Academic Social Networks and Learning Analytics to Explore Self-Regulated Learning: a Case Study

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***Abstract*— Social networks have become a new form of communication that allow students to share and collaborate. In this sense, they have joined forces with self-regulated learning (SRL) skills. This paper presents an experience at the University of Santiago de Compostela to analyze how SRL is developed in a course using a social network. This research used the following: 1) MSLQ questionnaire by Pintrich and 2) social network analysis techniques within the learning analytics framework. The results show that pedagogy encouraged students to interact and create a rich environment for developing SRL skills.**

***Index Terms*— Social network, Learning Analytics, Self-Regulated Learning.**

I. Introduction

IN A society continuously posing the challenge of learning, new needs are emerging that must be addressed. Self-regulated learning has become a key skill for students to set their own goals and strategies [1]. The university can be a key place for strengthening and developing these skills that are so in demand at the beginning of the 21st century [2].

As Vidal *et al.* [3] point out, social networks are tools that can help develop and strengthen processes of self-regulated learning through participatory methods adopted by the European Higher Education Area (EHEA). The context in which these processes are put into place fully affects other elements of this concept: behaviour, cognition and motivation [4]. Hence, when teaching and learning spaces are used to promote connections among different students, among teachers and students or between a community and its learning resources [5], regulation becomes not only "self-", but also socially-regulated.

This article presents a study highlighting and analysing the processes of socio-regulation of student learning in a course in the Faculty of Education Sciences at the University of Santiago de Compostela. The aim was for students to develop and use these strategies in a proprietary social network, where the tools for sharing and interacting would allow them to create a learning community.

In order to analyse how a social network influences the regulation of learning, we used: the MSLQ questionnaire by Pintrich *et al.* [6] and social network analysis techniques within the Learning Analytics framework (Ucinet and Netdraw) to comparatively analyse interactions (comments) and friend relationships during the 2013-2014 and 2014-2015 academic years. The findings highlight the importance of context in the regulation of student learning as well as the role of collaboration.

II. Socio/Self-Regulated Learning

Learning regulation is defined as an active and constructive process by which students set their own goals and attempt to monitor, regulate and control their thoughts, motivations and behaviour in line with those objectives [4].

Individuals need to select, study and create environments to optimize learning with *behaviours* that lead them to achieve their objectives [7]. *Cognition* includes processes of perception, attention, spatial cognition, imagination, language, memory, problem solving, creativity, thinking and intelligence [8]. *Motivation* is considered to be a set of processes involved in the activation, direction and persistence of behaviour [9]. All these factors are strongly influenced by the *context* in which they interact and are set into motion. The latter is not merely an element surrounding the aspects involved, but rather it directly influences how they develop.

Socio-cultural theory [10] calls attention to the fundamental fact that no student learns in isolation from the environment and social tools [11], because knowledge is the result of an interactive process between the individual and their environment [10]. As pointed out by Martin and McLellan [12], misinterpretations exist that often over-emphasize a self-regulation approach centred on the individual, while inadequately considering the social contexts that determine the regulatory function of behaviour through participation in activity systems [13], when learning tasks are supported by others, or when tasks, perceptions, goals and strategies are shared [14].

Hadwin and Oshige [15] point out that learning self-regulation can become socially regulated through activities that rely on others (co-regulation) or when individuals negotiate their perceptions, goals and strategies in shared tasks.

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Within this framework, social-cognitive models describe the individual as the protagonist of their self-regulated learning development, which is assisted and shaped by context, because learning only occurs in interaction with others. Higher mental functions occur first on a social level and then at the individual level [16].

This assistance takes the form of "scaffolding" [10]. It is a question of co-building regulation strategies and acting on those elements that help to transcend the Proximal Development Area [17] to overcome the distance between the real level, determined by the student's ability to independently solve a problem, and student potential.

Scaffolds are characterized as proposals for helping to solve a problem under adult guidance or in collaboration with peers. The exchange of ideas, explanations, goals and activities that are involved in a task contribute to the construction and reconstruction of the skills within the scope of self-regulated learning [13].

Recent research has shown that social networks can become spaces for promoting regulation [18] and suggests that social media facilitate and support self-regulated learning. Some authors note that the lack of social support is one of the main reasons why students fail to develop self-regulation skills (Self-Regulated Learning, SRL) [19]. Recent studies indicate that instructors should create SRL-conducive open social environments in which students can publicly practice SRL skills and encourage each other [19]. A variety of publications [20] have related regulation to interaction, noting that regulation skills are related to the quality of students' social interactions with their peers.

Thus, academic social networks can be transformed into work environments that enable the development of these skills owing to their potential for communication and collaboration.

III. Learning Analytics to Discover Processes

Virtual learning environments have expanded very rapidly, especially since the appearance of web 2.0. The work that students and teachers carry out in these spaces leaves traces that can reveal how learning processes occur, and makes it possible to overcome obstacles and/or improve these processes. It is common for teachers to be unaware of what their students do to learn beyond a final product. However, there are some tools in the context of Learning Analytics (LA) that reveal the path followed by students when they work with digital devices.

Here we aim to show some of the possibilities offered by LA. It is a question of "the measurement, collection, analysis and presentation of data regarding students and their contexts in order to understand and optimize learning and the environments in which it occurs" [21]. It allows the construction of meaning around a series of data. In particular, it provides understanding of the learning process involved in a specific task or subject and reveals the strengths and weaknesses of students and the teaching proposal.

Learning Analytics implies delving deeper into students' actual behaviours and identifying potential links with other data and findings. A combination of data can provide in-depth knowledge of the learning process that takes place in a given context.

IV. Socio/Self-Regulated Teaching and Learning

Designing learning environments and situations that provide suitable stimuli and support for the development of learning regulation skills [16] should be one of the aims of teaching in higher education. In this case, we wish to determine whether the social network used as a teaching environment, combined with e-portfolios, fosters the development of self-regulated learning strategies.

For this purpose, we analysed the characteristics of the academic social network and the teaching proposal which provide the backdrop for student work.

A. The Case of the Stellae Group Social Network

The Stellae research group in the Faculty of Education at the University of Santiago de Compostela has been participating since 2006 in subjects from different degree programs with the open source platform ELGG, hosted on an institutional server (htpp: // stellae.usc.es/red).

This social network includes discussion forums, blogs, micro-blogging in the central space, user profiles, friend lists, activities screen, personal wall, calendar, bookmarks, pages and the ability to comment on the contributions made by classmates. When a user adds content to the platform, they have the option of selecting whom to share it with (private, friends, all platform users or public). This means that content can be shared, or conversely, nothing is displayed and individual spaces are created.

These features are combined with a pedagogical outlook to form a proposal that supports the development of socio/self-regulated learning [22]. It should be noted that task type and learning context moderate the actual use of the technological tools [23].

B. The Subject and its Teaching Proposal

The context of this study was a core third-year subject in the Pedagogy degree combining class lectures with online learning (Blended-Learning).

The teaching proposal reflects new approaches that are gradually infiltrating university teaching: *Personal Learning Environments* (PLE), social networking and *e-portfolios* [24], [25]. The *e-portfolio* reveals student growth, strengths and weaknesses, and encourages the development of process skills; it communicates student achievements, serves grading purposes [26] and is an improvement over conventional assessment systems [27]. When students use e-portfolios, they assume greater responsibility for their learning, have a better understanding of their strengths and limitations, and learn to set goals [28]. It also allows for negotiating the meanings of the learning evidence presented by students and fosters progressive autonomy that enhances communication among students [29]. It aims to promote individual improvement, personal growth and development and commitment to lifelong learning [30], making it possible to develop and implement self-regulated learning skills.

The construction space was a social network shared with classmates in the subject (depending on privacy settings), who could read and comment on all contributions. Although the evidence gathered was individual, it was influenced at all

times by the social context in which it was set because it was shown publicly in the "virtual" space. Projects were also done in small groups, which cooperated to achieve shared products.

The assessment of all elements in their personal environment was carried out by teachers using a rubric presented at the beginning of the course, and took place in two stages: at mid-term and end of term.

The subject included a series of compulsory individual projects for class and others in the virtual space (critical review of articles and design of a multimedia production). Students also conducted a personal search for items to show how they had resignified class concepts; they selected an aspect or a path for delving deeper which represented a personal decision based on their goals, motivations and interests [22]. The outcome of this process was a text included in their personal space on the social network (either on their blog or file space). Students wrote about topics in the subject, related them to real life and other research and spontaneous feedback arose among them.

The rubric provided clear guidelines on what was required to pass the subject beyond the compulsory projects, and students set their own goals. Hence, each student's path was different.

It is assumed that the less structured an activity is the more learning strategies are implemented, which is a fundamental aspect of self-regulated learning [32].

Therefore, we tried not to offer any specific guidelines that could constrain the process. On the contrary, conscious decision-making was encouraged, as was collaborative learning because group members represented interdependent agents of self-regulation, yet they constituted a social entity creating possibilities and limitations for the group and individual commitment [32].

In this way, students were faced with situations of social learning with the presentation of collaborative activities and spaces for exchange requiring the development of motivational, cognitive and socio-emotional skills that differ from those in highly structured learning processes [33].

Regulation varies when processes are set in motion in the social environment. Skills are modified when they come into contact with other individuals, forming a space of confluence where interactions influence and affect the learning regulation of individuals.

V. Methodology

We aimed to find out about the existence of co-regulation within the group and how exchanges in those processes occur in the aforementioned subject, taking into account the importance of the social network context. To do so, we began by analysing the 2013-2014 Educational Technology course at the University of Santiago de Compostela, and then we compared a series of parameters between this course and the 2014-2015 course.

At the beginning of the 2013-2014 course, the MSLQ questionnaire by Pintrich *et al.* [6] was applied to evaluate the motivational orientations of university students and their use of various learning strategies.

The questionnaire results provided baseline information regarding student self-regulated learning. Then, *Learning Analytics* tools, specifically SNA (*Social Network Analysis*), were used to monitor network changes insofar as degree of centrality and density were concerned, based on comments to peers. Finally, indices from the two cohorts studied (2013-2014 and 2014-15) [34] were compared.

The MSLQ questionnaire (Motivated Strategies for Learning Questionnaire) by Pintrich *et al.* [6] was translated and adapted to the context of the subject. It included 81 items divided into two sections: motivational strategies (31) and learning strategies (50). The latter section is subdivided into questions analysing cognitive and metacognitive strategies, as well as student management of available resources. While reliability is higher for the seven-choice model, we used the five-choice options - from 1 to 5 - because differences are minimal, no information would be lost [35], and the sample was more familiar with this scale.

In order to highlight the interaction processes that occurred in the context of the social network, SNA techniques were used within the LA framework. By means of Ucinet and NetDraw software, interactions graphs (understood as the comments made to peer contributions) and student friendship graphs were constructed. The parameters analysed were network density and node centrality.

Density refers to the proportion of links between nodes of the graph with respect to total possible links. This parameter indicates the intensity of collaboration. The comments indicate whether all the participants in the network are linked and interacting, therefore, whether there is maximum density. In networks such as the one analysed, where participants interact over time, density may vary accordingly.

The second parameter analyses the *centrality*[1] *of a node* and indicates importance in the social network as a result of relationships. A centralized network will have a set of relevant nodes with a large number of relationships. In this case, they reflect the notion of *indegree* and *outdegree* representing relationships in and out of a node, i.e. both the friendships by others to the node (*indegree*) and those made by the node to other peers (*outdegree*). We also used the overall percentages of network centrality.

These two elements, centrality and density, provide insight into how this network works, friendship links, interactions between peers, and their evolution over time. As pointed out by Ricardo [36], we can identify peripheral members or groups, their connectivity and the emergence of core members and others who, without being core, act as mediators between other members of the network. In the present case, we sought to observe the students who were furthest from the process and those who were most immersed in the dynamics of the subject, to identify what direction the members were going, and, finally, to learn about the socio/self-regulated learning processes going on in this space.

[1]UCINET software calculates the normalized degree centrality understood as the degree divided by the maximum possible degree, expressed as a percentage. This is followed by the network centralization rate expressed as a percentage.UCINET 6 for Windows Help Contents –Guide-. Available in: *http://www.analytictech.com/ucinet/help/3ava_zr.htm* [last consultation: 16/10/2015]

Of special interest was determining if there were variations in the type and number of interactions that occurred in the subject throughout the course, and verifying whether they reflected an improvement in the socio/self-regulated processes of the class. To this end, SNA techniques were applied at four times (week 3, 5, 10 and 16) in order to compare the rates obtained for courses 2013-2014 and 2014-2015.

VI. Results

The MSLQ questionnaire was applied at the start of the course to gather information on student self-regulated learning skills before beginning the process and to implement strategies to encourage its development. The response rate was 72% (52 out of 72 students). The average score was 3.49 (corresponding to 4.88 on a scale of 1-7). Previous studies at universities in different countries using the same questionnaire obtained an average of 4.97 in Argentina [37] and 4.90 in Navarra, Spain [38], indicating that significant differences do not exist between universities.

This means that the students in our study had an average level of development with respect to self-regulated learning skills. The lowest score was 4.06 and the highest was 5.99. We can infer that the student with the lowest score had a low level of motivation and underdeveloped organizational strategies, such as asking for help from classmates and teachers, time management, and sustained effort.

Regarding the reliability of MSLQ, SPSS software yields a Cronbach's alpha coefficient of 0.84, considered to be a good consistency level by the scientific community [39].

The use of tools within the LA framework has generated graphs that show a decentralized network with high interaction density. The total of 2550 comments indicates that the 72 students enrolled maintained a high level of activity in the course.

Students are represented by nodes (squares) whose size is proportional to the number of comments received and sent. Arrows indicate the direction of interactions. If the tip of the arrow is pointing towards a node, it means that the subject has received a comment; if the tip is pointing towards another node, the subject has written the comment. As can be seen (Figs. 1a, 1b, 1c and 1d) many of the nodes on the margins have received or sent few comments.

The subjects' position in the network is also weighted, i.e., those at the centre have a larger node in keeping with their participation (wider squares mainly in Fig. 1a, 1b and 1c).

Construction of the maps is based on the data obtained from the beginning up to the week indicated in the graph, thus the data accumulated forming new pictures of what was happening in this space.

In this case, we can see that the network's degree of centrality decreased (Table I) while the degree of density simultaneously increased (Table II), which suggests that an increasing number of students interacted such that the base of interactions was distributed among many more nodes, as can be seen in Table I.

The analysis of each node's centrality reveals a trend towards the centre of the graph over time. This can be interpreted as advances in autonomy reflected by more comments about peers' contributions that increase network density.

TABLE I
Centrality Indexes for Weeks

WEEK	CENTRALITY (OUTDEGREE)	CENTRALITY (INDEGREE)
3º	81,966%	11,162%
5º	80,549%	14,437%
10º	79,030%	13,420%
16º	65,059%	14,374%

TABLE II
Densisty Indexes For Weeks

WEEK	DENSITY
3º	5,640
5º	8,047
10º	8,409
16º	25,297

TABLE III
Groups According to MSLQ Results

	MSLQ Low	MSLQ Medium	MSLQ High
Percentage selected	18%	64%	18%
Number of students	10	33	10
Scores obtained X	2.91>X<3.27	3.28>X<3.79	3.8>X<4.29

Students who obtained the highest score on the questionnaire at the beginning of the process, and who were thus considered to have highly development self-regulatory skills, remained at the centre of the graph from the start until week 16 (figures 1a, 1b, 1c and 1d). Meanwhile, after several weeks, many of the students who had obtained the lowest scores on the questionnaire increased their participation. The proportion of network interactions grew at a steady pace with a clear tendency for nodes to move toward the centre and contribute to network density. Low scores were considered to be those by the 10 students with the worst score on the MSLQ (standardized scores under -0.90) and high scores were considered to be those by the top 10 student Z scores over 0.90. This corresponded to 36% of the total (Table III); the highest 18% and the lowest 18%.

In the graphs shown in Figure 1 (a, b, c, d), various symbols have been placed (star, diamond, triangle, circle and X) on five of the students with the lowest scores, showing how they moved toward the centre of the graph and increased their number of interactions. We can see that those who were at the margins of the network moved towards the core of the group, and in Figure 1 (d) we can see how they became integrated.

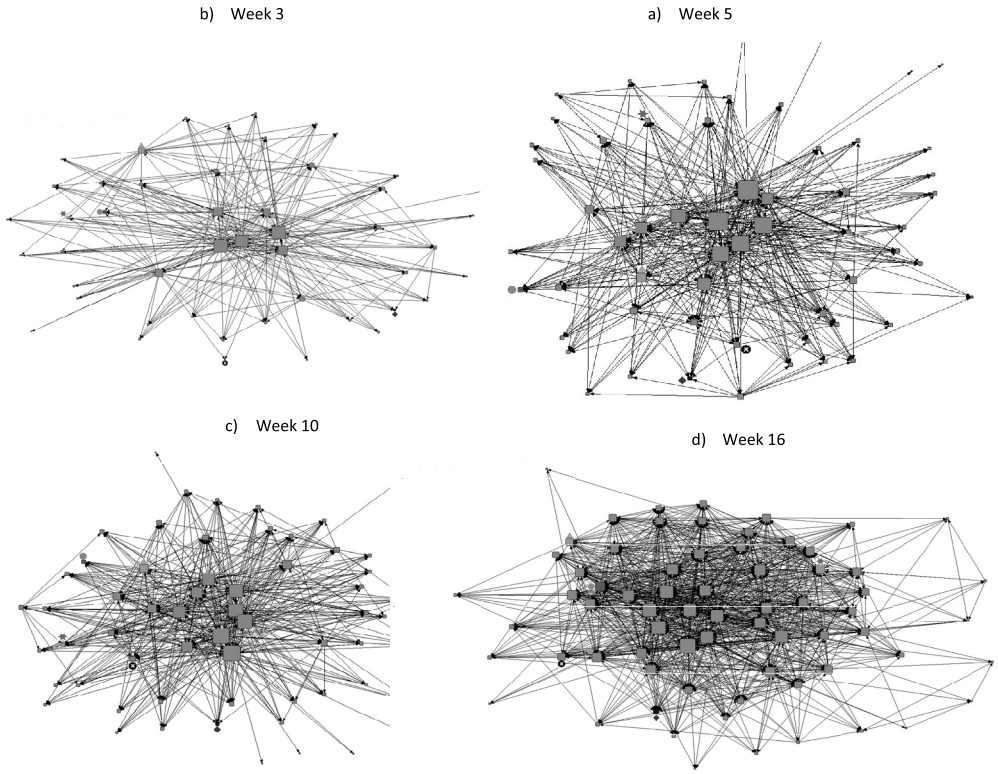

Fig. 1. 2013-2014. Course, Interaction map a) week 3 to d) week 16.

TABLE IV
STUDENTS WITH LOW MSLQ SCORES. CENTRALITY AT VARIOUS WEEKS

Al.	MSLQ/ Scores Z*	Week 3		Week 5		Week 10		Week 16	
		OUT	IN.	OUT	IN.	OUT	IN.	OUT	IN.
1	3.14/-1.36*	0,4	0,11	41	9	40	9	33	10
2	3.22/-1.07*	0,16	0,10	15	12	21	13	19	17
3	3.23/-1.03*	0	0,18	0	19	0	18	18	28
4	3.23/-1.03*	0	0,12	0	15	0	15	0	19
5	3.25/-0.98*	0	0,14	0	19	0	18	6	31

UT=Outdegree, IN=Indegree

The following table (Table IV) shows the percentages regarding the network's degree of centrality based on the 5 cases selected (approximating integers when there was more than 1%).

It should also be noted that as the course progressed, the number of nodes and interactions increased from 49 nodes in week 3 to 65 interactions in week 16. The 7 remaining students (72 were enrolled) may have either dropped the subject and not been part of the platform, or simply did not interact with any of their peers.

The data extracted by SNA and the grades resulting from the procedural evaluation performed by teachers in the subject show that a relationship exists between students' grades and their position in the graph. Not all the students in the central positions obtained the highest grades. However, those at the outermost margins most likely correspond to the students who obtained the lowest grades [3].

As the course progressed, however, the positions of these latter students tended to become more central, suggesting that the subject helped students who managed the worst at the beginning to implement strategies for improvement, which is reflected here by interaction with peers. We should point out that in the last week of analysis all students received comments (there is no 0% *indegree*) although not all students were equally active in terms of initiating or responding to these interactions.

The maps and analyses conducted in the 2014-2015 course give us a fuller picture of what happened in the social network in this subject and how the methodology influenced our students' regulation processes. In this course we gathered 1,320 interactions among students, representing a fall of 48% with respect to the previous year. We should point out that this course began a month later because of internships, so there were four weeks less of interactions and each of the four time periods were also correspondingly shorter. In the last week, 67 nodes interacted, thus reflecting a lower number of active students in the network as compared to the same period in the previous year.

The two courses presented similar density (Table V), seeing that the proportion of links between students was 25%. As has been pointed out [36], density also tends to represent a measure of group cohesion. We can see that it is not high, but this low level of connectivity was not uniform throughout the network. There are certain areas with a high level of connectivity, as can be seen in various areas of the graph where lines overlap. In the maps of both courses there are a set of nodes that are more active and encourage others towards the centre as they promote peer interaction to perform

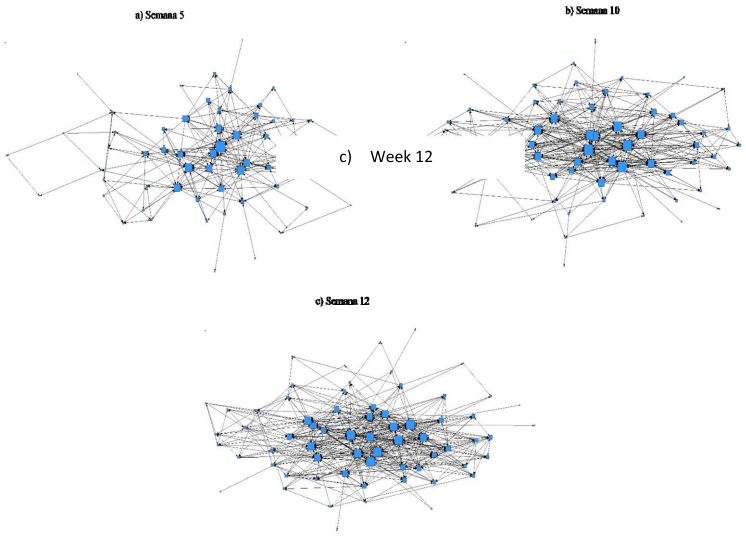

Fig. 2. 2014-2015 Course, Interaction map. a) week 5 to c) week 12.

a task, and people interact to build together during the process (learning co-regulation) [40]. In addition, a critical element in the regulation, learning continuity, is highlighted by continued growth in the number of interactions.

Regarding centrality, in this case we can see that the values were lower, the *outdegree* average was considerably higher in the 2014 course (43%) and *indegree was* 15% higher.

We can highlight that in the two courses (2013-2014 and 2014-2015) the outbound range (outdegree) is higher than the inbound range, i.e. more links are sent from subject-nodes (comments sent) than are received.

At the same time, interaction maps at different points (weeks 5, 10 and 12) (Figure 2a, 2b and 2c) show the construction of the network and graphically highlight the process and how interactions occurred. As we have already mentioned, the number of interactions in 2015 was lower as was centrality, which is evidenced in the maps by the dispersion of nodes, which move towards the centre over time. The dynamics of the subject continued to encourage a move towards the core, foster cognitive skills, and affect behaviour, which are all elements of regulation [2] that changed in the context of the academic social network

VII. Conclusions

As already pointed out in previous research [23], and as highlighted in this study, social networks enable the development of regulation skills in a context where participation, reflected by comments, can be critical. The relationship between student perceptions about their motivation and learning strategies and the teaching process carried out (what is said and done) demonstrated that those with better scores on the questionnaire (MSLQ) tend to establish more connections with others, moving to the centre of the graph as the course progresses. This reflects the use of academic support strategies with the teacher or with peers, which is a regulatory strategy indicating the value of the social dimension of the learning process. In this respect, it was observed that the teaching and learning proposal led those students with weaker skills at the beginning of the course to develop socio-regulatory strategies relying on peers (Figure 1), which became scaffolds for improving their own process. As can be seen in Fig. 1 and Fig. 2, the methodology used in the subject pushed students with weaker skills towards the centre, where core interactions were stronger and where they took on increasingly prominent roles [42].

Co-regulation of learning involves the reconstruction of one's own regulation, incorporating even more complex skills [32]. For this reason, students with weaker strategies could take longer to immerse themselves in the environment and start moving toward the centre of this network.

What is also highlighted is that, despite the fact that the subject's methodology was similar each year, student characteristics varied, although general trends existed. During the weeks of the two courses analysed, interaction between nodes increased, creating a denser and less centralized network. It should be noted that earlier research showed that the degree of centrality in social networks has an influence on learning effectiveness and achievement [43], [44]. In this case, protagonism was divided among many of its participants.

The data gathered (Tables V and VI) and shown in the maps (Fig.1 and Fig.2) reveal a methodology that fosters interactions, as no student remained completely isolated on a network that maintained and revived the "social" dimension, as seen in subsequent graphs. The scaffolding among students found its place in this web of relationships where social regulation of learning came into its own.

The observed relationships underscores once again the importance of the social dimension of learning [10] and the potential offered by collaborative work, which should be one of the objectives of university education. As Beltran pointed out [45], the quality of learning does not depend as much on the teacher's activities as on the quality of actions involving students, where both learning and teaching strategies are fundamental [46].

It is important to explore new learning spaces where knowledge, skills and attitudes associated with self-regulated

TABLE V
DENSITY PER WEEKS 2013/2014–2014/2015

2013-2014 Semanas:	*2014-2015 Semanas:*	*Densidad*	*Densidad*
3º	**1º**	5,640	5,2
5º	**5º**	8,047	11,3
10º	**10º**	8,409	19,6
16 º	**12 º**	25,297	25,1

TABLE VI
CENTRALITY 2013/2014–2014/2015

SEMANA	2013/14 (OUT)	2013/14 (IN)	SEMANA	2014/15 (OUT)	2014/15 (IN)
3	81,966%	11,162%	**1**	51,420%	7,267%
5	80,549%	14,437%	**5**	58,155%	12,873%
10	79, 030%	13,420%	**10**	63,287%	13,052%
16	65,059%	14,374%	**12**	58,064%	12,783%

OUT=Outdegree , IN=Indegree

learning can be developed [47]. We should keep in mind that this fundamental skill depends not only on the subject, but also on two other pillars: the objective or purpose of the action and the resources used [48]. These make up a triangle that is vital when analysing regulation in its various spaces.

Social networks can become a suitable support for work involving co-regulation skills. Zaidieh [49] noted that these sites would become useful tools that could generate a revolution in the field of education, if we were able to control them to meet needs. However, working in this environment requires the appropriate methodology. In this case, the *e-portfolio* and rubric supported self-regulated learning [49]. In short, educators believe that e-portfolios help turn students into active, independent and self-regulated [50] learners.

In its attempt to improve learning and teaching [51], the new discipline of "*Learning Analytics*" has made it possible to apply social network analysis techniques that reveal the situation of a class beyond the classroom and into virtual space. Which students are being left behind? Does the methodology used in the subject encourage interaction? Is there a relation between our students' regulation skills and interactions? The answer to these questions has been possible thanks to the new techniques offered by LA, which allow us to discover hidden learning processes and go beyond products.

Technology at the service of education undoubtedly holds a great deal of potential. It is important to continue working on the development and use of tools developed by and for education.

Finally, we consider it essential to foster the socio/self-regulated learning of our students and enable them to "learn to learn". As Weinstein said [52], it is perhaps the most important goal of university education.

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