Teamwork and leadership: a functional proposal for the evaluation of internal group dynamics*

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Resumen

Among the transversal competencies of the EHEA are those of teamwork and leadership. Two subjective competencies, difficult to measure but extremely important for professional practice. This work proposes to use the activity log of the laboratory practices, in which the SCRUM methodology is followed, to define a numerical model, very simple and functional, that assesses the type of leadership exercised and the type of collaboration followed by a development team. This numerical model can be a great contribution to assess these competencies in an objective, non-intrusive way, and even for a more effective evaluation of the practices of a subject, making visible variables that would otherwise remain invisible to the eye of the teacher.

Keywords

Leadership, Teamwork, transversal competences

1. Introduction

Teamwork and leadership competencies are two of the transversal competencies of the EHEA that are most valued in the professional practice of Computer Science [6] and that receive considerable attention at the academic level [1, 6, 7, 10, 11, 12]. Despite their importance, they are two very elusive competencies when it comes to detecting them and to measure them. Although a very complete definition of leadership is given in [4] as "the establishment of a direction and strategy to get a work team to accomplish its goals, if possible, efficiently and, additionally, to get the team to be satisfied", in the literature on types of leadership there is no clear consensus on how to measure leadership capacity and the types of leaders that exist and their influence on the style of teamwork. The theories developed range from the analysis of the leader in the context of the team, the relationships between members and the tasks to be developed to the analysis of the leader's behavior [9], the latter being one of the most widely accepted models, which posits the following three types of leaders [4]. Authoritarian leader: the team leader makes the decisions and the team executes them. Democratic leader: any work plan is discussed within the team, something that the leader encourages. Laissez-faire leader: the leader does not exercise any authority and gives total freedom of action to the team members, with little or no intervention.

If we focus more specifically on the analysis of leadership and teamwork in the university teaching environment, there is also an extensive bibliography on the importance of these competencies, with proposals for educating students in them, their main values [6, 7], warning them of the limiting factors they may encounter [1], and defining an appropriate environment for their development [10]. But for now, the only feedback for the monitoring of their correct evolution and evaluation, in all of them, are the instruments such as the surveys [5, 6, 10], the follow-up reports [1, 12], the project's own evaluation through specific rubrics of the teacher [5, 11], peer evaluation [5] and generic surveys such as the "Leadership Test", which is passed to the team leader, and the "Blake and Mouton Leadership Questionnaire" which is passed to the rest of the team members [4]. All these instruments are qualitative models, difficult to put into practice because they require answering many questions, many of which are very subjective, so their execution is very intrusive, produces low motivation in the respondents and, consequently, the results can be questionable, without taking into account that they do not evaluate internal dynamics of collaboration in the team.

This article presents an alternative proposal, very objective and not very intrusive, to try to measure the type of leadership and internal group dynamics that have been followed in the practices of a subject. With the aim of promoting self-organized group work, the

*This is an English version onf the paper [3]

SCRUM methodology is followed in this course, in which the groups are led by one of the members, who, among other functions, keeps a detailed record of the time spent by each member of the team on each task of a project [2]. This proposal is based on the hypothesis that the leader of each team should be distinguished, in some way, in the time dedicated to the project and that both the type of leadership exercised and the internal dynamics of the group leave an imprint on this record of activity. It is clear that the exercise of leadership in a team cannot be measured only on the basis of time spent, but detecting and measuring all the areas of influence of a leader requires instruments and surveys whose complexity and implementation are beyond the scope of this paper.

In any case, it is important to note that these project tasks recorded in SCRUM do not collect only software development activities, but can also collect software design issues, documentation and team discussion meetings, so that the recording of time spent in all these tasks acquires very interesting nuances and gives greater relevance to this record. Therefore, through a detailed analysis of the activity log, these dynamics detected in the time spent on the project can be revealed to the teacher, both to identify dysfunctional leadership dynamics, and to identify hidden collaboration dynamics, which could affect the evaluation of the group. The results of this proposal are cross-analyzed with the aforementioned surveys to check their degree of agreement.

In Section **??**, the numerical model for analyzing the SCRUM activity log is proposed to extract the most basic functions. Next, Section **??** presents the more complex functions, based on the previous ones, for the extraction of information related to leadership and intragroup dynamics. Section "data"describes the data collection and data analysis and, finally, the last section presents the main conclusions.

2. Basic Model

In the SCRUM methodology [8] a set of people P develops a software product in a set of days D which is called a sprint. $P = \{p_1, p_2, p_l dots, p_k\}$,$D = \{d_1, d_2, \ldots, d_n\}$.

The set of people is led by one of them, who leads the work of the team $Lead(P) = p_i \in P$. To carry out this development, in a product development planning session, they decompose the project into a set of stories S, named backlog, each of which represents a functional unit of the project. $S = \{s_1, s_2, ldots, s_m\}$ which is assigned an estimated development time $t(s_i)$. Thus, the team P commits to develop all the stories S in a total estimated time T that fits into the time available in the sprint D.

$$T = \sum_{s_i \in S} t(s_i)$$

Throughout the sprint D, on a daily basis, a record R is kept on how much time has been spent on each story by each team member P [1]. Generally speaking, a "day" is usually used as the time unit, but an "hour" can also be used as the base time unit [**?**, **?**].

$$\forall r, r =< p_r, d_r, s_r, t_r >$$

$$p_r \in P, d_r \in D, s_r \in S, t_r > 0$$

By analyzing the log R we can find the daily effort DE of each team member, understood as the number of hours each person $p_i \in P$ spends on any story of S on any given day of $d_j \; inD$.

$$DE(p_i, d_j) = \sum_{s_k \in H} \sum_{<p_i, d_j, s_k, t_r> \in R} t_r$$

And henceforth, the total effort E devoted to the sprint D by team P.

$$E = \sum_{p_i \in P} \sum_{d_j \in D} DE(p_i, d_j)$$

The value E is the actual time spent on the project, which could vary with respect to the estimated time T and it is normal, especially in the first sprints in which students come into contact with the SCRUM methodology, or in general, with a development time planning, that $E > T$. For this reason, the time measurements related to the sprint will be referenced to E, the actual time spent, instead of T, the initial planned time.

It is necessary to emphasize the cumulative daily effort DE^a by a team member as the total time spent on the project during a given sprint period measured from the start to any day of the sprint.

$$DE^a(p_i, d_j) = \sum_{d_k \in D, d_k \leq d_j} DE(p_i, d_k)$$

This function gives us dynamic information, along the sprint D about the workload of a team along the sprint. Figure **??** graphically illustrates this function and shows how, as the project progresses, the total cumulative time for each person grows and can be different among team members. It also shows that from day 1 to 23 it is $p1$, the leader, who has put in the highest effort, although he is overtaken by $p3$ in the last days of the sprint.

[1] All the data for this activity log and the Java code to load and process it can be found at http://bit.ly/2VqmpLF

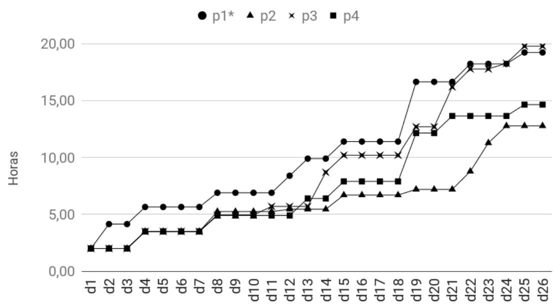

Figura 1: Graphical representation of the cumulative daily effort $DE^a(p_i, d_j)$, in hours, of a four-member team in a 26-day sprint, The group leader is marked with (*).

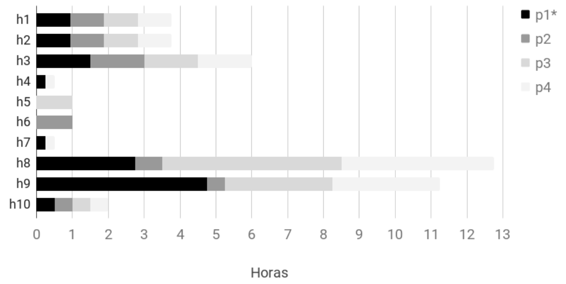

Figura 2: Graphical representation of the effort that any team member p_i has devoted to the story s_j, $SE(p_i, s_j)$. The leader is marked with (*)

We can also segment the effort by story, SE, as the time each team member has spent on a given story over the entire sprint.

$$SE(p_i, s_j) = \sum_{d_k \in D} \sum_{<p_i, d_k, s_j, tr> \in R} t_r$$

The graphical representation of this function can be seen in Figure 2 and provides very useful aggregate information. And, from here, the total cumulative time spent on each story by any team member $SE^a(s_j)$:

$$SE^a(s_j) = \sum_{p_i \in P} SE(p_i, s_j)$$

Note here that the same consideration above between E and T applies to $SE^a(s_j)$ (the actual time spent in developing the story s_j) and $t(s_j)$ (the time that had been planned for it).

3. Analysis of inner dynamics

So far, the analysis of inner collaborative dynamics explicitly requires surveying the team carefully, however, it is likely that these dynamics had left a detectable trace in the record R. This section is devoted to extracting those traces, by using the functions above, to reveal the type of leadership and other inner group dynamics. Thus, we can detect whether there has been a dominant member of the team, understood as the member who has devoted more time to the project cumulatively, throughout the sprint, or in each story, and whether this dominant member has been the leader or not.

3.1. Heading the effort of the sprint

The auxiliary function $DH(d_i, p_j)$, daily heading, will let us know if the member p_j has headed the project effort on day d_i, that is, if he/she has accumulated the highest amount of hours from the beginning until that day of the sprint.

$$DH(d_i, p_j) = \begin{cases} 1 & \text{if } DE^a(p_j, d_i) = \\ & = max_{p_k \in P} DE^a(p_k, d_i) \\ 0 & \text{otherwise .} \end{cases}$$

From this, arises one of the first metric of this paper, it is going to be named *Heading*, $\mathcal{H}$, and it refers to the percentage of days a person has headed the effort devoted to the sprint.

$$\mathcal{H}(p_i) = \frac{\sum_{d_j \in D} DA(d_j, p_i)}{|D|}$$

.

Looking at Figure 1, one can see the following:

- Leader p_1 has headed the effort during 23 days of the sprint (from 1 to 23) out of 26, hence $\mathcal{H}(p_1) = 0{,}88$.
- Member p_2 heads 1 day, the first day, which co-leads with the whole team, hence $\mathcal{H}(p_2) = 0{,}04$.
- Although p_3 is not the leader, s/he heads 4 days: the 1st, the 24th (by very little), 25th and 26th. Therefore $\mathcal{H}(p_3) = 0, 15$.
- $\mathcal{H}(p_4) = 0, 04$ same as p_2.

This metric is intended to capture the member or members who had devoted more time to the project and it will end up being a very important information.

3.2. Work Overload

When one person heads the effort of part of the sprint, this implies that this person has devoted more hours than his teammates, but we do not know how strong is this amount of time. Hence, the following measure, named *Overload*, $\mathcal{O}$, defined exclusively for people who had lead the sprint effort, measures the intensity of this extra effort, understood as the difference in time spent between the heading person (or heading persons) with respect to the average dedication of the team, accumulated throughout the sprint. The numerical data in Figure 1 indicate that:

- Leader p_1 has headed the sprint during $\mathcal{H}(p_1)$ fraction of the sprint, and during that period, he devoted an intensity of 2.97 % of the total project time above the average of the team, $\mathcal{O}(p_1) = 0{,}0297$.
- p_2 has never devoted more time that the average while heading the sprint, hence $\mathcal{O}(p_2) = 0$.
- $\mathcal{O}(p_3) = 0{,}005$.
- $\mathcal{O}(p_4) = 0, 0$ same as p_2.

3.3. Team collaboration

Further analysis of the R record data can also find traces of how team members have collaborated. Starting by detecting how many people have collaborated on the same story.

$$PS(s_i) = \{p_j \in P \ / \ SE(p_j, s_i) > 0\} \subseteq P$$

Looking at Figure 2 one can see the following values:
$PS(s_4) = \{p_1, p_4\}$
$PS(s_6) = \{p_2\}$
$PS(s_8) = \{p_1, p_2, p_3, p_4\}$.

And from here another important indicator, named *Collaboration*, $\mathcal{C}$, which measures the average number of collaborators in all stories of S and gives us an idea of how collaborative a development team is within each story.

$$\mathcal{C} = \frac{1}{|S|} \sum_{s_i \in S} |PS(s_i)|$$

Next, the function that is named *Participation*, $\mathcal{P}$, as the percentage of stories in which the same member has collaborated, which gives an idea of the degree of involvement of each member, a high value of $\mathcal{P}(p)$ indicates that the member $p \in P$ which has participated in many different stories.

$$SP(p_i) = \{s_j \in S \ / \ p_i \in PS(s_j)\} \subseteq S$$

$$\mathcal{P}(p_i) = \frac{|SP(p_i)|}{|H|}$$

3.4. Dominated stories

The function $PS(s_i) \subseteq P$ tells us which team members have collaborated on the same story s_i, but does not indicate how they have collaborated. A further step can be taken in the analysis of the record in order to compare how much time each member has devoted to a certain story and to get to know if there is a member who dominates the story, that is, the member who had strictly devoted more time, among all the collaborators of the story s_i. In this case, if the dominant member exists, it would be unique.

$$DS(s_i, p_j) = \begin{cases} 1 & \text{if } SE(p_j, s_i) > SE(p_k, s_i) \\ & \forall p_k \in PS(s_i) \wedge p_k \neq p_j \\ & = max_{p' \in \mathcal{C}(s_i)} SE(p', s_i) \\ 0 & \text{otherwise} \end{cases}$$

For example, the data $PS(p_i)$ shown in previous sections would produce the dominance matrix shown in Table 1.a). As seen above, story s_4 is participated by the whole team, all of them with an equal dedication, so it is not dominated. The story s_6 has been done exclusively by p_2 so he is the one who dominates it. Finally, the story s_8 is participated by the whole team but it is p_3 who has strictly the highest dedication, so he dominates the story.

This leads us to know a further metric, named *Dominance*, $\mathcal{D}$, defined as the percentage of stories dominated by the same member. A high value of $DOM(p_i)$ would indicate not only that p_i has participated in many stories, but also that he/she has spent the most time on each of those stories out of the whole team.

	p_1	p_2	p_3	p_4
h_4	0	0	0	0
h_6	0	1	0	0
h_8	0	0	1	0

(a)

	p_1	p_2	p_3	p_4
h_4	0	0	0	0
h_6	0	1	0	0
h_8	0	0	0	0

(b)

Cuadro 1: (a) Dominance matrix based on the function $DS(s_i, p_j)$ for the 4-people team and some of the storie from Figure 2. (b) Individualism matrix, based on the funcion $IN(s_i, p_j)$

3.5. Individualism

The above dominance value is very relevant in order to know what kind of collaboration is established within the team, but it might happen, that an extreme individualism per story would be reached, i.e., the team does not collaborate on stories at all, but develops them individually. This leads to a more extreme indicator that measures the *Individualism*, $\mathcal{I}$, defined as the percentage of stories carried out exclusively by a single member.

$$IN(s_i, p_j) = \begin{cases} 1 & \text{if } SE(p_j, s_i) = SE^a(h_i) \\ 0 & \text{otherwise} \end{cases}$$

$$\mathcal{I}(p_i) = \frac{\sum_{s_j \in H} IN(s_j, p_i)}{|S|}$$

For example, given the PS data shown in previous sections, relative to team collaboration by stories in Figure 2 would show the individualism matrix shown in Table 1.(b). Only story s_6 is developed by a single team member, p_2.

These are the most important metrics that can be extracted from the log and that could allow us to capture part of the leadership and collaboration dynamics within the team. Additionally, for more detailed analysis, these functions will be segmented to highlight certain types of information On the one hand, the indicator $\mathcal{H}_L = \mathcal{H}(Lid(P))$ measures the extent of the sprint that the team's designated leader has been able to head the sprint. Although there might possibly be other co-leaders who, without being the designated leader, have also dominated some part of the sprint, hence the maximum of the heading values of the team would also be an important metric $\mathcal{H}_M = max_{p_i \in P}\mathcal{H}(p_i)$. And last, the median of the values $\mathcal{H}_T = \text{Median}_{p_i \in P}\mathcal{H}(p_i)$

The same would be done for the functions $\mathcal{O}$, $\mathcal{P}$, $\mathcal{D}$ and $\mathcal{I}$, instantiating them for the values of the leader, the median value and the maximum value of the team, except for the function COL, which, being a global measure of the team, is not instantiated in those particular cases.

The following section shows how these indicators behave and a first analysis of these data.

4. Data recollection and analysis

This section shows the data collected in the record R during the first semester of the 2018-2019 academic year in the subject "Agent-Based Development" of the fourth year of the Degree in Computer Science at the University of Granada. During this semester, SCRUM follow-up data have been collected from 11 groups during two consecutive sprints taking into account that, although the groups are the same, the leaders of the second sprint are different from those of the first sprint, precisely, to promote those transversal competences of leadership and teamwork. A total of 22 groups were recorded. From these groups, the values relative to the designated leader, the median values and the maximum values of each of the above variables are extracted. The data collected are shown in Table 2.

In general, it can be observed that the designated leader in the group is the one who heads the sprint the longest ($\mathcal{H}_L = \mathcal{H}_M$), the one who endures the most overload ($\mathcal{O}_L = \mathcal{O}_M$) and the most participative of the whole team ($\mathcal{P}_L = \mathcal{P}_M$), confirming the hypothesis that it is the designated leader who seems to spend more time and be more participative.

Analyzing the average values across the 22 groups studied in the experiment, it can be seen that the average team leader dominates the team development effort in $\mathcal{H}_L = 58\,\%$ of the sprint amplitude, the remainder of which can be co-lead with other team members with a $\mathcal{H}_T = 22\,\%$ co-leadership. Leaders support an overload $SOB_L = 2\,\%$ relative to the team average over the entire sprint and a participatory $PAR_L = 68\,\%$ of stories.

However, the analysis of these data also shows two types of groups which, we might say, are special, whose behavior seems to deviate from this average pattern. First, there are the groups identified as G5, G8, G12, G17, G19 and G21, which we could call category A. In these groups it can be observed, that there is a team member who is not the designated leader, but behaves as a true hidden leader, since he dominates the sprint with a much larger amplitude $\mathcal{H}^A_M >> \mathcal{H}^A_L$ and with a much larger work overload also $\mathcal{O}^A_M >> \mathcal{O}^A_L$. In groups 16 and 18 there is also this non-designated leader, but the difference between them is much less significant, and we can almost speak of co-leadership, so they are not included in this group.

The segmented average of the groups in this category A (see Table 3) shows that the effort of the designated leaders is very marginal with $AMP^A_L = 11\,\%$ of the sprint dominated and with a very low overload $SOB^A_L = 0{,}4\,\%$. Values well below the hidden leaders who dominate the sprint with an amplitude $\mathcal{H}^A_M = 92\,\%$ and with an overhead $\mathcal{O}^A_M = 7{,}4\,\%$, both values, by the way, well above the average values of the experiment.

In second place are the groups identified as G3, G6, G14 and G20 that we could call category B, in which the designated leader absolutely dominates the sprint with $\mathcal{H}^B_L = 100\,\%$ (see Table 3), with zero co-leadership $\mathcal{H}^B_T = 0\,\%$, without letting other teammates get to lead the effort at any time. The leader overload, in this case, is also above the mean of the experiment $\mathcal{O}^B_L = 5{,}2\,\%$, reaching the maximum value of the whole experiment $\mathcal{O}^3_L = 8{,}3\,\%$.

The remaining groups (G1, G2, G4, G7, G9, G10, G11, G13, G15, G16, G18 and G22), which we could call category C, on the contrary, it is the designated leader that dominates the sprint $\mathcal{H}^C_L = \mathcal{H}^C_M$, but it is also, firstly, the one that allows the highest co-leadership ($\mathcal{H}^C_T = 36\,\%$), secondly, the least overloading ($\mathcal{O}^C_L = 1{,}8\,\%$) when compared to true leaders, whether designated or hidden, and, thirdly, they are the most participative ($\mathcal{P}^C_L = 77\,\%$), well above average.

It seems that this partitioning of the groups into these three categories shows relevant relationships with regard to the indicators associated with the footprint left by the leader's behavior. In fact, if one looks at the relationship between the $\mathcal{H}^L ID$ and $\mathcal{O}^L ID$ variables shown in Figure 3, it can be seen that each category is grouped in a region clearly differentiated from the others.

Grupo	$\mathcal{H}_L$	$\mathcal{H}_M$	$\mathcal{H}_T$	$\mathcal{O}_L$	$\mathcal{O}_M$	$\mathcal{O}_T$	$\mathcal{P}_L$	$\mathcal{P}_M$	$\mathcal{P}_T$	$\mathcal{D}_L$	$\mathcal{D}_M$	$\mathcal{D}_T$	$\mathcal{I}_L$	$\mathcal{I}_M$	$\mathcal{I}_T$	$\mathcal{C}$
G1	**0,636**	0,636	0,409	**0,045**	0,045	0,010	**0,813**	0,813	0,438	0,250	**0,313**	0,219	**0,188**	0,188	0,063	2,063
G2	**0,848**	0,848	0,227	**0,020**	0,020	0,002	0,714	**0,762**	0,714	**0,238**	0,238	0,143	**0,095**	0,095	0,071	2,857
G3	**1,000**	1,000	0,000	**0,083**	0,083	0,000	**0,529**	0,529	0,412	**0,353**	0,353	0,235	**0,235**	0,235	0,176	1,647
G4	**0,469**	0,469	0,281	**0,014**	0,014	0,007	**0,722**	0,722	0,667	**0,278**	0,278	0,139	**0,167**	0,167	0,056	2,500
G5	0,154	**0,885**	0,096	0,005	**0,030**	0,003	**0,708**	0,708	0,646	**0,250**	0,250	0,167	**0,208**	0,208	0,063	2,625
G6	**1,000**	1,000	0,000	**0,049**	0,049	0,000	**0,714**	0,714	0,643	**0,571**	0,571	0,214	**0,214**	0,214	0,143	1,929
G7	**0,667**	0,667	0,233	**0,010**	0,010	0,005	0,632	**0,737**	0,684	**0,158**	0,158	0,132	**0,105**	0,105	0,053	2,737
G8	0,292	**1,000**	0,333	0,000	**0,104**	0,000	**0,667**	0,667	0,444	**0,444**	0,444	0,167	**0,333**	0,333	0,167	1,889
G9	**1,000**	1,000	0,167	**0,032**	0,032	0,000	**0,833**	0,833	0,778	**0,167**	0,167	0,111	**0,056**	0,056	0,000	2,944
G10	**0,846**	0,846	0,154	**0,041**	0,041	0,002	**0,938**	0,938	0,656	**0,250**	0,250	0,063	**0,125**	0,125	0,000	2,750
G11	**0,840**	0,840	0,620	**0,002**	0,002	0,001	0,652	**0,739**	0,674	**0,130**	0,130	0,109	0,000	**0,087**	0,022	2,739
G12	0,091	**0,909**	0,045	0,007	**0,054**	0,004	**0,476**	0,476	0,405	**0,286**	0,286	0,238	**0,143**	0,143	0,143	1,571
G13	**0,485**	0,485	0,258	**0,018**	0,018	0,002	**0,700**	0,700	0,625	0,200	**0,300**	0,225	0,100	**0,150**	0,125	2,500
G14	**1,000**	1,000	0,000	**0,045**	0,045	0,000	**0,579**	0,579	0,526	**0,316**	0,316	0,237	0,158	**0,211**	0,158	2,105
G15	**0,500**	0,500	0,234	**0,022**	0,022	0,005	**0,684**	0,684	0,658	**0,211**	0,211	0,105	**0,105**	0,105	0,053	2,526
G16	0,636	**0,909**	0,591	0,004	**0,018**	0,002	0,846	**0,962**	0,808	0,115	**0,346**	0,096	0,038	**0,077**	0,019	3,231
G17	0,000	**1,000**	0,000	0,000	**0,083**	0,000	0,452	**0,484**	0,452	0,387	**0,452**	0,387	0,323	**0,387**	0,323	1,161
G18	0,364	**0,545**	0,227	0,012	**0,015**	0,007	**0,714**	0,714	0,595	0,095	**0,286**	0,167	0,048	**0,143**	0,071	2,429
G19	0,000	**1,000**	0,000	0,000	**0,153**	0,000	0,462	**0,846**	0,615	0,077	**0,462**	0,231	0,000	**0,308**	0,077	1,923
G20	**1,000**	1,000	0,000	**0,031**	0,031	0,000	**0,667**	0,667	0,639	**0,278**	0,278	0,167	0,056	**0,111**	0,083	2,500
G21	0,147	**0,735**	0,162	0,009	**0,023**	0,006	0,529	**0,647**	0,529	**0,294**	0,294	0,206	0,118	**0,176**	0,118	2,176
G22	**0,903**	0,903	0,903	0,000	**0,001**	0,000	0,947	**1,000**	0,947	0,000	**0,053**	0,000	0,000	**0,053**	0,000	3,842
$\overline{x}$	0,585	0,826	0,225	0,020	0,040	0,003	0,681	0,724	0,616	0,243	0,292	0,171	0,128	0,167	0,090	2,393
σ	0,355	0,191	0,236	0,021	0,037	0,003	0,140	0,139	0,136	0,129	0,118	0,080	0,095	0,089	0,076	0,596

Cuadro 2: Data collected during the first semester of the 2018-2019 academic year. The maximum value of each variable is indicated in bold. The last two rows show the mean values and standard deviation.

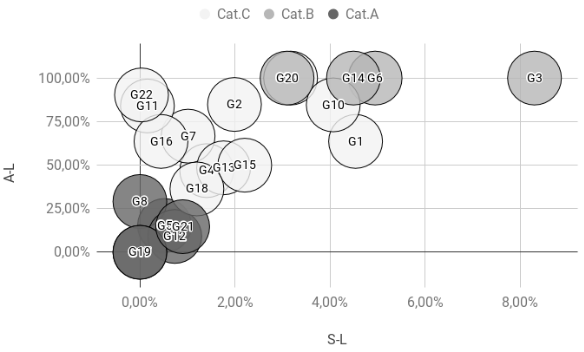

Figura 3: Clusters obtained by comparing metrics $\mathcal{H}_L$ y $\mathcal{O}_L$.

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tencia transversal de trabajo en equipo. In *Actas de las XXII JENUI*, pages 119–126. Universidad de Almería, 2016.

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But let's now see what happens with respect to the other indicators, those referring to collaboration among team members. In general, it can be seen that the average designated leader is the one who masters the most stories $\mathcal{D}_L = \mathcal{D}_M$ and also tends to be the one who does the most stories individually $\mathcal{I}_L = \mathcal{I}_M$. Again it is the leader who stands out in the effort devoted to the project. The teams are generally quite collaborative (COL), with more than half of the team collaborating on each story. Table 2 shows the average values for the experiment with $\mathcal{D}_L = 24{,}3\,\%$, $\mathcal{I}_L = 12{,}8\,\%$, and $\mathcal{C} = 2{,}4$.

Regarding the segmented analysis of the groups in category A (see Table 3), it can be observed that the hidden leader is very dominant with $\mathcal{D}_M^A = 36{,}5\,\%$ (compared to $\mathcal{D}_L^A = 29\,\%$) and is also very individualistic with $\mathcal{I}^M AX = 25{,}9\,\%$ (compared to $\mathcal{I}_L^A = 18{,}7\,\%$) and influences less group collaboration, with $\mathcal{C} = 1{,}9$ people per story. The designated leader again falls below the hidden leader.

The segmented analysis of the groups in category B shows that the dominant leader in the sprint is also very dominant in the stories, dominating many stories ($DOM_L^B = 37{,}9\,\%$) and peaking at $DOM_L^6 = 57{,}1\,\%$ These dominant leaders are also highly individualistic with $\mathcal{I}_L^B = 16{,}6\,\%$ of individual stories, both values well above the experiment average, and describe teams that are not very collaborative, with an average of $\mathcal{C} = 2$ people per story.

Finally, the analysis of the groups in category C allows us, on the contrary, to find the least dominant leaders of all, with $DOM_L^C = 17\,\%$ dominated stories, little individualistic, with $IND_L^C = 8{,}6\,\%$, both below the experiment's average. These leaders also promote the most collaborative teams, with an average of 2,8 people per story, reaching a maximum of collaboration at 3,8. Looking at Figure 4, which compares the variables, $\mathcal{P}_L$ and $\mathcal{C}$, we can see a partition into regions that are well divided, although less clearly than in the previous sections because they are more overlapping. Moreover, Figure 4 also shows a strong correlation between them (Pearson correlation $r = 0{,}784$) where category A is the lowest, B occupies the middle zone, which is the most overlapping zone, and C occupies the top of this correlation.

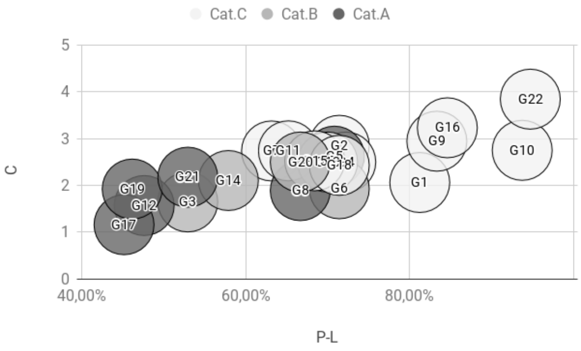

Figura 4: Clusters found by comparing variables $\mathcal{P}_L$ y $\mathcal{C}$.

It seems, therefore, quite clear that these three categories are well differentiated and could reflect three distinct clusters of teams and their impact on the collaborative dynamics of the groups they lead. Moreover, it is also not difficult to observe that these three disjunct categories correspond to the types of leadership described in [**?**]:

- Category A corresponds to the laissez-fair leader, a leader who does not act as a leader, and whose vacuum of authority is supplanted by another member of the group who, surely reactively to the absence of a leader, overly dominates the work of the least collaborative groups of all.
- Category B clearly corresponds to the authoritarian and dominant leader, with a lot of strength, who does not let the work be co-lead and dominates the project with authority in a large number of stories, very individualistic, giving rise to teams that are not very collaborative.
- Category C also clearly corresponds to the democratic leader, a leader who dominates the sprint, but with little overload with respect to the others, who allows to co-lead the work, not very dominant in the stories and not very individualistic, who works in very collaborative groups in which the work is homogeneously distributed.

Having done this analysis of the results, this paper proposes to use the average values of each category (Table 3) as the centroids of each leadership category [13] and apply cosine-based similarity measures to, given the calculation of the values of the six variables of the Table 3 of an unknown group, predict to which category it belongs. This prediction capability has been applied to the 22 groups of the experiment and has been able to correctly classify all of them with a hit rate of 100 %, something that was not easy to achieve given the overlapping of some of the categories, as shown in Figure 4 and demonstrates that the centroids chosen for each category (Table 3) are very robust, at

	$\mathcal{H}_L$	$\mathcal{O}_L$	$\mathcal{P}_L$	$\mathcal{D}_L$	$\mathcal{I}_L$	$\mathcal{C}$
Average Cat.A G5 G8 G12 G17 G19 G21	0,114	0,004	0,549	0,290	0,187	1,891
Average Cat.B G3 G6 G14 G20	1,000	0,052	0,622	0,379	0,166	2,045
Average Cat.C G1 G2 G4 G7 G9 G10 G11 G13 G15 G16 G18 G22	0,683	0,018	0,766	0,174	0,086	2,760

Cuadro 3: Summary of the characterization of the groups relative to the designated leader of each group

least in the sample analyzed.

In order to validate these criteria shown in Table 3 and the proposed automatic leadership classification, elaborated exclusively from the R activity log, two of the tests mentioned in the introduction have been passed to all groups, both to the leader (to assess his own attitude) and to the rest of the team (to assess the attitude of the designated leader), and the result is not very encouraging. Thus, the "Leadership test" does not yield significant results given that 100 % of the designated leaders consider themselves to be democratic leaders, clearly contrary to the evidence shown. This result is already advanced in [4] although in a different domain. The "Blake and Mouton questionnaire" has yielded a greater diversity in the classification of the groups (64 % authoritarian leaders, 23 % democratic and 13 % let). If these results are crossed with the previous automatic method, the coincidence is 36.4 %. The small size of the sample and the number and subjectivity of the questions that the students had to answer, together with their low motivation to fill in the surveys, mean that these cross-checked results are not very good. Surely a better motivation of the students to take the surveys should have been worked on.

5. Conclusions

This work has presented a functional and simple method that allows using the activity record of the practices of a subject, in which the SCRUM methodology is followed, to reconstruct the trace left by the activity of each group and to infer variables such as the type of leadership exercised, collaboration model, existence of dominant or individualistic members. All this supported by a very clear reasoning, which allows to obtain these variables in a non-intrusive way for the student, without having to make surveys. Moreover, many of the criteria of a group work [6] that are considered as positive, such as: avoiding working separately or competitively, integrating those who do not participate, working collaboratively, avoiding dominant attitudes or distributing tasks fairly, correspond in this work with the variables detected for a democratic leader and his team in the section **??**, so that the results of this work can be considered as a quantitative confirmation of the fulfillment of these requirements.

Although standard surveys have also been carried out to validate the results, this is a long and subjective process, with little motivation on the part of the students, and the result has not been good (36.4 % of coincidence) in spite of the fact that the proposed method achieves an excellent 100 % accuracy on the data collected, which is why more effort will have to be devoted to carrying out the surveys under better conditions.

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