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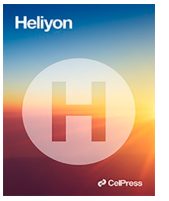

How to share the leadership competence among the team members in active learning scenarios: Before, during and after COVID-19 pandemic

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ABSTRACT

Teamwork is one of the most demanded generic competencies by international organizations, and higher education institutions train and assess that competence to prepare students for working life. Leadership is a crucial part of teamwork development, and previous research has shown that shared leadership tasks between team members present more advantages than the traditional concept of a formal leader. Shared leadership seems to be the best option in the academic context due to the university students' characteristics. This paper aims to prove that students can identify, distinguish and exercise shared leadership actions based on the needs that arise during the development of teamwork and that derive from the teamwork method applied rather than by the training modality that is followed (face-to-face – online). The achievement of the aim has been possible through a qualitative study of the teamwork development of 40 teams of new university entrance (237 students) with the Comprehensive Teamwork Competency Formation Model. The research has been carried out during three consecutive academic courses, with different training modalities for each course, forced by the COVID-19 pandemic (face-to-face for the pre-COVID-19 course, online for the COVID-19 course and face-to-face during the post-COVID-19 course). The shared leadership tasks and responsibilities, defined by students, were categorized in the same way independently of the training modality, which validates the proposed ontology. Also, the three academic courses studied the evolution of the primary shared leadership responsibilities by category. Besides, it is concluded that the primary responsibilities for each category remained unchanged during the three academic years but that some other categories were affected to some extent by the exceptionality caused by COVID-19. The ontology validated here constitutes a recommendation for future teams working with an evidence-based methodology.

1. Introduction

Generic competencies (transversal or soft skills) are widely demanded in the productive fabric of countries and, specifically, higher

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education. These generic skills are common to any degree. They are in great demand in Society and in students' professional development [1,2].

One of the most demanded generic skills by international organizations, in any area of knowledge, in different industrial sectors, and, in general, in Society, is teamwork.

> Within teamwork competence (TC), the skills associated with leadership stand out. Good leadership work is a crucial and fundamental piece for the team to carry out its work effectively and efficiently [3], achieve the work's objectives [4], have a good work environment without conflicts, and promote the individual work of each member. A team made up of highly valued and expert people can only succeed if there is good leadership work.

There are different approaches regarding how leadership is carried out during teamwork. The two classic approaches are based on hierarchical vertical leadership, which is always exercised by a single person [5]. It is exercised through [6]. Within this vertical leadership, there are several organizational approaches, such as transactional leadership, which uses rewards and chooses team members who perform their tasks well [7], and aversive leadership, which uses intimidation and reprimands [8].

Leadership is considered a management process to improve the results of the organization [9] and the results of the work team itself [10]. Thus, training in leadership roles and responsibilities within the TC is critical since it affects leadership behavior in different organizations [11].

One of the problems with leadership training for our students is that the teams could be more significant, short-lived, and framed in an academic context. This means that only one person does the leadership work; therefore, developing this competence is difficult to share with the rest of the team.

In this regard, the distribution of leadership among different members of the organization is crucial [12], where several team members exercise leadership [13].

One of the main objectives of distributing leadership among different members is the informal distribution of responsibilities within the same work team [14]. This distribution of leadership is called Shared Leadership (SL) and is considered a new model in leadership [15] and an emerging characteristic of work teams [16].

The associated SL is dynamic and distributed organizations; in this context, different people can assume a leadership role at any time based on the needs that arise [17]. In addition, it can be applied in situations where tasks and objectives are interdependent within the same team [18]. The SL has demonstrated advantages such as substantial influence between different team members [19] and is positively related to team performance [3] and satisfaction [13].

SL is also related to the cognitive learning process, and if the goal is for the team to acquire competence through shared learning, then all team members must be able to perform leadership tasks [20]. For all these reasons, it is convenient to use the SL in academic teamwork since it responds to a natural and emerging need in organizations and solves the problem that all team members must be trained in leadership tasks within the development of the same work team.

Regarding the functions that can be developed jointly within a team, it has yet to be previously theorized or tested. However, there are studies where teachers define different roles, which are rotated among the people who make up a work team [21].

Thus, there is a separation between the model to be applied to teamwork and the type of leadership. Among the types of leadership, the SL is the most emerging and appropriate to apply in a TC learning process when it is desired that all the members of a team act as leaders sharing responsibilities and functions.

Concerning the teamwork model, one of the most used in academic contexts is Tuckmam's model [22,23] for small work groups. A set of stages or phases defines a team's model. These phases are those used by the International Project Management Association (IPMA) for the accreditation of the TC both in a group [24] and individually [25,26].

This research uses the Tuckman and IPMA models for teamwork development, and SL is applied as a leadership method. Leadership responsibilities and roles are freely defined, assigned, and executed by each team member and apply during all phases of teamwork. This action is valid since it has been shown that there are leadership functions during all phases of teamwork development [10], and the SL method is also suitable since shared leadership allows the expression of a wide variety of behaviors for leadership [19].

In the previous approaches, it has been shown that SL can generate various leadership actions and apply them during all phases of teamwork. With all this, the following research hypothesis is defined here:

Based on the needs that arise for students during the development of teamwork, shared leadership actions derive from the teamwork method applied rather than from the training modality (face-to-face – online).

To demonstrate the research hypothesis, we will consider the university students' teamwork carried out during three consecutive academic years: before, during, and after the pandemic caused by COVID-19 [27,28]. That is the 2019–2020 academic course (called the pre-COVID-19 course), the 2020–2021 academic course (called the COVID-19 course), and the 2021–2022 academic course (called the post-COVID-19 course).

This research study examines shared leadership tasks implemented in short-term teams within the university context, utilizing an evidence-based approach to team development. The objectives of this study are as follows:

- Objective 1: To classify, group, and categorize the different activities and responsibilities of shared leadership based on the real-life experience of each team.
- Objective 2: To identify the most relevant categories and responsibilities that have remained unchanged during the three academic years analyzed across different modes of education: face-to-face, online, and hybrid (pre-COVID, COVID, and post-COVID).
- Objective 3: To analyze the variability of categories and activities/responsibilities over three consecutive academic years, highlighting notable peculiarities.

To achieve these objectives, a TC development method has been applied in the university environment for three consecutive academic years, and a qualitative evaluation tool has been used to obtain the results that allow the objectives to be achieved.

The following sections will present the functional model for the development of Teamwork, the methodology and context of the study, the results obtained, and the conclusions of the work.

2. Functional model

The teamwork method used is called Comprehensive Teamwork Competency Formation Model (CTMTC) [29]. This method is based on dividing the development of teamwork into five states (Forming, Storming, Norming, Performing, Delivery, and Documentation), first defined by Tuckman [23] for small work teams. Subsequently, the "Delivery and Documentation" stage was added both in university contexts [30] and professional contexts [24,26].

The CTMTC method provides, in each of the stages described, the necessary evidence to evaluate the development of the phases cooperatively (group evidence), as well as evidence that allows knowing the degree of involvement of each team member (individual evidence) in the different tasks [31], responsibilities and functions assigned to them.

The work scheme combines the Flipped Classroom method with the development of teamwork. The students work cooperatively (both online and face-to-face), and regular face-to-face sessions are held with the entire teaching group to check the progress of the different teams [32]. The work process is described in Fig. 1 with the following stages:

A. The faculty outlines the objectives for each phase and the corresponding deliverables that must be produced to ensure proper execution. Each phase concludes with a distinct deliverable for evaluating its accuracy, such as the milestones and timeline for completion resulting from the planning phase. Additionally, the teaching staff and previous course participants have created a series of videos demonstrating each phase's objectives, implementation, and outcomes.
B. The work team members collaborate via networking to execute each phase, and their contributions are documented in the online platform utilized for networking. By examining these contributions, it is feasible to assess both the individual competencies acquired and the level of participation of each team member in its progression.
C. The work teams upload the deliverables to an online repository where the output of each team is accessible only to its members and the instructional faculty. This outcome is considered provisional as subsequent sessions involve a cooperative review of the results from all teams. The outcome determines the completion of group competition for a particular phase.
D. During synchronous sessions open to all participating teams, the faculty facilitates a collective review of the results from each phase. Each team can revise its deliverables in real-time or via networking during these sessions.
E. The updated, improved result is considered the final submission and, as noted in Section C of Fig. 1, determines the outcome of the group competition.

During the first synchronous session with all the students, the teachers emphasize the errors the teams have had due to absences in monitoring, coordination, responsibility, and cooperation. Likewise, students are informed of the tasks teachers will carry out continuously to verify that the team acquires group and individual skills. In Fig. 2, the first session is represented by "S1."

In this way, the teaching staff transmits to the team that they must distribute the functions and tasks of leadership. At the same time, tools are provided to assign tasks and functions in a cooperative, transparent, and accessible way online.

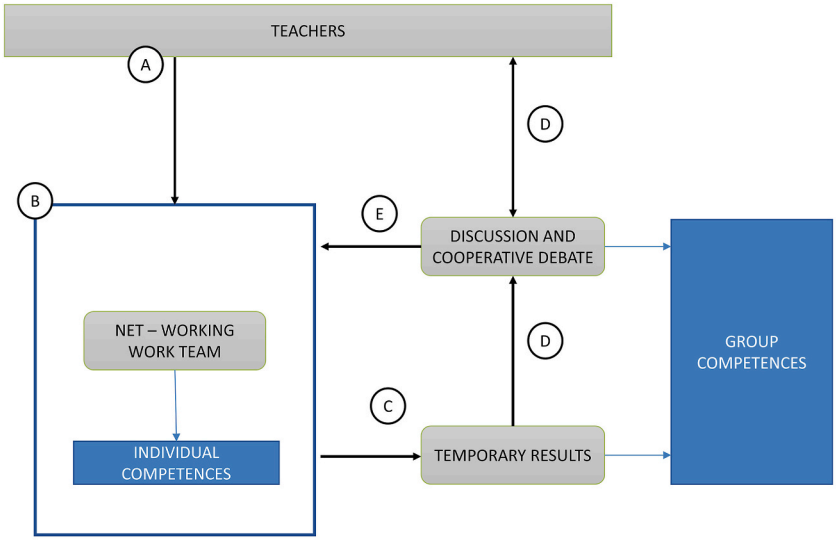

Fig. 1. Work scheme of the teams to obtain results from each phase.

Each team begins to assign itself, firstly, leadership actions to guarantee that the mistakes already committed do not occur again and, later, to coordinate based on the actions the teachers will carry out to continue the teamwork. Thus, as indicated in Fig. 2, leadership actions are performed continuously at each stage of teamwork.

Each team has a set of mechanisms that allow reflection on the different actions and responsibilities of the team. The actions are divided into technological, content development, and shared leadership. This set of actions is reflected in a table called the Responsibilities Map, which is prepared during the "Storming" phase and assigns each team member the leadership actions they will develop, among others.

Likewise, each team prepares regulations, a set of laws that hierarchically have more weight than individual leadership actions. It is similar to a Constitution with mandatory laws for the different team leaders.

In addition, there are mechanisms for each "temporary leader" to verify the actions each team member is carrying out individually and the collective actions that indicate the achievement of the different results expected by the work team.

Next, the context of the application of this model is described, which allowed the analysis of all the responsibilities and functions of the team member who has exercised leadership tasks. They have also been categorized, establishing the different typologies, and their evolution has been studied before the COVID-19 pandemic [33], the course of the pandemic, and the course after it.

3. Methodology

The evidence consists of the activities and responsibilities of shared leadership. The tasks are specified in a table, completed within a few weeks of starting teamwork, and updated as new responsibilities arise. The faculty members compare the evidence from the table each team created with the activities carried out by its members.

The qualitative analysis involves examining these pieces of evidence, first classifying them, and then grouping them into higher-level categories. An ontology is derived from the most frequently used categories and their corresponding responsibilities.

Once classified and categorized, a frequency and percentage analysis is conducted to create and validate the proposed ontology.

A suitable method for giving meaning to information is based on adding metadata describing it [34], thereby enabling its conceptualization [35]. Ontologies facilitate the establishment of relationships between concepts and metadata [36]. In previous studies, this method has been utilized to classify the information provided by students in the same context where the current research has been conducted [32,37–39].

In this study, the proposed ontology is validated through qualitative analysis of the categories and their associated responsibilities over three consecutive academic years, encompassing various modes of education.

Concerning the application context of this methodology, 40 work teams and 237 students participated in this research work. The work teams comprised 6 people, although there could be a team with 5 members. The subject in which the experience was carried out was "Fundamentals of Programming" in the first year and first semester of the Biotechnology degree at the *anonymized*.

The teamwork carried out in the subject mentioned above deals with any topic taught in the subject, such as algorithms or programming, and even the development of teamwork itself. The teams look for organizational and academic deficiencies in the subject (for example, concepts that are difficult to understand, exam questions, proposed exercises, etc.) and develop resources to solve these deficiencies and improve the subject's performance. Therefore, the type of work could apply to any subject.

During the 2019–2020 academic year (pre-Covid-19 Pandemic), 15 teams and 90 students participated face-to-face (37.11% male and 62.89% female). In the 2020–2021 academic year (Covid-19 Pandemic), 12 teams and 70 students participated online (34.78% male and 65.22% female). During the 2021–2022 academic year (post-Covid-19 Pandemic), 13 teams and 77 students participated in person (41.03% male and 58.97% female).

All the research was carried out in compliance with the standards defined by the Ethical Committee of the *anonymized* (where the experience was done) congruently with [40]. The participants were explicitly informed that the data would be used for research, the confidentiality of the data was guaranteed, and their processing was carried out respecting the anonymity of the participants, given the option of not participating if somebody was not according with that use of their data.

4. Results

During the development of the CTMTC mentioned above method, each work team carries out a Table of Responsibilities (TR) where

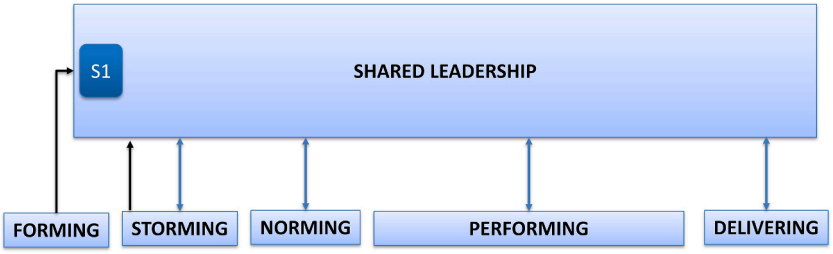

Fig. 2. Application of Shared Leadership during the development of teamwork.

the team collaboratively decides the tasks and responsibilities of each team member. The TR is made up of three columns. The first column defines the tasks related to the final academic work. The second column includes the tasks/responsibilities of shared leadership, and the third column contains those related to the technology used.

Each team defines its own TR under a set of general rules included in the Regulations (for example, regarding the temporary operation, role assignment, decision-making, conflict resolution, non-compliance with regulations, etc.) [41].

A total of 40 TRs have been analyzed: 15 in the 2019–2020 academic year, 12 in the 2020–2021 academic year, and 13 in the 2021–2022 academic year.

The systematization work was carried out by analyzing each entry in the TR and grouping it into a set of categories (grouping responsibilities with common characteristics). Grouping the different activities by categories, the nine categories shown in Ref. [42] were also obtained, and the meaning of each category is briefly described below and constitutes the proposed ontology:

1. Support for team members: Help the rest of the team members with their tasks in each phase.
2. External communication to the team: Communication with the teaching staff of the subject, with other work teams, and with entities/persons external to the subject, as well as the external diffusion of the team's work.
3. Internal communication in the team: Communication with the other work team members through the established rules for reminders of tasks.
4. Quality assurance: Actions to ensure the quality of the work to be developed both in the intermediate phases and the final result.
5. Conflict management: Actions aimed at preventing and resolving conflicts between members and with the development of work.
6. Meeting management: Actions to organize meetings within the team and generate evidence, both in conducting the meeting and its results.
7. Micro-planning: Temporary and progressive planning such as, for example, the tasks to be carried out the following week.
8. Content organization: The generated intermediate contents and the final results.
9. Follow-up: Supervisory actions, follow-up of team planning, and individual responsibilities (tasks).

The same analysis system has been applied in this work, including evaluating the remaining academic years. No new category was obtained from analyzing all the added TRs, so the proposed ontology has been valid for the rest of the academic years. The dataset of this study has been included in Ref. [43].

Based on this system of categories, the number of different responsibilities per category and year, the number of teams that present the same categories, and the number of students involved have been analyzed.

Likewise, the three responsibilities associated with Categories and academic year are analyzed:

- *4.1* Analysis of results Categories/Volume of responsibilities/Academic year.
- *4.2* Analysis of results Categories/Number of teams involved/Academic year.
- *4.3* Analysis of results Categories/People Involved/Academic year.
- *4.4* Most used responsibilities for the most used categories.

The first three points will be analyzed from the first three categories of each academic year. From them, two types of analysis will be carried out: the first will be carried out by grouping the categories that have remained in the first three positions with their possible variation. This analysis corresponds to the rows with three columns corresponding to the academic year in bold font. The second analysis will contrast the categories that have not been maintained consistently in the three academic years, analyzing their singularities. This analysis corresponds to the tables' rows with one or two bold columns.

4.1. Analysis of category results/volume of responsibilities/academic year

Table 1 shows the number of total responsibilities associated with each category. The responsibilities are the total considering all the teams; For example, if 7 teams have assumed the same responsibility, the volume would be 7 responsibilities.

The volume of responsibilities in the courses is as follows:

Table 1
Volume of responsibilities.

Category/percentage of categories volume	2019–2020	2020–2021	2021–2022
Support for team members	5.7	2.4	2.1
Conflict management	2.6	1.9	2.6
Quality assurance	**21.7**	5.3	**14.7**
Internal communication	5.7	9.6	14.7
External communication	**16.1**	**15.4**	**17.7**
Micro-planning	13.0	9.6	13.4
Content organization	9.6	**16.3**	9.0
Meeting management	3.9	8.2	6.0
Follow-up	**21.7**	**31.3**	**19.8**

- 230 responsibilities during 2019–2020
- 208 responsibilities during 2020–2021
- 232 responsibilities during 2021–2022

Note: in each course, there are different numbers of teams and students.

The first column shows the nine categories, the second column includes the percentage of each category in the total of responsibilities for the 2019–2020 academic year, the third column for the 2020–2021 academic year, and the fourth column for the 2021–2022 academic year.

The percentage has been calculated based on the number of responsibilities within each category compared to the total responsibilities in each academic year. For example, the category "Support for team members" represents 5.7% out of 230 responsibilities in the 2019–2020 academic year, 2.4% out of 208 responsibilities in the 2020–2021 academic year, and 2.1% out of 232 responsibilities in the 2021–2022 academic year.

Furthermore, in Table 1, the three most frequently used categories in each academic year are highlighted with colors (green for the first, orange for the second, and yellow for the third). In the 2019–2020 academic year, two categories are highlighted in green as the first place is shared.

It can be seen that the "Follow-up" category is the one that has accumulated the most responsibilities in the three courses, with a higher percentage in the 2020–2021 academic year, and the percentage is more similar in the pre-and post-COVID-19 courses.

The "External communication" category is one of the three most used in the three academic years with a similar percentage.

From the point of view of the analysis of the Pandemic, two unusual cases can be observed: one case is that of the "Content organization," which has a high increase in the 2020–2021 academic year (second place) while remaining stable compared to the pre, and post-COVID-19 courses (outside the three most used categories).

The second singular case is the category referring to "Quality assurance" since in the pre, and post-COVID-19 years it is among the three categories with the most responsibilities. At the same time, it has been significantly lower in the COVID-19 course (2020–2021).

4.2. Analysis of category results/number of teams involved/academic year

In this analysis of categories by the number of teams, the first column of Table 2 includes the categories, the second includes the percentage of teams that are engaging with each one of the categories in the 2019–2020 academic year, the third column for the 2020–2021 academic year and the third for the 2021–2022 academic year.

Table 2 displays the percentage of teams with at least one responsibility in the corresponding category. For example, in the "External Communication" category, in the 2019–2020 academic year, 93.3% of the teams had responsibilities in that category, and in the 2020–2021 and 2021–2022 academic years, 100% of the teams had responsibilities in that category.

Two of the most used categories remain, the first and the second, in the same positions during all the academic years "External communication" and "Follow-up." In both cases, during the COVID-19 academic year (2020–2021), the percentage increased to 100%, maintained in the post-COVID academic year. In this analysis, singularities affect four categories. "Quality assurance" follows a trend like the analysis in Table 1 since it suffered a sharp decrease in the COVID-19 course (2020–2021), while it remains in the top three in the pre-and post-COVID-19 courses. The "Content organization," as in the previous analysis (Table 1), moves up in the 2020–2021 academic year and remains in the 2021–2022 academic year. Similarly, the inclusion of "Internal communication" increases in the 2020–2021 academic year and is maintained in the 2021–2022 academic year. Regarding the "Micro-planning" category, it is among the first three categories during the 2019–2020 academic year, but in the COVID-19 course, it falls from the top three positions and remains stable in the post-COVID-19 course (2021–2022).

Table 2 analyzes the categories based on the number of teams included in their teamwork. The rows, columns, and color codes are used with the same meaning as in Table 1. In this analysis, it can be observed, for example, that the first place is shared by two categories that are the most included by teams throughout the three academic years: "Monitoring" and "External Communication."

4.3. Analysis of results categories/people involved/academic year

In the following case, the categories are analyzed by the number of people who worked in responsibilities associated with each

Table 2
Volume of team involvement.

Category/percentage of teams	2019–2020	2020–2021	2021–2022
Support for team members	66.7	41.7	38.5
Conflict management	40.0	33.3	46.2
Quality assurance	93.3	50.0	92.3
Internal communication	53.3	91.7	92.3
External communication	93.3	100.0	100.0
Micro-planning	93.3	75.0	76.9
Content organization	80.0	91.7	92.3
Meeting management	46.7	83.3	69.2
Follow-up	93.3	100.0	100.0

category, concerning the total number of students in the course who participated in the research. The first column of Table 3 includes the categories. The second includes the percentage of people involved in each category in the 2019–2020 academic year, the third column for the 2020–2021 academic year, and the third for the 2021–2022 academic year. Compared to the previous one, this analysis is carried out with the number of teams since several people can share the same responsibility within the same team.

Therefore, in the "External Communication" category, 76% of students in the 2019–2020 academic year had at least one responsibility, 100% in the 2020–2021 academic year, and 87% in the 2021–2022 academic year. The rows, columns, and color code have the same meaning as in the previous tables.

There is a high coincidence between the first two most used categories in all academic courses, "External communication" and "Content organization." However, the student involvement percentage has increased during the 2020–2021 academic year (COVID-19 academic year). It is observed that 100% of the students participate in the "External communication." In the 2020–2021 academic year, "Follow-up" increases significantly, and this growth is maintained for the 2021–2022 academic year (Post-COVID-19) compared to 2019–2020 (Pre-COVID-19). Participation in "Internal communication" activities has increased, ranking third in the 2021–2022 academic year (Post-COVID-19). The low percentage of participation in the "Quality assurance" category during the 2020–2021 academic year (COVID-19 course) is also observed.

4.4. Most used responsibilities for the most used categories

Lastly, Table 4 shows the first three responsibilities plus each category and for each academic year. The selection has been made based on the number of times the same responsibility is repeated during an academic year. In other words, it means the times that the responsibility has been assumed by one person belonging to any team.

Through this overall analysis, it can be observed that the two most frequently used categories by teams (Table 2): "Monitoring" and "External Communication," share the same top responsibility across the three academic years.

5. Discussion

In the traditional professional context of work teams, the leader is typically expected to be an expert in teamwork processes and the tasks, tools, and resources necessary to achieve project goals. In contrast, the rest of the team can be experts in specific tasks [3,4]. However, even in this context, the benefits of sharing leadership tasks among members of the same team have been demonstrated, and studies have been conducted on the effects on team performance and team satisfaction [13]. Only recently have the specific leadership actions carried out within this shared leadership framework been studied, as in corporate teams [19].

This work addresses the study of the concrete leadership tasks and responsibilities of shared leadership in short-term work teams in the academic context, where team competence is formed and assessed [44,45]. The shared leadership approach is more appropriate than the traditional concept of a formal leader [46] for academic teamwork, as all work team members are equal in exercising leadership and can participate in the process and receive training through their own experience.

Shared leadership enables interaction among team members and facilitates mutual guidance toward accomplishing the team's objective [47]. The findings align with this concept, as individuals lead and support each other in reaching common targets through teamwork processes or outcomes.

The nine confirmed categories of shared leadership responsibilities presented in this work have been derived from actual experiences in applying a teamwork method that favors the creation of individual and group evidence of its development [29]. These categories are essentially consistent with the ten established by Ref. [19] in organizational teams (the tenth category is team formation, which has been omitted in this work as the students formed the teams voluntarily and most of them did not know each other as it was the first semester at the university). However, as will be seen later, differences in the number of responsibilities shared in specific categories due to the different contexts of application, where the teams are long-term, and hierarchies may exist.

On the other hand, Sweeney [19] proposes a higher-level categorization that groups these ten categories into three called "Task-oriented: behaviors as those which are used primarily to improve efficiency and process reliability" (seven categories), "Relation-oriented: behaviors are primarily used to improve human relations" (two categories), and "Change-oriented; behaviors are primarily used to improve adaptation to external environments" (one category).

Moreover, the nine categories formed by a wide range of leadership responsibilities and shared by several team members in an

Table 3
Volume of people involvement.

Category/percentage of students	2019–2020	2020–2021	2021–2022
Support for team members	42	22.9	9.1
Conflict management	10	5.7	9.1
Quality assurance	**58.9**	20.0	57.1
Internal communication	20	34.3	**66.2**
External communication	**75.6**	**100.0**	**87.0**
Micro-planning	34.4	31.4	42.9
Content organization	**61.1**	**87.1**	**75.3**
Meeting management	11.1	50.0	24.7
Follow-up	56.7	**85.7**	61.0

Table 4
List of most used responsibilities by category and academic year.

Support for team members	2019–2020	2020–2021	2021–2022
First	Willingness to support	Identifying doubts	Support for problems
Second	Help with the tasks	Resolving doubts	
Third	Help with setbacks		
Conflict management	**2019–2020**	**2020–2021**	**2021–2022**
First	Mediation	Mediation	Mediation
Second			Judging
Quality assurance	**2019–2020**	**2020–2021**	**2021–2022**
First	Review for errors	Review for errors	Review for errors
Second	Comply Intellectual property	Homogenize deliverables	Homogenize deliverables
Third	Fix errors detected in synchronous sessions	Fix errors identified in synchronous sessions	Review progress document
External communication	**2019–2020**	**2020–2021**	**2021–2022**
First	Communication with teachers	Communication with teachers	Communication with teachers
Second	Analyze external resources	Multimedia communication in class (spokesperson support)	Analyze external resources
Third	Spokesperson in front of the students	Spokesperson in front of the students	Spokesperson in front of the students
Internal communication	**2019–2020**	**2020–2021**	**2021–2022**
First	Manage online communications	Manage online communications	Manage online communications
Second	Make summary and conclusions of communications	Participation in channels for internal communications	Leave online evidence of personal work
Third	Participation in channels for internal communications	Leave online evidence of personal work	Participation in channels for internal communications
Micro-planning	**2019–2020**	**2020–2021**	**2021–2022**
First	Coordination	Coordination	Coordination
Second	Planning	Review responsibilities	Planning
Third	Coordination support	Management of the modification of the regulations	Review responsibilities
Content organization	**2019–2020**	**2020–2021**	**2021–2022**
First	Upload content to the team space	Upload content to Moodle	Upload content to all spaces
Second	Pdf file management	Upload content to the team space	Team Space Management
Third	Upload content to Moodle	Team Space Management	Link resources
Meeting management	**2019–2020**	**2020–2021**	**2021–2022**
First	Drafting minutes	Drafting minutes	Drafting minutes
Second		Participate in meetings	Scheduling meetings
Third		Screen recording	Reading minutes
Follow-up	**2019–2020**	**2020–2021**	**2021–2022**
First	Verify compliance with the Regulations	Verify compliance with the Regulations	Verify compliance with the Regulations
Second	Know the tasks of the whole team	Check the work done before sharing the class	Verify homogeneous participation in communication spaces
Third	Check the work done before sharing the class	Verify homogeneous participation in communication spaces	Manage the evidence of individuals and put them together to see the progress of the team

academic context contradict [48] claim that each member can only perform one leadership task in short-term academic teams. This difference is likely due to the nascent application of shared leadership in these ten years and especially to the applied teamwork method, as traditionally, in the academic context, teamwork models with responsibilities more focused on work elaboration and less on the generation of individual evidence regarding its development have been applied.

The categories in which the various shared leadership responsibilities analyzed in this paper are grouped remained the same during the three academic years: pre-COVID-19 (2019–2020), COVID-19 (2020–2021), and post-COVID-19 (2021–2022). Thus, the article's research demonstrates that students can identify, assign, and execute shared leadership responsibilities, carrying out these actions themselves while developing the applied teamwork method (CTMTC) regardless of the teaching mode.

The teams most frequently used shared leadership categories in this work are also invariable during the three academic years. Therefore, it is demonstrated by the research hypothesis that these are derived solely from the applied teamwork method (CTMTC) and are independent of the academic year. In other words, they do not depend on the academic changes in the formative modalities (face-to-face, hybrid, online) [49], which were derived from the pandemic suffered by COVID-19.

Besides, the validation of the proposed ontology with the evidence confirms Objective-1 associated with the research hypothesis "To classify, group, and categorize the different activities and responsibilities of shared leadership based on the real-life experience of each team.".

Moreover, the analysis of the most used responsibilities in each category during the three academic courses shows two categories as the most used in all academic courses and all analyses performed. "External communication" and "Follow-Up" contain the most significant responsibilities. "External communication" is first in analyses 4.2 and 4.3 (Tables 2 and 3), followed by "Follow-Up" in 4.2 and "Content organization" in 4.3 (where "Follow-Up" occupies third place). Similarly, "External communication" interchanges the first and second positions with "Follow-Up" in analysis 4.1 (Table 1). Therefore, the two most used categories have been maintained in all analyses. That the category "External Communication" is one of the most considered by academic teams coincides with the results of [19] for organizational teams. However, the fact that "Follow-Up" is the second most considered in this work contrasts with the results of [19], where "Performance feedback" is one of the categories of responsibilities that members of organizational teams like and apply the least. This may be because a hierarchy may already exist within those teams, and most members consider that these actions correspond to certain types of positions. In contrast, in academic teams, they are all equal and only differ in their personal characteristics.

The specific responsibilities associated with each category were analyzed in the last study, the most used and those with some uniqueness. It can be observed in Table 4 of analysis 4.4 that the most used responsibility is the same in all categories, regardless of the academic course analyzed. Additionally, in the categories most used in the three academic courses, two responsibilities coincide with 100% of occurrences in all tables. This confirms Objective 2, "To identify the most relevant categories and responsibilities that have remained unchanged during the three academic years analyzed across different modes," and supports the research hypothesis.

Regarding the evolution of the responsibilities volume, Objective 3, singularities of each academic course, can be observed while changes occur due to the COVID-19 pandemic. These singularities follow three trends:

- S1. Increased responsibilities associated with specific categories during the COVID-19 period, returning to normal levels in the post-COVID-19 period.
- S2. A decrease in responsibilities associated with specific categories during the COVID-19 period, returning to normal levels in the post-COVID-19 period.
- S3. Change in responsibilities during the COVID-19 period and their persistence post-COVID-19 period.

In group S1, the categories of "Follow-up" and "Content organization" (Table 1) stand out, as well as "External communication" and "Follow-up" in Table 3. This may be because during the shift to online mode due to COVID-19, academic and social restrictions affected both the need for external communication (changing the means, increasing the scope of action to other teams, etc.) and organizing the content created by the team in a more precise and more detailed way.

In group S2, "Quality assurance" stands out in all the analyses conducted (Table 1, Table 2, and Table 3) as the category whose number of responsibilities has decreased during the COVID-19 course, which may be due to the difficulties produced by the abrupt shift from in-person to online mode.

In group S3, the categories of "Follow-up," "External communication," "Content organization," "Micro-planning," and "Internal communication" from Table 2 stand out. Furthermore, "Internal communication" in Table 3 follows an ascending order.

Likewise, in Tables 2 and it can be observed that the responsibilities within the "Internal Communication" category are used in a higher proportion (almost double) by teams during the COVID-19 period (2020–2021), and this trend continues in the subsequent academic year. The confinement situation caused by COVID-19 increased internal communication within teams, which has persisted even after the end of isolation measures.

Finally, concerning the categories where three responsibilities have not been obtained in all academic courses, there is unanimity in including mediation tasks to resolve conflicts as the most crucial task in the "Conflict management" category. However, in the "Support for team members" category, there are differences in the denominations of the tasks that, on occasion, do not allow us to know whether they refer to academic support or also to personal relationships, indicating a need to clarify for students whether they are "Task-oriented" or "Relation-oriented" responsibilities [19]. Regarding the "Meeting management" category, the first responsibility is, unanimously, the creation of meeting minutes (included in the team working method). However, in the COVID-19 course, the minute-taking responsibility is replaced by the meeting recording.

6. Limitations and threats to validity

Regarding the study's limitations, the entire process described is based on qualitative analysis, and as a result, the only numerical data available are the mentioned frequencies and percentages. The longitudinal study takes advantage of the opportunity to consider the same context, resulting in a small sample size equal to the population that participated in the course over three years. Therefore, using quantitative methods to triangulate the data was not feasible.

Furthermore, decision-making while implementing a qualitative method can lead to non-unique solutions.

7. Conclusions

Based on experience, this study shows that students can identify, assign, and execute shared leadership responsibilities during the development of teamwork in three consecutive academic courses, considering the influence of the COVID-19 pandemic (before, during, and post).

It is observed that the number of different leadership responsibilities assigned to members of the same team depends on the teamwork model applied and is independent of the instructional modality (face-to-face or online).

This suggests that any teamwork model that promotes shared leadership can be effectively applied, even if external circumstances impose certain academic restrictions, as happened with the COVID-19 pandemic, which converted face-to-face teaching to online instruction [50–52].

Categories of shared leadership responsibilities have been identified that remain unchanged over time, among which are those that include the most responsibilities ("External communication," "Follow-up"), while others have been modified during the COVID-19 pandemic, decreasing their application ("Quality assurance"), changing the type of responsibilities ("Meeting management"), returning to the normality of the pre-COVID-19 when the teaching returns to face-to-face ("Micro-planning"), and even improving in their consideration by students ("Internal communication").

On the other hand, the proposed and validated ontology of responsibilities regarding shared leadership includes various categories and responsibilities, as it is based on a functional model of teamwork that emphasizes the continuous and progressive creation of individual and group evidence (rather than solely relying on the evaluation of the final work). Monitoring this evidence fosters a high degree of interaction between the team, the faculty, and the team members, facilitating the development of specific responsibilities. Additionally, the composition of team can influence the performance of specific shared responsibilities, such as those related to communication, among other categories, as the team members may know already each other and have a pre-existing relationship.

In this study, an ontology based on categories of shared leadership responsibilities, including developing teamwork over three consecutive academic years, has been validated, and the primary responsibilities for each category have been identified. It is proposed to use these categories and responsibilities to train teams in the competence of shared leadership, even if teamwork is based on other functional models and training strategies (if continuous evidence exists). The proposed ontology of categories and the primary responsibilities (included in Table 4) already serve as a recommendation for future teams.

However, while it may be oversimplifying, based on Table 4 and the authors' own experience, the following list is proposed with the primary responsibility for each category that should be included in any shared leadership responsibility table. Each category and its corresponding responsibility are indicated below:

- Support: Support for problems.
- Conflicts: Mediation.
- Quality Assurance: Review for errors.
- External Communication: Communication with teachers.
- Internal Communication: Manage online communications.
- Micro planning: Coordination.
- Content organizations: Upload content to the team space.
- Meetings: Drafting minutes.
- Follow-up: Verify compliance with the Regulations.

Therefore, there has been no variation regarding the most frequently used categories and responsibilities due to the COVID-19 pandemic. Still, some responsibilities have been strengthened or present some singularity during COVID-19. This result may be the subject of further studies to observe whether trends are consolidating and how they can affect changes in the perception of teamwork produced by the pandemic. Another research area is the study of analogies between the shared leadership categories detected from these experiences and the categories defined by Ref. [53] regarding the characteristics of Agile Leadership in work teams [54,55].

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Ethics statement

This study has been done under the standards defined by the Ethics Committee of the Polytechnic University of Madrid (UPM, https://bit.ly/3DyBork) and the Ethical Guidelines for Educational Research guidelines of the British Educational Research Association (BERA, https://bit.ly/35ZT8v1). The data for the research work allow for analyzing evidence obtained from teamwork results. All information related to student data has been obtained from this evidence without affecting any fundamental rights. This scenario is not contemplated by the Ethics Committee of the Polytechnic University of Madrid as a case requiring approval by the Ethics Committee itself, as it is detailed in the Article One of the Regulation of the UPM Ethics Committee.

Author contribution statement

Ángel Fidalgo-Blanco: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

María Luisa Sein-Echaluce: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Francisco José García-Peñalvo: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Ana María Balbín: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data accessible in the open repository https://zenodo.org/record/7978693.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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