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Using Social Network Analysis for Analysing Online Threaded Discussions

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Abstract. This study analyses the use of online threaded discussions (OTD) through social network analysis (SNA). The participants involved are university students in a Cuban higher education setting. It was conducted in the Programming Technologies course of the Information Sciences, at the Universidad Central "Marta Abreu" de Las Villas (UCLV). An intervention study was conducted involving students in Information Sciences during one semester. Both survey research and content analysis for online discussions have been used in this research. The social network analysis shows that online discussions reinforced student peer relationships and network dynamics. Furthermore, it is shown that SNA is a useful approach to analyze students' peer interactions in the digital space by comparing the peer relations before OTD and those during the OTD. The results are beneficial for both teachers and students to get a better view of the interaction patterns in online learning activities and thus helpful for further structuring and supporting students in online learning environment.

Keywords: social network analysis, online threaded discussions, peer relationship, online collaboration.

Introduction

Today social Web's emergence has come to play an important role in education. It is in a core position in the development of students as the paradigmatic "laboratory" supporting the learning processes where the students are immersed. The socio-constructivist theories laid by Dewey, Piaget, Vygotsky and Bruner (Bruner, 1966, 1977; Dewey, 1916; Piaget, 1971; Vygotsky, 1978) support the contemporary e-social constructivism (Salmons, 2009), the collaborative e-learning principles and the co-construction of knowledge when social software mediates the learners' interaction. Currently educational practices with social software supporting teaching and learning activities are increasing (Zhu, 2013). In Cuba, the demand for the use of social software for

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learning is increasing in order to improve the teaching and learning processes (Zhu et al., 2012).

Online threaded discussions

In recent years, online threaded discussions (OTD) have been widely used as communication and collaborative learning tools in e-learning and blended learning settings (Zhu et al., 2009). Instructional designers use online discussions to encourage students' active participation in the learning process (Maurino, Federman, & Greenwald, 2007; Ng & Cheung, 2007). Online collaborative learning activities can promote critical thinking, facilitate peer assessment and peer interaction (Chrystal, 2009; Jeong & Frazier, 2008; Rizopoulos & McCarthy, 2008; Chan, Hew, & Cheung, 2009; Ioannou & Artino, 2009; So & Brush, 2008). In OTD settings, discussions can be supported by an open-ended prompt (Rizopoulos & McCarthy, 2008) or raising questions (Lee, 2009). Moreover, the process of discussing online brings along some other tasks such as sharing and comparing information, exploring dissonance, agreeing the application of meanings and supporting people (Veerman & Veldhuis-Diermanse, 2001).

Current use of OTD in Cuban higher education settings

Online threaded discussions are used within the teaching and learning process to support students' interactions and knowledge sharing in some Cuban higher education settings, especially in Information Sciences and related fields. It can support the instructional activities such as lectures, workshops and online learning (Borges-Frias, 2009; García-Garay, 2005; Rodríguez-Torres & Anta-Vega, 2006). Although quite a lot of studies have recognized the effectiveness of OTD in teaching and learning, its applications in the Cuban higher education context are not yet widely spread. This is on the one hand related to teachers' familiarity with traditional, face-to-face teaching and monitoring students' learning processes, and on the other hand related to the limited internet access among Cuban universities. In order to overcome the hurdle of limited internet access, many universities use intranet to host social software applications and online tools including OTD tools in Cuban universities.

Social Networks Analysis

Social network analysis (SNA) is a way of analysis for mapping and measuring of relationships and flows between people, groups, organizations, computers, URLs, and other connected information/knowledge entities (Abbasi & Altmann, 2011; Numela, Lehtinen, & Palonen, 1999; Wasserman & Faust, 1995). The nodes in the network are the people and groups while the links show relationships or flows between the nodes. SNA can provide both a visual and a mathematical analysis of human relationships. These measures can give us insight into the various roles and groupings in a network (Abbasi & Altmann, 2011; Butts, 2008; Hanneman, 1998; Laat, Lally, Lipponen, & Simons, 2007; Xia, Wang, & Hu, 2009). Using SNA for online communications and OTDs can help us studying the structures and dynamics of online communities.

However, in the knowledge base of computer supported collaborative learning (CSCL) and the analysis of OTDs, there is a lack of analysis of the relationship

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structures and dynamics of online communication using SNA (Abbasi & Altmann, 2011; Butts, 2008). Furthermore, there is a lack of knowledge especially in the context of Cuban higher education regarding student interactions and peer relationships in OTD learning designs. The use of SNA for analysing OTDs is unique for studying the online learning communities within Cuban higher education. It provides the steps to use SNA software to visualize the students' social network states and can provide guidance for teachers' decision making regarding the level of online collaboration and peer relationships and thus improve the learning design of their courses.

Content analysis of OTDs

Peer relationships and interactions can be analysed at the content level (Pena-Shaff & Nicholls, 2004). In the literature, the models of Gunawardena et al (1997) and Veerman and Veldhuis-Diermanse (2001) are widely used. The instrument of Gunawardena et al. (1997) is presented as a tool to examine the social construction of knowledge in computer supported learning. It is based on grounded theory and uses the phases of a discussion to determine the amount of knowledge constructed within a discussion. The model of Veerman and Veldhuis-Diermanse (2011) situates the use of CSCL within a constructivist framework and presents an analysis of the type of comments and discussions (De Wever et al., 2006; Rienties et al., 2009; Zhu, 2012). Next to the use of SNA for analysing the peer dynamics in online communities, content analysis is used to analyse peer interactions at the content level. Through both ways, this study will be able to reveal the actual interactions among university peers in OTD learning settings.

Objectives and research questions

This research aims to investigate the role of OTD in reinforcing student peer relationships in learning and how students interact with each other in OTD settings. The following research questions guide this research:

1. How do student peer relationships differ during OTD learning context from the relationships before starting the OTD learning activities?
2. Does OTD reinforce student peer relationships in learning?
3. How students interact with each other at the content level?
4. How do students perceive the effectiveness of OTD for learning?

Method

Design of the study

This research involves an intervention study of using OTDs among 4th year bachelor students in Information Sciences during the 2010-2011 academic year at UCLV in Cuba. Before the start of the intervention, a survey was administered, including three measurement scales: students' current social network relationships, preferred social network relationships and views on collaborative learning. These quantitative data were analysed through descriptive statistics and SNA (Butts, 2008). The students were involved in OTD learning activities for the course of Programming Technologies during one semester. After the intervention of one semester, a questionnaire was administered to measure

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students' views of the OTD and perceived effectiveness of OTD. The OTD activities were analysed with SNA and content analysis.

Participants
Participants of this study were 21 students who attended the course of Programming Technologies in Information Sciences (IS) at the Faculty of Information and Educational Sciences (FCIE). This was the population of a whole class. All of them were between 22 and 24 years old. Among them, there were twenty female students and one male student.

Instruments
At the start of the study, a questionnaire was administered to the students to gather data about their peer relationships and preferred peers for study, and their views about collaborative learning. The students were asked to answer questions regarding (1) their current peer relationships for study (the number and names of peers that a student frequently studied with), (2) their preferred peer relationships for study (the number and names of peers that a student preferred to study with), and (3) views about collaborative learning.

At the end of the intervention study, a questionnaire was administered to the same group of students assessing their views of using OTD for learning and student self-efficacy. The questionnaire included three scales: students' self-efficacy (SE) about learning the subject (Programming Technologies), perceived importance of using OTD for learning the subject (I.TD, 8 items), and perceived effectiveness of using OTD for learning the subject (E.TD, 6 items). The SE scale inquired specifically about students' self-efficacy about their knowledge on the course. The SE scale included 34-items reflecting three sub-scales, namely self-efficacy in Programming Language, self-efficacy in programming Tools, and self-efficacy in current Web Programming Technologies. The composition and reliability of the scales are shown in Table 1.

Table 1. Self-efficacy scales and student perceptions of Threaded Discussion for learning

<table>
<tr><th>Scale</th><th>Items</th><th>Type</th><th>Reliability (Cronbach's alpha)</th></tr>
<tr><td>1. Self-efficacy in Programming Technologies (SE)</td><td>34</td><td rowspan="4">6-point Likert Scale ranging from Not Confident to Strongly Confident</td><td rowspan="4">α=0.96</td></tr>
<tr><td>a)Self-efficacy in Programming Languages (SE.PL)</td><td>12</td></tr>
<tr><td>b) Self-efficacy in Programming Tools (SE.PT)</td><td>12</td></tr>
<tr><td>c)Self-efficacy in Current Web Programming Technologies (SE.NT)</td><td>10</td></tr>
<tr><td>2. Importance of Threaded Discussion for learning</td><td>8</td><td>6-point Likert Scale ranging from Not</td><td>α=0.69</td></tr>
</table>

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(I.TD)		Important to Very Important	
3. Effectiveness of Threaded Discussions for learning (E.TD)	6	6-point Likert Scale ranging from Completely Disagree to Completely Agreed	α=0.78

Intervention
The intervention of this research took place during a full semester. Two communication tools were used to support student online threaded discussions: OTD and Feedreader (a RSS news aggregator). The students were required to participate in four online learning activities supported by OTD. The OTDs were hosted on the intranet of the university. The teacher and students also used emails for communication, especially when there were problems with OTDs. The teacher used the Feedreader for monitoring students' participation in the OTD throughout the RSS channels. A worksheet was designed for archiving students' learning activities and performance during the course. It consisted of a sheet per activity for facilitating the tracking of student participation in OTDs. The teacher used it to record student activities and performance per activity. The worksheet also contained the observation guide that the teacher used to assess student online learning activities.

At the end of the intervention, both qualitative data and quantitative data were gathered. Qualitative data were collected through student actual participation of discussions online. The students' online discussions and comments in the OTD were used for content analysis. Quantitative data were gathered through a questionnaire, which was introduced in the above '*Instruments*' section. The questionnaire was administered during the last workshop session of the intervention course.

Data Analysis
Regarding the quantitative data, reliability analysis and descriptive analysis were conducted for all measured scales. As for the qualitative data, we focused on student actual participation in OTD and their peer relationships online. With regard to online discussions, content analysis was applied to analyse students' actual participation while using OTD during the learning process. Regarding the peer relationships, the software tool Gephi was used for conducting the Social Network Analysis, modelling and monitoring the interactions of the students while learning online. The Gephi tool includes plug-ins for gathering live data about social interactions within virtual learning environments. This software combines the graphs theory with a strong visualization engine facilitating the social networks presentation. Student desired peer relationship, prior peer relationship and actual peer relationship during the OTD were analyzed and compared.

Results
The results of this study focus on three aspects: first, student interactions and peer relationships in OTD as analysed by SNA; secondly, content analysis of

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student online discussion in OTD; thirdly, students' perceptions and views about OTD and their perceived importance and effectiveness of OTD.

Student peer relationships analysed by SNA

First of all, students' reported peer relationships before the intervention was analysed. The data gathered at the beginning of the research regarding student peer relationships for study was used to construct the graph *B (N, E)* (*B* refers to the status of the network before using OTD); where *N* was the set of nodes representing the students and *E* was the set of edges representing the study relationships they declared to have at the start of the research (Figure 1).

Secondly, a graph concerning the desired peer relationships of the students was modelled. It included the colleagues the students would like to study with. This graph was constructed by using the same analogy of the previous one. It was denoted as *D* (N, E_d) (*D* refers the desired network for learning), whose nodes are the same –*N*- and the edges are represented as E_d (Figure 2). This graph depicts the students' desired peer relationships for studying this course.

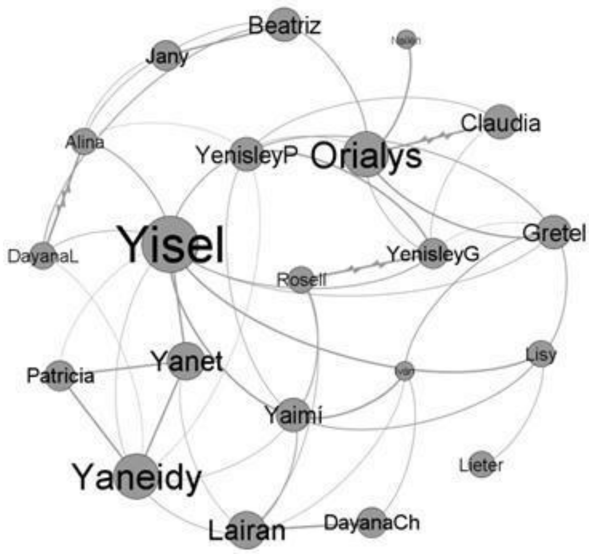

Figure 1. Composition of the network for studying PT [B (N, E)] before the study began.

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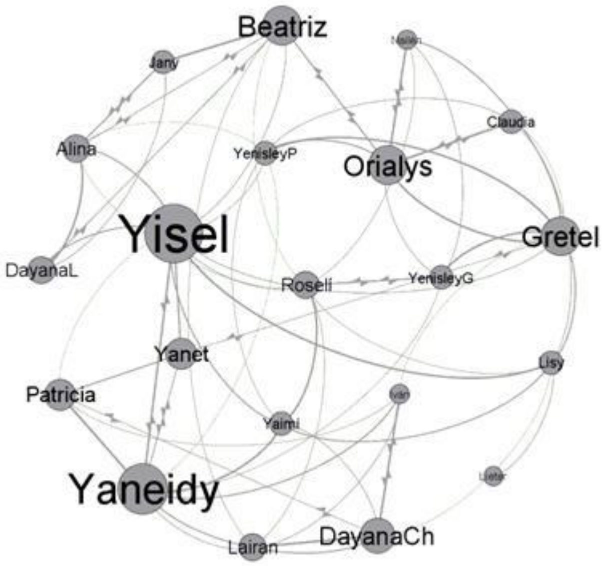

Figure 2: Composition of the desired, ideal network for studying PT [D (N, Ed)]

Thirdly, the state of peer relationship network that was shaped during the interaction while using the OTD was examined. The graph $T\ (N_t, E_t)$ (*T* refers to threaded discussions) denotes the relationships the students established through interacting and commenting within the OTD (Figure 3). Next to the actual peer relationships among the students, this graph included the participation and interaction of other two members: the teacher of this course (*Teacher*) and the students of other academic years of IS who were involved in the discussions– these were denoted by *Others*. Thus the following formula was used:

1. $N_t = N \cup (Teacher, Others)$

The teacher and the other members (senior students of the same program) had an added value in this social network, as they had the possibility of monitoring students' online activities in OTD. It also gave the teacher an effective way to assess the students' learning progress. Moreover, it allowed the students of preceding academic years to enhance their knowledge about the topics that were discussed in OTD.

Another two auxiliary graphs were shaped to analyse the composition of the network states formed during online learning activities. The other, auxiliary graph represents the result of unifying the graph *B* with the graph *T*. This union ($B \cup T = I_r$) surpassed the supposed ideal state of the network (*D*), taking into account the cardinality of the new set of edges obtained. The following equations show the foundations of this finding:

2. $B\ (N, E) \cup T\ (N_t, Et) = Ir\ (N \cup N_t, E \cup E_t)$
3. $|N \cup N_t| > N_t \equiv 23 > 21$
4. $|E \cup E_t| > |E_d| \equiv 85 > 78$

The improvement of the network (Figure 4) for studying PT was confirmed by its metrics' improvement after the course finished. The results showed that the

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cardinality of the nodes ($|N \cup Nt|$) increased. It refers to the quantity of nodes interacting in the social network. The same occurred in the case of the edges. Both were beneficial for students' learning relationships. A comparison between Ir and D is presented in the Table 2, where the shaded columns show the metrics of these two network's states. The main improvement of Ir consists on the augment of the cardinality of the set of nodes, by including the teacher and other students (Equation 3). Moreover, there is an augment in the cardinality of the set of edges (Equation 4), but it is not significant if considered the incorporation of the teacher and other students. The results show that there was a meaningful improvement of the network in terms of the relationships established through the OTD, taking into account that the state denoted as D shows an ideal state of this social network. A comparison between the metrics of the initial network's state –shown in the first column of the Table 2- with the metrics of the final state, illustrates the improvement on the final network's state, taking into account that the students never abandoned their study habits before using the OTD. They just combined the use of OTD with their learning habits.

Density

The density measures how close the network was to complete every possible edge among all pairs of nodes. A full-connected graph/network has a density value equal to 1. The higher the density of a network, the better is the connectivity among its nodes.

The Ir's density increased with respect to the initial state of the network (B). When these states are interpreted as directed graphs the density values increased from 0.136 to 0.168. Otherwise, considering the network as an undirected graph, the density increased from 0.229 to 0.273. These values are not considered significant, even when a little improvement of the network is perceived, because the students were in their fourth university year; so they previously had established almost all the learning relationships they would want. It is also the cause of the absence of isolated students within Ir and B. Once the students have been in touch during three academic years they have had the possibility to choose the peers they consider suitable to study with.

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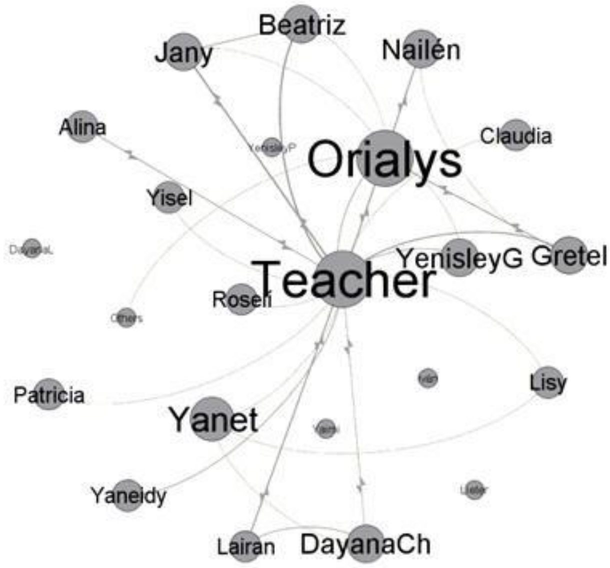

Figure 3: Graph denoting the relationships established by the students while commenting within the OTD

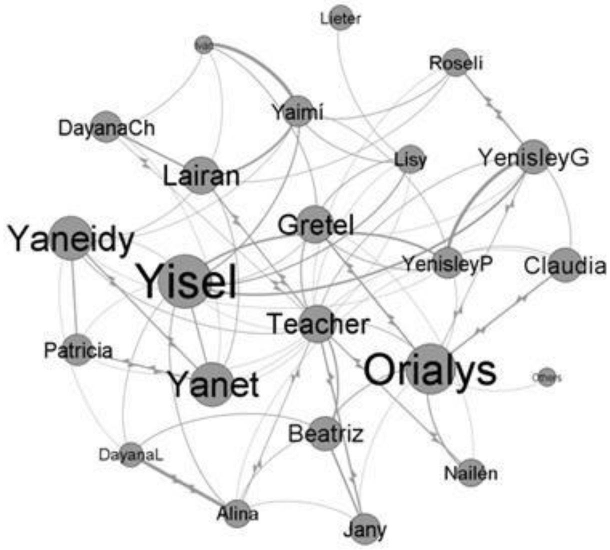

Figure 4: Union of the network for studying PT (B) and the relationships established through the OTD (B ∪ T = Ir)

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Strongly connected components

The quantity of strongly connected components of a graph is the minimum number of sub-graphs whose density is equal to 1 (e.g. an isolated node in a network represents a strongly connected component). The smaller the quantity of strongly connected components of a social network, the best is the information flow between the network's nodes.

There was a reduction from seven (within *B*) to four strongly connected components (within I_r) whereas the ideal status –represented by *D*- has only two. This reduction contributed to the improvement of the learning possibilities by increasing the information flow among the network nodes. The increasing of the edges connecting the nodes of the network is visually obvious in I_r when comparing Figure 1 with Figure 4.

Shortest paths

In the graphs theory, the shortest path from a to b ($a, b \in N$) in a given graph G (N, E), is the path with the minimum number of intermediate nodes $c_1, c_2, \ldots, c_n$ between a and b; where the path length is equal to $n+1$.

A meaningful augment was found in the quantity of shortest paths of *B* with respect to I_r (from 229 to 442). It can mean an improvement in terms of time and effort spent by the students for finding information through the interaction with their classmates. Moreover, the number of weakly connected components did not change across the study; which confirms the absence of isolated nodes in the network. Besides, the number of full-connected triads (triangles) in the network varied from 34 to 80, being better than the 56 triangles of *D*. A triangle in a given graph G (N, E) is constituted by a triad of nodes $a, b, c \in N$, *such that* $\exists$ $(a, b), (a, c), (b, a), (b, c), (c, a), (c, b) \in E$.

Closeness centrality

One of the best improvements of I_r concerns the centrality metrics. The closeness centrality metric (Brandes, 2001) indicates how often a node is found in the shortest paths between each pair of nodes of the network. This metric, whose average is 0.407, is significantly better than the initial average of the state *B* (0.491). Hence, it is very close to the average closeness centrality of *D* (0.392). Contextualized to this study, it indicates how long it would take for the information from a given node to reach the other nodes in the network, supposing that the time taking for the information to reach the node *b* from the node *a* is equal to one unit when exists an edge from *a* to *b* within the network.

Table 2: Metrics' comparison of the different states of the network

Metric	B	D	T	$I_r = B \cup T$	$I_r \cap D$
Isolated nodes	0	0	5	0	0
Nodes	21	21	23	23	21
Directed edges (Edges' cardinality)	57	78	33	85	48
Graph Density (for Directed-Undirected networks)	0.136-0.229	0.186-0.290	0.065-0.103	0.168-0.273	0.114-0.190
Shortest Paths	229	400	162	442	135

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Average Path Length	2.638	2.625	2.333	2.688	1.978
Average Betweeness Centrality	0.047	0.081	0.020	0.070	0.017
Average Closeness Centrality	0.491 (1)	0.392 (1)	0.541 (12)	0.407 (1)	0.643 (1)
Clustering Coefficient	0.273	0.311	0.236	0.313	0.252
Triangles	34	56	13	80	18
Weakly Connected Components	1	1	6	1	1
Strongly Connected Components	7	2	15	4	11

There is only one node of the network whose closeness centrality is null, which means that its correspondent student does not have an effective way to share or consult information with the others. The smaller the value of this metric, the smaller will be the delay for sharing information among the students of the network, which also improves the learning results.

The benefits of sharing information among the students are also confirmed by the analysis of its average betweeness centrality (Brandes, 2001), whose value varies from 0.047 to 0.070. This metric indicates how often a node is found on the shortest paths of the network. In this study, it is understood as a measure of knowledge sharing capabilities. Moreover, the average clustering coefficient (Latapy, 2008) –indicating how close the neighbourhood of a specific node is to a complete subgraph- augmented from 0.273 to 0.313, which is even greater than the ideal (desired) value of D. So, it means an enhancement of I_r when comparing with B or D in terms of the probability of each student to access the knowledge flowing in the network. Another analysis intersected the resultant state of the network with the desired one ($I_r \cap D$, Figure 5).

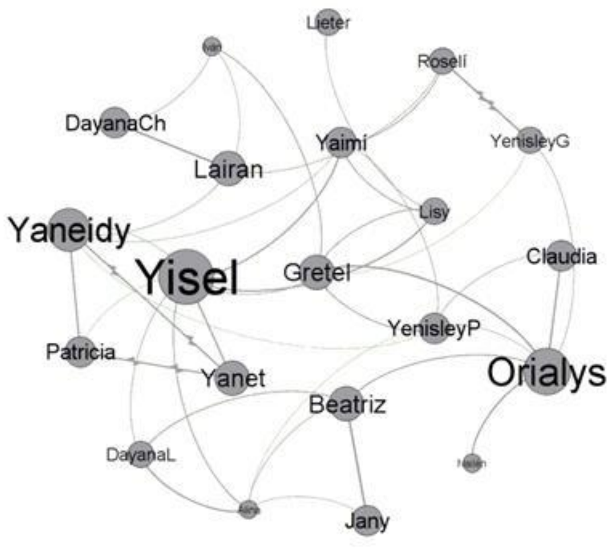

Figure 5: Coincidences of the union of social network for studying PT and the OTD interactions' network, with the desired network for studying PT

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Figure 5 shows a great covering of the desired relationships (*D*) represented by E_d in the intersection, as well as a great covering of the real relationships (I_r). The percent of edges covered were 62% and 56% respectively. A shallow analysis suggests that the students used the OTD for establishing relationships with some of the peers they wanted to interact with –as they declared in the sociometric questionnaire.

Content analysis: students' online comments and discussions

The students' online comments and discussions were analysed according to the established content analysis' approaches (De Wever et al., 2010; Gunawardena et al., 1997; Veerman & Veldhuis-Diermanse, 2001). The purpose was to analyse the experience they acquired during the course in the use of OTD; which was, for them, a novelty way on facing the learning activities. **Error! Reference source not found.** shows a detailed summary of their comments and discussions, classified by the coding schemes based on the discussion types (Veerman & Veldhuis-Diermanse, 2001) and the levels of knowledge construction (Gunawardena et al., 1997). Additionally, the comments containing assessment evidences were coded and marked with other two codes signalling the presence of assessment and/or peer-assessment scripts.

Table 3: Content analysis of the students' comments within the OTD

Code	*Comments*	*% of the total of comments*
Task-oriented analysis		
Task oriented	59	87%
Non-task oriented	52	76%
Irrelevant	5	7%
Technical	10	15%
Planning	29	43%
Social	22	32%
*Levels of knowledge construction**		
Sharing and comparing information	21	31%
Assessment		
Assessment	15	22%
Peer-assessment	6	9%

* The rest of the codes of this approach (exploration of dissonance, negotiation of meaning, testing synthesis and agreement-application) are not included because there were no comments concerning these levels of knowledge construction.

The students had an acceptable participation within the OTD. Fifty-three students' comments and 15 teacher's comments were coded 168 times, according to the codes of the referred approaches. It suggests a mean of more than two comments per student while the teacher monitored the OTD. Fifty-nine comments were coded as task-oriented ones, representing 87% of the total of comments and showing a very good symptom of students' focus on the learning activities. They also used the OTD for writing additional, inline scripts which were marked as non-task-oriented ones. The most of these comments (29, 43% of 68) referred planning aspects regarding the usefulness of these activities for subsequent studies and knowledge management on the subject of PT's topics.

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Twenty-two comments (32%) contained social scripts and 10 (15%) of them contained technical ones, where the students asked for help to use the OTD. Only five comments (7%) treated irrelevant issues.
Concerning the levels of knowledge construction, only 21 comments are marked with the codes of this analysis approach. All of these are dedicated to share or compare information, indicating the shallow experience of the students when interacting through social software. The other four superior levels of knowledge construction conceived in this content analysis approach were not used within the students' comments.

presents a matrix indicating the codes' coincidences within the collected comments. The rows and columns indicate the considered codes for accomplishing the content analysis. Moreover, it shows the percentages of coincidences, with respect to the total of codes in the rows, separated by slashes.

Table 4: Codes' intersection matrix and percentages of codes with two or more scripts coded

Codes	*Task oriented*	*Irrelevant*	*Technical*	*Planning*	*Social*	*Sharing-comparing*	*Assessment*	*Peer-assessment*
Task-oriented analysis								
Task oriented	*59 (100%)*	1 (2%)	10 (17%)	25 (42%)	15 (25%)	20 (34%)	14 (24%)	6 (10%)
Non-task oriented								
Irrelevant	1 (20%)	*5 (100%)*	0	0	2 (40%)	0	0	0
Technical	10 (100%)	0	*10 (100%)*	4 (40%)	2 (20%)	0	5 (50%)	0
Planning	25 (86%)	0	4 (14%)	*29 (100%)*	6 (21%)	0	13 (45%)	0
Social	15 (68%)	2 (9%)	2 (9%)	6 (27%)	*22 (100%)*	*0*	1 (5%)	6 (27%)
Levels of knowledge construction[*]								
Sharing-comparing	20 (95%)	0	0	0	0	*21 (100%)*	0	0
Assessment analysis								
Assessment	14 (93%)	0/0	5 (33%)	13 (87%)	1 (7%)	0	*15 (100%)*	0
Peer-assessment	6 (100%)	0	0	0	6 (100%)	0	0	*6 (100%)*

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In this table, the task oriented and planning comments represent the biggest quantity of them containing scripts marked with a couple of codes, which is 25 in this case.
A further analysis shows high percentages for almost all of the comments containing scripts marked with the "task-oriented" code, medium percentages for almost all of the "planning"-coded scripts and a considerable portion for the "social"-coded scripts. It confirms that the students have mainly focused on the online learning tasks. Moreover, this table shows that 100% of the comments containing "technical" and/or "peer- assessment" scripts are also task-oriented comments. Considering that the peer-assessment implies a level of socialization with other peers, all the "peer-assessment"-coded comments (100%) are also marked as "social" ones.

The most participative OTD was the task in which the students posted their personal information. This way they shared some of their skills, likings and career's records so they could motivate the others to discuss about those topics. It was also the most social online learning activity (21 of 22 "social"-coded comments) due to the nature of the discussions, on which they evaluate their classmates' performance in the university. The whole of the "peer-assessment"-coded comments were detected within this activity.

The content analysis of the OTD gave the teacher the possibility of rapidly analysing the students' comments, like a parallel task. The teacher could perform better by assessing them immediately they posted their comments. Likewise, the peer-assessment of the students was improved by providing them with an effective way to evaluate their classmates' online learning. However, the scaffolding for this kind of assessment can be improved by increasing the activities following this instructional design during the courses.

Student self-efficacy, perceived importance and effectiveness of OTD
The means of the administered OTD's importance and effectiveness scales, I.TD (M=3.78, *SD=0.47*) and E.TD (M=3.82, *SD=0.85*) respectively, confirmed its importance and effectiveness within this setting. Consequently, the effectiveness of the computer-supported framework for analysing OTD was confirmed. Although the mean of the self-efficacy scale (SE) on the course topics was relatively low (M=2.90, *SD=0.80*), it was acceptable taking into account the complexity of the course topics. Moreover, the students performed very well at the end of this course (M=4.32, *SD=0.82*).

Discussions and conclusions
The results show that students' relationships were reinforced by using OTD for learning. Many evidences of collaboration emerged within the social network after using OTD while learning online (I_r). Collaboration emerged from students' interactions and it occurred consciously or spontaneously. Gephi explorative data analysis showed the advantages of OTD in terms of time and effort spent by the students for finding and sharing information through the interaction with their classmates. Another actor actively participated within the social network was the teacher, who could intervene during the learning process to provide

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additional feedback. Moreover, some senior students could participate within the OTD; encouraging a wide range of critical thinking responses from the students, as well as situating them as the discussions leaders (Wishart & Guy, 2009).

The use of social software to promote critical thinking has been considered in other studies (Jeong & Frazier, 2008; Lee, 2009; Rizopoulos & McCarthy, 2008). This intervention study demonstrates that integrating analytical and social software guarantees the teacher presence in the social space and gives him/her a constant feedback about the students' learning process, which provides more evidences for assessment and enhances the knowledge construction by improving critical thinking. The assessment practices reported by other authors (Chan et al., 2009; Chrystal, 2009; Ioannou & Artino, 2009; Isotani et al., 2010; Kang et al., 2010; Lee, 2009; Maurino et al., 2007; So & Brush, 2008; Wishart & Guy, 2009) might be encouraged by combining with content analysis methods (Gunawardena et al., 1997; Veerman & Veldhuis-Diermanse, 2001) in order to improve the quality of assessment.

Monitoring students' learning process facilitates the intervention of the teacher and thus the possibility of giving immediate aids and feedback. Moreover, it motivates the students to reflect on their learning process through peer-assessment and critical thinking. In this study, it was confirmed that the assessment quality was improved by using the social software for improving this key component of the teaching and learning process.

The present study has contributed to the using of Social network analysis (Scott & Carrington, 2011) in analyzing online learning spaces and communities (Rainie & Wellman, 2014). In this research, we have elaborated the importance of social network analysis for analysing student peer relationships and interactions in online discussions. Understanding the network of interaction between students can help teachers monitor the interaction structure of students, and have a clear view of the role of students in discussions and the patterns of peer interaction behavior (Scott, 2013). For example, which students were taking the lead and which students were peripheral. This is also important to measure the effectiveness of students' actual participation in online learning activities (Borgatti & Everett, 2013).

Some limitations need to be noted in this study. First, the sample size of this study was small, limited to the 21 students involved in a specific course under this study. Secondly, the results of this study need to be considered with caution as it applied to a specific setting. In addition, the results might be related to the so-called Hawthorne effect as the participants were introduced to new methods and got extra attention (Hansson & Wigblad, 2006).

Nevertheless, this study has a number of important implications for the use of online learning activities in Cuban higher education. The analysis of threaded discussions facilitates the scaffolding of the students' learning and gives the teacher more evidences for their assessment. The combination of social software

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with SNA and content analysis methods provides a suitable framework to promote collaborative learning practices within Cuban higher education settings, where the Internet gap weakens the knowledge socialization. The more the teachers would know these methods, the more they would be successful to confront the challenge of transforming the teaching practices to more analytical approaches. Even though the tools and methods for applying the approach described in this study are known in Cuban higher education, it is important to promote a culture of using those ones for assessing the students and analysing their performance within their learning social networks. According to the emergence of social software and new learning environments, it is beneficial for the teachers to use it to support their learning activities, thus motivating the students to accomplish their learning tasks. Hence, the teachers would apply more analytical practices and more innovative assessment, on the basis of collaborative learning and social interaction.

This learning approach, supported with online collaborative learning, has been applied in other courses too in the Cuban setting. The present study provides significant evidences regarding the effectiveness of computer-supported collaborative learning in Cuban higher education.

References

Abbasi, A., & Altmann, J. (2011). On the Correlation between Research Performance and Social Network Analysis Measures Applied to Research Collaboration Networks, in *Hawaii International Conference on System Sciences*, (pp. 1-10). Proceedings of the 41st Annual. Waikoloa, HI: IEEE. doi:10.1109/HICSS.2011.325

Borges-Frias, J. L. (2009). Presupuestos pedagógicos para el uso de las Tecnologías de la Información y las Comunicaciones en la Universalización de la Educación Superior cubana. Revista Pedagogía Universitaria, XIV(2), 38-50.

Borgatti, S. P., & Everett, M. G. (2013). *Analyzing Social Networks*. New York, NY: Sage Publications.

Brandes, U. (2001). A faster algorithm for betweeness centrality. Journal of Mathematical Sociology, 25(2), 163-177.

Bruner, J. (1966). Toward a theory of instruction (2nd ed.). New York, NY: W.W. Norton & Company.

Bruner, J. (1977). The process of education (2nd ed.). Cambridge, UK: Harvard University Press.

Butts, C. T. (2008). Social network analysis: A methodological introduction. Asian Journal Of Social Psychology, 11(1), 13-41. doi:10.1111/j.1467-839X.2007.00241.x

Chan, J. C. C., Hew, K. F., & Cheung, W. S. (2009). Asynchronous online discussion thread development: examining growth patterns and peer-facilitation techniques. Journal of Computer Assisted Learning, 25(5), 438-452. doi:10.1111/j.1365-2729.2009.00321.x

Chrystal, S. J. (2009). Technology leverages a community university collaboration. In J. Salmons & L. Wilson (Eds.), Handbook of Research on Electronic Collaboration and Organizational Synergy (pp. 130-141). Hershey, NY: Information Science Reference.

De Wever, B., Schellens, T., Valcke, M., & Van Keer, H. (2006). Content analysis schemes to analyse transcripts of online asynchronous discussion groups: A review. *Computers & Education*, 46, 6-28.

De Wever, B., Van Keer, H., Schellens, T. & Valcke, M. (2010). Roles as a structuring tool in online discussion groups: the differential impact of different roles on social knowledge construction, *Computers In Human Behavior*. 26(4). 516-523.

© 2015 The authors and IJLTER.ORG. All rights reserved.

Dewey, J. (1916). Democracy and education. New York, NY: Macmillan Company.

Enriquez, J. G. (2008). Translating networked learning : un-tying relational ties. Journal of Computer Assisted Learning, 24, 116-127. doi:10.1111/j.1365-2729.2007.00273.x

García-Garay, J. (2005). Diseño curricular de la disciplina Electricidad y Automatización para la carrera de Ingeniería Mecánica. Instituto Superior Politécnico "José Antonio Echeverría" Centro de Referencia para la Educación de Avanzada (CREA), Ciudad de la Habana, CU.

Gunawardena, C. N., Lowe, C. A., & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. Journal of Educational Computing Research, 17, 397-431.

Hanneman, R. A. (1998). Introduction to Social Network Methods. Network.

Hansson, M., & Wigblad, R. (2006). Recontextualizing the Hawthorne effect. Scandinavian Journal of Management, 22(2), 120-137. doi:10.1016/j.scaman.2005.12.003

Hemphill, L. S., & Hemphill, H. H. (2007). Evaluating the impact of guest speaker postings in online discussions. British Journal of Educational Technology, 38(2), 287-293. doi:10.1111/j.1467-8535.2006.00622.x

Ioannou, A., & Artino, Jr., A. R. (2009). Wiki and threaded discussion for online collaborative activities: students' perceptions and use. Journal of Emerging Technologies in Web Intelligence, 1(1), 97-106. doi:10.4304/jetwi.1.1.97-106

Isotani, S., Mizoguchi, R., Inaba, A., & Ikeda, M. (2010). The foundations of a theory-aware authoring tool for CSCL design. Computers & Education, 54(4), 809-834. Elsevier Ltd. doi:10.1016/j.compedu.2009.09.010

Jeong, A., & Frazier, S. (2008). How day of posting affects level of critical discourse in asynchronous discussions and computer-supported collaborative argumentation. British Journal of Educational Technology, 39(5), 875-887. doi:10.1111/j.1467-8535.2007.00789.x

Kang, J.-hyung, Kim, J., & Shaw, E. (2010). A network analysis of student groups in threaded discussions, 359-361.

Laat, M. D., Lally, V., Lipponen, L., & Simons, R.-J. (2007). Investigating patterns of interaction in networked learning and computer-supported collaborative learning: A role for Social Network Analysis. Computer-Supported Collaborative Learning. doi:10.1007/s11412-007-9006-4

Latapy, M. (2008). Main-memory triangle computations for very large (sparse (power-law)) graphs. Theoretical Computer Science (TCS), 407(1-3), 458-473.

Lee, L. (2009). Scaffolding collaborative exchanges between expert and novice language teachers in threaded discussions. Foreign Language Annals, 42(2), 212-228. doi:10.1111/j.1944-9720.2009.01018.x

Maurino, P. S. M., Federman, F., & Greenwald, L. (2007). Online threaded discussions: purposes, goals, and objectives. Journal of Educational Technology Systems, 36(2), 129-143. doi:10.2190/ET.36.2.b

Moreno, J. L. (1951). Sociometry, Experimental Method and the Science of Society. An Approach to a New Political Orientation. Beacon House, Beacon, NY.

Ng, C. S. L., & Cheung, W. S. (2007). Comparing face to face, tutor led discussion and online discussion in the classroom. Australasian Journal of Educational Technology, 23(4).

Numela, K., Lehtinen, E., & Palonen, T. (1999). Evaluating CSCL log files by social network analysis. Computer Supported Collaborative Learning.

Pena-Shaff, J. B., & Nicholls, C. (2004). Analyzing student interactions and meaning construction in computer bulletin board discussions. Computers &Education, 42, 243-265.

Piaget, J. (1971). Biology and knowledge. Edinburgh: Edinburgh Press.

© 2015 The authors and IJLTER.ORG. All rights reserved.

Rienties, B., Tempelaar, D., Van Den Bossche, P., Gijselaers, W., & Segers, M. (2009). The role of academic motivation in Computer-Supported Collaborative Learning. Computers in Human Behavior, 25(6), 1195-1206. Elsevier Ltd. doi:10.1016/j.chb.2009.05.012

Rizopoulos, L. A., & McCarthy, P. (2008). Using online threaded discussions: best practices for the digital learner. Journal of Educational Technology Systems, 37(4), 373-383. doi:10.2190/ET.39.4.c

Rodríguez-Torres, G. A., & Anta-Vega, J. M. (2006). El perfeccionamiento de la educación superior y su repercusión en la enseñanza de las matemáticas en las carreras técnicas. Ingeniería Mecánica, 2, 55-58.

Rainie, L., & Wellman, B. (2014). *Networked: The New Social Operating System*: The MIT Press.

Salmons, J. (2009). E-social constructivism and collaborative e-learning. In J. Salmons & L. Wilson (Eds.), Handbook of Research on Electronic Collaboration and Organizational Synergy (pp. 280-294). New York, NY: Information Science Reference.

Scott, J. (2013). *Social Network Analysis*. London, UK: SAGE Publications.

Scott, J., & Carrington, P. J. (Eds.). (2011). *The SAGE handbook of social network analysis*. London, UK: SAGE Publications Ltd. doi: http://dx.doi.org/10.4135/9781446294413

Silverman, I. (1977). Why social psychology fails. Canadian Psychological Review, 18, 353-8.

So, H., & Brush, T. (2008). Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment: Relationships and critical factors. Computers & Education, 51(1), 318-336. doi:10.1016/j.compedu.2007.05.009

So, H.-J., Seah, L. H., & Toh-Heng, H. L. (2010). Designing collaborative knowledge building environments accessible to all learners: Impacts and design challenges. Computers & Education, 54(2), 479-490. Elsevier Ltd. doi:10.1016/j.compedu.2009.08.031

Stewart S. A., Abidi, S.S. (2012). Applying social network analysis to understand the knowledge sharing behaviour of practitioners in a clinical online discussion forum. *Journal of Medical Internet Research*. 4(6). doi: 10.2196/jmir.1982.

Suthers, D., & Medina, R. (2008). Tracing interaction in distributed collaborative learning. In B. Wasson, S. Ludvigsen, & U. Hoppe (Eds.), Designing for Change in Networked Learning Environments (pp. 24-28). Kluwer Academic Publishers. Retrieved from http://metheny.ics.hawaii.edu/lilt/papers/2008/Suthers-Medina-AERA-2008.pdf

Todd, Z., Nerlich, B., McKeown, S., & Clarke, D. (2004). Mixing methods in psychology (pp. 3-16). Hove: Psychology Press.

Veerman, A., & Veldhuis-Diermanse, E. (2001). Collaborative learning through computer-mediated communication in academic education. In P. Dillenbourg, A. Eurelings, & K. Hakkarainen (Eds.), European Perspectives on Computer-Supported Collaborative Learning. Proceedings of the First European Conference on CSCL. Maastricht.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Wasserman, S., & Faust, K. (1995). Social network analysis: methods and applications.

Wishart, C., & Guy, R. (2009). Analyzing responses, moves, and roles in online discussions. Interdisciplinary Journal of E-learning and Learning Objects, 5.

Xia, H., Wang, R., & Hu, S. (2009). Social Networks Analysis of the Knowledge Diffusion among University Students. 2009 Second International Symposium on Knowledge Acquisition and Modeling, 343-346. IEEE. doi:10.1109/KAM.2009.240

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Zhu, C., Valcke, M., & Schellens, T. (2009). Cultural differences in the perception of a social constructivist e-learning environment. *British Journal of Educational Technology*, 40(1), 164-168.

Zhu, C. (2012). Students' satisfaction, performance and knowledge construction in online collaborative learning. *Educational Technology & Society*, 1(15), 127 - 136.

Zhu, C. (2013). The effect of cultural and school factors on the implementation of CSCL, *British Journal of Educational Technology*, 44 (3), 484-501.

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