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Using Learning Analytics to Detect Authentic Leadership Characteristics in Engineering Students

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Abstract

Previous research has shown that teamwork between students underpins the communication interactions among team members, and these interactions are underscored in the work environment, job quality, work outcome and, of course, grades. Analysing the interactions among the members of a team using a learning analytics system allows for a formative evaluation that indicates the progress of each team member and taking remedial actions if appropriate progress has not been made. This paper uses a learning analytics system to study interactions between students and detect the values and attitudes demanded of a leader by society. The results of this analysis are keys for avoiding corruption and wrong practices and can even provide a solution to global intercultural troubles. In this study, a validated questionnaire of authentic leadership was given to 78 team members in a university context; the influence of some values and attitudes on leadership is proved with grades; and a learning analytics system was used to analyse information that could predict a leader's behaviour during the development of teamwork.

Keywords: authentic leadership; teamwork; learning analytics; flip teaching.

1. INTRODUCTION

People's interactions with Information and Communication Technologies (ICT) create thousands of data per second in a way that, when people interact with ICT for the very first time, an obvious information trace is left behind until they obtain the objective of the interaction. Technological services providers often use those data to improve their own services. They also use those data to inform the "business intelligence" model, which includes knowing people's daily habits, the kind of service they are looking for and the effectiveness of some advertising campaign. In general, this information and analysis of that information allows technological service providers to make decisions [1].

Nowadays, ICT is frequently used in the educational context, and Learning Management Systems (LMS) can produce thousands of data as a result of the interaction between students and the provided resources and learning activities. The relevance of this increases given that those LMS are embedded in technological ecosystems in which students and teachers are continuously interacting. Those generated data could be used to analyse the trace of information students leave behind while they are interacting with the ICT in the educational context in order to improve, for instance, student learning. The use of those business intelligence techniques at the academic level is called Learning Analytics (LA), which can be defined as "The data measure, recollection, analysis and report of students and their context, with the purpose of understand and optimize the learning itself and the environments where it happens" [2].

On the other hand, higher education institutions and instructors emphasize the importance of developing teamwork competences in their degree programs as well [3], as international accreditation agencies of university degrees such as ABET (Accreditation Board for Engineering and Technology) demand proficiency in teamwork skills in engineering programs [4]. Moreover, teamwork competencies have been widely demanded by employers [5], and despite current changes resulting from the implementation of ICT technologies, teamwork proficiency continues to be one of the top ten skills most demanded by employers [6].

The traditional model of education uses evidences to assess students' performance, but those evidences tend to be the final result of students' work, and the same is true when assessing teamwork (TW). The traditional methods tend to analyse the results of teamwork without considering the activity of every member of the team. This method is called "black box methodology", and it is dominant from the primary educational level to the university level, as shown in previous studies [1], [7], [8].

Using traditional methods, teachers cannot verify students' adquisition of teamwork competence (TWC) [9]. Thus, for several decades, teachers have demanded new methodologies that can develop students' teamwork competence as individuals [9], [10]. Additionally, the use of ICT in the development and training of TWC enables to the teacher to follow the actions of each member of the team. One method that does this is the CTMTC (Comprehensive Training Model of the Teamwork Competence) [8], [11], in which the trace left by students' interactions is analysed to get evidences of the level of TWC acquisition. Previous studies have shown that individual evidence analysis can be done using an LA system, and the results of that analysis are related to each team member's TWC acquisition level. In addition, LA systems can assess and predict the acquisition of TWC and take decisions in order to improve that acquisition, allowing teachers to identify lazy participants and predict teammates' final grades. Previous studies prove the relationship between TWC and student interactions [1], [12].

However, nowadays institutions are demanding not only the technical acquisition of TWC but also certain personal qualities and values that must be considered integral to that competence. The Secretary General of the United Nations includes TWC amongst the ITS Core Competencies, which "…refer to the combination of skills, attributes and behaviour required of all staff, regardless of their level or function''. Regarding the UN, the Secretary-General has indicated that "the Organization's greatest strength—and the key to our success—is the quality of our staff and managers" [13]. One of the web pages of the UN's website [14] explains that in order to get a position in the United Nations, you need a combination of skills, attributes and behavior related to being successful in work. Among those needed core competencies, the TWC was indicated as essential in the United Nation, and Leadership was specified as one of the necessary managerial competencies for working at the organization: "At the United Nations, leaders serve as role models for the staff. They listen before they act; and while they nurture relationships and gain broad support, they also make tough decisions and drive change that is necessary. They make things happen with the support of others."

In 2014, the OECD produced a summary of the required competences for working and achieving maximum success in their organization and say: "The Core Competencies summarise the capabilities that are important across all jobs and that we believe collectively contribute to the OECD's overall success." [15, p. 4]. Among the Core Competencies, Teamwork and Team Leadership are included in the group of delivery-related competencies. The summary also includes some indicators for the different levels of attainment of TWC. Also, the emerging OECD 2030 framework explains that teachers must teach not only competences and knowledge but also principles and attitudes [16]. Even UNESCO sees in those principles and attitudes a solution to global intercultural troubles [17].

One of these new types of leadership is based on positive psychology in which the leader should try to resolve the negative aspects of their relationship with team members and to promote and develop the positive ones [18]. This approach has been applied in the field of leadership and has proposed a new model called Authentic Leadership (AL). Authentic leaders recognize and appreciate individual differences and are able to identify people's talents or positive qualities, thus helping people to strengthen [19].

Arda [20] explains, "In the early 2000s, positive organizational behavior concepts emerged as response to corporate scandals and accountability problems in organizations. As the research on authentic leadership evolves, the scholars realized that the concepts should go well beyond 'being true to oneself'", and "the common idea of the studies on authentic leadership reveals that self-awareness and acting in accordance with self-reference are the most significant notions for a leader to be perceived as authentic by the followers."

A key point in an article by Avolio [21] is the importance of authentic followership, its development, and its relationship with authentic leadership. Avolio presents "a comprehensive, self-based model of authentic leader and follower development", and the author's central premise is that "through increased self-awareness, self-regulation and positive modelling, authentic leaders foster the development of authenticity in followers. In turn, followers' authenticity contributes to their well-being and the attainment of sustainable and veritable performance."

In addition, Ilies [22] demonstrates the positive impact of authentic leadership on followers' different emotional aspects and their overall well-being. Steffens [23] says: "Growing evidence points to the role of authentic leadership in enhancing followership. It examines the impact of leaders' championing of collective (group) interests on authentic leadership. The study shows experimentally that compared to a leader who advances personal interests, a leader who advances the interests of a collective is (a) perceived as offering more authentic leadership and (b) more likely to inspire followership."

Studies that address the positive influence of authentic leaders on the behavior of their followers support the necessity of finding methodologies that integrate the authentic leader attitudes and values into teamwork. The acquisition of those

values can be measured using the Authentic Leadership Questionnaire (ALQ), which has been validated in its original version by Walumba [24] and by Moriano et al. [19] in its Spanish version, and both versions of the questionnaire have been implemented in a corporate context.

This study considered an engineering educational context (where TW was a specific object of study); thus, the followers of a leader were the members of a team, and the ALQ questionnaire was proposed as an important tool for the TW competence, once the adjustment to this context was validated.

The ALQ allowed for an assessment of the leader's features once TW was realized—not during its development. On the other hand, LA systems have already proved their effectiveness to analyse information about team members' interactions during the development of TW and have already shown the positive relationship between teamwork and final performance (grades) [1].

This research suggests the use of an LA system for obtaining information about students' interactions (which are related to the final assessment) and associating those interactions with the values and attitudes defined in ALQ. Therefore, the main objectives of this paper are as follows:

1. Validate the ALQ questionnaire in an engineering university context.
2. Prove that leaders who have AL skills achieve better grades in their team projects.
3. Prove that evidence regarding some leaders' communication, obtained with the LA system, is related to AL skills.

The following sections will describe the methodological context, in which the CTMTC model will be detailed, including the used LA system and the ALQ dimensions. Next, a description of the research context, which was composed of teamwork in three different degrees, will be provided. Finally, the results of the study will be reported, and a discussion and conclusion will be provided.

2. CTMTC MODEL

The implementation of an LA system requires analysis of the information generated by a particular process. Therefore, the evidence generated during TW must first be analysed. There are three types of this evidence: individuals, group and outcomes.

Outcomes evidence

Outcome evidence refers to the result of teamwork, which is what teachers often use for analysis. That evidence can be on-line work (e.g., a web page) or a written document (e.g., a pdf file). This evidence does not provide information about members' TWC acquisition level in each team assignment. Thus, outcome evidence cannot be analysed by an LA system.

Group evidence

Another type of evidence that is less widespread than outcome evidence but that can be used in the professional environment is group evidence. This evidence is obtained from the phases that form TW development. One of the most extended models in the professional environment is the one defined by Tuckman [25], who specified a set of steps small groups should follow to achieve a goal. The proposed steps are Forming, Storming, Norming and Performing. This model has been extended with two new phases: the delivery of the final product of the project and the development of lessons learned. This new model is widely used by several renowned professional and academic institutions; for example, the model is used in the international accreditation agency IPMA for professional environments [7] and the conduction of team projects at MIT [26]. This type of evidence provides more detail than outcome evidence and confirms whether the essential phases needed to achieve TWC were followed. However, group evidence does not give information related to the individual acquisition of TWC and cannot be analysed by an LA system because group evidence is based on reports.

Individual evidence

Individual evidence is based on the interactions between different members of a team. Members of a team communicate using these interactions, establish norms, take group choices, solve conflicts, produce resources from different phases of the team project and create the final product. Therefore, this type of evidence allows for the analysis of individual acquisition of TWC: lazy members can be detected, the involvement of each team member in resources creation during each phase can be checked, the way in which the leader faces the troubles can be revealed, the way in which the plan was followed can be understood, etc. This type of evidence is not used in team projects because the discussion analysis requires a big effort. However, this evidence is susceptible to analysis through an LA system.

The model used in this work is called the CTMTC (Comprehensive Training Model of the Teamwork Competence) [8], [27], [28]. It is a "white box" teamwork method and integrates the three types of evidence. It continuously generates evidence of students' work during the different phases of teamwork as well as information about the final results. Both faculty and teams can observe this evidence at any time and make decisions accordingly.

The "white box" method allows the team leader (and other members) to check the individual responsibility of each team member, the degree of development of the tasks and the evidence that the teacher will assess. Therefore, the leader has the important capability to transform the group into a high-performance team.

The CTMTC model is composed of three layers: the *conceptual layer* is based on the integration of different types of evidence plus the processes that generate them; the *technological layer* giving data to supports evidences; and the *methodological layer* presents a way to apply this model in the learning-teaching process. The first two layers are inherent to the model and the third can change as a function of the application context because it represents how to use that model. Figure 1 outlines the conceptual and technological layers of the CTMTC model.

2.1 Conceptual Layer

The objective of the conceptual layer is to ensure the acquisition of TWC. This layer establishes the phases that must comprise TW. The overall aim is that, through these phases, the students acquire skills and use tools similar to those that can be found in the professional environment.

The conceptual layer incorporates phases defined by Tuckman (Figure 1-a) as well as the improvements generated in the deliverables given in the professional environment (IMPA) and excellence engineering teaching (MIT) (Figure 1-b). This model also gives evidence for each phase (Figure 1-c) and evidence for interactions among team members (Figure 1-d).

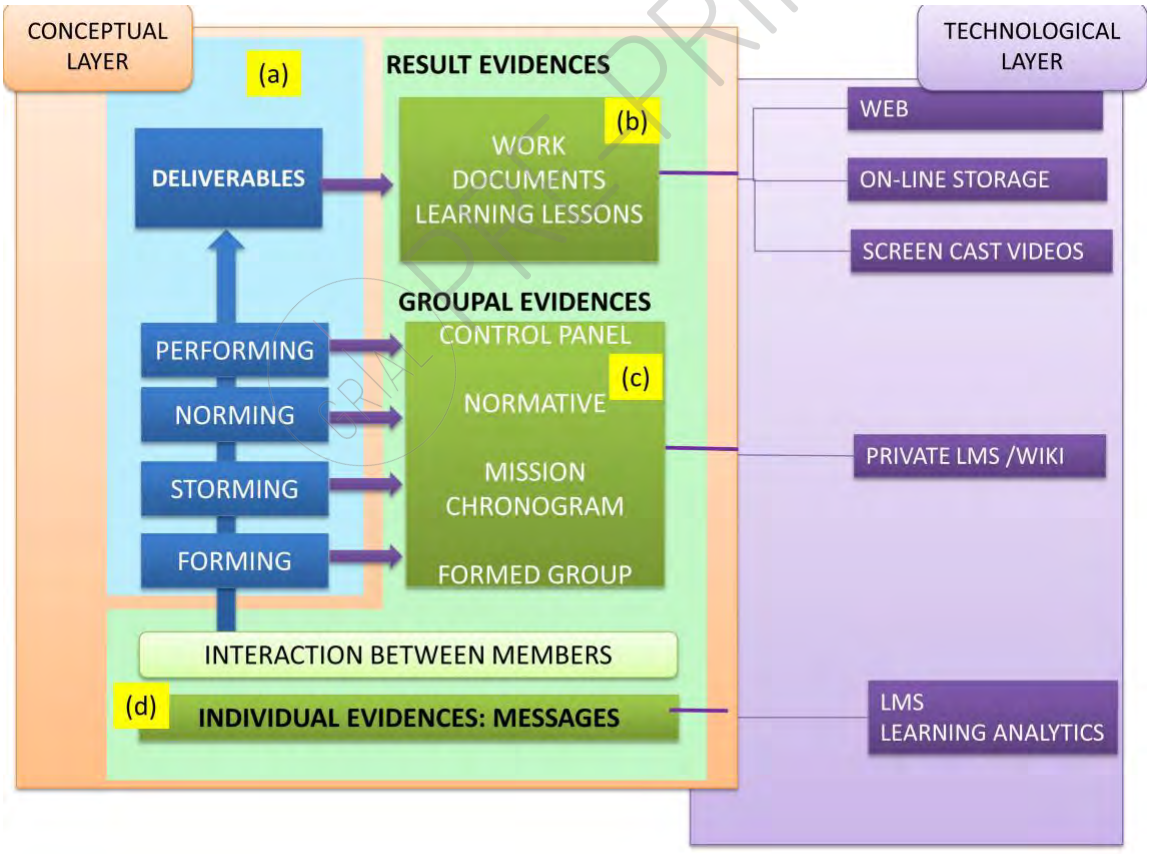


Figure 1. Conceptual and technological layers of the CTMTC model

Fidalgo-Blanco [12] showed the relationship between different phases of the team assignment and group/individual evidence(related to communication).

- *Forming* phase: Formed group / Interactions to choose team leaders.
- *Storming* phase: Mission, objectives, utility, target audience, map of responsibilities, planning and schedule / Interactions to plan different phases.

- *Norming* phase: Rules designed by the team /Interactions to develop the rules and discuss the viability of the team assignment.
- *Performing* phase: Monitoring of daily evolution / Interactions for building the control panel. Interactions showing the evolution of each individual (personal work journal reports).
- *Deliverable*: Final score, Content organization / Final online product. Organization online content.
- *Learned lessons*: Videos with reflection on the phases. Videos with reflection on the final product / Videos stored in a knowledge management system to facilitate its use by future teams.

2.2 Technological Layer

The CTMTC model has a technological layer that supports the different types of evidence generated during teamwork development, as shown in Figure 1. Team members, the leader and faculty have the same access to the technology layer. Therefore, all actors involved in the teamwork can accurately and timely monitor any stage of teamwork development.

From a teamwork development perspective, the framework allows students to achieve higher performance in each phase and provides evidence of the work completed (group and individual). The technology is scalable and admits the use of a single system, such as a Learning Management System (LMS) like Moodle (http://moodle.org), but also allows for a greater variety of technological tools for different purposes. Table 1 shows the technologies associated with each source of evidence.

Table 1. Used technologies to give support to different evidence.

Evidence	**Technology**
Formed group	LMS. Election of groups
Mission, objectives, utility, target audience, map of responsibilities, planning and schedule	LMS Wikis
Rules designed by the team	LMS Wikis
Monitoring of daily evolution	LMS Wikis
Final score	Wiki and web pages
Content organization	Online Storage System
Videos with reflection on the phases and the final product	Screen Cast videos
Interaction between team members	LMS forums. Learning Analytics.

The data linked to each technology have a specific scope, as shown in Figure 2. The technologies used technologies to generate the evidence are available, in real time and during the development of TW, to the team members and the faculty. The technologies used to store the deliverables are public (the result and the learning lessons), and the storage space is available to the teamwork and the faculty. The LA system is only available to the faculty.

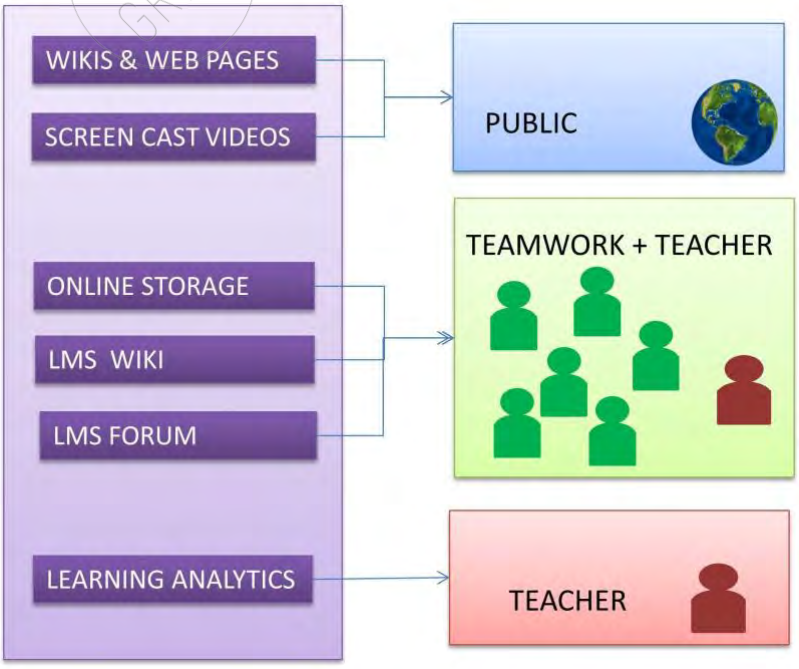


Figure 2. Scope of the technologies used in the technological layer

The LA system facilitates the assessment of the individual activity of each team member when the team member applies the CTMTC methodology. In order to do so the LA provides access to the information recorded in Moodle logs. This information is used to analyse the evidence required for each of the methodology stages. It should be noted that the tool does not focus on group evidence but on the interactions the students carried out to achieve results.

In order to describe the CTMTC learning analytics tool, it is necessary to explore two issues: how the tool was implemented and the functionalities that it provides.

Regarding the implementation, it is necessary to consider that the tool is intended to access to students' records in the LMS. This feature can be articulated in several ways: 1) Direct access to the database; 2) Define a standard extension or plug-in for it; 3) Use of web services.

The first of these options was limited by the version of the LMS; that is, if there was a change in the database, changes in the tool would also be necessary. The second option would limit the development done to a specific LMS, which would limit the flexibility and portability of the tool. Given these facts, we decided to use web services. The use of web services ensures, amongst other things, that the solutions defined are independent of the underlying implementation [29], which solves the aforementioned problems.

Once this was decided, the Moodle web service layer was used to access the information and some additional functions were added to the Moodle External Layer so logs could be accessible. This was necessary because Moodle did not make accessible the information that we needed to access through using the web service. In addition, it was necessary the definition of a web service client so the information could be accessed without logging into Moodle. More information about the connection of the tool to Moodle and the changes made in the Moodle external layer and the client can be found in [30, p. 1].

The tool provides several functionalities, including information about students' interactions into a course from three different view modes: the whole forum, a team using that forum and an individual thread created by a specific team. By selecting a forum, the system provides data about the number of total messages in the forum, the number of people registered in the forum, the average number of messages of every member of all teams, the list of teams and the total list of students with their respective number of messages. By selecting a participating team in the forum, the obtained data is comprised of the total number of team messages, total number of team views, number of members in the team, average number of messages of each member of the team, creation dates of the first and last thread, list of threads (with the date of creation for each thread, total views and total messages) and list of the team members (with the number of messages and percentage in relation to team messages). By selecting a thread for the specific team, the system provides data about the number of messages of the thread, the author of the first message and its date of creation, the author of the last message and its date of creation, the members of the team that have participated in the thread, the number of messages of each member and the percentage of participation, the total number of messages in the thread and the number of thread views. In addition, in this view rules of action can be defined based on thresholds set upon the number of messages [1].

2.3 Methodological Layer

The purpose of this layer is to facilitate training and assessment strategies to foster the creation of high performance teams in which each team member should understand the development of teamwork and in which individuals acquire the teamwork competence, which will help them in both their academic and professional careers.

The framework provides advantages for the teaching staff, as the CTMTC allows formative and summative assessment through individual and group evidence. Those assessments allow teachers to track team evolution, the degree of development and completion of group tasks and the degree of commitment and activity of each team member. Summative evaluation (continuous or final) allows assessment of the degree of individual and group acquisition of TWC. The costliness in effort of assessing individual evidence by teachers requires the application of LA [1], [8], [11], [27].

The technological layer was designed to be versatile in order to be implemented in different ways according to the context, temporal duration of the teamwork, time assigned to the teaching, etc.

3. RESEARCH METHODOLOGY

This section describes the measurement instrument used to obtain data for this research.

3.1 Measurement Instruments

The ALQ, Authentic Leadership Questionnaire, was designed by Walumbwa and is based on the theory of "Authentic Leadership". He used five samples of corporations in China, Kenya and the United States [31]. In 2011, this survey was translated to Spanish, validated again, and applied to a sample of 600 respondents [19]. The ALQ survey assesses four dimensions using five-point Likert scales: Self-awareness, Transparency, Ethical-moral, Balanced processing

ALQ is comprised of 16 questions. In the Spanish version of the questionnaire, questions ALQ1 to ALQ5 represent the *Transparency* dimension; questions ALQ6 to ALQ9 represent the *Ethical-moral* dimension; questions ALQ10 to ALQ12 represent the *Balanced processing* dimension; and questions ALQ13 to ALQ16 represent the *Self-awareness* dimension. The calculation of the score for each leader consists of the simple addition of the scores of each dimension. Because each dimension has a different measurement scale, all results are then normalized to a ten-point scale. The questions are included in Table 2.

Table 2. Spanish questions (and their translation) of ALQ dimensions

Name	Question
Dimension: Transparency	
ALQ1	Digo exactamente lo que tengo que decir / I say exactly what I have to say.
ALQ2	Admito los errores cuando los cometo / I admit my mistakes when I've made them .
ALQ3	Animo a cada persona a expresar su opinión /I encourage every person to express their opinion.
ALQ4	Digo la verdad aunque sea dura / I always tell the truth even if it is hard to hear.
ALQ5	Muestro las emociones que se corresponden exactamente con mis sentimientos / I show emotions that respond exactly to my feelings.
Dimension: Ethical-moral	
ALQ6	Muestro creencias que son consistentes con mis acciones / I show beliefs that are consistent with my actions.
ALQ7	Tomo decisiones basadas en los valores que son importantes para mi / I take decisions according to my fundamental values.
ALQ8	Pido a los miembros del equipo que asuman posiciones que estén de acuerdo con los valores que son importantes para ellos / I request that the team members take positions related to the values that are relevant for them.
ALQ9	A la hora de tomar decisiones difíciles para mí son muy importantes los aspectos éticos. / When I have to make hard decisions, ethical aspects are very important.
Dimension: Balanced processing	
ALQ10	Solicito puntos de vista contrarios a las opiniones que mantengo / I seek opinions that are different from my own opinions.
ALQ11	Analizo los datos relevantes antes de llegar a una decisión / I analyse relevant data before taking a decision.
ALQ12	Escucho cuidadosamente diferentes puntos de vista antes de llegar a conclusiones / I listen very carefully to different points of view before making decisions.
Dimension: Self-awareness	
ALQ13	Busco la opinión de los demás para mejorar las relaciones con ellos / I seek other's opinions to improve my relationship with them.
ALQ14	Tengo una idea bastante exacta de cómo otras personas ven mis capacidades de liderazgo / I've got an accurate idea about how others' see my leadership skills.
ALQ15	Sé cuándo es el momento de volver a examinar mi posición sobre cuestiones importantes / I know when I need to review my position about fundamental questions.
ALQ16	Muestro a los demás que comprendo cómo las acciones específicas que pongo en marcha les afecta / I show others that I can understand how they are affected by the actions I have made.

3.2 Research Context

This work was conducted with 78 teams, with a mean of six members per team. The teams were students in different degree programmes studying three subjects on first academic year at the Technical University of Madrid: "Computing and Programming", or C&P (course 2016-17, Miner Technology Engineering Degree, first semester), "Programming Fundaments", or PF (course 2016-2017, Biotechnology Degree, first semester); and "Computing and Programming" (course 2015-2016, Energy Engineering Degree, second semester).

Those three subjects were assigned with 10 hours for the TWC in C&P subjects and 14 hours for the Programming Fundaments subject. The work was conducted throughout the entire academic course. The subjects in the first quarter started in September of 2016 and finished in January of 2017. The subjects in the second quarter started in February of 2016 and finished in June of 2016. The teamwork was graded with a final mark of 15% in C&P and 30% in PF.

The implementation was carried out in four steps:

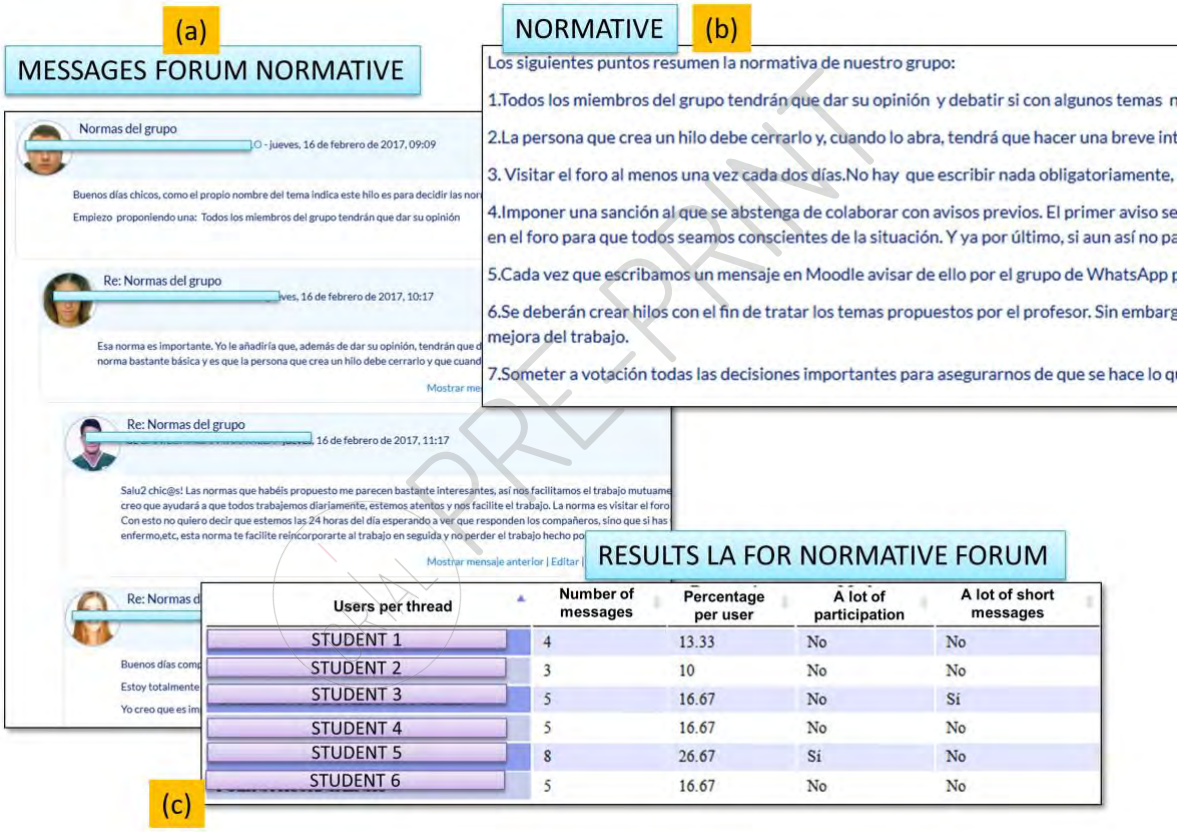
Step 1: Teamwork development. Students performed the group work using the CTMTC while formative evaluation of each team was performed at different stages; in-class formative evaluation was used as resource training for all the teams. This process is the key to the development of teamwork competence. Students must produce evidence through student-student interactions. Formative evaluation of evidence occurs at the group and individual levels.

This step was conducted using the Flip Teaching [32]–[36] methodology Flip teaching is a disruptive methodology that allows students to increase their active participation in a cooperative way. It was divided into two parts:

1) *Lectures at home*. Every work group has available teacher's videos and learned lessons from other students where students can find the objectives of each phase of the work and find examples of evidence obtained from pervious teamwork. The team members using this technological layer interact (generating individual evidence) to complete phase of the TW (generating group evidence), as shown in Figure 3.

2) *Class activity*. During the course, five, two-hour sessions were held during which the teams exhibited their outcomes to their classmates. All the resources (well done or unfinished) were used as academic resources, and the students debated the effectiveness of those resources in order to improve the resources. In those sessions, the teams reviewed their contributions and improved their results.

In this first step, all evidence was generated. Figure 3 shows the individual evidence (Figure 3-a) present in the messages exchanged by the team to create the regulations (30 messages). The outcome of those interactions is the development of team regulations (Figure 3-b), which is evidence of the Norming phase. The LA system can be used at any time during the work development phase in order to analyse every message sent by the team or to select a thread in the forum. Figure 3-c shows an analysis made by the system in which it can be observed that the most working user was number five (with 26.67% of the participation) and the least working user was number 2 (with 10% of the participation).



Users per thread	Number of messages	Percentage per user	A lot of participation	A lot of short messages
STUDENT 1	4	13.33	No	No
STUDENT 2	3	10	No	No
STUDENT 3	5	16.67	No	Sí
STUDENT 4	5	16.67	No	No
STUDENT 5	8	26.67	Sí	No
STUDENT 6	5	16.67	No	No

Figure 3. Group and individual evidences generated in phase one.

Step 2: Presentation of deliverables. In this step, the teams present the deliverables (work, lessons learned and temporary files). This phase is conducted after the sessions in the group work classroom. Each team makes and delivers three deliverables:

- Final work. This final work is delivered though a web page or a wiki so the receiver public acquires access to the resource. The quality approach of this deliverable is the resource utility to the receiver public as well as the need and utility of the generated resource. A video was included with a presentation of the work conducted by students.
- Content organization. Content organization was made in order to access the content of each team project if team members need to use it. In this case, the organization, classification, meta-information and ease of identification associated with each content was assessed.

- Learned lessons. These are videos in which each team describes their experience in the development of the group work, either during each phase or the entire working process.

Step 3. Survey completion to assess Authentic Leadership (ALQ). The students were separated into two groups: team leaders and the rest of students. The students completed a survey prior to grading.

Step 4. Final evaluation. This step involves assessment of individual skills using the LA system and manual assessment of group evidence and results. The process is identical to the formative evaluation but uses the final evidence. Student-student interactions were organized into threads, with each thread corresponding to a given stage. The LA system shows the start and end dates of each phase as well as the student-student interactions in each of them.

The assessment was conducted from the analysis of the individual evidence (1/3 of final grade), phases evidence (1/3 of final grade) and deliverables (1/3 of final grade).

The evidence and deliverables of each step were analysed in a manual way by faculty. However, this analysis did not require a big effort because during the lessons the teacher observed the progression of the teamwork; in other words, a continuous assessment was made.

Analysis of individual evidence was conducted through the LA system in which each forum thread was analysed. The LA system shows the team outcomes (Figure 4-a), including the effort made by each team member as expressed by the number of team messages (column 2); moreover, it shows the number of long messages (column 3) and short messages (column 4) as well as the number of team members (column 5). Thus, the workload of every team can be assessed.

For every team, the thread of the forums was showed (Figure 4-b). Threads respond to the messages that were exchanged in each phase; hence, the date in which team members started to interact to perform a phase (column 2) and the effort used in each phase analysed from the number of exchanged messages (column 3) were included.

Furthermore, for each thread, the effort measured in messages number for each team member can be analysed, and the workload of the different team members can be analysed for the entire development. (figure 4-c)

(a)

	Total messages	Short messages	Long messages	Number of students
TEAMWORK 1	509 (13.77%)	188 (5.09%)	321 (8.68%)	5 (8.33%)
TEAMWORK 2	498 (13.47%)	162 (4.38%)	336 (9.09%)	6 (10%)
TEAMWORK 3	105 (2.84%)	49 (1.33%)	56 (1.51%)	6 (10%)
TEAMWORK 4	303 (8.2%)	68 (1.84%)	235 (6.36%)	6 (10%)
TEAMWORK 5	352 (9.52%)	135 (3.65%)	217 (5.87%)	7 (11.67%)
TEAMWORK 6	285 (7.71%)	66 (1.79%)	219 (5.92%)	6 (10%)

(b)

Users per thread (teamwork 2)	Total messages	Short messages	Long messages
STUDENT 1	66 (13.5%)	16 (3.27%)	50 (10.22%)
STUDENT 2	94 (19.22%)	35 (7.16%)	59 (12.07%)
STUDENT 3	74 (15.13%)	11 (2.25%)	63 (12.88%)
STUDENT 4	89 (18.2%)	26 (5.32%)	63 (12.88%)
STUDENT 5	101 (20.65%)	22 (4.5%)	79 (16.16%)
STUDENT 6			

(c)

PRIVATE FORUM FOR WORK TEAM 2	Creation date of thread	Total messages
THREAD	2016/11/01 20:19:16	18 (3.68%)
THREAD	2016/11/07 18:40:02	14 (2.86%)
THREAD	2016/11/14 20:26:57	15 (3.07%)
THREAD	2016/11/15 23:15:49	5 (1.02%)
THREAD	2016/11/16 16:15:21	4 (0.82%)
THREAD	2016/11/17 22:21:09	55 (11.25%)
THREAD	2016/11/20 08:39:07	4 (0.82%)
THREAD	2016/11/22 21:13:21	49 (10.02%)
THREAD	2016/11/25 13:32:40	27 (5.52%)
THREAD	2016/11/26 12:07:02	17 (3.48%)
THREAD	2016/11/26 18:42:41	35 (7.16%)
THREAD	2016/11/26 18:44:15	34 (6.95%)

Figure 4. Data generated by the LA system

4. RESULTS

The data from the three groups were obtained from three sources of data: the ALQ, the LA system and the final grades of the team leaders. These results can be used to validate the ALQ questionnaire in the educational context and show the

relationship between ALQ skills and a leader's final grades as well as the relationship between a leader's communication skills (number of messages from the LA system) and those of the rest of the team members.

To obtain these results, 75 answers from the ALQ questionnaire were used from 78 leaders, and 253 answers from a total of 490 participants were used from the groups of the leaders of the three above-mentioned subjects.

4.1. Validation of the ALQ

Two different versions of the ALQ questionnaire were used with the same questions: one version to ask team leaders about their own perception of different dimensions of leadership and the other to ask the team members about their perception of their leader.

4.1.1 Internal Consistency Analysis

In order to validate the questionnaire's internal consistency, a Cronbach Alfa test was performed [37]. Its coefficient is used in order to value the level at which the items of the same scale are evaluating a concept common to all of them. The math in the alpha coefficient was based on the mean correlation of each item in the scale with regard to the total alpha. The value of this coefficient goes from zero to one; if the standard alpha value was over 0.7, the test will be found valid [38]; others authors accept values over 0.5 as valid [39].

The leader questionnaire was validated by 75 surveys answered by leaders. The global alpha is 0.7339.

Because two different questionnaires were conducted, one for leaders and the other for team participants, it is also necessary to check the internal consistence of the latter questionnaire. The standardized alpha value for the entire test is 0.9341, which is much higher than the minimum 0.7 required. Compared to the previous case, the upper values are due to the number of responses obtained for the team questionnaire. The questionnaire was validated with 253 surveys answered by the team members (excluding the leaders). Therefore, all these outcomes confirm the internal consistence of the team member test.

As the ALQ questionnaire has four internal dimensions, a verification of its internal consistence was made for each dimension. For that purpose, the 253 answers from the ALQ test for the team members was used. The answers from the leaders was not used because there were few responses. A Cronbach Alpha test was used in order to verify the internal consistence of each dimension in the test.

For that purpose, the outcomes of each dimension of the ALQ questionnaire were added and normalized to ten points, and an Cronbach Alpha value was calculated for each of four dimensions, yielding the results shown in Table 3.

In conclusion, the outcomes previously presented support the internal consistence of the ALQ test for leaders, the global test for group members and the four dimensions of ALQ.

Table 3. Cronbach Alpha for ALQ dimension

Dimension	Alpha	Std.Alpha
Transparency	0.8482	0.8490
Ethical-moral	0.7773	0.7809
Balanced processing	0.6765	0.6836
Self-awareness	0.7319	0.7298

4.1.2 Confirmatory factor analysis

In order to verify the viability of the sub-scales a confirmatory factor analysis was conducted. The confirmatory factor analysis was chosen because an exploratory analysis cannot quantify the goodness-of-fit of the resulting factor structure [40]. The confirmatory factor analysis can measure the test's lack of external consistence. A RMSEA test was done to check the viability of the model, according to Batista et al. and Cea [41], [42] a model with a p-value > 0.05 can be accepted. A RMSEA value lower than 0.05 indicates a good model and a value between 0.05 and 0.08 indicates a reasonable model [43]. A first attempt was made using the 16 variables, but a 0,097 value was obtained in the RMSEA coeficient, that result was unacceptable. A second attempt was done excluding the variables ALQ3 and ALQ13. In that case, the model, obtained a chi-square of 89.55 with 71 freedom degrees and a p-value of 0.06765403. The RMSEA index was 0.05941922 with 90% reliability. That means that the obtained model is close to a good one.

4.2. Relationship between the LA Features and Leader Grades

Given the academic context, an analysis of the relationship between the features of LA and the grades obtained in the teamwork was presented. The *Transparency*, *Ethical-moral*, *Self-awareness* and *Balanced processing* dimensions are desired to form leaders with moral values and positive attitudes, but a test must be done in order to check if these characteristics have a relationship with grades obtained by leaders and if this relationship is positive or negative.

Table 4 show the scores in 75 leader responses to an ALQ test and its different dimensions, where the second column represents the mean rated by leaders (Mean) and the third column represents the standard deviation (SD). Each score is normalised to ten points.

Table 4. Normalized mean in AQ

Dimension	Mean	Sd
ALQ	8.12	0.7396356
1-Self-awareness	7.5933	1.1987982
2-Transparency	8.26133	0.8304823
3-Ethical-moral	8.147	1.2074469
4-Balanced processing	8.55111	1.075936

Then, each dimension of the ALQ test was analysed in relation to leader grade. The final grade, as explained above in the context section, was obtained from three different grades: individual, group and team work outcome. Using a correlation bilateral Spearman test, a high correlation of over 0.5 was found (Rho column in Table 5) between the leader grades (both individual and final) and the *Self-awareness* dimension of the ALQ test.

Table 5. Correlation between leader grades and *self-awareness*

Variable	Rho	p-value
Leader individual grade	0.60	0.0007 (<0.01)
Leader final grade	0.55	0.0019 (<0.01)

For the remaining dimensions, significant correlations were not found for grades; however, significant correlations were found between grades and some questions of the ALQ test on two dimensions.

Regarding the *Transparency* dimension, a moderate correlation was found (above 0.3 in the Rho column) with a p-value < 0.03, between grades and the ALQ3 question (Table 6).

Table 6. Correlation between ALQ3 and grades

Variable	Rho	p-value
Leader individual grade	0.33	0.0017 (<0.01)
Leader final grade	0.34	0.0013 (<0.01)

Regarding the *Ethical-moral* dimension, the results only show a positive and low correlation (Rho column < 0.3), with a p-value < 0.05, between grades and the ALQ6 question (Table 7).

Table 7. Correlation between ALQ6 and grades

Variable	Rho	p-value
Leader individual grade	0.26	0.0103 (<0.05)
Leader final grade	0.23	0.019 (<0.05)

4.3. The use of LA Systems Improves Prediction of Behaviour for Teams with AL

In order to form the values and attitudes related to TWC, is needed than teachers can verify the work evolution before it was finished. Accordingly, the verification involves a big effort because the messages produced in the interaction between students must be analysed. To gain efficiency in this process, the LA system was used as a predictor of the team behavior. In this work, it is necessary to demonstrate that the data given for the LA (number of messages) are useful to predict if the leader of a team is an authentic leader (or at least has some dimensions of the ALQ)

Therefore, the data given by the LA system (number of messages) was checked to determine the relationship between the ALQ questionnaire and number of messages. In this case, only long messages were considered because they require more effort from the students and more exchange of information among members of the group. The data given by the LA system was analysed using a correlation Spearman test. The outcomes are shown in Table 8. A low correlation was found between items ALQ6 and ALQ11 (column Rho <0.3) and the number of long messages sent by the leader. A moderate correlation was found (column Rho >0.3) between item ALQ3 and the number of long messages sent by the leader. The p-value column gives the confidence in each outcome. The lower the p-value the higher the probability that the outcome can be extended to the population. P-values < 0.01 give a possible error of 1%, and p-values < 0.05 give an error of 5%.

Table 8: Correlation between ALQ3/ALQ6/ALQ11 and leader messages

Variable	Rho	p-value
ALQ3(*transparency*)		

Leader long messages	0.31	0.0033 (<0.01)
ALQ6 (*ethical-moral)*		
Leader long messages	0.20	0.0367 (<0.05)
ALQ11 (*balanced processing*)		
Leader long messages	0.20	0.0401 (<0.05)

5. DISCUSSION

The validity of the ALQ questionnaire was shown in a corporate context by Walumbwa [31]; after that, the questionnaire was translated into Spanish by Moriano [19] in the corporate context as well. In an academic context, the development of teamwork is common, and new claims in teamwork [17] require developing an approach to training in values and attitudes. For this reason, it is necessary to validate the tools that measure those values in an educational context. In this work, a sample of 78 teams from three subjects in three different degrees was used. The obtained outcomes validate the ALQ questionnaire in an academic context; this validation was the first objective proposed in this work. In the original ALQ questionnaire [31], the internal reliability of the sub-scales was as follows: *Self-awareness*: 0.92; *Relational transparency*: 0.87; *Internalized moral*: 0.76 and *Balanced processing*: 0.81. The confirmatory factor analysis adds more information to the previous results, indicating that questions ALQ3 and ALQ13 must be removed from the final edition of the Spanish version of the ALQ to obtain a good model without these questions.

Connecting the dimensions of the ALQ questionnaire with other research in education, it is known that self-awareness is a skill related to a self-regulated learner, and self-awareness is considered a skill of successful students [44]. Transparency is positively correlated with other qualities such as rapport and empathy, which have an positive impact on the relationship into the teamwork [45]. The concept of balanced processing is taken from cognitive psychology, which indicates that humans are inherently flawed and biased information processors [46], [47]. A good leader must consider multiple sides of an issue and multiple perspectives to assess information in a balanced manner. Ethical-moral leadership was analyzed by Northouse [48], who argued that virtues and moral abilities are not innate but can be acquired and learned through practice, and leaders must personify appropriate values.

Though demanded for several decades [6], [49] teamwork continues to be one of the most demanded competences. Because it is a highly demanded competence, TWC was taught and assessed among the team members. The CTMTC method has shown its effectiveness and efficiency (using LA systems) to train students in this competence. However, when new variables are introduced in the process of training the competence (values and attitudes), a new test must be done in order to know if those new variables affect (positively or negatively) the effectiveness and efficiency of the CTMTC method. For this reason, the second objective was to study the influence of leaders that show authentic leadership features in grades. In the outcomes, a negative influence in the leaders' grades was not found in the dimensions and variables that measure the ALQ questionnaire.

Furthermore, a high positive correlation was found between leaders with the highest scores in the *Self-awareness* dimension with individual and final grades. For the other dimensions (*Transparency*, *Ethic-moral* and *Balanced processing*), a correlation was not found; however, some questions of these dimensions demonstrated correlations. Thus, the action "ALQ3- I encourage every person to express their opinion" of the *Transparency* dimension had a moderate, positive correlation with the final and individual leader grade. The question "ALQ6- I show beliefs that are consistent with my actions" from the *Ethic-moral* dimension showed a low, positive correlation with individual and final leader grade.

In several studies, the number of messages posted by students was used as a measure of students' participation [50]; in this work, a new distinction was introduced to characterize long and short messages as two different types of messages.

6. CONCLUSIONS

The deployment of the LA systems, which were developed for use with the CTMTC method to analyse individual evidence, has shown its effectiveness to predict the grades of all team members. Thus, it was shown that there is a correlation between information generated by the LA system and the quantitative data (grades) of TW. It is also necessary to verify if the LA system can predict the behaviour of the leader (qualitative analysis of questionnaire), and, for this reason, the correlations between useful information to predict the grades (messages) and the ALQ questionnaire was studied.

When number of messages is considered, it can be observed that a positive correlation occurs with the same questions studied in the case of grades: ALQ3 (*Transparency*) and ALQ6 (*Ethic-moral*) are both moderate correlations, as is the question "ALQ11- I analyse relevant data before taking a decision" (*Balanced processing*). Therefore, the LA system can be used to predict some of a leader's behaviours.

However, a relationship between the *Self-awareness* dimension and the number of leader messages was not found. One possible explanation for this is that a leader's awareness of his or her own actions may not have an influence on communication skills (number of messages) with the rest of the team members but may have a positive influence on the final grade of leader.

As a future line of work, a deeper study of the dimensions and questions that correlated with leader grades must be done in order to know how this influence operates. Moreover, the study must be extended to team members to confirm if their behaviour is influenced by leader performance. In addition, information generated by the LA system must be extended with the inclusion of behaviour studies.

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