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Promoting Collaborative Learning in Students Soon to Graduate through a Teaching–Learning Model

Marisela Rodriguez-Salvador * and Pedro F. Castillo-Valdez

School of Engineering and Sciences, Tecnologico de Monterrey, Monterrey 64849, Nuevo León, Mexico; a01318528@tec.mx

* Correspondence: marisrod@tec.mx

Abstract: For students to compete in the globalized world, it is essential to be proficient not only in knowledge but also in soft skills. Students should know how to work collaboratively towards a common goal; in this sense, it is recommended for educators to enhance collaborative learning competency, particularly in students in the final part of their studies. Important efforts have been made to study collaborative learning; however, those that focus on collaborative competencies in engineering students close to finishing their studies have not yet been explored. In this context, this research proposes a teaching–learning model named "Colabora" to foster collaborative competencies in students soon to graduate from an industrial engineering program. It includes the development of a progressive final project, the use of a digital platform, and specific assessment tools. An exploratory study was conducted in a private university in Mexico during a semester-long innovation management course. Results show that the students who applied "Colabora" obtained the most knowledge on the subject of innovation management and showed greater collaborative competence. This approach adds value for educators and researchers interested in fostering collaborative competencies useful for future professionals that work in teams pursuing common goals.

Keywords: collaborative learning; collaborative competency; teaching–learning resource; higher education; educational innovation

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1. Introduction

In the educational field, promoting collaborative competencies in students who graduate soon is essential, particularly for future professionals involved in innovation, whether a product or a service. The development of successful innovations requires effective team effort that fosters interaction and knowledge sharing in a collaborative environment to achieve common goals. In that sense, besides cognitive abilities such as critical thinking, information literacy, reasoning, and argumentation, an education of excellence should also increase intrapersonal and interpersonal collaborative competencies for proficiency in a globalized and complex world [1]. There is a need to strengthen skills and competencies in higher education to satisfy the workforce demands of an increasingly globalized world. Educators should help students to face the challenge of interacting with diverse cultures, and it is essential to prepare them with a perspective of collaborative work to develop common solutions, promoting better working relationships [2]. For instance, with the current challenges, to be competitive, companies and institutions need to develop international collaboration strategies and alliances, which requires the effective execution of collaborative work competences [3].

Collaborative learning uses a learner-centered approach in which participants work together to acquire knowledge. It integrates students in an environment where everybody grows by learning and students exchange knowledge continuously to develop a common task. Effective collaborative learning is developed through equal work, promoting cooperation among the members of the group instead of competition between individuals [4,5]. Learning in cooperation is a prelude to the eventual practice of the collaborative

teamwork approach to solve problems and conduct projects based on mutual interactions. Cooperative learning describes a set of instructional practices that promote student interdependence to achieve cognitive and social growth, while collaborative learning is based on a social constructivist perspective in which learners gain knowledge in a social context, which promotes the assimilation of values, behaviors, and beliefs within a community of learners [6]. Collaborative and cooperative learning techniques encourage students to improve their ability to formulate and discuss ideas to effectively both assimilate the information they receive and communicate it [7]. Collaborative learning is also a factor in encouraging continuous improvement in education, boosting elements of the teaching process, and providing the opportunity to develop new strategies to enhance students' competencies [5]. In addition, the experience provided by collaborative learning gives students a more effective form of interaction since every participant develops valuable problem-solving skills by testing their ideas and obtaining coordinated feedback under a synergic approach [8]. Collaborative learning can empower students' high-level thinking and improve their critical thinking by asking, analyzing, synthesizing, interpreting, reasoning, and inferring [9]. While critical thinking encompasses a process of logically and objectively analyzing information, problem-solving involves a process of identifying a problem and reasonably evaluating its details to determine the most appropriate solution. According to Campo et al., debates, projects, practice in realistic situations, research, cooperative learning, and case studies are the main activities that students identify as being most effective in the development of critical thinking [10].

Students can strengthen their competencies by integrating new networks of information and knowledge and becoming inspired to join efforts, working as a team towards common goals [11]. Organizing students into groups to carry out class assignments and projects is not the same as team assemblies, even when the term "team" is used, and collaborative learning is particularly focused on team assemblies that develop specific competencies by working together. Teamwork, communication, individual priorities, and external influences are some of the main perceived challenges for the students in collaborative learning [12]. Frequently, students are simply placed in team projects without any specific direction and, as a result, students may graduate without being adequately prepared to achieve team goals, triggering ambiguous goals, with unequal distribution of activities that causes conflicts and, therefore, poor results [13,14]. A certain degree of dissatisfaction and frustration can occur in students due to their inability to deal with team issues, such as workload distribution, logistics, and group dynamics, causing demotivation [15]. Precisely, the main problems that students face are related to scheduling disagreements, absence of leadership, opportunism, or social laziness from their members. Sometimes this causes some students to prefer to work on their own [15]. Different studies have analyzed the development of competencies from a collaborative team approach, including the early detection of problems during the execution of joint activities [16].

Professors are crucial in preventing such circumstances and can take action to improve the educational model. It is necessary to encourage professors to teach collaborative competencies in group projects [17]. Frequently, these competencies are often learned by students on their own, while struggling with many problems. Since these abilities are a fundamental part of the successful development of students, educators should take the responsibility of leading, guiding, and giving students tools for working collaboratively [17,18]. Moreover, educators that apply collaborative learning can enhance their leadership and promote shared responsibility for their students' progress, helping one another to excel in the classroom [19]. Constructive management of emotions, critical thinking, problem solving, creativity, initiative, decision making, and risk assessment also contribute to collaborative learning. Students develop the ability to learn thanks to the proper motivation, time management, and organization of group or individual tasks [20]. They also develop self-awareness of duly achieving their goals on time, overcoming obstacles step by step while assimilating new knowledge and developing new skills. To enhance collaborative learning, different strategies can be helpful, including expositional

participation, in which having organized content following a sequential module is essential, as proposed by Ryu and Parsons [21]. Another is the so-called exploratory learning, where participants discover knowledge and arrive at conclusions through different paths. A third strategy is related to sharing participation, where the creation of communities or teams is the key to understanding and accomplishing tasks; finally, there is experiential learning: a technique focused on combining real-world interactions with digital representations and physical elements to explore concepts and improve skills such as leadership. In addition, collaborative learning has been explored along with other approaches, such as service learning, which integrates community service and social commitment integrating knowledge learned through collaboration.

Particularly, in students soon to graduate, collaborative learning strategies should be implemented to promote collaborative competencies since are fundamental to become successful professionals, prepared for the uncertainties and difficulties of the modern world. According to the World Economic Forum [22], graduates are expected to have competencies that enable them to create a more inclusive, connected, and productive world, where problem-based and collaborative learning have a determinant role for peer collaboration and real-world problem solving. Deliberate interventions are needed under educator-led and school-based approaches to innovation [23]. In this context, it is essential to teach students a set of fundamental teamwork-oriented soft skills such as organization, work planning, collaboration, and communication, among others [24]. For this aim, information technology (IT) is key in fostering collaborative practices that influence quality teaching [25] by providing tools that help strengthen collaborative work, team organization, and continuous interactions, leading students to improve their learning experience [26]. As technology becomes increasingly relevant in education, the use of technology-based collaborative learning is also becoming more important to assist in finding solutions to team organization problems.

Educators have an important role in the transformation of traditional education, especially with the emergence of educational environments supported by IT [27]; they should promote conditions for effective peer interactions. When designing collaborative learning tools, professors need to start with clear activities that provide a framework for collaboration and problem solving that require explicit guidance for students to complete the tasks and encourage them to explain concepts to each other. Important efforts have been made to develop collaborative learning tools. For instance, Laakso et al. designed ViLLE, a collaborative learning tool that includes activities for teacher–student and student–student collaboration and provides automatic evaluations and real-time feedback to support the teaching of computer science and mathematics [28]. On the other hand, Tiradentes et al. designed a collaborative learning tool called the Method 300 application with features such as mobility and accessibility that can be applied in different domains to enhance the team learning process [29].

Collaborative learning models that focus on fostering collaborative competencies in soon to graduate engineering students have not yet been explored. In this context, this research proposes a teaching–learning model named "Colabora" that was designed to promote collaborative competencies in soon to graduate students that belong to an industrial engineer program. This model includes a final project which students develop during one semester, the use of a digital platform, and assessment tools. To accomplish this, "Colabora" comprises collaborative learning strategies such as the expositional participation, exploratory learning, and sharing participation previously mentioned. This model is particularly useful due to new working modalities conceived during the COVID-19 pandemic, such as physical, digital, or hybrid modes where teamwork and collaborative activities are required to pursue common goals.

To gain insights into the execution of "Colabora", an exploratory study was conducted in a private university in Mexico during a semester-long innovation management course. This private university was established in 1943, and it has 25 campuses across the country and 13 link offices around the world, including Europe, having over 100,000 students and

almost 9000 faculty professors. The approach of this research was conceived in the main campus of this university which is in the northeast of Mexico.

2. Methodology

The teaching–learning model "Colabora" was developed using key components of the collaborative learning approach, through specific guidance and clear collaborative activities. The key components of collaborative learning considered in this study are positive interdependence, student–student and student–educator interaction, individual responsibility, and interpersonal and group skills. Table 1 shows these components and how the teaching–learning model of "Colabora" incorporated them.

Table 1. Collaborative Learning focus of "Colabora".

Key Components of Collaborative Learning	Alignment of the "Colabora" Model
Positive interdependence	"Colabora" encourages shared leadership for the development of a final group project. Teams select a leader to guide them towards the goals of each assignment, promoting a collaborative environment under the supervision of a professor.
Student–student and student–educator interaction	"Colabora" allows team leaders to monitor the participation of each team member through the use of a digital platform. In addition, the educator gives constant feedback during the classes and project submissions.
Individual responsibility	"Colabora" fosters equal participation, considering the workload and team consensus; each team member is given a specific activity to complete by a set date.
Interpersonal and group skills	"Colabora" stimulates collaborative work through face-to-face communication in class and by promoting values such as organization, planning, shared leadership, and knowledge sharing.

In this context, "Colabora" was designed based on three components as Figure 1 shows: (1) a final project that students progressively develop in teams during the course, (2) a digital platform that facilitates organization, and (3) assessment tools that evaluate student accomplishment of the competencies. These components will be explained in the following sections.

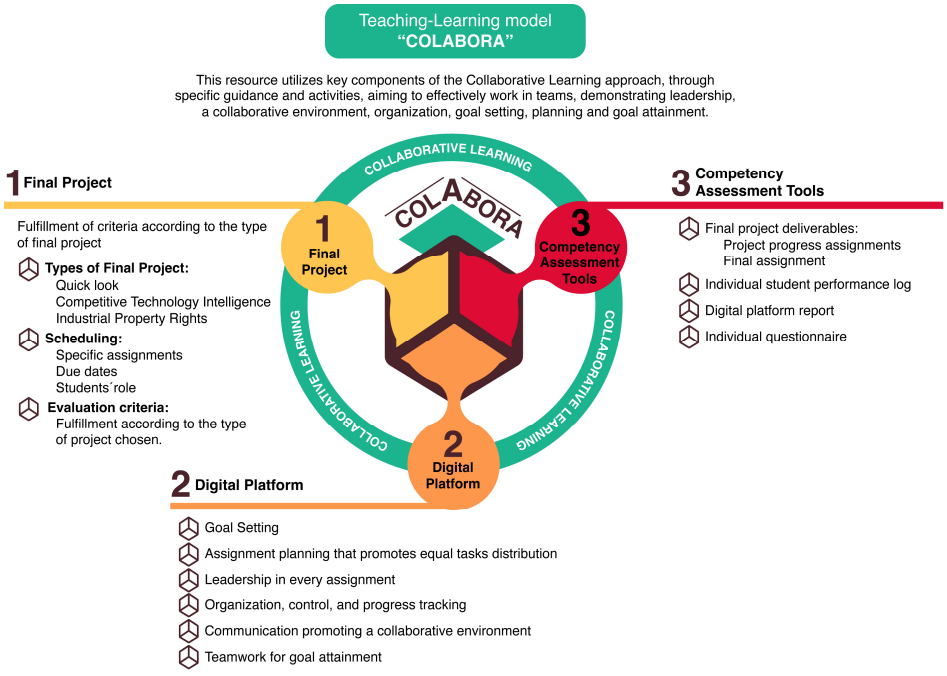

Figure 1. Teaching–Learning model "Colabora".

A case study was executed at the main campus of the private university in Mexico previously mentioned. Founded almost 80 years ago by the participation of a group of companies, this university has a strong link with industry, being a big supporter of innovation through education and joint projects. As we discussed in the Introduction, it is important to prepare students to face challenges of globalization. Careers that involve creating technological solutions like those related to engineering are growing and it is necessary to examine the best strategies to prepare engineers for the future, who should address global issues and propose technical solutions according to real problems.

2.1. Focus

The industrial engineering program was selected to apply our approach, since it is one of the most in-demand careers, due to its versatility with students being able to work in different industries and to perform a variety of activities; for this, they require effective interaction and collaboration with people not only from their field but from other fields too. In particular, the teaching–learning model "Colabora" was developed for students to accomplish a specific competency of this program, which states that industrial engineers should be able to *effectively work in teams, demonstrating leadership, a collaborative environment, organization, goal setting, planning, and goal attainment*. For this purpose, "Colabora" was executed in the innovation management course since it is a topic of fundamental relevance for students to compete in a globalized world, requiring knowing how to innovate and collaborate. This course is taught to industrial engineering students in the final part of their studies to facilitate their entry into the world of work.

2.2. Organization in Teams

To assess the contribution of the full application of the "Colabora" model, students of the innovation management course were randomly organized into teams as follows: an experimental group (consisting of teams 2, 3, and 4) and a control group (composed of teams 1, 5, and 6). In the experimental group, the teaching–learning "Colabora" approach (final project, digital platform, and assessment tools) was implemented through key elements of collaborative learning, such as: positive interdependence, student–student and student–educator interactions, individual responsibility, and interpersonal and group skills (see Table 1). Meanwhile, in the control group, the final project and the assessment tools were implemented without a collaborative learning approach. This organization was decisive in assessing student performance in terms of the competency analyzed as well as the knowledge acquired and consequently the impact of the "Colabora" model. In the experimental group, components of the competency included: leadership as a team, planning, and organization, as well as effective and collaborative work. And in the control group, students received general recommendations and guidance to work as a team, but the professor did not encourage those specific elements of collaborative learning.

The sharing participation strategy approach mentioned previously was also applied in the experimental group and included: the development of specific activities, establishing goals, deadlines, roles, and having a leader for each project deliverable, promoting collaborative work, as well as monitoring of their colleagues together with the professor. In addition, the experimental group utilized a digital platform as part of the "Colabora" approach to facilitate their team organization while the control group organized their activities on their own.

The private university where this study was undertaken is committed to providing students with high-quality education, complying not only with national but also international standards from institutions such as ABET and others. Ethical considerations were made to ensure equal learning opportunities for all students involved. A fundamental set of principles such as voluntary cooperation, confidentiality, and informed consent were considered to guide this research. At the end of the study, the teaching–learning "Colabora" model was promoted among the control group too so they could benefit from this model. Although the full application of "Colabora" was not possible, with "Colabora" requiring

validation in part of the course, students in the control group increased their knowledge and could practice the competency under study before ending the course.

2.3. Final Project

This first component of the "Colabora" model was designed in accordance with the syllabus of the innovation management course, where three categories of final project were established for students to select from. Students had the freedom to choose what type of project wanted to do from:

- Quick Look: This involves an evaluation of the technological transference potential of a new technology using a nine-step methodology established by NASA [30]. The objective is to identify a suggested level of early interest in a particular technology, identifying potential partners pointing to possible "trouble spots". Results may show areas of opportunity and warning signs to evaluate the viability of the new process, product, or material.
- Competitive Technology Intelligence: This comprises an analysis of global tendencies for a specific product, technology, or service using an eight-step methodology developed by Rodriguez-Salvador and Castillo-Valdez [31]. It helps to identify technological opportunities and threats to innovation.
- Industrial Property Rights: This entails protecting a business, product, or technology through industrial property, mainly brands and patents, and it is developed using a nine-step protocol designed by Rodriguez-Salvador [32].

The details of specific assignments, including the scheduling, were given to the students in accordance with the type of project that teams selected. In all cases, the students presented four deliverables during the semester to show the progress of the final project; these assignments were graded, and all teams received feedback to improve their final project, which was handed in (project report and exposition) at the end of the semester.

2.4. Digital Platform

The second component of the "Colabora" model considers the use of a digital platform. Among the different digital platforms used by teams, ASANA was chosen due to its practicality and performance management of tasks by teams, giving the user the possibility to use the mobile application or web version. It is a tool designed to manage projects and foster teamwork, facilitating organization; a friendly platform used to organize projects, prioritize tasks, collaborate with the team, and track progress [33]. And it also complies with the educational quality standards required for the competency under study, stimulating student–student and student–educator interaction.

This platform was used by the experimental group (teams 2, 3, and 4) to boost the development of the competency, in particular: goal setting, choosing a team lead responsible for each deliverable, planning of activities, aiding students with managing their tasks, and promoting an equal distribution of responsibilities and workload among peers. The professor explained to the students the main characteristics of ASANA and gave advice on how to use it as well as how to prepare the corresponding reports. This platform also allowed the teams and professor to control and monitor progress.

2.5. Competency Assessment Tools

Finally, the third component of the "Colabora" model involves an integral evaluation of both the knowledge acquired in the innovation management course and the development of the components of the industrial engineer program collaborative competency, which includes leadership, collaboration, organization, goal setting, planning, and goal attainment. This was the basis to determine the evaluation criteria during the innovation management course which is supported by the next four tools:

1. Final project deliverables: To track the progress of all students, four project progress deliverables throughout the semester (at weeks 4, 7, 10, and 12) were established in

addition to the final project report and presentation (at week 15). For this, a numerical 100-point grading scale was used according to the specific requirements of the type of project the students chose (Quick Look, Competitive Technology Intelligence, or Industrial Property Rights).

2. Individual student performance log: This was designed considering the elements of the competency under study, covering planning, collaboration, and goal attainment, during their progress and final project deliverables. It also considered the student–student and the student–professor interactions during the semester to evaluate the elements of collaborative learning such as positive interdependence, individual responsibility, and interpersonal and group skills. It involved non-numerical grading integrated with fulfilled or non-fulfilled scores.
3. Digital platform report: Students developed a report providing evidence of its use in each of the project deliverables as well as in the final project assignment. This report helped the professor to identify the elements of the competency under study including leadership, planning, organization, goal setting, collaboration, and goal attainment. A numerical 100-point grading scale was used.
4. Individual questionnaire: Students were asked about their organization and collaborative work during the semester. In the experimental group, students reflected on elements of the competency and their experience with "Colabora" including the use of the digital platform ASANA, particularly in which way it helped the team lead to coordinate each project assignment or not and how it contributed or not to the project assignment goals and to the planning and organization of the assignments including the equal workload distribution and promotion of a collaborative environment. However, the control group (students who did not use "Colabora") analyzed if collaborative guidance from the professor and a digital platform would have helped them to better manage their activities and accomplish their goals, as well as answered questions addressed to them, which helped the professor identify elements of the competency, including if a team lead was selected for the different project assignments, if they established goals in each assignment, and if there was a plan for the establishment of tasks and workload distribution with specific deadlines. In this sense, a qualitative evaluation was carried out based on the professor's experience of teaching the innovation management course for more than 10 years.

Once these assessment tools were established, the industrial engineer program collaborative competency was broken down into different elements, and specific criteria to indicate their fulfillment were established as follows:

- Goal attainment and active learning: A student who individually obtains a grade of 90 (on a 100-point grading scale) or more in the final project including report and exposition fulfills this criterion. Each team pursues a common goal in terms of the characteristics of the final project, and the professor evaluates the individual performance of each student according to their contribution to the project, both in the partial deliverables and especially in the final project, which includes the exposition as well as the final report. The professor uses his experience to determine students' accomplishments. It is important to mention that educators need to focus not only on the content of students' interactions but also notice students' non-verbal behaviors, such as their body language and facial expressions, because some students can be actively involved in teamwork but sometimes they do not communicate much.
- Ability to effectively work in teams, demonstrating leadership: To fulfill this element, four main aspects are involved: (1) team grade for the final project (report and exposition) of 90 or more; (2) individual student performance log showing equal project workload distribution, organization, relevant contribution to goal attainment, and no complaints from their teammates; (3) for the experimental group, the digital platform report should demonstrate the use of ASANA according to the collaborative elements of the competency related to teamwork and leadership; and (4) the individual ques-

tionnaire showing teamwork competency including commitment to a common team goal and leadership.

- Establishment of a collaborative environment: It is evaluated through two components, one individual and the other as teams. In the first case, the individual student performance log is analyzed; it meets this criterion when showing collaborative working elements and the equal distribution of responsibilities. In the second case, the team performance is assessed through the different project deliverables (progress report and final project report and presentation); to meet this criterion, the average grade should be 90 or above.
- Goal setting and planning: The students in the experimental group were evaluated through the digital platform report, while in the control group the students were evaluated through the individual questionnaire. In addition, for both the experimental and the control group, the individual student performance log was also considered, and in all cases, students met these criteria if they showed evidence of goal setting and planning of the project progress and final project deliverables.

Table 2 shows the four assessment tools and the competencies they assess. They were used to evaluate both the experimental and control groups. Both groups completed the same activities: the final project with progress deliverables, final report and presentation, individual performance log, and individual questionnaire, except the use of the digital platform. Collaborative learning was promoted in the experimental group through the full application of the "Colabora" approach, which included the use of a digital platform among other elements; whereas in the control group, collaborative learning was not promoted, and students carried out traditional collaborative activities developed by the students themselves. To obtain an objective perspective, the assessment tools for the experimental and control groups were the same, with the only difference being the digital platform report, which provides evidence of the use of the digital platform by the experimental group. The final intention was to evaluate the contribution of the "Colabora" model in all its components. For this aim, the two groups were compared to understand if the use of this approach had a positive effect on the development of the competency selected, which is closely related to collaborative learning.

Table 2. Application of the assessment tools.

Assessment Tool	Competency Assessed	Group Evaluated
Final project deliverables	• Goal attainment and active learning • Ability to effectively work in teams, demonstrating leadership • Establishment of a collaborative environment	Experimental and control
Individual student performance log	• Ability to effectively work in teams, demonstrating leadership • Establishment of a collaborative environment • Goal setting and planning	Experimental and control
Digital platform report	• Ability to effectively work in teams, demonstrating leadership • Goal setting and planning	Experimental
Individual questionnaire	• Ability to effectively work in teams, demonstrating leadership • Goal setting and planning	Experimental and control

Having discussed the methodology, the following section will highlight the main results obtained in the application of the teaching–learning model "Colabora", which, as

mentioned previously, was applied in an innovation management course for undergraduate engineering students.

3. Results

In order to determine the effectiveness and value of the innovative model "Colabora", both the experimental and the control groups were evaluated. As previously stated, four tools were considered for this task: final project, individual student performance log, digital platform report, and an individual questionnaire. The elements that compose the industrial engineer program collaborative competency were assessed: ability to effectively work in teams, demonstrating leadership, a collaborative environment, organization, goal setting, planning, and goal attainment.

The non-numeric evaluation of the experimental group and of the control group is displayed in Tables 3 and 4, respectively. As can be seen, in the experimental group, 100% of students accomplished the goal attainment element (Table 3). Meanwhile, the control group, who completed a final project without the guidance and tools for organization, leadership, collaboration, and planning enabled by "Colabora", demonstrated lower performance: only 60% of students accomplished goal attainment (Table 4).

Table 3. Non-numeric evaluation of the experimental group.

Student	Team	Ability to Effectively Work in Teams, Demonstrating Leadership	Establishment of a Collaborative Environment	Goal Setting and Assignment Planning	Goal Attainment	Digital Platform Contribution to a Collaborative Environment * (Yes/No)
Student 2.1	2	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 2.2	2	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 2.3	2	Not fulfilled	Not fulfilled	Fulfilled	Fulfilled	Yes
Student 2.4	2	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 2.5	2	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 2.6	2	Not fulfilled	Not fulfilled	Fulfilled	Fulfilled	Yes
Student 3.1	3	Not fulfilled	Not fulfilled	Fulfilled	Fulfilled	Yes
Student 3.2	3	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 3.3	3	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 3.4	3	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 3.5	3	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 3.6	3	Not fulfilled	Not fulfilled	Fulfilled	Fulfilled	Yes
Student 4.1	4	Not fulfilled	Not fulfilled	Not fulfilled	Fulfilled	Yes
Student 4.2	4	Not fulfilled	Not fulfilled	Not fulfilled	Fulfilled	Yes
Student 4.3	4	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 4.4	4	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 4.5	4	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 4.6	4	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
% of people that fulfilled the competency		66.67%	66.67%	88.89%	100.00%	100.00%

* Collaborative environment includes positive interdependence, individual responsibility, interpersonal, and group skills.

Regarding the use of the digital platform ASANA, 100% of the students declared that it was a useful tool to foster a collaborative environment, including positive interdependence, individual responsibility, and interpersonal and group skills, for each assignment (Table 3). It was also noted by the students that they would be interested in the future use of this kind of digital tool in their assignments and professional activities. Only one student had initial trouble while using the mobile version of the digital platform; however, when switching to the web version, this problem was solved. Regarding the control group's perception of the use of digital platforms, 30% declared it unnecessary for their organization since their teams used other applications such as WhatsApp and Google Drive, 10% said that a digital

platform tool may be useful but for more elaborate projects, and 65% claimed that the use of a digital platform would have been useful for better teamwork, leadership, organization, scheduling, goal setting, and communication (Table 4).

Table 4. Non-numeric evaluation of the control group.

Student	Team	Ability to Effectively Work in Teams, Demonstrating Leadership	Establishment of a Collaborative Environment	Goal Setting and Assignment Planning	Goal Attainment	Digital Platform Contribution to a Collaborative Environment * (Yes/No)
Student 1.1	1	Not fulfilled	Not fulfilled	Not fulfilled	Not fulfilled	No
Student 1.2	1	Not fulfilled	Not fulfilled	Not fulfilled	Not fulfilled	Yes
Student 1.3	1	Fulfilled	Not fulfilled	Not fulfilled	Not fulfilled	Yes
Student 1.4	1	Fulfilled	Not fulfilled	Not fulfilled	Not fulfilled	Yes
Student 1.5	1	Not fulfilled	Not fulfilled	Not fulfilled	Not fulfilled	Yes
Student 1.6	1	Fulfilled	Not fulfilled	Not fulfilled	Not fulfilled	No
Student 5.1	5	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 5.2	5	Not fulfilled	Not fulfilled	Not fulfilled	Fulfilled	No
Student 5.3	5	Not fulfilled	Not fulfilled	Fulfilled	Fulfilled	Yes
Student 5.4	5	Not fulfilled	Not fulfilled	Fulfilled	Not fulfilled	Yes
Student 5.5	5	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 5.6	5	Not fulfilled	Not fulfilled	Fulfilled	Fulfilled	Yes
Student 5.7	5	Not fulfilled	Not fulfilled	Not fulfilled	Not fulfilled	No
Student 6.1	6	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 6.2	6	Not fulfilled	Not fulfilled	Fulfilled	Fulfilled	Yes
Student 6.3	6	Not fulfilled	Not fulfilled	Fulfilled	Fulfilled	-
Student 6.4	6	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 6.5	6	Not fulfilled	Not fulfilled	Fulfilled	Fulfilled	No
Student 6.6	6	Fulfilled	Fulfilled	Fulfilled	Fulfilled	Yes
Student 6.7	6	Fulfilled	Fulfilled	Fulfilled	Fulfilled	No
% of people that fulfilled the competency		45.00%	30.00%	60.00%	60.00%	65.00%

* Collaborative environment includes positive interdependence, individual responsibility, interpersonal, and group skills.

Tables 5 and 6 display the numeric evaluation of the experimental and the control group, respectively, according to the final project grading, the individual average grading, and the group average course grading. Results obtained exhibit that the most effective teamwork and collaboration occurred in the experimental group (teams 2, 3, and 4).

As Table 5 shows, the teams in the experimental group obtained the highest grades in the final project report and exposition, with average individual grades and group average course grades ranging from 90 to 100. Regarding the non-numeric assessment, the experimental group also managed to stand out, as observed in Table 3. The students mostly fulfilled all the elements of the competency under study (ability to effectively work in teams, demonstrating leadership, a collaborative environment, organization, goal setting, planning, and goal attainment), and stated that the use of a digital platform added value to their project assignments and it was seen as a necessary tool for future work. A better performance was obtained by the experimental group than in the control group due to the "Colabora" model followed.

In the case of the control group, the quantitative assessment shown in Table 6 indicates that grades varied greatly, ranging from 75 to 93 (final project report, exposition, individual average grade, and group average grade), for example, in the final project the lowest was 75 (exposition) and the highest was 95 (report and exposition), while the individual average grade varied from 78 to 93 and the group average grade from 78.3 to 91.8. Regarding the non-numeric assessment, Table 4 shows that not all the students met the elements of the competency under study, indicating a lower performance.

Table 5. Numeric evaluation of the experimental group.

Student	Team	Final Project Grading		Individual Average Grading (Report and Exposition)	Group Average Grading (Report and Exposition)
		Report	Exposition		
Student 2.1	2	97	95	96	98.9
Student 2.2	2	100	100	100	
Student 2.3	2	100	100	100	
Student 2.4	2	100	95	98	
Student 2.5	2	100	100	100	
Student 2.6	2	100	100	100	
Student 3.1	3	100	100	100	100
Student 3.2	3	100	100	100	
Student 3.3	3	100	100	100	
Student 3.4	3	100	100	100	
Student 3.5	3	100	100	100	
Student 3.6	3	100	100	100	
Student 4.1	4	90	95	93	92.5
Student 4.2	4	90	95	93	
Student 4.3	4	90	95	93	
Student 4.4	4	90	95	93	
Student 4.5	4	90	95	93	
Student 4.6	4	90	95	93	

Table 6. Numeric evaluation of the control group.

Student	Team	Final Project Grading		Individual Average Grading (Report and Exposition)	Group Average Grading (Report and Exposition)
		Report	Exposition		
Student 1.1	1	80	75	78	78.3
Student 1.2	1	80	75	78	
Student 1.3	1	80	80	80	
Student 1.4	1	80	75	78	
Student 1.5	1	80	75	78	
Student 1.6	1	80	80	80	
Student 5.1	5	87	95	91	90
Student 5.2	5	87	95	91	
Student 5.3	5	87	95	91	
Student 5.4	5	87	90	89	
Student 5.5	5	87	95	91	
Student 5.6	5	87	95	91	
Student 5.7	5	85	87	86	
Student 6.1	6	95	85	90	91.8
Student 6.2	6	95	90	93	
Student 6.3	6	95	90	93	
Student 6.4	6	95	90	93	
Student 6.5	6	95	90	93	
Student 6.6	6	95	85	90	
Student 6.7	6	95	90	93	

4. Discussion

The results obtained in this research show that individually and in teams, the students of the experimental group exhibited a better performance in terms of learning and competency development than those who belonged to the control group. The "Colabora" model implemented made this possible by providing conditions that fostered effective peer interactions. Students perceived the "Colabora" model positively and expressed their acceptance as a valuable collaborative experience, suggesting that learning to collaborate was occurring. They also reported a desire to engage in similar practices in their future workplace. More than an individualistic approach, aspects of a social nature, which in-

clude collaborative learning, represent a significant element to support learning, as Pishtari et al. [34] found in their analysis of model-based learning analytics (MbLA) that facilitates the interaction between educators and intelligent systems.

Global insights obtained indicate that when students are empowered to choose the final project type they are interested in (in this case from Quick Look, Competitive Technology Intelligence, or Industrial Property Rights), they work with specific collaborative guidance, and in addition, with a digital platform that facilitates their assignment management as proposed by the innovative model "Colabora", students improve their knowledge and better develop the collaborative competency, which is useful for their future professional life. As Pozzi et al. [35] demonstrate, establishing social negotiation empowers knowledge development by encouraging critical thinking, understanding, and group reasoning. By incorporating innovative teaching–learning strategies, students can gain insights useful to be integrated in their workplace [36]. This is a step towards preparing engineers of the future to address global challenges and propose innovative solutions that require efficient collaboration.

The limitations of this exploratory study are related to the assessment method that combined quantitative and qualitative elements, with the latter being the most difficult to measure. Another limitation is that while students in the experimental group had the opportunity to fully explore the "Colabora" model, students in the control group only had this chance when the study ended, since evaluating Colabora's contribution took place over part of the course, and consequently the control group could not apply it fully. On the other hand, "Colabora" was applied to only one undergraduate course as a case study, as was mentioned before, the innovation management course, and despite the analysis developed during the entire semester of this course, it could have been useful to apply "Colabora" to other courses and compare performance of more students, as the data obtained are not representative of all students enrolled in the industrial engineering academic program. Future research should include a complete number of students, and diverse careers and courses are recommended to include the implementation of the "Colabora" model.

5. Conclusions

The present study proposes the teaching–learning model "Colabora" to promote collaborative learning in engineering students soon to graduate. For this, an industrial engineer program collaborative competency, which is essential for future professionals, was analyzed in an innovation management course at the main campus of a private university in Mexico. This competency establishes that *industrial engineers should be able to effectively work in teams, demonstrating leadership, a collaborative environment, organization, goal setting, planning, and goal attainment*. And this was evaluated through each of its elements.

During this exploratory study, students had to overcome different obstacles both in the final project and in the project progress deliverables; they had to solve conflicts and communication, organization, and collaboration issues in their teams; for the experimental group, the use of the "Colabora" approach, including the digital platform, provided significant advantages to prevent and solve these kinds of problems.

"Colabora" is an innovative model whose contribution has been reflected in the students' performance, encouraging collaborative elements such as positive interdependence, student–student and student–educator interaction, individual responsibility, and interpersonal and group skills. The teams who applied this model had a superior performance, obtaining better grades than those that did not use it. Through "Colabora", the development of the collaborative competency analyzed was possible, fostering leadership, goal setting, planning, and goal achievement in a collaborative environment, as was demonstrated by different evidence (reports, expositions, individual questionnaires, student–student and professor–student interactions, etc.). The use of "Colabora" boosted knowledge learning, as well as the fulfillment of the selected competency.

This approach stimulates key elements of the collaborative learning domain where students learn technical knowledge on the subject and develop new skills. Collaborative

learning is an important technique that allows students to work in coordinated groups, assuming and fulfilling specific roles for effective collective achievements; in addition, it represents a method to carry out equal work. The findings of this study suggest the importance of developing new educational tools within collaborative learning as a central axis for teamwork, empowering students as leaders who will guide activities towards common goals.

In summary, this study explores the establishment of new strategies that facilitate active learning and contribute to preparing undergraduate students in the final part of their university studies for their upcoming work where they will have to face global challenges.

We encourage the adoption of "Colabora" in academic institutions because, overall, it adds value for educators and researchers to develop collaborative competencies that will be useful for future professionals involved in innovation projects in companies, government, or academia.

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References

1. Yeager, D.S.; Walton, G.M. Social-Psychological Interventions in Education. *Rev. Educ. Res.* **2011**, *81*, 267–301. [CrossRef]
2. Murad, T.; Assadi, N.; Zoabi, M.; Hamza, S.; Ibdah, M. The contribution of professional learning community of pedagogical instructors, training teachers and teaching students within a clinical model for teacher education to their professional development. *Eur. J. Educ. Res.* **2022**, *11*, 1009–1022. [CrossRef]
3. Almahendra, R. Disentangling Learning Network Dilemma: A Small-World Effect in a Globalized World. *Sustainability* **2023**, *15*, 2288. [CrossRef]
4. Panitz, T. A definition of Collaborative vs. Cooperative Learning. *Deliberations* **1996**, 1–3, London Metropolitan University UK. Available online: http://colccti.colfinder.org/sites/default/files/a_definition_of_collaborative_vs_cooperative_learning.pdf (accessed on 14 September 2022).
5. Martinez, R.; Yap, G.M. Continuous improvement innovation in Philippine education: A reflective approach. In Proceedings of the 12th European Conference on Innovation and Entrepreneurship, Paris, France, 21–22 September 2017; pp. 410–416.
6. Oxford, R.L. Cooperative Learning, Collaborative Learning, and Interaction: Three Communicative Strands in the Language Classroom. *Mod. Lang. J.* **1997**, *81*, 443–456. [CrossRef]
7. George, K.; George, R.L. Cooperative Learning Reflection: Virtual Connections Post-COVID. *Transform. Dialogues Teach. Learn. J.* **2023**, *15*, 55–64. [CrossRef]
8. Laal, M.; Ghodsi, S.M. Benefits of collaborative learning. *Procedia Soc. Behav. Sci.* **2012**, *31*, 486–490. [CrossRef]
9. Ramdani, D.; Herawati, S. The effectiveness of collaborative learning on critical thinking, creative thinking and metacognitive skill ability: Meta-analysis on biological learning. *Eur. J. Educ. Res.* **2022**, *11*, 1607–1628. [CrossRef]

10. Campo, L.; Galindo-Domínguez, H.; Bezanilla, M.-J.; Fernández-Nogueira, D.; Poblete, M. Methodologies for Fostering Critical Thinking Skills from University Students' Points of View. *Educ. Sci.* **2023**, *13*, 132. [CrossRef]
11. Brindley, J.E.; Walti, C.; Blaschke, L.M. Creating effective collaborative learning groups in an online environment. *Int. Rev. Res. Open Distance Learn.* **2009**, *10*, 1–18. [CrossRef]
12. Pang, C.; Lau, J.; Seah, C.P.; Cheong, L.; Low, A. Socially Challenged Collaborative Learning of Secondary School Students in Singapore. *Educ. Sci.* **2018**, *8*, 24. [CrossRef]
13. Cox, P.L.; Bobrowski, P.E. The team chapter assignment: Improving the effectiveness of classroom teams. *J. Behav. Appl. Mgmt.* **2000**, *1*, 92–103.
14. McCorkle, D.E.; Reardon, J.; Alexander, J.F.; Kling, N.D.; Harris, R.C.; Iyer, R.V. Undergraduate marketing students, group projects, and teamwork: The good, the bad, and the ugly? *J. Mark. Educ.* **1999**, *21*, 106–117. [CrossRef]
15. Feichtner, S.B.; Davis, E.A. Why Some Groups Fail: A Survey of Students' Experiences with Learning Groups. *Organ. Behav. Teach. Rev.* **1984**, *9*, 58–73. [CrossRef]
16. Rebollar, R.; Lidón, I.; Cano, J.L.; Gimeno, F.; Qvist, P. A tool for preventing teamwork failure: The TFP questionnaire. *Int. J. Eng. Educ.* **2010**, *26*, 784–794.
17. Rotfeld, H. Hello, bird, I'm learning ornithology. *Mark. Educ.* **1998**, *17*, 4–6.
18. Verderber, K.S.; Serey, T.T. Managing in-class projects: Setting them up to succeed. *J. Mgmt. Educ.* **1996**, *20*, 23–28. [CrossRef]
19. Hamengkubuwono; Asha, L.; Warsah, I.; Morganna, R.; Adhrianti, L. The effect of teacher collaboration as the embodiment of teacher leadership on educational management students' critical thinking skills. *Eur. J. Educ. Res.* **2022**, *11*, 1315–1326. [CrossRef]
20. Halász, G.; Michel, A. Key Competences in Europe: Interpretation, policy formulation and implementation. *Eur. J. Educ.* **2011**, *46*, 289–306. [CrossRef]
21. Ryu, H.; Parsons, P. *Innovative Mobile Learning: Techniques and Tecnologies*; Information Science Reference (IGI Global): Hershey, PA, USA, 2008; pp. 1–20. [CrossRef]
22. Schools of the Future: Defining New Models of Education for the Fourth Industrial Revolution (2020) World Economic Forum. Available online: www.weforum.org (accessed on 21 June 2023).
23. Halász, G. Measuring innovation in education: The outcomes of a national education sector innovation survey. *Eur. J. Educ.* **2018**, *53*, 557–573. [CrossRef]
24. Macek, O.; Kom'rek, M. Evaluation of student teamwork. In Proceedings of the 2012 IEEE 25th Conference on Software Engineering Education and Training, Nanjing, China, 17–19 April 2012; pp. 130–133. [CrossRef]
25. Drossel, K.; Eickelmann, B.; Schulz-Zander, R. Determinants of teachers' collaborative use of information and communications technology for teaching and learning: A European perspective. *Eur. Educ. Res. J.* **2017**, *16*, 781–799. [CrossRef]
26. Yunus, M.; Setyosari, P.; Utaya, S.; Kuswandi, D. The influence of online project collaborative learning and achievement motivation on problem-solving ability. *Eur. J. Educ. Res.* **2021**, *10*, 813–823. [CrossRef]
27. Duţă, N.; Martínez-Rivera, O. Between Theory and Practice: The Importance of ICT in Higher Education as a Tool for Collaborative Learning. *Procedia Soc. Behav. Sci.* **2015**, *180*, 1466–1473. [CrossRef]
28. Laakso, M.J.; Kaila, E.; Rajala, T. ViLLE–collaborative education tool: Designing and utilizing an exercise-based learning environment. *Educ. Inf. Technol.* **2018**, *23*, 1655–1676. [CrossRef]
29. Tiradentes Souto, V.; Ramos Fragelli, R.; Henrique Veneziano, W. Designing an Innovative Collaborative Learning Application: The Case of Method 300. In *International Conference on Human-Computer Interaction*; Marcus, A., Rosenzweig, E., Eds.; Springer International Publishing: Cham, Switzerland, 2020; p. 12202. [CrossRef]
30. Cornwell, B. "Quicklook" commercialization assessments. *R D Ent. Asia Pac.* **1998**, *1*, 7–9. [CrossRef]
31. Rodriguez-Salvador, M.; Castillo-Valdez, P.F. Integrating Science and Technology Metrics into a Competitive Technology Intelligence Methodology. *J. Intell. Stud. Bus.* **2021**, *11*, 69–77. [CrossRef]
32. Rodriguez-Salvador, M. "Technology Innovation Systems," Course Material, Tecnológico de Monterrey, Monterrey, Nuevo León, México. 2021.
33. Explore Ways to Use Asana. Available online: https://asana.com/uses (accessed on 9 November 2022).
34. Pishtari, G.; Ley, T.; Khalil, M.; Kasepalu, R.; Tuvi, I. Model-Based Learning Analytics for a Partnership of Teachers and Intelligent Systems: A Bibliometric Systematic Review. *Educ. Sci.* **2023**, *13*, 498. [CrossRef]
35. Pozzi, F.; Manganello, F.; Persico, D. Collaborative Learning: A Design Challenge for Teachers. *Educ. Sci.* **2023**, *13*, 331. [CrossRef]
36. Badilla Quintana, M.G.; Meza Fernández, S. A pedagogical model to develop teaching skills. The collaborative learning experience in the Immersive Virtual World TYMMI. *Comput. Hum. Behav.* **2015**, *51*, 594–603. [CrossRef]