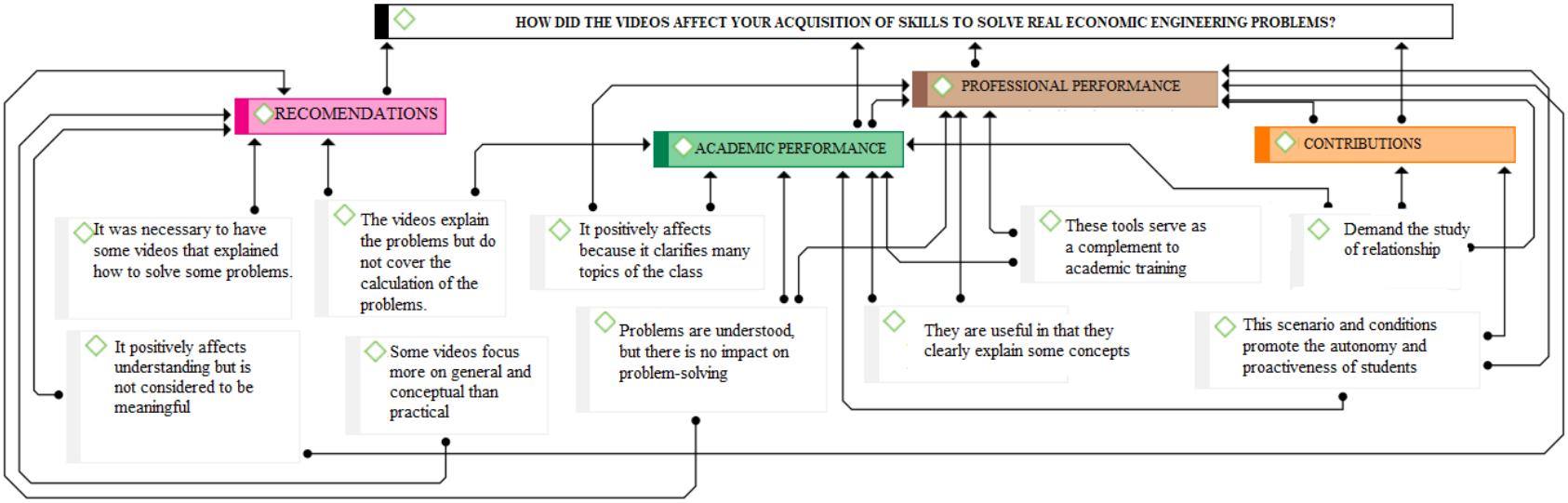


Figure 39. Q2q32. How did the videos help you gain a better understanding of the fundamentals of engineering economics

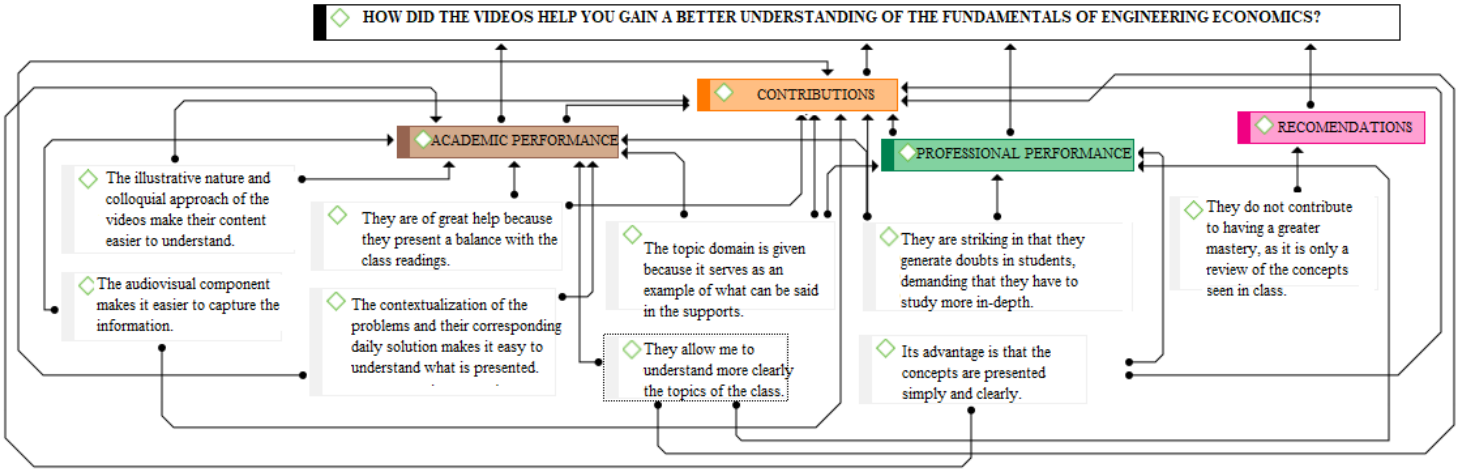


Figure 40. Q2q33. How did the videos allow you to learn about Economic Engineering concepts and apply them to real problems?

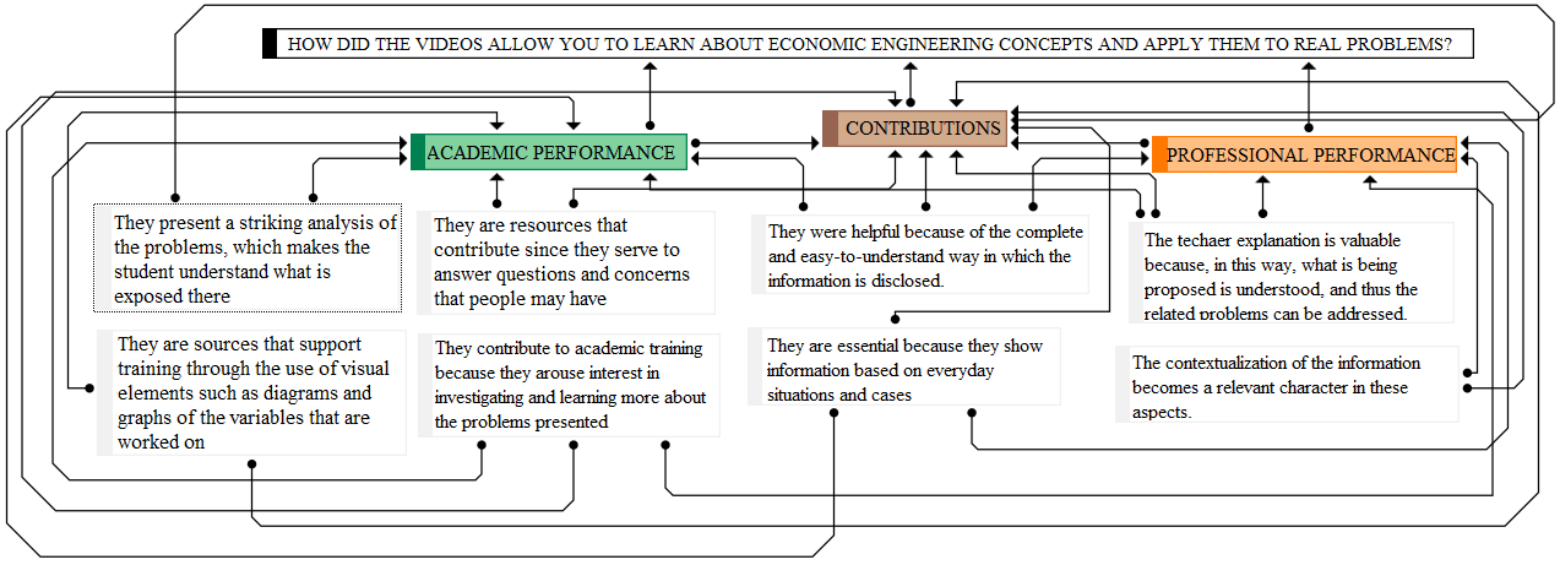


Figure 41. Q2q34 Did the videos increase your interest in finding solutions to problems?

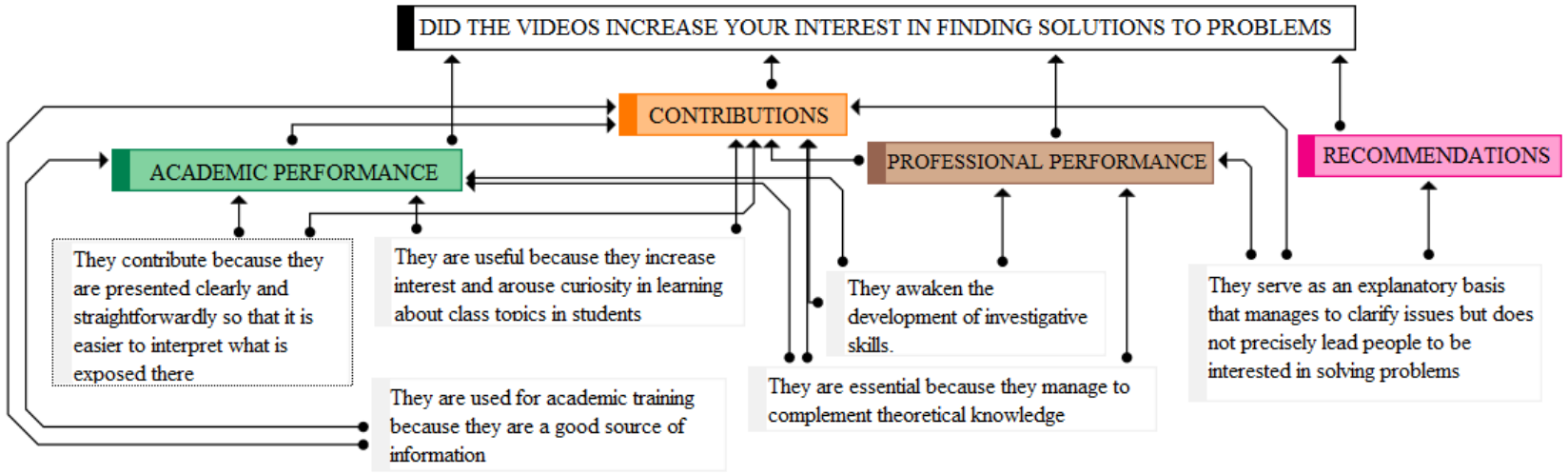


Figure 42. Q2q35 Did you access the video several times to use its content to solve the problem, as questions arose on the subject?

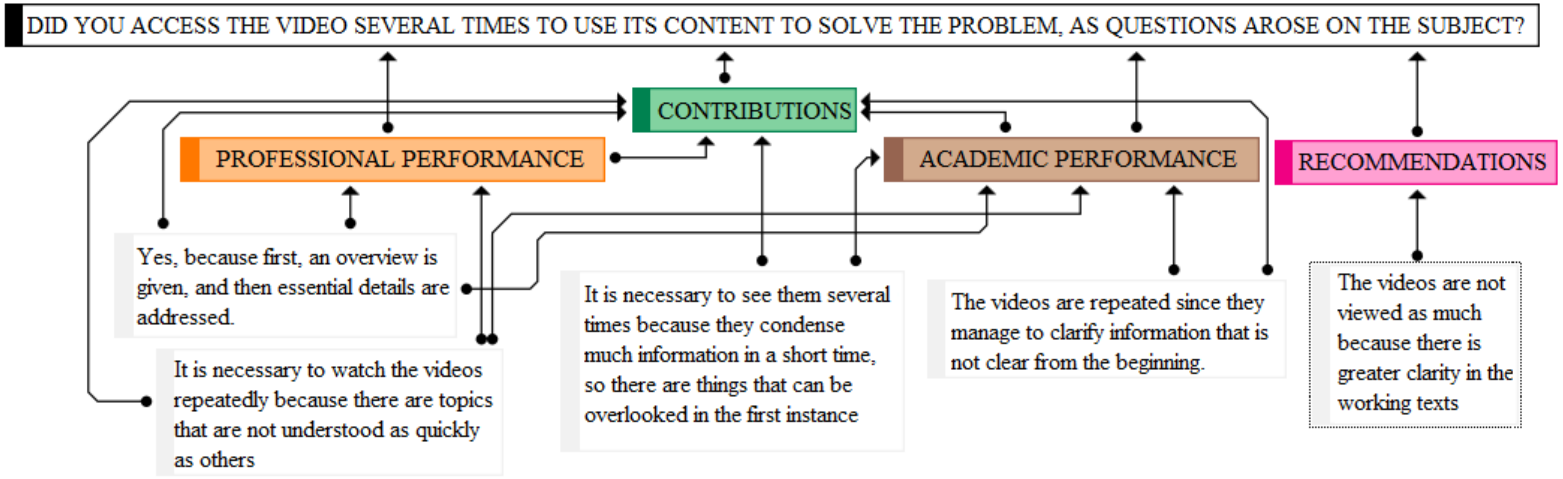


Figure 43. Q2q36 How, when using videos, did you see that you achieved a conceptual change? (Improved the acquisition and application of knowledge)?

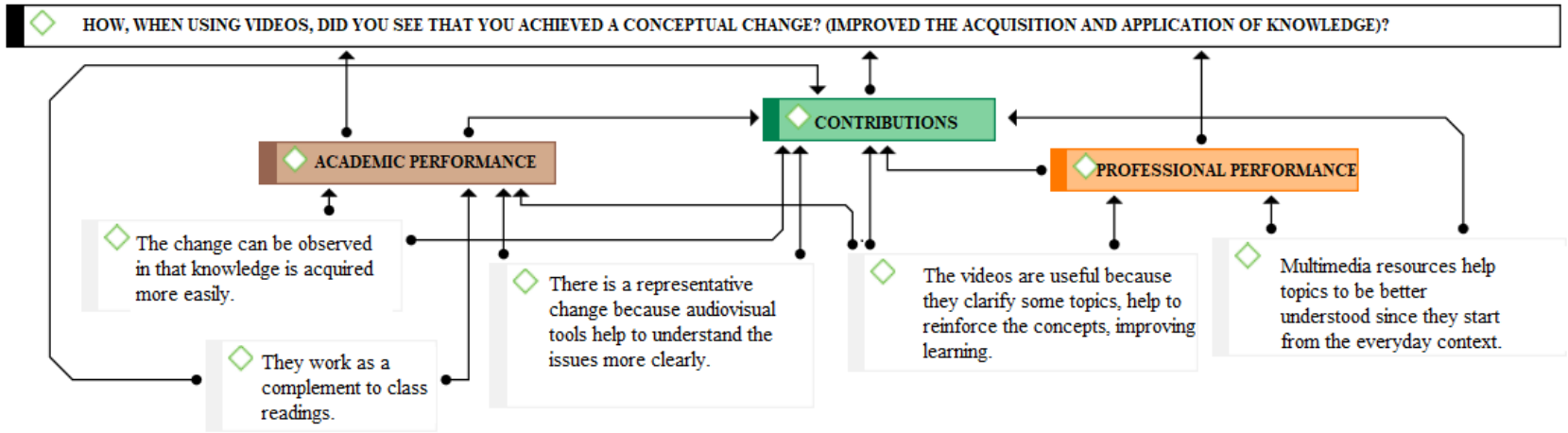


Figure 44. Q2q37. Do you think you can monitor your own building of knowledge by re-accessing videos to address new gaps in knowledge?

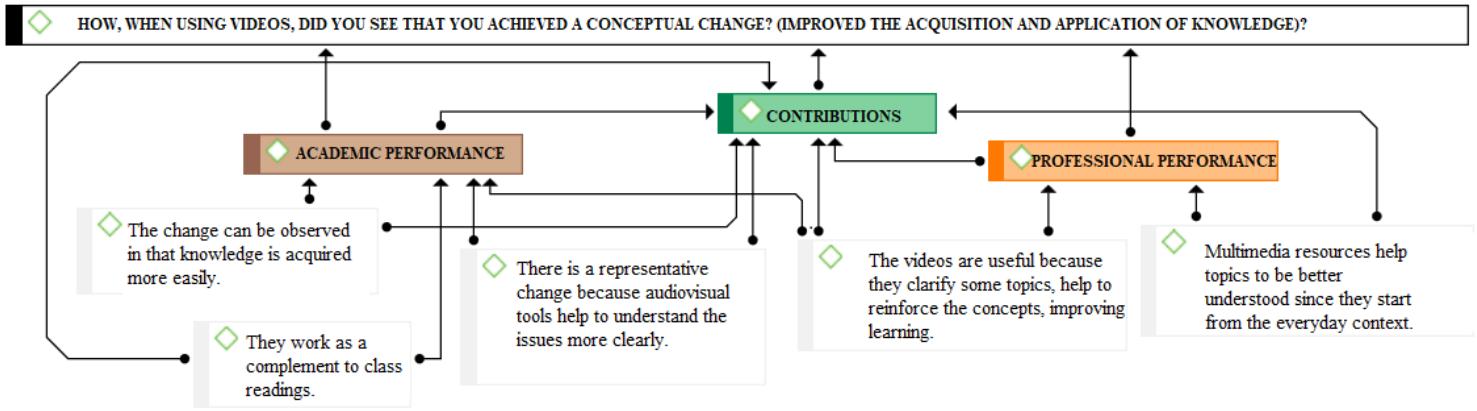


Figure 45. Q2q38 Did the videos allow you to answer specific questions about the concepts required to solve the real problem?

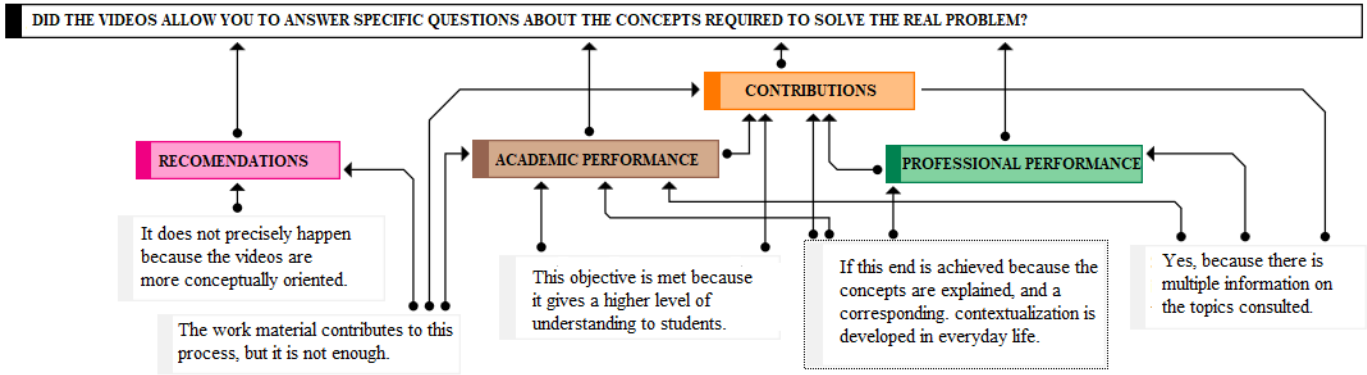


Figure 46. RQc How do students perceive the effectiveness of the teacher under the FPBL approach?

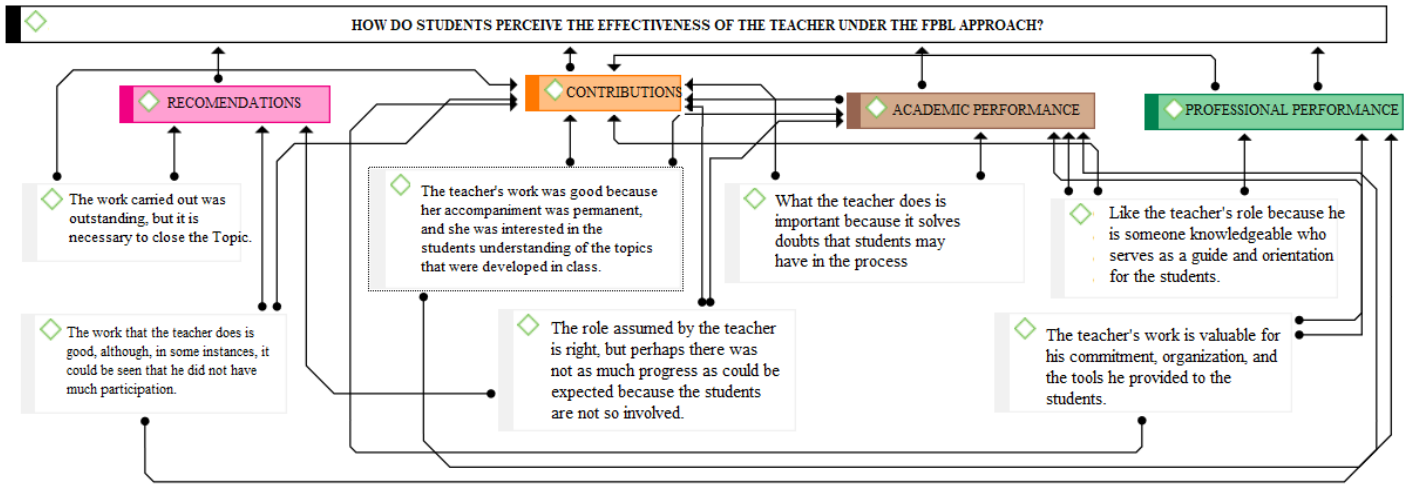


Figure 47. Q2q39. What was the main contribution of the teacher in the development of the final project?

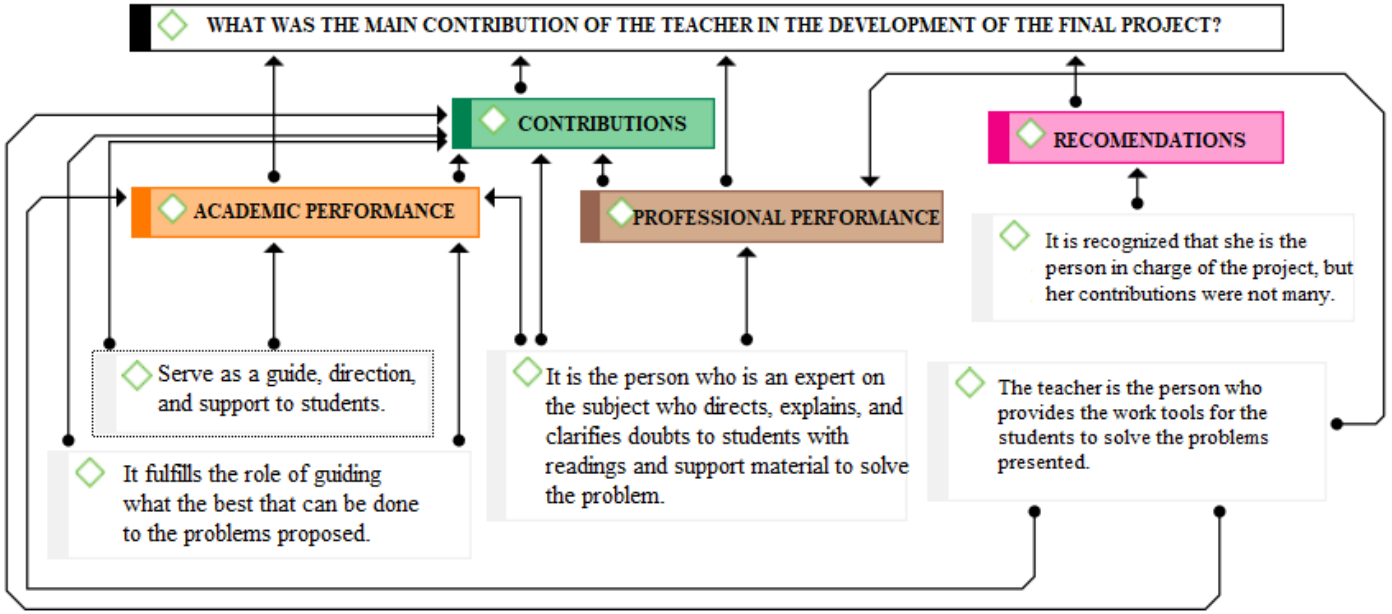


Figure 48. Q2q40. What aspects do you consider to be relevant regarding the formulation of the teacher's problems for the final project?

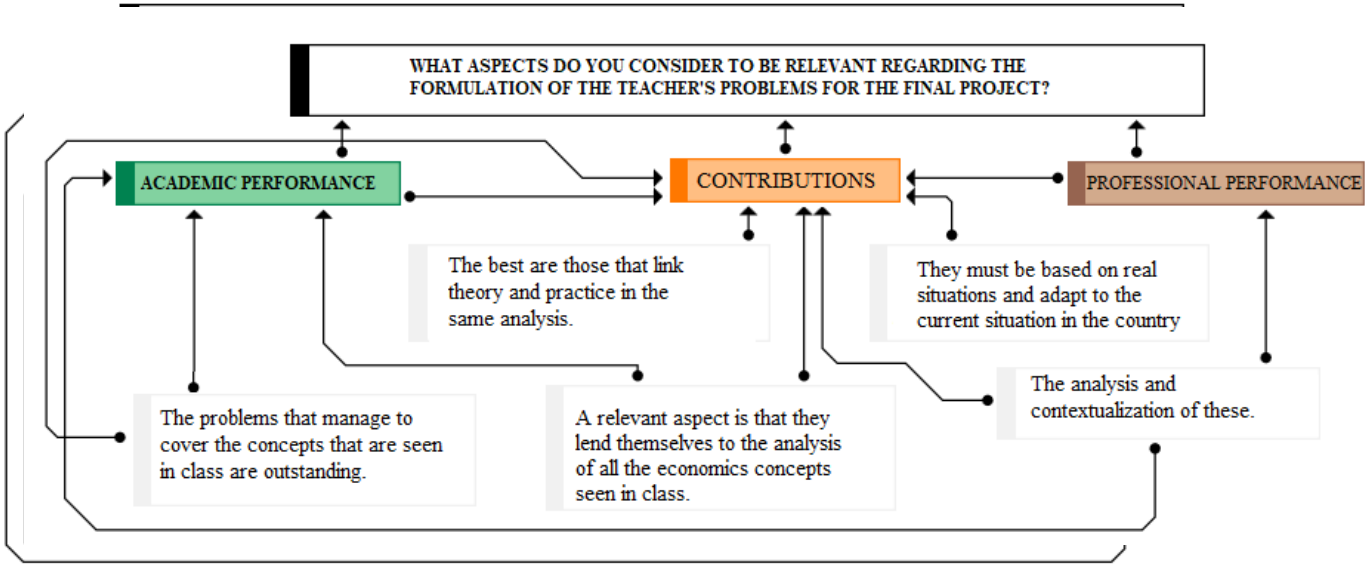


Figure 49. Q2q41. How did the new role of the teacher influence your learning process?

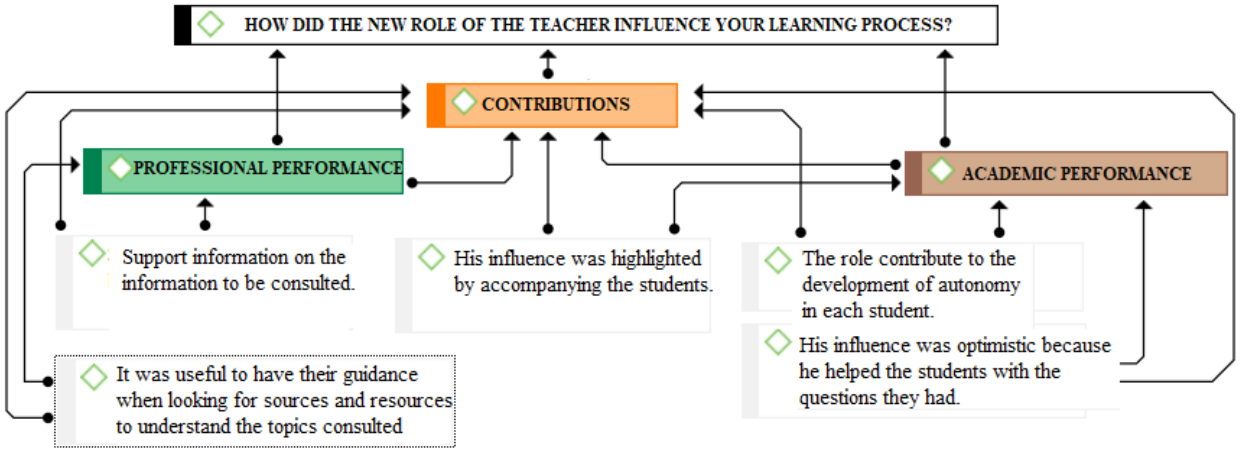


Figure 50. Q2q43. How did the problem-based approach allow you to interact with the other members of your team during the final project?

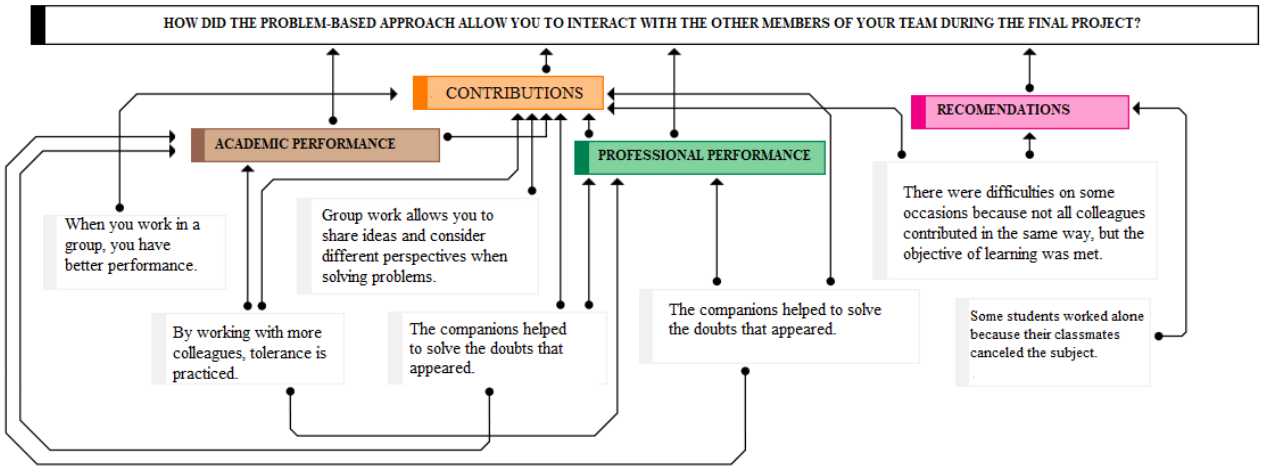


Figure 51. Q2Q44 How do you consider your participation was in solving the problems formulated in the final project?

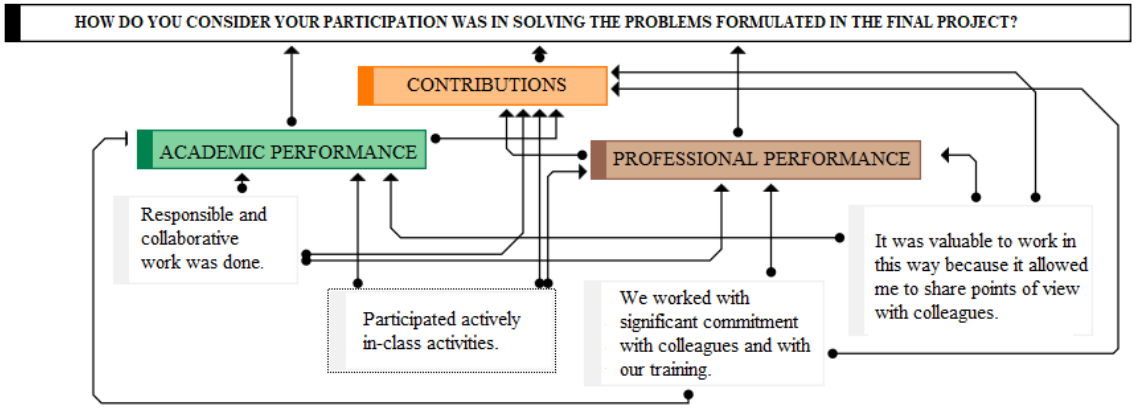
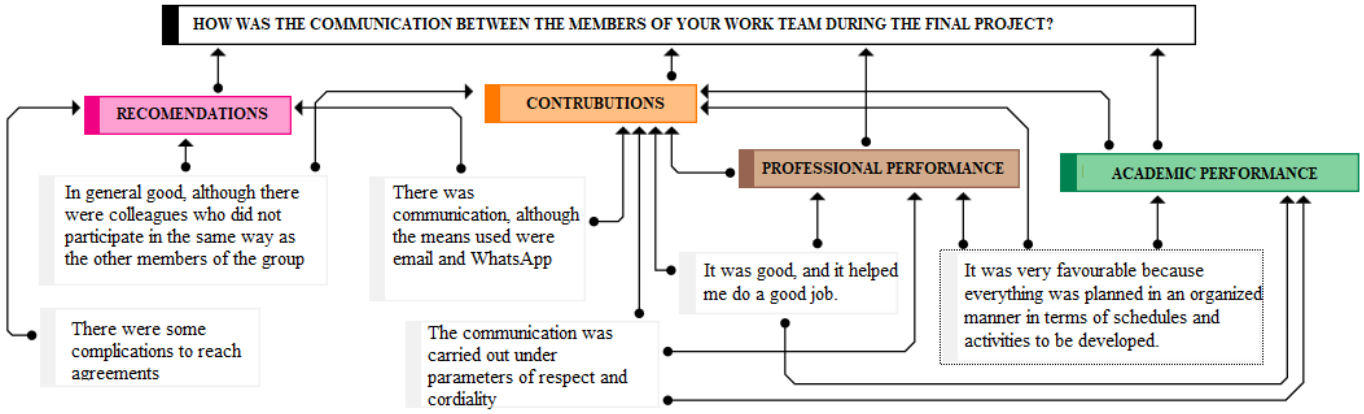


Figure 52. Q2q46 How was the communication between the members of your work team during the final project?



Annex 18. Quantitative Analysis Questionnaire 2- Section 1.

This Annex includes the result of the quantitative analysis for each of the questions in each section.

Self-directed learning in students				
Question	Strongly disagree	Disagreement	Agree	Strongly agree
1	0	9	27	7
2	0	1	24	18
3	0	5	27	11
4	0	4	19	20
5	0	9	18	16
6	0	4	31	8
7	0	4	27	12
8	0	2	26	15

Perception regarding the development of the final project				
Question	Strongly disagree	Disagreement	Agree	Strongly agree
1	0	5	26	12
2	0	2	27	14
3	1	4	19	19
4	0	5	23	15
5	0	6	21	16
6	1	7	22	13
7	0	4	24	15
8	0	4	25	14
9	0	4	26	13
10	0	4	26	13
11	0	8	24	11

Importance of the learning activities developed in the course			
Question	Moderately important	Important	Very important
1	1	14	28
2	2	9	32
3	6	14	23
4	10	19	14
5	0	15	28
6	2	9	32
7	13	20	10
8	4	14	25

To what extent do you consider that each of the designed learning activities contributed to the development of your knowledge?					
Question	Very Low	Low	Medium	High	Very High
1	0	0	7	20	16
2	0	1	4	12	26
3	0	6	6	13	18
4	0	4	10	19	10
5	0	1	3	18	21
6	0	0	3	15	25
7	1	6	16	14	6
8	0	1	8	16	18

Teacher's role in the course				
Question	Strongly disagree	Disagreement	Agree	Strongly agree
1	1	5	24	13
2	0	2	25	16
3	0	3	21	19
4	0	4	21	18
5	0	3	19	21
6	0	2	26	15
7	0	3	22	18

Teamwork during the development of the final project				
Question	Never	Sometimes Always	Many Times	Always
1	0	4	14	25
2	2	8	13	20
3	7	12	17	7
4	1	4	20	18
5	0	7	15	21
6	2	8	20	13
7	0	9	12	22
8	0	10	12	21
9	2	3	16	22
10	0	3	15	25
11	5	10	14	14
12	0	4	20	19
13	1	6	23	13

14	0	6	17	20
15	2	9	20	12
16	0	4	14	25
17	0	1	15	27
18	1	2	14	26
19	0	4	23	16
20	0	3	15	25

Teamwork during the course development					
Question	Totally Disagree	Disagree	I have doubts	Agree	Totally agree
1	4	7	13	13	6
2	1	18	19	5	0
3	3	10	11	16	3
4	9	14	12	7	1
5	13	18	11	1	0
6	1	2	4	16	20
7	1	10	17	13	2
8	16	14	11	1	1
9	8	12	17	5	1
10	4	10	20	9	0
11	6	10	11	12	4
12	10	11	14	8	0
13	3	5	11	17	7
14	6	5	18	12	2
15	1	5	15	15	7
16	6	13	14	9	1
17	3	3	5	20	12
18	6	21	11	5	0
19	1	7	11	16	8
20	10	20	11	1	1
21	6	15	15	7	0
22	2	0	4	14	23
23	6	8	13	13	3
24	1	7	22	13	0
25	2	1	10	22	8
26	9	17	10	5	2
27	2	9	21	10	1
28	6	18	14	4	1
29	1	0	6	15	20
30	2	5	18	12	6

Annex 19. Qualitative Analysis Questionnaire 2- Section 2 Consolidate Information.

The Table 20 presents the consolidated information of the code network that the Atlas TI software generated for each of the open questions about the student's perception of the implementation of the FPBL approach. This table includes the information related to the codes for each open question: contributions, academic performance and professional performance. As well as recommendations. Also, the Table 16 include the information of each semantic nodes. The code network for each question is included in Annex 10.

Table 20. Results Qualitative Analysis with Atlas TI Questionnaire 2 Section 2

	Contributions		
Question	**Academic Performance**	**Professional performance**	**Recommendations**
• ***Teacher's role in the course***			
Q2q5. What was your perception of the teacher's role in the Problem Based Learning methodology supported by flipped learning classroom used in the course?	Doubts are solved clearer when they are contextualized in an environment of problems typical of the race. It is useful for theoretical contextualization.	Knowledge has transcendence beyond the academic. Contributes to development as a professional future. It is more demanding because many questions appear. Contributes to university and work-life. Concepts are better understood when applied. This method is more student-friendly in virtual mode. Contributes to research development. Helps develop skills such as teamwork. Encourage self-employment. Contributes to the appropriation of knowledge.	It is recommended to specify that the final work consists of these dynamics. Greater participation of the teacher is recommended in her role as a person who knows the subject. Link theoretical knowledge with everyday reality.
Q2q6. What do you think was the main contribution of teamwork in your learning process during the course?	Help solve class doubts. Improve communication with other people.	Develop tolerance and understanding skills. Foster initiative, autonomy, and leadership Strengthen responsibility and collaboration skills among colleagues. Interacting with other colleagues is useful to clarify doubts and have more ideas to develop in the project.	
• ***Teamwork during the course development***			
Q2q9 During the development of the course's learning activities, in your work team, were actions established to achieve the objectives (individual responsibilities, rules, or precise tasks for each of the members)?	In some cases, individual tasks were given that contributed to the general development of the project.	If it was necessary because there were parameters that had to be met, such as work delivery dates. The corresponding designation of responsibilities was made for all the members of the group. It was done or not, depending on the difficulties that had to be done.	Communication on this aspect was not much. It was not necessary to do so, because you work individually and then socialize in a group.

	Contributions		
Question	**Academic Performance**	**Professional performance**	**Recommendations**
Q2q10 How were decisions made in your work team during the course?	Each person made their contributions, and the corresponding feedback was made between all. Options were raised, analyzed, and submitted to consensus.	They worked in a group almost all the time.	The dialogue was the critical resource for mutual understanding.
Q2q11 Did you identify a leader or leaders in your work team during the development of the course's learning activities?	The figure of a leader is not considered to have existed because everyone contributed. Mainly they were the people who took the initiative in certain activities.	In general, everyone assumed this role at different times. There were several leaders according to the skills and needs of the project.	
Q2q12 How did you demonstrate your commitment and responsibility to your work team during the development of the course's learning activities?	Providing questions and ideas to work. Collaborating with colleagues with possible doubts that may be generated. Contributing to the group with work ideas	Fulfilling the tasks assigned in the stipulated times. Working hard on project deliveries. Participating in meetings scheduled by colleagues.	
Q2q13 How did teamwork motivate you to create knowledge during the development of activities in the course?	Helps the development of academic skills and characteristics of autonomy in the search for information. Starting from the debate of ideas and learning from others.	Taking responsibility for one's work and others. Recognizing that each person can contribute different ideas during group work. He made known the importance of understanding with colleagues when doing teamwork. Giving room to socialize ideas with colleagues. Through mutual cooperation. Reason to actively participate in groups.	Raised awareness of the importance of teamwork.
• ***Perception regarding the development of the final Project***			
Q2q16 How did the final project support self-directed learning when solving real-world Economic Engineering problems?	Development of autonomy. It allows having greater clarity and better understanding of class topics. The practical exercises help to understand more the topics covered in class. Improves the qualities of understanding of problems in the classroom.	Appropriation of knowledge. Strengthens conceptual learning through practical application. Contributes to the investigation of specific topics. The link between theory and practice makes the topics better understood.	

	Contributions		
Question	**Academic Performance**	**Professional performance**	**Recommendations**
Q2q17 How did the final project affect your knowledge of engineering economics?	The Final Project had a profound impact because it generated a space for practice and evidence of the knowledge acquired. It was useful since it made it necessary to review previous topics. A more excellent approach to the research field There is greater diversification and appropriation of the topics because the information has to be consulted in different sources. Generates greater autonomy. A greater understanding of the issues was obtained.	Decisions are more accurate as long as they are based on theoretical criteria. Students take more ownership of the knowledge acquired in class. The project demands that student's study in greater depth. The project consolidates what has been learned throughout the semester.	
Q2q18 How did the final project affect your acquisition of skills to solve real economic engineering problems?	Contributes to teamwork. It is important for decision making. Helps to consolidate the knowledge acquired in class. It demands the organization of time and space. recommendations Some issues and problems were dealt with in a hurry; therefore, they could not be made the most of The project focuses more on teamwork than problem-solving.	Provides a better approach to real problems. Promotes the development of academic and professional autonomy. Provides tools for problem-solving. It is useful for understanding problems of the profession. Development of skills such as group and individual responsibility	
Q2q19 Did the development of the final project allow you to gain a greater command of economic engineering's fundamental concepts?	It favours group work. Helps strengthen specific knowledge. Contributes to the development of scientific criteria. Allows more significant link between theory and practice	There are greater clarity and understanding of the issues. Strengthen skills through problem-solving. Contributes to making more assertive decisions. Real problems allow the greater possibility of decision. Encourages the development of academic skills. It presents the possibility of solving problems in the long term.	
Q2q20 Did the final project's development allow you to know concepts of Economic Engineering and apply them in real problems?	Many topics are covered in class and also presented in real life. It serves as a route plan because it allows us to know the concepts but not apply them. Topics are understood in greater depth when	The contextualization of the problems makes their understanding and approach more conducive. It demands to develop of skills related to autonomous and investigative study.	

	Contributions		
Question	**Academic Performance**	**Professional performance**	**Recommendations**
	theoretical knowledge is applied. There is not much knowledge regarding real problems, but there is much knowledge regarding the proper handling of concepts for possible future conflicts.		
Q2q21 Did the development of the final project increase your interest in finding a solution to the problems?	The methodology manages to attract the attention of students, encouraging their interest. Students are interested in addressing issues and related situations.	It serves as a theoretical input, but in daily practice, it may be different. It demands that each person study on their own and take ownership of the topics covered in class.	Some topics focus more on the theoretical than on the practical The pedagogical relationship between theory and practice gives rise to the growth of interest. The importance of concepts is recognized as they are addressed in classes.
Q2q22 When developing the final project, do you consider that you achieved a conceptual change (an improvement in the acquisition and application of knowledge)?	There is a more remarkable performance in group work. Complements what was learned in class. It is good because it contributed a lot to the development of knowledge. Knowledge is consolidated. Contributes to the development of investigative skills.	It generated a change because the problems are based on everyday aspects.	It is recognized that there are favourable changes, but it is highlighted that there are complementary elements to be addressed.
Q2q23 Do you think you could monitor your own building of knowledge when developing the final project to address new knowledge gaps?	It allows a greater interpretation of the academic reality. The topics studied to contribute to the development of greater understanding. Encourages the development of investigative skills. Group work allows ideas to be shared and developed in a better way. They like them because they are exciting topics. The contextualization of information gives rise to a greater interest in solving problems, investigating solutions.	They contribute insofar as it is applied knowledge and is based on real situations.	
Q2q24 Did the assigned readings allow you to answer specific questions	Provides an understanding of the research methodology.	There is a development of the investigative criterion.	

	Contributions		
Question	**Academic Performance**	**Professional performance**	**Recommendations**
about the concepts required to solve the problems?	A broader understanding of the different concepts There is a more significant appropriation of concepts and phenomena.	It is good to work on these activities because they allow the development of skills and knowledge typical of engineering. There are greater depth in-class topics.	
• ***Perception regarding the use of videos***			
Q2q25. What aspects of the videos impacted self-directed learning?	It is essential because it makes it necessary to consult other external sources. Sometimes it contributes, sometimes not so much. The proposed activities contribute to meeting the project objectives. There is further investigation of the problems. Contributes to learning. Problems develop with greater understanding and develop in less time.	It is advantageous because it allows linking practice and bullfighting. Allows greater autonomy in the process. It is necessary for the assistance of someone who allows a greater understanding of the subject. The project demanded the study of previous issues.	
Q2q26. Did you see improvements in your learning process by accessing the videos? Contributions	Videos are a good source of learning. When theory and application are linked, topics are better understood. The use of multimedia resources is seen as a favourable aspect. The readings contribute, although it is necessary to consult more sources.	Problems are better understood with this font. The readings are good, but other people prefer these kinds of resources. The videos allow us to solve doubts that the readings may not address. Some students understand better when information is explained in this way.	
Q2q27. Do you feel confident about learning the fundamental concepts and applying them to real problems?	When the study sources are reliable, the acquired learning is more robust, as in this case. This methodology provides security, but the possibility and need to continue studying is not ruled out. The use of explanatory resources such as readings and videos make the topics better understood. In general, it is considered that if there is security in the acquired learning.	It is striking when working with everyday professional situations. The lessons learned are important insofar as they serve as a basis that is reinforced in practice.	This first approach to the subject is essential, but it is not considered sufficient.
Q2q28. Did the videos give descriptive examples of the exercises to be performed?	The videos were outstanding, practical, pedagogical, and didactic. When there are a more significant amount and diversity of support material for the study, students understand better. They help people unfamiliar with the subject to understand it.	This material invites you to investigate in greater depth, The audiovisual content contributes to the greater understanding of the information.	

	Contributions		
Question	**Academic Performance**	**Professional performance**	**Recommendations**
	Videos invite a critical thinking. Some concepts seem easy but have their complexity. The videos are a source to clarify various questions.		
Q2q29. How did the videos support self-directed learning when solving real-world Economic Engineering problems?	They present the strategies that are used to develop problems of these problems. They are vital as they are based on everyday examples to explain problems in class. They contribute to the solution of problems related to the profession.	They are useful for decision making. It becomes an explanatory source that helps to address, understand and solve various problems. They serve to reinforce and consolidate the concepts seen in class. They contribute to the investigation of information in various sources. They promote the autonomous study. They manage to integrate the theoretical and practical contexts, reaching a greater understanding. The videos are useful examples in terms of explaining everyday situations.	
Q2q30. How did the videos affect your acquisition of knowledge about engineering economics topics?	It allows us to review and reinforce concepts and themes. I help to clarify doubts while the topics were reviewed. It serves to give a greater understanding of class topics. Topics manage to get people's attention because they are presented in a precise way. Its pedagogical nature allows it to be easier to interpret the information. They are supportive to the extent that they facilitate the work.	It allows understanding the causes and consequences of specific phenomena studied in class. They present information more precisely, and that makes it better understood.	
Q2q31. How did the videos affect your acquisition of skills to solve real economic engineering problems?	It positively affects because it clarifies many topics of the class, Problems are understood, but there is no impact on problem-solving. They are useful in that they clearly explain some concepts, These tools serve as a complement to academic training.	Demand the study of relationship issues. This scenario and conditions promote the autonomy and proactiveness of students.	It was necessary to have some videos that explained how to solve some problems. It positively affects understanding but is not considered to be meaningful. The videos explain the problems but do not cover the calculation of the problems.
Q2q32. How did the videos help you gain a better understanding of the fundamentals of engineering economics?	The illustrative nature and colloquial approach of the videos make their content easier to understand.	They are striking in that they generate doubts in students, demanding that they have to study more in-depth. Its advantage is that the concepts are presented simply and clearly.	They do not contribute to having a greater mastery, as it is only a review of

	Contributions		
Question	**Academic Performance**	**Professional performance**	**Recommendations**
	The audiovisual component makes it easier to capture the information. They are of great help because they present a balance with the class readings. The contextualization of the problems and their corresponding daily solution makes it easy to understand what is presented. The subject domain is given because it serves as an example of what can be said in the supports. They allow me to understand more clearly the topics of the class.		the concepts seen in class.
Q2q33. How did the videos allow you to learn about Economic Engineering concepts and apply them to real problems?	They present a striking analysis of the problems, which makes the student understand what is exposed there. They are sources that support training through the use of visual elements such as diagrams and graphs of the variables that are worked on. They are resources that contribute since they serve to answer questions and concerns that people may have. They contribute to academic training because they arouse interest in investigating and learning more about the problems presented. They were helpful because of the complete and easy-to-understand way in which the information is disclosed. They are essential because they show information based on everyday situations and cases.	His explanation is valuable because, in this way, what is being proposed is understood, and thus the related problems can be addressed. The contextualization of the information becomes a relevant character in these aspects.	
Q2q34 Did the videos increase your interest in finding solutions to problems?	They contribute because they are presented clearly and straightforwardly so that it is easier to interpret what is exposed there. They are useful because they increase interest and arouse curiosity in learning about class topics in students.	They awaken the development of investigative skills. They are essential because they manage to complement theoretical knowledge.	They serve as an explanatory basis that manages to clarify issues but does not precisely lead people to be interested in solving problems.

	Contributions		
Question	**Academic Performance**	**Professional performance**	**Recommendations**
	They are used for academic training because they are a good source of information.		
Q2q35 Did you access the video several times to use its content to solve the problem, as questions arose on the subject?	The videos are repeated since they manage to clarify information that is not clear from the beginning. It is necessary to see them several times because they condense much information in a short time, so there are things that can be overlooked in the first instance.	Yes, because first, an overview is given, and then essential details are addressed. It is necessary to watch the videos repeatedly because there are topics that are not understood as quickly as others.	The videos are not viewed as much because there is greater clarity in the working texts.
Q2q36 How, when using videos, did you see that you achieved a conceptual change? (Improved the acquisition and application of knowledge)?	The change can be observed in that knowledge is acquired more easily. They work as a complement to class readings. There is a representative change because audiovisual tools help to understand the issues more clearly.	The videos are useful because they clarify some topics, help to reinforce the concepts, improving learning. Multimedia resources help topics to be better understood since they start from the everyday context.	
Q2q37. Do you think you can monitor your own building of knowledge by re-accessing videos to address new gaps in knowledge?	If possible, using research as a source of support for this activity. The resources with which this task can be carried out may be known.	Autonomous monitoring can be done since there are useful tools for this purpose.	A part of students considers that if it is possible, while another part affirms the opposite. The videos are useful, but they are not enough to have an adequately strengthened performance.
Q2q38 Did the videos allow you to answer specific questions about the concepts required to solve the real problem?	This objective is met because it gives a higher level of understanding to students.	If this end is achieved because the concepts are explained, and a corresponding. contextualization is developed in everyday life. Yes, because there is multiple information on the topics consulted. The role of the teacher	It does not precisely happen because the videos are more conceptually oriented. The work material contributes to this process, but it is not enough.
• ***The role of the teacher in the student's learning in the project***			
Q4SR How do students perceive the effectiveness of the teacher under the FPBL approach?	The teacher's work was good because her accompaniment was permanent, and she was interested in the students understanding of the topics that were developed in class. The role assumed by the teacher is right, but perhaps	Like the teacher's role because he is someone knowledgeable who serves as a guide and orientation for the students. The teacher's work is valuable for his commitment, organization, and the tools he provided to the students.	The work carried out was outstanding, but it is necessary to close the subject. The work that the teacher does is good, although, in

	Contributions		
Question	**Academic Performance**	**Professional performance**	**Recommendations**
	there was not as much progress as could be expected because the students are not so involved. What the teacher does is important because it solves doubts that students may have in the process.		some instances, it could be seen that he did not have much participation.
Q2q39. What was the main contribution of the teacher in the development of the final project?	Serve as a guide, direction, and support to students. It fulfills the role of guiding what the best that can be done to the problems proposed.	It is the person who is an expert on the subject who directs, explains, and clarifies doubts to students with readings and support material to solve the problem.	It is recognized that she is the person in charge of the project, but her contributions were not many. The teacher is the person who provides the work tools for the students to solve the problems presented.
Q2q40. What aspects do you consider to be relevant regarding the formulation of the teacher's problems for the final project?	The problems that manage to cover the concepts that are seen in class are outstanding. The best are those that link theory and practice in the same analysis. A relevant aspect is that they lend themselves to the analysis of all the economics concepts seen in class.	They must be based on real situations and adapt to the current situation in the country. The analysis and contextualization of these.	
Q2q41. How did the new role of the teacher influence your learning process?	The role contribute to the development of autonomy in each student. His influence was optimistic because he helped the students with the questions they had. His influence was highlighted by accompanying the students.	Support information on the information to be consulted. It was useful to have their guidance when looking for sources and resources to understand the topics consulted.	
• ***Teamwork during the final project***			
Q2q43. How did the problem-based approach allow you to interact with the other members of your team during the final project?	When you work in a group, you have better performance. By working with more colleagues, tolerance is practiced. Group work allows you to share ideas and consider different perspectives when solving problems.	The need to work as a team and to have good communication among all was prevalent.	There were difficulties on some occasions because not all colleagues contributed in the same way, but the objective of learning was met. Some students worked alone

	Contributions		
Question	**Academic Performance**	**Professional performance**	**Recommendations**
	The companions helped to solve the doubts that appeared.		because their classmates cancelled the subject.
Q2q44. How do you consider your participation was in solving the problems formulated in the final project?	Responsible and collaborative work was done. Participated actively in-class activities.	We worked with significant commitment with colleagues and with our training. It was valuable to work in this way because it allowed me to share points of view with colleagues.	
Q2q46, How was the communication between the members of your work team during the final project?	It was good, and it helped me do a good job. There was communication, although the means used were email and WhatsApp. The communication was carried out under parameters of respect and cordiality.	It was very favourable because everything was planned in an organized manner in terms of schedules and activities to be developed.	In general, good, although there were colleagues who did not participate in the same way as the other members of the group. There were some complications to reach agreements.