Study of the flexibility of a Learning Analytics tool to evaluate teamwork competence acquisition in different contexts

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Abstract. Learning analytics tools and methodologies aim to facilitate teachers and/or decision makers with information and knowledge about what is happening in virtual learning environments in a straightforward and effortless way. However, it is necessary to apply these tools and methodologies in different contexts with a similar success, that is, that they should be flexible and portable enough. There exist several learning analytics tools that only works properly with very specific versions of learning platforms. In this paper, the authors aim to evaluate the flexibility and portability of a methodology and a learning analytics tool that supports individual assessment of teamwork competence. In order to do so the methodology and the tool are applied in a similar course from two different academic contexts. After the experiment, it is possible to see that the learning analytics tool seems to work properly and the suggested new functionalities are similar in both contexts. The methodology can be also applied but results could be improved if some meetings are carried out to check how team works are progressing with their tasks.

Keywords: Learning Analytics tool, teamwork competence, participation, forums

1 Introduction

Nowadays we live in the digital society. Lot of our daily activities are mediated by the technology. We use the Information and Communications Technology (ICT) anywhere and anytime and with different proposes. For instance, we use them to work, to access to the information, to play games, to see music or films, to learn, to interact with others, etc. For most of these activities the technology is also recording information about what we are doing (not always with the user awareness or consent), and this information can be later analyzed for making decisions [1].

When talking about the application of ICT in learning contexts, and from a formal learning perspective, most educational institutions are providing students with tools such as Virtual Learning Environments (VLE) and/or Learning Management Systems (LMS) [2, 3]. These platforms facilitate spaces with tools that extend and give support to the traditional concept of a class, because they are mostly centered in helping the teachers, due to their emphasis on facilitating administrative and management work relative to learning (which includes tools for document management, questionnaire correction automatization, discussion spaces, etc.) [4]. For students, they constitute spaces where they can carry out their lecture activities or with which they can complement their classes. For these reasons VLEs and LMSs has been widely accepted both by education institutions [2, 5, 6], and in businesses [7].

These platforms generate a great amount of information, and dealing with it and extracting useful knowledge from that data, is not easy. It is necessary to apply methodologies and tools that allow having knowledge about students' effort and competence development, about how resources are being used, which are the moments of highest activity in the platform, the impact of some contents in students' performance, teachers' performance, etc. [8, 9]. Those methodologies and tools are given by what is known as Learning Analytics and other disciplines such as Educational Data Mining and Academic Analytics.

Learning analytics is a research field devoted to understand how learning took place online [10]. 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 [11]. According to [12], 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 improving learning via the interpretation and contextualization of educational data [13].

Given this context and the different possibilities provided by learning analytics, we should explore the problem we aim to address. In this case, the issue to analyse is the individual assessment of teamwork competence (TWC). The development of this competence is highly demanded by employers [14, 15] and is supported both by policy makers [16] and by higher education institutions [17]. But why is TWC so appreciated? Because: 1) teamwork involves sharing of information and discussion among students to build mental models in a cooperative way, ultimately contributing to the improvement of students' learning [18, 19]; 2) companies seek that prospective employees have developed the TWC because members of an organization are working together in

groups to achieve common goals [20]; 3) the application of the Bologna process positions TWC as a key competence that students should develop in Higher Education.

Learning platforms may provide us with evidence about the development of teamwork competence by students. However, lots of time are required to evaluate this competence acquisition from this data so we need two things: a methodology to assess TWC development and a learning analytics tool [21].

Regarding the former, for this research work we have used CTMTC (Comprehensive Training Model of the Teamwork Competence). It explores the group results and how each individual has acquired the competence. The methodology relies on the analysis of learning evidence from data generated by the use of IT-based learning tools by student teams during a project development [4]. Moreover CTMTC application entails that teams develop the project in several stages adapted from the International Project Management Association (IPMA) [22].

In relation to the latter, that is, the learning analytics tool, there exist several options. It is possible to use some of the existing the cross-platform and platform-specific general purpose dashboards (Moodle Dashboard, Google Analytics, etc.). or learning analytics frameworks (GISMO, VeLA), but in this case, they are not adapted to the methodology and would mean that teachers should carry out an extra effort. In this sense it is better to develop an ad-hoc tool [23]. For CTMTC an ad-hoc learning analytics tool was developed and successfully applied in several experiments but in specific environments [21, 24, 25]. For instance it was used in 7 different courses of the University of León [26].

In this project, what we aim to check is the differences between the application of this tool in two different universities in two courses with similar aims, contents and students. From the experiment our goal is to know how flexible the CTMTC methodology and the learning analytics tool are. We also aim to check what happens with students grades when we define some on-going interviews during the methodology application to see groups progress and without them.

In order to achieve this the paper is structured as follows. In next section, we introduce the methodology CTMTC and describe briefly the tool. In Section 3 we present the experiments carried out. Section 4 shows the results obtained that are discussed in the following section. Finally, some conclusions are posed.

2 Background of the research

In this section, we describe the CTMTC methodology and the learning analytics tool to facilitate understanding the experiment.

2.1 CTMTC Methodology

CTMTC method [27, 28] puts the focus on TWC components such as leader behaviour, cooperation between peers, problems between team members and performance of each member. It takes into account the group results and how each individual has acquired the competence.

CTMTC is conceptually based on the phases described by Bruce W. Tuckman [29] and used by AIEIPRO-IPMA [30] and MIT [31] as a helpful framework for recognizing a team's behavioral patterns and to assess the development of teamwork competence. The defined stages were: Forming, Storming, Norming and Performing.

For each stage CTMTC defines a set of individual evidence that each group member should achieve. These evidence are generated by the use of web-based learning tools during a project development and can be exploited by a learning analytics tool [32]. The evidence evaluated for each of the stages are the following:

- Forming. This phase consists of the definition of the working team, which can be defined by the teachers, by the students or automatically depending on the students' profiles. The evidence is in this case the team defined.
- Storming. It consists of the definition of mission, goals, target audience, purpose and the reason to develop the work. In addition, it requires also the definition responsibilities for each team member. The evidence in this case is the description of this information about the project development.
- Norming. It is based in the definition of a set of norms to be applied by the team members in order to develop the project. The evidence are the normative and the interactions to define it.
- Performing. In this stage, each team should define a tracking map to know when each member has completed a task. This includes the distribution of tasks, scheduling, definition of milestones and indicators to know when they are achieved. These elements can be used as evidence and also the interactions required to define them.
- Final process. It is not included in Tuckman stages. However it is very used in academic contexts. It consists of the the final outcomes of the project.

However, CTMTC and other similar ones, on their own, are not completely effective. The reason is that monitoring individual evidence in the teamwork and evaluating its performance requires a great deal of time for the teaching staff (the effort should be multiplied by the number of students), because monitoring and assessment (formative and summative) of the individual evidence require a qualitative analysis of all of the interactions in the forum (what students say, how they say it, and when they say it) [21].

2.2 The Learning Analytics tool

In order to facilitate the application of CTMTC an ad-hoc Learning Analytics tool was developed. This tool aimed to facilitate accessing to the information stored into Moodle logs. This information would be used to analyze the evidence required for each of the stages described above. It should be noted that the tool is not focused in what we defined as group evidence, that can be checked by assessing the results published in the Wiki, but to explore the students' interactions carried out to achieve that results.

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

Regarding the implementation, it is necessary to take into account that 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) Define a standard extension or plug-in for the LMS; 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 would be also necessary in the tool. 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 [33], which solve the problems previously mentioned.

Once this was decided Moodle web service layer was used to access information and some additional functions were added to Moodle External Layer, so logs could be accessible. This was necessary because Moodle did not make accessible the information that we need to access by using the web service. In addition, the definition of the web service client was necessary in order to access the information without login into Moodle. More information about the connection of the tool to Moodle, the changes made in Moodle external layer and the client can be found in [21, 32].

With regard to the functionalities of the learning tool, it is necessary to explore the information that the web services client provides to the user and how it is represented.

Fig 1. shows the different navigational contexts. These are:

- Courses context. When the users access to the client they can see a list of the available courses in the LMS explored, the name of each of them is a link that lead to the forums view.
- Forums context. It includes a list of the existing forums in the course. Information about each of them could be obtained by clicking in the forum name, which would lead the user to the groups context. It is also possible to navigate to the previous context.
- Groups context. For a specific forum, it provides information about the number of posts, users and posts per user. Moreover, it includes two lists one with information about groups and other with information about students involved in the forum. The first list includes the name of the groups with a link to the groups context, the number of messages of each group (and percentage regarding the total of number), information about the number of long and short messages and about the number of students in each group. The second list shows the same information but per student.
- Discussion threads context. When clicking in one group it is possible to access to this context. In it the user can see general information about the group messages (short, long, number, first and last post author and date) and two lists. The first have information about the discussions for this group and forum. For each one, it is possible to see when it was created and the distribution messages and views of the students in this thread. The thread name can be clicked which will lead the user to the posts info context. The second list includes information about the students of the group. Fig 2. shows and example with the discussion threads context.
- Posts info context. It includes general information about the specific thread messages (short, long, number, first and last post author and date) a list and a form. The list shows the students involved in the discussion and information about the messages

and views for each of them. The form allows defining date ranges to see what messages where posted out of dates.

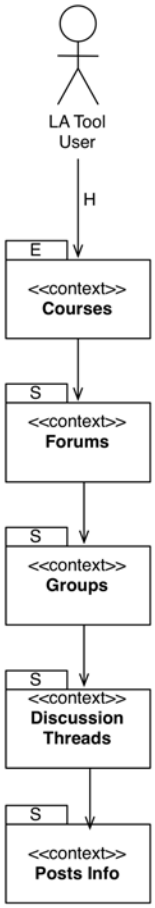

Fig. 1. OOWS Navigation Map [34] for the Learning Analytic tool

3 The experiment

The tool and the methodology have been tested in different contexts as described in the introduction. However, those experiments were carried out into a single educational institution, and in several cases in different courses. From these experiments, it was possible to say that the methodology and tool can be easily adapted to the course context and particular features. In this work, our idea was to compare what happens when we applied the methodology and tool in similar courses of different institutions. In this section we describe how this was carried out.

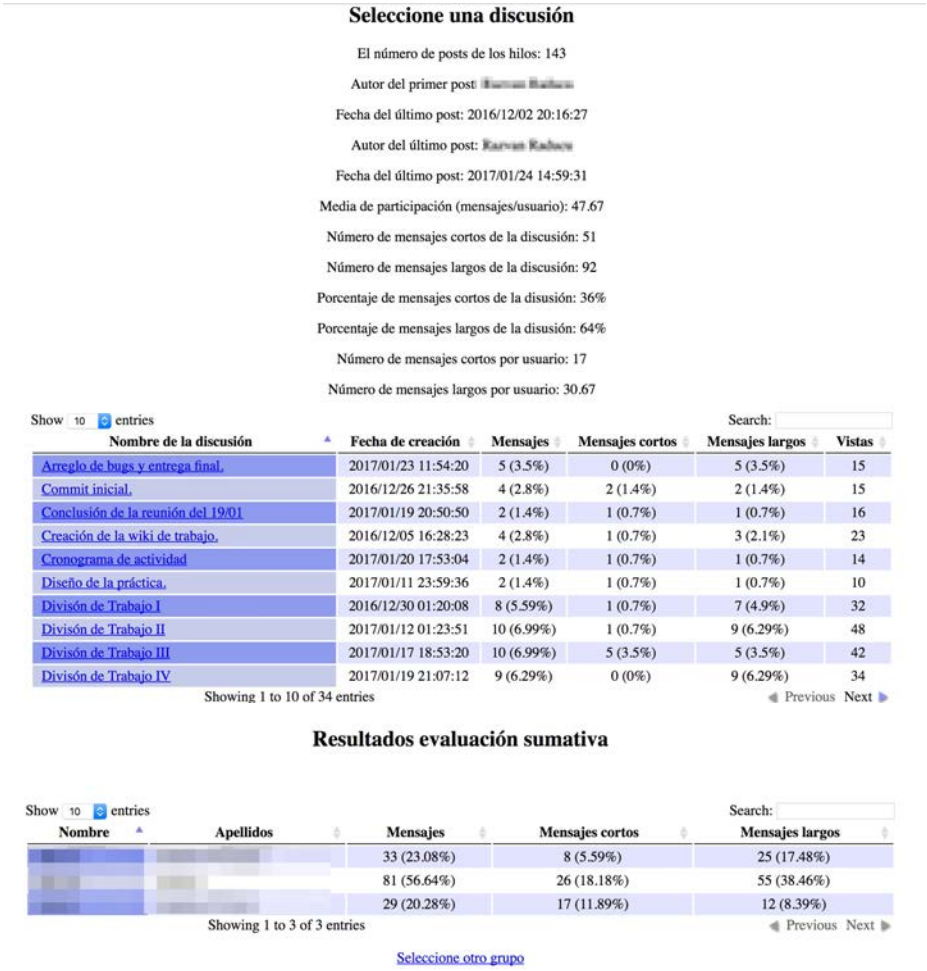

Fig. 2. Group context view of the Learning Analytic Tool

3.1 Context of the experiment

The experiment was carried over two different courses, one from the University of León and the other from the Universidad Politécnica de Madrid in Spain. These courses were:

- S1. Informatics. This is a course of the first course of Bachelor of Science on Electronic Degree of the University of León. It has 70 students. In this course students learn programming concepts by using C language. The course has an intermediate assignment to which CTMTC is applied. This assignment has a weight of the 24% over the final grade. Although choice of team members and coordinators is open, the group must choose one of the three possible topics for the work. Groups have 3 or 4 members, who use the LMS forums to interact between them; additionally, some of

the students also use instant messaging tools such as WhatsApp. Each group publishes its partial outcomes in the LMS wiki and delivers their final outcome using Moodle LMS assignment block.

- S2. Informatics and Programming. This is a course of the first course of Bachelor of Energy Engineering of the Politechnical University of Madrid. It has 186 students enrolled in the course. In it, students learn algorithm and programs fundamentals. The course has an assignment to which CTMTC is applied with a weight of 15% over the final grade. Students could choose a team up to a deadline. After that, teachers will define groups with the unassigned students. Team members choose their leader. Groups have from 5 up to 7 members, who use the LMS forums to interact between them. Each group publishes its partial outcomes in the LMS wiki and publish their final outcome in a web and produce a video presentation of their work.

For the assessment of the results a rubric described in [32] is used. It explores both individual and group outcomes.

3.2 The method

In order to explore the possible differences between the application of CTMTC and the Learning Analytics tool we decided to use a mixed methodology [35], that consists of a quantitative and a qualitative analysis.

First, quantitative data from application of CTMTC and the learning tool is compared between both case studies. We check the participation, the grades for individual and group works and the number of posts/discussions per student. This information can be seen in tables 1 and 2.

Next, two satisfaction questionnaires are carried out. They collect teachers' and students' perceptions. Teachers' perceptions are related to the learning analytics tool and the methodology, and students' perceptions are related to the methodology, because they did not interact with the learning analytics tool. The information gathered through the satisfaction questionnaires is analysed following a qualitative methodology. The qualitative analysis consists of an examination of the text from the responses given by participants [36]. This procedure includes grouping responses based on topic-proximity criteria for both involved courses. After classification, we have combined the results in a matrix in order to extract conclusions. We had 8 teachers involved in the experiment and matrix about their perceptions can be seen in Table 3. On the other hand, we should consider more than 250 students. The representation of a matrix with 250 rows is quite difficult to read, so we have taken a sample of 30 students for this analysis (15 per course) with the most relevant results (Table 4).

4 Results

The results are shown in this section following the methodology mentioned above. Firstly, it is possible to see general information about the students involved in the experience and their actions (Table 1). In such table, it is possible to see that there is more

participation in S1 than in S2 and also a higher number of students' interactions. Regarding the groups also there are more groups in S2 than in S1.

Table 1. Information about participation, activity and number of groups

	Number of Students	Average Number of actions/user	Number of Groups
S1	64/70 (91.42%)	607.5	23
S2	177/186 (95.16%)	645.2	32

Without the use of the learning analytics tool a manual inspection of each group's activity takes between 40 minutes and 1 hour (this time does not include assessment) [24]. This would mean between 15 and 23 hours to check S1 and 21 and 32 hours for S3. By applying the learning analytics tool 12 minutes were needed per each group. That is, around 4 hours for S1 and 6 hours and a half for S2.

Table 2 shows the results attending to number of posts, average individual grade and average group grade.

Table 2. Information about CTMTC methodology application

	Post/User	Average Group Grade	Average Individual Grade
S1	16.2	7.08	6,80
S2	25.5	8.26	8.56

Results from tables 1 and 2 were obtained from the information gathered by the learning analytics tool.

The information about teachers' satisfaction about the tool and methodology can be seen in Table 3. In this case, the categories chosen to group terms of the open questions were the LA tool, the methodology and problems found with both. Results can be seen in Table 3.

Table 3. Teachers perceptions about the methodology and tools

	LA Tool	***Methodology***	***Problems***
S1 T1	Cool	Some students did not apply it	Lack of interest of the students
S1 T2	More information	Allows us to objectively measure individual TWC	None
S1 T3	Time saving	Students do not understand how important is interaction with their peers	Access through the tool the specific information about one student
S1 T4	Very useful although interface should be improved	Students do not like to use Moodle forums	Warnings about students' application of CTMTC
S2 T5	Check CTMTC indicators effortlessly	Students learn to work in groups	Include whatsapp analysis
S2 T6	It can be improved with a warning system	It allows students to know how to deal with real projects	Individual information in the tool
S2 T7	All the information at a sight	Something to assess what each one does in a group	None
S2 T8	Include leadership indicators	It allows TWC development	None

Table 4. Students' perceptions about advantages and problems of CTMTC and the tools used to apply it

	Advantages	***Problems***	***Tools***
S1 ST1	None	Problems with other group members (distribution of tasks)	None
S1 ST2	Planning and deadlines	Implication of other	Whatsapp
S1 ST3	Organization improvement	Randomly defined groups	None
S1 ST4	Work as a team	Distribution of tasks	None
S1 ST5	Work organization	Lack of interest of peers	Instant messaging
S1 ST6	Distribute work to achieve our goals	Problems with coordination to integrate the parts	None
S1 ST7	Deadlines, work distribution, work together	None	None
S1 ST8	Leadership, Agile methodology, tracking tools	Coordination problems	Dropbox
S1 ST9	Good distribution of tasks	Integration is not always easy	None
S1 ST10	We are best working as a team	None	Whatsapp
S1 ST11	Work together and that my work was assessed	Coordination	None
S1 ST12	Work with peers	Communication tools	Whatsapp
S1 ST13	Goals and deadlines	None	None
S1 ST14	Better planning	Work completion	None
S1 ST15	Collaboration with peers	Necessity of using forum	Trello
S2 ST1	Organization	None	Redmine
S2 ST2	Coordination	Communication is not straightforward	Whatsapp
S2 ST3	Planning and scheduling	Complete your tasks	Tools for scheduling
S2 ST4	Tasks distribution	None	None
S2 ST5	None	Maintain motivation	Skype
S2 ST6	Working together	Deal with team members' capabilities	Whatsapp
S2 ST7	Making decisions as a group	None	None
S2 ST8	Distributed leadership	Coordination problems	Video editing tools
S2 ST9	Dialogue to find solutions	Communication	Skyke, whatsapp
S2 ST10	Constructive criticism	Moodle forums	Whatsapp
S2 ST11	Distribution of tasks	Implication of peers	None
S2 ST12	Work organization	Discussion with the others	Whatsapp
S2 ST13	Improvement in problem solving	Deadlines stress team members	None
S2 ST14	Improve our work	None	None
S2 ST15	Support others work	Tracking with other members have done is not easy	Control Version System

5 Discussion and conclusions

During the experiment carried out it was possible to explore two different issues: results related to the application of the methodology, that can easily be analyzed and compared thanks to the application of the Learning Analytics tool and perceptions about the tool and the methodology.

Regarding the first issue, the learning analytics tool provides us information about the students and group interactions while applying CTMTC (number of messages per student, short messages, long messages, messages per group, distribution of the messages between team members, number of views, etc.). Taking into account that such indicators have been shown to be related with students' performance [21, 37] and with the application of a rubric [32] it is possible to observe the individual and group grades obtained when developing the tasks applied during the project.

For the present experiment and the data shown in Table 1 it is possible to say that there is a slightly higher participation in S2 than in S1 with also a higher number of interactions per user. This can be motivated because in S2 this is the third year of the application of the methodology with good results while in S1 is the first edition. However, there is also an interesting difference between the number of messages posted by students of S1 and S2. This use to be an indicator of students' performance and it is possible to see better individual and group grades for S2 students than for S1. This difference can be motivated because in S1 there were not checking meetings to know what groups were doing, so no corrective interventions can be applied; while for S2 there were two of these meetings. This means that the application of the methodology does not only require a good description of what to do, but also checking groups progress in the application of the methodology.

We should also attend to the time necessary to check each group activity, between 40 minutes and 1 hour without the tool and around 12 minutes by applying it. That is a save of a 75% of the time when using the learning analytics tool.

Regarding teachers' perception about the tool, all of them find it useful and that it helps them to save time when checking the learning evidence. There are several suggestions to improve the tool: the improvement of the interface (that is quite simple because the tool was implemented as a proof of concept); to include a warning system that allows teachers knowing if the methodology is being applied properly and if teams accomplish deadlines; and also, to have access to specific information about single students' actions. With regard to the methodology they also seem to be happy because it allows them assessing in an objective way individual acquisition of TWC, and help the students to deal with complex projects in their courses. Finally, some of the teachers of S1 claim about their students' motivation with the activity and note that students have problems by using Moodle Forums as the main interaction tool.

Attending to students' perceptions, it should be noted that most of them are happy dealing with a complex project, working as a group, distributing the efforts, learning how to plan and schedule the tasks, etc. That is, they highlight advantages related to teamwork behaviours, as described in other works related to teamwork behaviour [26, 38]. Regarding the problems several students do not find any, but others have problems with the distribution of work, completion of the tasks by their peers and implication.

Moreover, several of them are not happy with the use of Moodle Forum for interaction. They suggest the use of instant-messaging tools such as Skype or Whatsapp, and tools to manage projects such as Redmine and/or a control version system. It is interesting to see that the opinions gathered for S1 and S2 are quite similar.

After this experiment, we can conclude that the learning analytics tool and the methodology are flexible enough to be applied in different academic contexts.

The tool can be improved by including more information about students, developing a friendlier interface, including information from instant messaging tools, and providing a warning system for teachers, which is going to be addressed as future research lines.

We also have seen that the methodology can be applied successfully in different contexts, but that it is not enough with providing students with contents describing the methodology and explaining it to them, they also need that teachers check how they are progressing during the application and that they define corrective actions if needed. This is a lesson learned for future applications of the methodology.

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