Teamwork assessment in the educational web of data: A learning analytics approach towards ISO 10018

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ABSTRACT

The Web of Data is an emerging research field that contributes to make better decisions because it gathers, combines and analyses different data sources available worldwide. Educational data is an interesting domain because it deals with the quality of the education itself and educational institutions which are common goals for every country. This paper is devoted to present how this idea has been used to improve a learning analytics tool. By means of this tool, teachers can perform teamwork competence assessment of a group of students taking into account how the individuals acquire the essential components of such competence. In this sense, authors use the Comprehensive Training Model of the Teamwork Competence in Engineering Domain (CTMTC) method to gather competence evidences and improve the system with a learning analytics tool to support the process. This tool is able to transform competence evidences and stores them in a competence ontology built upon ISO 10018 concepts. The final result is the production of educational results for the web of data.

1. INTRODUCTION

With the growing importance of Information and communication technologies (ICT) in the educational field, learning management systems (LMS) have been maturely developed and widely adopted (García-Peñalvo and Seoane-Pardo, 2015) to store a wide range of data, including students' characteristics, learning histories,

achievements, testing scores and grades (Huang et al., 2016). Although LMS present their drawbacks (Stantchev et al., 2014), these systems can offer a great variety of instruments to facilitate information sharing and communication among learning stakeholders (Romero et al., 2008). Given that LMS generate a vast amount of data, the problem of categorizing, analysing and using these data is not trivial. Researchers have encountered different ways to use these data in acquiring understanding of students' effort and competence development (Iglesias-Pradas et al., 2015) and giving this fact, the need to understand and use data available in LMS is unquestionable. However, given the amount of data available in a LMS, in many cases, data are either overlooked or underused (Daniel, 2015). As a result of this, learning analytics is a fertile research field devoted to understand how learning took place online (Ferguson, 2012). Learning analytics is becoming an essential tool to inform and support learners, teachers and their institutions in better understanding and predicting personal learning needs and performance (Greller and Drachsler, 2012). According to (Long and Siemens, 2011), Learning analytics is the "measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs". The final goal of learning analytics is improved learning via the interpretation and contextualization of educational data (Siemens, 2013). Using learning analytics, universities are able to improve decision making and resource allocation, identify at-risk learners and areas of concern, they can get a better insight into their strengths and weaknesses, they can drill down on causes of complex challenges, and they can create and try different academic models (Marks et al., 2016). Examples on the use of Learning Analytics include aspects like analytics of communities of inquiry (Kovanović et al., 2015), mobile learning (Miguel et al., 2016), learners engagement (GopalaKrishnan and Sengottuvelan, 2016), social relationships (Gómez-Aguilar et al., 2014; Gómez-Aguilar et al., 2015) and procrastination factors (del Puerto Paule-Ruiz et al., 2015) citing just some of the most important and recent ones.

In parallel, human factors are key for business environments. The knowledge about individuals' competences and skills are essential both for the educational institutions and for the companies. In fact, competence management has been a fertile field of

study. Since the nineties, organizations and educational institutions are adopting a competence-centric approach in human capital management (De Leenheer et al., 2010). The study of competences and their management using semantic technologies is not new. Literature has reported several efforts in aspects like social media tagging (Braun et al., 2012), performance based simulation (Stantchev et al., 2013), consensual knowledge derived ontology-based system (Kimble et al., 2016) or competence profile management (Tarasov, 2012). Apart from purely academic approaches, competence management has also been approached in a more industry-oriented approach (García-Peñalvo et al., 2014). Maybe the most important one is the Unified Enterprise Modelling Language (UEML), a language that provides constructs to cover process, resource, competence and enterprise entities (Pépiot et al., 2007). Other previous initiative worth to mention is the HR-XML by the HR Open Standards consortium.

These specifications are, as mentioned above, especially useful in such industrial environments, where the need of employee education is, again, crucial to improve overall quality in both services and products (Boys and Wilcock, 2014). The standard, ISO 10018, Quality Management – Guidelines on People Involvement and Competence, was published in September 2012 (ISO, 2012). The idea behind the standard is to help organizations in the involvement of people. The following human factors are addressed in the ISO 10018 standard: attitude and motivation, education and learning, empowerment, leadership, networking, communication, recruitment, awareness, engagement, teamwork and collaboration, responsibility and authority, creativity and innovation, and finally, recognition and rewards.

In the context of the initiative, teamwork results from the ability of people to work together in a creative and productive relationship within a process, leading to enhance and assure quality in products and services (ISO, 2012). Teamwork is a recognized competence present in both curricular activities and professional educational endeavours (Colomo-Palacios et al., 2013). Not in vain, the importance of teamwork is determined by the fact that an effective team increases the probability of achieving set results for any project, process, product or service, including learning.

However, and in spite of the importance of teamwork in education in general and in eLearning settings in particular, just 20% of the students have never been evaluated in

teamwork (Fidalgo-Blanco et al., 2015b). In the LMS scenario, literature has also reported initiatives to assess teamwork competence (TWC) e.g.(Conde et al., 2016; Fidalgo-Blanco et al., 2015b; Koh et al., 2016; Sun and Shen, 2014; Tarmazdi et al., 2015).

The aim of this work goes beyond the recognition and assessment of competences or the representation of competence acquisition following a language or methodology. The idea is the definition of a tool that allows assessing teamwork competence acquisition that includes functionalities to populate a competence ontology as a result of the final process, including competence evidence as an extension of what is meant to be a competence ontology, like for instance the one proposed by (Dodero et al., 2007). This extension of the ontology was designed to be complaint with the ISO 10018. The final aim is making the whole system open for the production of Linked Data, following the path drawn by previous initiatives like (Alor-Hernández et al., 2014) including statistical aspects (Alvarez-Rodríguez et al., 2013) and focusing in the educational field in works like (Piedra et al., 2014) or more recently (Zablith et al., 2015).

The reminder of the paper is as follows. Section 2 presents state of the art. Section 3 describes the methodology employed for teamwork competence assessment and the tool developed. Section 4 presents a case study carried out to test them. Section 5 presents the results that in Section 6 are discussed. Finally, some conclusions are posed.

2. STATE OF THE ART

In order to clarify what is the research gap covered by this work it is necessary to explore two issues: 1) if there are learning analytics tools that facilitate teamwork competence assessment from and individual and group perspective; and 2) If those tools allow tagging these learning evidences and populating them into a competence ontology.

Regarding the first issue, there are several learning analytics tools that provide information about what students have done in web-based learning environments. The works by (Hernández-García and Conde, 2014) describe different categories of them. Maybe, the most employed tools nowadays are the dashboards that can be included in the LMSs. Examples are: Lenoy (2012) experiment with LearnGlass, Amo (2014) use of Google analytics to assess the time employed to complete activities or the Moodle dashboard plugin (Conde et al., 2015).

These tools gather lots of information about students' activities, but not specifically the information required to assess TWC.

There are also tools that are specially focused on the interactions of students with their peers in forums and their interaction with resources such as VeLA (Conde et al., 2014) or Gismo (Mazza and Milani, 2004) but again they are not adapted to competence assessment. Moreover there are tools that support competence assessment such as (Rayón et al., 2014; Shum and Crick, 2012) however, they do not give the teacher the possibility to label the outcomes to later be used in web of data settings. This means that there is a gap to be covered in this sense.

Regarding ontology population, literature has reported dozen of tools on the topic since the beginning of the past decade. In general they can be divided into Manual, Automatic and Semi-automatic approaches and techniques used include machine learning, semantic preferences, rules, information extraction and agents naming just some of the techniques. In general, these tools and approaches are not defined to populate competence ontologies or ontologies in the learning scenario. However, literature also reported several cases on competence management ontologies and their population (Dodero et al., 2007; Forbes and Wongthongtham, 2016; Ilahi et al., 2014; Khemaja and Mastour, 2014).

Nevertheless, to the best of authors' knowledge, none of these works are devoted to investigate competences from the viewpoint of ISO 10018 and the automatic population of ontologies taking competence evidences from the eLearning scenario. Given this context, it seems clear that there is a gap regarding the possibility to explore students' evidences by using a Learning Analytic tool and to assess and label that evidences to further populate a competence ontology.

3. METHODOLOGY AND TOOL

In this section authors describe the methodology used to assess the teamwork competence development and the tool employed to facilitate such evaluation and to produce educational data stored in an ontology.

3.1. CTMTC Methodology

CTMTC method (Fidalgo-Blanco et al., 2015a; Lerís et al., 2014) puts the focus on TWC components such as leader behaviour, cooperation between peers, problems between team members, performance of each member. It takes into account the group results and how each individual has acquired the competence. It relies on the analysis of learning evidences generated by the use of web-based learning tools during a project development (evidences such as the number of interactions, the type of interactions, when they were done, who has begun the discussions, etc.).

CTMTC is based on three aspects of group-based learning: teamwork phases (mission and goals, responsibility maps, planning, implementation and organization of documentation), collaborative creation of knowledge, and cloud computing technologies (wikis, forums, social networks and cloud storage systems) (Conde et al., 2016). Teachers continuously monitors students' collaboration and individual evidences along the teamwork phases. Monitoring also enables teachers to guide students' individual learning. CTMTC allows teachers to do partial summative assessments of TWC (Sein-Echaluce Lacleta et al., 2015).

This research work applied CTMTC methodology in several contexts and the information taken into account was related to the students' interactions with their peers and the resources during the development of teamwork phases, and the results that each team produces as evidences of the work done (the definition of a mission and goals section in a wiki, the responsibility map, the scheduling, etc.)

3.2. The tool

The application of the methodology described above requires the review of students' outcomes along with the individual activity of each member during the development of the project. As stated by (Conde et al., 2016), the problem of the CTMTC approach in normal classes is information overload. An average assessment of a normal group could be around 105 hours. In order to tackle the problem, an ad-hoc learning analytics tool was developed. This tool should facilitate the evaluation of students' outcomes and teamwork process but also should allow teachers labelling teamwork evidences by using an ontology based on previous initiatives and complaint with ISO 10018. The labelled information would populate an ontology that later could be consumed as educational data. Taking this into account, the tool should access to the information, process and show teamwork evidences and facilitate labelling of evidences and the ontology population.

Regarding the first issue, the tool is intended to access to the students' records in the LMS. This feature could be articulated in several ways:

1. Direct access to the database.
2. Standard Application.
3. Web services.

For the definition of this learning analytics tool, the latter option was used. The experiment was to be done in a Moodle 2.0 platform, so the client was developed in PHP and the Moodle Web Service Layer was adapted. Moodle includes an external library with different functions to be used by the web services, but they do not include all the required information. Thus, it was necessary to extend the external layer to include the new methods. Specifically, these methods were as follows:

- get_courses(). This method returns a list of the courses for a specific user. Per each course the id and full name are returned. This method was necessary to show the list of possible courses to analyse for a given user.
- get_forums_by_courseid(idCourse). Once a course is selected, it is possible to gather the list of its forums. The method returns a list with the id and full name of each course forum. The forum id is necessary to analyse the activity of each user and group.

- get_groups_by_courseid(idCourse). This method returns the list of defined user groups for a specific course received as a parameter. This list includes the id and the name for the group. The group id is necessary in order to analyse forum information classified by group.
- get_discussions_by_forum_and_group(idCourse,idForum,idGroup). This method returns a list with information about the discussions of a forum for a concrete group. The list contains per each discussion, the id, the name, the first_post id and the name of the author of the first post. In this way, it is possible to check if the discussion is open by student who was supposed to do so (usually the group coordinator). It should be noted that in Moodle, a forum can be shared by different groups but a discussion thread is defined for a specific group.
- get_posts_by_discussion(idDiscussion). This method returns a list of information about the posts for a specific discussion id. The information includes per post the id, title, text, author and the creation time. The id and title let us identify the post; the text makes possible to study if it can be considered as a short or a long message (an issue that can be interesting when assessing individual participation); the author id makes possible to count the number of post per user; and the creation time gives information about when the message was posted (something useful to know if the discussion was carried out during the period it should be done).
- get_posts_user_information(idDiscussion). This method returns information about the author for each of the post of a discussion. The information returned is the user id, the first name, the last name, the email and the post id. This information is used to analyse individual performance in the discussion.
- get_post_by_id(idPost). This method returns information about a concrete post that id is known. The information includes the discussion id, the date when it was created, the author who creates the post and the text of the post. This is useful when the analysis is done post by post.
- get_users_info_by_group(idCourse,idForum,idGroup). This method returns information related to the users and posts for a specific course, forum and group. The information includes user id, user full name, user email and post id.

With this information it is possible to elaborate stats about the users for a very concrete context.

- get_views_by_discussion($idDiscussion). This method provides information about the views of the posts for a discussion. The information returned is the moment in which the view is carried out, the user id and the course id. In this way it is possible to analyse not only active interactions in forums, but also when the student reads the information.
- get_views_by_discussion_and_user(idDiscussion,idUser). This method is similar to the previous one, but it returns view information for a specific discussion and user.
- get_posts_by_forum(idCourse,idForum). This method returns information about the posts for a specific forum and course. The information returned includes per post the id, the author id, the author name, the message text, when it was created, the discussion where it is included and the group associated to that discussion.
- get_users_info_by_forum(idCourse,idForum). This method returns information about the posts authors for a specific forum and course. The information returned includes per each post author, the user id, the first and last name, the email, the post id and the group the student belong to.

This set of methods is included into the Moodle external lib and it is linked to a web service provider that publishes their interfaces. These interfaces can be used by a web-client that includes a web service consumer as enunciated in (Stantchev et al., 2009).

The web service consumer should invoke the methods and gather the information. This information is processed by the web service consumer and showed in the web client.

The web client with all this information includes different information views and lists:

- List of courses with links to the specific information of each of them.
- List of forums with links to the course forums.
- Forum information. This view includes information about the number of users, posts and posts per user. There is also a list with links to the information of the

groups for the forum and course. Moreover, a list with general user information for that forum is shown (this information allow to compare the participation of students).

- Group information. This view includes information about the group, including information such as the number of messages of this group, the average posts per user, number of short messages, number of long messages, percentages of participation, etc. It includes also access to the information of each discussion and general information about each group user.
- Discussion information. This view shows general information about the participation of the students in this thread, including the number of messages per user, the author of the first and last messages, participation percentage. In addition, it includes information per group member about the participation, if the post was short or long and if the message was posted or not in a configurable period of time.

With all this information, it is possible to asses at the same time both the group activity (taking into account other groups activity) and also individual one. However, the web client should allow also teachers labelling individuals' outcomes following a taxonomy. This has three views associated:

- Assessing view. The tool allows teachers assessing a specific student or a concrete outcome by taking into account a rubric (described later). Once the evidence is assessed, it is possible to label it. Taking into account the debate on certification criterion (De Amescua et al., 2016), this is a sound way to certify competences developed.
- Labelling view. The teacher can label the evidence following a taxonomy that is based on the assessment rubric.
- Populating view. Through this view, the teacher can decide the learning evidences to populate the ontology.

The labelling and populating operations require some additional methods that are included in the web client business logic, they are:

- select_student (idCourse,idGroup). This method returns information about the student filtering by the idCourse and idGroup.
- select_outcome (idStudent, idCourse). This method returns information about an outcome for a student and a course.
- get_taxonomy_categories(). This method returns the different categories for the defined taxonomy.
- get_taxonomy_category_values(idCategory). This method returns the possible values for a taxonomy category.
- set_label (idCategory, Value, idOutcome, idStudent). This method assigns and stores a category and value to a student's outcome.
- get_labeled_evidences (idCourse). This method returned all the labelled outcomes for a course.
- get_labeled_evidences_by_student(idStudent). This method returned all the labelled evidences for a student.
- populate_evidence(idStudent, idOutcome). This method populates the ontology with evidences for specific students.

With this tool, it would be possible to assess TWC acquisition in an individual way. Moreover, it is also possible and to label competence evidences and to populate an ontology that later could be exploited in educational linked data contexts. The next section describes a case study where the methodology and the tool were tested.

4. CASE STUDY

The application of CTMTC gives us information about the acquisition of the TWC as a team and individually based on the gathered information. However, as this paper aims to produce TWC evidences that can be exploited in educational linked data contexts, it would be interesting to compare how it works in different scenarios. For example, in courses where CTMTC activities are compulsory and have an important impact in students' grade and in other subjects where the method is elective and/or it has a low weight in final grades.

In this case study, a comparison between the application of CTMTC for two courses in different contexts and with different constraints is presented. The teachers posed an activity in Moodle that should be completed in teams applying CTMTC methodology. Moodle forum was the main space for interaction. In the Moodle forum, a group member can only read messages and threads created by their group partners, and teachers may read all the messages in every group, and also read them on a per-group basis. When the interaction among students takes place in other systems, such as WhatsApp for instant messaging, students have to upload the conversation as attached files in forum posts.

Students display the outcomes of the activities by means of a wiki. The wiki is private for group members and teachers. The work done in the wiki has to incorporate the phases described in CTMTC, information about the activity and the name of the group coordinator. Each phase is associated to a particular page in the wiki and a link to the forum thread where the discussion about the issue took place. Finally, the students deliver the final result of their project through a Moodle assignment block.

In addition to these tools, it is also possible to define and change the number of students of each group, whether they are created randomly, if students can choose their coordinator, if they can choose the activity to develop, etc.

Regarding the context, the case study took place in two Bachelor courses on Computer Science. The first subject (named as SA, fictional name) is in second year course and has 110 students. The experiment is applied to an interim activity weighted with a 22% of the final grade. Students can choose their group, their coordinator and one among three possible assignments to complete the activity. Groups should have 3 or 4 members, they should interact through the forums, publish their partial results in the subject wiki and submit the final activity trough the Moodle assignment activity.

The second subject (named as SB, fictional name) is a first year course and involves 144 students. The experiment is applied to the final activity of the course. The application of the methodology is not mandatory and has associated 1 extra point to the final grade. The teams are predefined by the teachers, and they consist of 3 or 4 students. Students can freely choose their coordinator but the assignment to carry out is the same for all of them. The tools used in this case are the same than for SA except

because students used GitHub to deliver the final work and previous versions of their work.

For these two subjects, the learning analytics tools are applied and the information is gathered. Such information is assessed taking into account two rubrics based on previous applications of CTMTC (Fidalgo-Blanco et al., In press; Fidalgo-Blanco et al., 2015b; Lerís et al., 2014). The first rubric (Table 1) analyses issues related to summative assessment (evaluation of the group activity). In this case, the groups should work not only in the solution to the assignment but they should develop the solution completing the CTMTC phases. This information can be obtained from the evaluation of wikis and reading the forums and does not required the data provided by the learning analytics tool.

Table 1. – Rubric to assess group evidences

RUBRIC FOR GROUP EVIDENCES	
Mission and goals	• Is the final aim of the work described? • Is target audience identified? • Is the necessity of the work described? • Is the utility of the work described? • Is it possible to match the goals with the final results?
Team normative	• Are there rules to manage individual work in forums? • Are there communication procedures for the team to follow when an emergency happens? • Are there rules that describe what happens when team members break the rules?
Responsibility Map	• Are responsibilities distributed among members? Are team members reviewing team outcomes? • Is work equally distributed?
Planning	• Are exams, holidays, or other non-working days taken into account?

	• Are related tasks groups in milestones? • Is there a kick-off and closure date for each milestone? Are they briefly described? • Is there a work schedule? • Is work distribution realistic (more job when end is nearer) • Is there some estimated time for the review and integration of the work?
Implementation	• Is it possible to check individual responsibilities? • Is it possible to compare the implementation with the defined planning? • Is it possible to see what the team is carrying out week by week? • It should not be a copy of the work schedule.
Final outcomes	• Is it easy to access and test the final work? • Is the wiki well organized? • Do the outcomes include a descriptive 5-minutes video with the final outcome? • Do the outcomes include a descriptive 5-minutes video about how the work was carried out?

Another rubric (Table 2) is employed to assess the individual acquisition of the TWC and, in this case, the information used is the data that the learning analytics tool returns. The idea is to evaluate the evolution of the group, average interaction of its members and the level of cooperation among them, level of students' engagement with the assignment and if the leader is acting as expected.

Table 2. – Rubric to assess individual work

INDIVIDUAL WORK RUBRIC	
Responsibility and	• Is student participating actively in all discussions? Take into

engagement*	account percentage of short vs long messages. • Are the number of similar to the average number in their team (+/- a 20%)? Take also into account number of messages in other groups.
Tracking*	• Are students visiting all the threads? • Are the number of thread views near to the average number in the team (+/-) a 20%? Take also into account the average number of views in other groups. • Has this team individual threads to show a temporal description of what each team member is doing?
Discussion	• Are team members commenting and giving suggestions to help their peers?
Leadership	• Who is starting the threads? • Who is solving problems? • Who is making decisions?

*If the learning analytics tool returns information about low participation of any of the members of a team a personal analysis of work and activity would be required.

These two rubrics are used as the base for the taxonomy that is employed to label students learning evidences and that later can populate the ontology.

In order to understand how the rubric is applied, authors illustrate it with an example. For this example, group 5 of SA is explored. Results are summarized in Table 3.

Table 3 – Example of rubric application

GROUP EVIDENCES FOR Group 5					
Mission and goals	Team Normative	Responsibility Map	Planning	Implementation	Final Outcomes

9	9	8	10	9	9

INDIVIDUAL EVIDENCES FOR Group 7				
	Responsibility and Engagement	Tracking	Discussion	Leadership
S1	8.5	8.9	8.8	10
S2	9	9.2	9	10
S3	9	9.5	9	10
S4	8	10	8.5	10

The group present 9/10 in mission and goal because the target audience was not described; in the team normative is not described what happens if a member breaks the rules; the grade for the responsibility map is 8/10 because it is too generic; regarding the planning (10/10) it is very well detailed, tasks and milestones are properly described and scheduled; at the end, the final outcome for this group has grade of 9/10 because they have not included a video describing the process or the results.

Regarding the individual evidences, the learning analytics tool provides the average number of messages for the group, the average number of views, who has written the first and last messages of each discussion, when are posted published, etc. With this information it is possible to see that this is one of the groups with a higher participation. The students with a higher number of messages have a better grade in engagement, for tracking the number of views is taken into account. Regarding the participation in discussion, the forums are explored and also the number of short messages is checked, (if they only use short messages their participation in discussion is being poor). Regarding leadership, it is possible to explore by using the learning analytics tool who has opened the discussion. In this sense to alternatives are possible, on the one hand that the coordinator opens and control the threads; on the other, the tasks were distributed and each member of the team opened the threads related to

the tasks she was developing. This last option was better valued by teachers, and it is what has happened for group 5.

This was done for each group with a considerable reduction of effort and time. By using the learning analytics tool and these rubrics, the time to evaluate a group was around 20 minutes for one summative and two formative assessments. Anyway, the summative assessment requires also to evaluate the final outcome of the assignment and not only the methodology.

Once the evidences were assessed, it is possible to label them by using the taxonomy and the web client. The teacher can select S1, all evidences of this student would be returned. One of them could be selected and labelled, for instance the teacher can select the subcategory responsibility in the category individual performance and assigned a value based on the number of posts. Later on, the teacher can populate the ontology with this methodology or do it in another moment. The teacher can also select an evidence to label it and the results for all the students will be shown.

5. RESULTS

In order to understand the methodology success and the utility of the learning analytics tool, the two previously mentioned subjects were compared. In order to do that, we compared three issues: the information returned by the learning analytics tool; the obtained students' grades from the group and individual evidences (evaluated following the previously described rubrics taking into account students and groups results for teamwork phases); and the self-perception of students about the acquisition of TWC using Team Work Behaviour Questionnaire (TWBQ) (Tasa et al., 2007). This information is going to be analysed quantitatively and in order to support some conclusions a qualitative study is carried out to analyse teachers' perception about the tool.

The sample for this experiment is composed by 254 students, 110 from the SA and 144 from SB. Ages of this students are between 18 and 23; the 78% assert in a questionnaire previous to the beginning of the classes that they have carried out an

activity in teams. The qualitative analysis is performed taking into account the perceptions of 6 teachers, 3 from SA and 3 from SB.

As commented above, the first issue to explore is the information returned by the learning analytics tool.

Table 4 presents some general information about each subject, including number of students, number of students that participate in the methodology, number of possible groups, number of discussion per effective group, number of post per user, messages per user, average group grades (obtained by applying the rubric to asses group evidences – Table 1), average individual grade (obtained by applying the individual work rubric – Table 2)..

Table 4. - Stats returned by the learning analytics tool about subjects SA and SB

	St. Num	**Part. Num**	**Group Num**	**Discussion Group**	**Av. Post (Std. Dev)**	**Av. Views (Std. Dev)**	**Av. Group Grade (Std. Dev)**	**Av. Ind. Grade (Std. Dev)**
SA	110	106 (96.36%)	28	8.57	14.36 (0.946)	105,85 (6.811)	7.54	7.54 (0.162)
SB	144	98 (68.05%)	35	1.40	4.24 (0.553)	47.28 (5.100)	4.53	3.61 (0.315)

In Table 4 is possible to see that the sample is similar but the number of active users is less in SB. This is because it is an elective assignment. The groups present the same number of students (3 or 4) but in SB the members of each team are predefined. Some of SB groups have not any active interaction. Regarding the discussion per groups, the posts per user, the views per user, the long and short messages, there are clear differences between both subjects. In the average grade for the group and for each student also there is an important difference.

In order to explore these outcomes, more details are needed. Table 5 includes stats for SA. The table presents number of students, discussions, short and long messages per group and also the grades for the group and the average grade for each member.

Table 5. – Stats related to subject A

	Students	**Discussions**	**Short Posts**	**Long Posts**	**Views**	**Team grade**	**Ind. Av. grade**
SAG1	3	11	17	45	474	8.83	9.16
SAG2	4	14	20	75	662	9.16	9.18
SAG3	4	7	24	26	344	6.83	7.43
SAG4	4	6	15	25	293	8	7.06
SAG5	4	8	11	53	549	9	9.43
SAG6	4	8	24	66	644	8	9.46
SAG7	4	11	22	26	294	9.25	7.40
SAG8	4	7	13	18	210	3.83	6.90
SAG9	4	9	13	22	320	9.5	6.90
SAG10	3	5	18	8	219	5.75	5.58
SAG11	4	11	70	87	932	9.33	9.53
SAG12	3	6	8	14	177	7.5	6.79
SAG13	3	10	9	78	636	8.33	9.25
SAG14	4	10	34	26	478	9.33	7.34
SAG15	4	16	22	54	543	8	7.78

SAG16	3	6	23	24	278	8.33	8.20
SAG17	4	7	28	13	299	6.66	6.28
SAG18	4	7	21	56	638	9.5	9.84
SAG19	4	9	15	14	155	7,33	4.56
SAG20	3	9	8	35	317	6	7.66
SAG21	4	11	17	20	289	8	7.18
SAG22	4	5	11	17	171	5.5	6.5
SAG23	4	7	5	48	561	6.5	8.75
SAG24	4	6	9	20	178	3.5	5.81
SAG25	4	8	13	23	346	8.83	5.53
SAG26	3	4	11	6	81	1.33	4.87
SAG27	4	17	46	45	720	8.83	9.34
SAG28	4	5	21	29	412	9	7.81

Table 6 shows the same information that Table 5 but for SB.

Table 6. – Stats related with subject B

	Students	**Discussions**	**Short Posts**	**Long Posts**	**Views**	**Team grade**	**Ind. Av. Grade**
SBG1	4	5	11	15	311	5.6	7.5
SBG2	3	7	7	12	184	5	5.66

SBG3	4	0	0	0	13	5.6	2.5
SBG4	4	5	13	27	354	6.6	7.25
SBG5	4	9	15	5	229	5.1	5.5
SBG6	4	4	6	8	221	7.7	5
SBG7	4	4	7	7	169	4	2.75
SBG8	4	8	11	7	191	7.7	4.25
SBG9	4	7	3	14	113	3.8	1.75
SBG10	2	1	0	1	8	0.8	0
SBG11	4	5	5	10	137	6.9	1.5
SBG12	3	5	9	12	289	6.2	6
SBG13	4	5	8	20	495	8.2	2.75
SBG14	4	3	9	6	97	5.6	1
SBG15	4	6	10	23	355	6.9	6.75
SBG16	3	3	4	4	123	6.4	4.66
SBG17	3	5	15	12	174	6.4	6.33
SBG18	2	2	0	3	63	4.2	1
SBG19	2	0	0	0	35	0	0
SBG20	4	2	10	7	376	4.6	7.75
SBG21	4	2	4	2	29	3.2	6.25
SBG22	4	6	11	9	298	6.6	4.3
SBG23	3	3	5	5	113	4.6	1

SBG24	3	1	0	2	33	0	1
SBG25	3	1	1	1	38	4.8	1
SBG26	3	0	0	0	10	0	1
SBG27	2	2	2	2	62	0.2	1
SBG28	3	2	4	2	83	5	1
SBG29	3	3	1	9	138	4.6	4.33
SBG30	4	1	8	5	155	2	3.5
SBG31	1	7	3	8	141	4.2	3.66
SBG32	2	0	0	0	18	5.6	1
SBG33	1	0	0	0	28	1.2	1
SBG34	4	20	33	35	437	8	5.25
SBG35	3	4	2	2	59	1.4	1

While in Table 5 all groups have interactions, it should be noted that in Table 6, six groups have not active interaction.

From this information, teachers have labelled 63% of students' evidences (43% from SA and 20% from SB). 45.5% of the labelled evidences belong to good practices with a positive grade and the rest to store bad practices that can be taken into account in other contexts when assessing TWC acquisition.

It is interesting to explore possible correlations between students' actions and individual grades. Before any correlation test a normality test is required. The Kolmogorov-Smirnoff test was selected because in both groups n>50. This test returns that, in both courses, the distribution is not normal for the variables that were to be compared.

Table 7. – Normality test

Tests of Normality

	Group	Kolmogorov-Smirnov[a]		
Posts	SA	0.116	106	0.001
	SB	0.240	118	0.000
Views	SA	0.107	106	0.004
	SB	0.202	118	0.000
Ind. Grade	SA	0.101	106	0.010
	SB	0.362	118	0.000

a. Lilliefors Significance Correction

Taking into account the values are quantitative, authors applied a Spearman's rho test between posts and grades and views and grades for both groups.

Table 8- Correlation test for post/individual grade and views/individual grades

	Posts / Indv. Grade	Views/Indv. Grade
SA	0.851*	0.817*
SB	0.635*	0.807*

Signification < 0.01

There is a significant correlation between posts and grades in both cases. However, this correlation is not so strong in the SB subject. Regarding the views, the correlation seems to be very similar.

In order to explore the success of the methodology, the students' perception about TWC acquisition is studied before and after the course is carried out. Specifically, TWBQ is used to do this. Students are asked to score several items regarding their TWC development and the other members in their teams. To do so, a 7 value Likert scale was used. Table 8 shows the results for the two courses before and after the experiment.

Table 9.- Average values for TWBQ

	SA	SB
Self-Before	5.19 (0.078)	4.98(0.080)
Self-After	5.44 (0.070)	5.05(0.097)
Others-Before	5.03 (0.098)	5.07(0.077)
Others-After	5.27 (0.115)	4.71(0.126)

It is interesting to compare self and others perception before and after the experience. To this aim, first normality is explored to define if parametric or non-parametric test can be applied. Normality is explored applying Kolmogorov-Smirnof tests. Signification for each subject is shown in table 10.

Table 10 – Normality test (Kolmogorov-Smirnof) for average values

	SA - Signification	SB - Signification
Self-Before	0.200	0.001
Self-After	0.200	0.047

Others-Before	0.008	0.014
Others-After	0.035	0.001

All distributions are not normal for both subjects except self and after perception for SA. In those distributions that are not normal, it is indicate to use Man-Whitney U test to compare values. In the case of normal distributions, Student's T Test is used. In these tests the null hypothesis is that the compared groups are similar and if signification is under 0.05, this hypothesis is rejected. The results obtained can be seen in Table 11.

Table 11 – Comparison before and after the experience

	t	Sig	U	Sig
Self (Before vs After) SA	-2.302	0.022		
Others (Before – After) SA	-	-	4121.0	0.040
Self (Before vs After) SB	-	-	4834.0	0.356
Others (Before – After) SB	-	-	4453.5	0.068

From Table 11 it is possible to see that null hypothesis is rejected for the comparisons related to students' perception in course SA. That is, there is a significant difference in the self-perception about the acquisition of TWC in SA subject and also regarding perception about partners' development of such competence. However, in course SB null hypothesis cannot be rejected and the perception is the same for both groups.

Finally, another interesting issue is analysing teachers' perception about the methodology and the tool. In order to gather this information, teacher filled a questionnaire with 2 open questions:

- Q1. What are the main advantages and drawbacks of the methodology?
- Q2. What are the main advantages and drawbacks of the tool?

The gathered information is analysed following a qualitative methodology. The qualitative analysis consists of an examination of the text from the responses given by participants (Miles and Huberman, 1994). This procedure includes grouping responses based on topic-proximity criteria for Q1 and Q2. After classification, authors combined the results in a matrix in order to extract conclusions. The results of this analysis are shown in Table 12.

	Met. Advantages	**Met. Drawbacks**	**LA Tool Advantages**	**LA Tool Drawbacks**
T1	Flexible	Not all interaction explored	Reduce effort	None
T2	Project Management	Lot of work for reduced assignments	Information at a glance	Other representations
T3	Use existing material	None	Easy to track and compare outcomes	Explore instant messaging
T4	Easy to apply	Continuous tracking	Time saving	Integration institutional LMS
T5	Portable	None	Objective data without errors	None
T6	Manage their work	Evaluation without tool	Store and labelling	More interaction with data

Table 12 summarizes the teachers' perception about the methodology and the tool. Regarding the methodology, the teachers see it as something easy to apply, portable and flexible and can be easily applied in the context of the web of data. Moreover CTMTC is aligned with a project management methodology that can be useful for them. Sample also point out some problems of the methodology such as the effort required to track students' activities without a learning analytics tool and that it is not possible to analyse all the students' interactions (for example what they have discussed in face-to-face meetings).

When talking about the tool, they make special emphasis in the time saving and effort reduction and that it is possible to have all the required information for assessment at a glance. One of the teachers view as the tool useful in order to label and to store learning evidences. Regarding the drawbacks, teachers would like more friendly and interactive representation of information. Moreover, some of them have had problems to integrate this tool with their subjects because the university did not allow it.

6. DISCUSSION

The perception of educational linked data is associated to some challenges such as: integrating distributed data from heterogeneous educational repositories, manage continuous change, metadata mediation, etc. (Dietze et al., 2012). Most of these challenges are related to the connection of educational resources. In this sense, students' interaction can be an interesting educational resource (Abernethy et al., 1999; Foster and Rosenzweig, 1995) and learning analytics tools can help to obtain knowledge from this kind of information.

With this aim in mind, our experiment was carried out. It aims three things: 1) showing the information that the learning analytics tool can provide to teachers and how it works in different educational contexts; 2) showing the flexibility of an educational methodology to develop teamwork competence in different contexts; and 3) showing

that students' learning evidences are produced and stored in order to be later consumed.

Regarding the first goal of the experiment, the tool provides valuable information about what the students and the groups have done. In this way, it is possible to evaluate their results and to compare if there are differences between the application of the methodology in a compulsory assignment with a representative weight over the final subject score or an elective assignment with lower impact in final grades; in Tables 4, 5 and 6, it is possible to see these results. The participation, the number of discussions and post employed are lower in the optional subject, something that can be related to the low weight of the task in the final grade. Also, grades are worst for the course with the elective assignment, a fact detected in the literature revealing that motivation for results is higher in compulsory activities than in elective activities (Pérez-Martínez et al., 2014). It is also noticeable the percentage of information labelled and populated: 63% of the evidences with a higher percentage of labelled information in SA. The interesting thing in this case is that the learning analytic tool lets track what students are doing or have done and generates knowledge to be used in other educational contexts. In fact, the teachers are quite satisfied with the tool, as they reported in the qualitative analysis, because it saves a lot of time, although it can be improved with new representations. They are also worried about the problems they have found for the integration of this kind of tools, something common because institutions do not facilitate the of access to the stored information (Mott and Wiley, 2009; Piscitelli et al., 2010). As described in section 2, there are other learning analytics tools designed to explore LMS logs, but they are not adapted to TWC development assessment taking into account both the group and the individual. In addition, there are not tools that give the teachers the possibility to label the outcomes to later be used in web of data settings.

Other issue to take into account beyond how the tool is perceived, it is whether the methodology works properly in different environments. Given the two different contexts that we have, where the methodology is applied in different ways, we can check the methodology efficiency by exploring two issues: performance indication

(post and views correlation with individual grades) and self-perception about TWC development.

Post and views correlation has been previously studied (Agudo-Peregrina et al., 2014; Fidalgo-Blanco et al., 2015b), however the key element in this case is to test if it works in the same way for the same methodology in different contexts. Table 8 shows that there is a significant correlation between posts/views and individual final grades, so the students' passive or active interactions have impact in individuals grades independently on the context. This means that independently of the context, a high active or passive interaction in teamwork activities used to be associated to the students' performance, and, therefore, could be an indicator to take into account to assess TWC acquisition. This can be taken into account when analysing the use of educational resources and the interaction that takes place in the web of data.

Regarding the self-perception of TWC development, previous works have explored this by using TWBQ with different results. In (Pérez-Martínez et al., 2014) several subjects TWBQ results are compared in order to see how specific training improves students' teamwork capacity. Other works such as (Garcia-Martin et al., 2013) also use TWBQ but do not find differences in teamwork acquisition before and after the application of two methodologies. In this case, a comparison has been also done. For the compulsory assignment there is a significant difference in both the self-perception of TWC and when students explore their partners TWC competence. This means that perception of teamwork competence acquisition has changed after the application of CTMTC. When exploring this in elective assignment with a low participation, there are not differences before and after, which means that as their motivation was not the same the TWC development has not been increased.
Also when talking about the methodology, it is interesting to explore teachers' perceptions. For them, it is a valid tool to apply in different contexts, flexible and portable. However, without the learning analytics tool, this application requires lot of effort by teachers.

7. CONCLUSIONS

This paper has explored a field that requires special attention: competence recognition and assessment. Competence recognition has a special value in business and it is very necessary to define tools that really allow showing the acquisition of a competence. In this case, it is aimed is to provide a learning analytics tool that helps teachers apply competence assessment methodologies in different contexts. However, the interesting thing here is not only to give teachers the data they need to assess a competence

acquisition but also to give them tools that allow producing learning resources based on students' experiences that can be used in educational linked contexts.

In order to do so, we have focused our efforts in the definition of a learning analytics tool that analyses the students' evidences related to TWC development. The tool gives support to a well-known and flexible evaluation methodology called CTMTC. But the tool goes also beyond this, it includes functionalities to label the students learning evidences and to populate with the results as an ontology adapted from previous works and extended to support ISO 10018.

After this experiment, it was possible to see that the tool and the methodology work properly in different contexts, they help teachers saving lot of time for them and they allow the definition of new educational resources based on learning outcomes.

It was also detected an important issue related to confidentiality. The populated results can be used as learning resources without students' associated personal data, however in this case the evidences could not be employed in other contexts, such as in subjects to know what the students know or in companies to know their staff capacities. That is, in order to guarantee the portability and value of the populated evidences it is necessary to include personal information and confidentiality problems should be addressed. This problem is not new, but is hard to solve. For example, TRAILER project (García-Peñalvo et al., 2013) aims to tag, recognize and acknowledge informal learning evidences, but it is the student who decides the information to share. In this case the teacher decides the evidences to label and store so, an interesting challenge can be how to deal with this problem.

As future research work it would be also interesting to improve the tool including the analysis of students' discussions in instant messaging tools such as WhatsApp or multi-device contents (Vásquez-Ramírez et al., 2014a, 2014b) and providing new ways to represent the information. The labelling tool should support other taxonomies beyond the defined from the CTMTC rubric and the population tool other OWL-defined ontologies.

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