Social network analysis for social network-based projects in project-led education

A case study from an engineering course

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Abstract

Social networks and project-led education are two research topics that have been increasing over the last years. This paper is focused on application of social network analysis on a social network-based project, developed for an engineering course of University of Minho, which followed the project-led education methodology. The study aims at analyzing the importance of adapting social network analysis techniques to evaluate students that work on social network-based projects. The results showed the ties between the participants and enabled the identification of the project and students' behavior, features relevant for evaluation of the students' work, as well as for the project's structure and organization design and management.

Keywords

Engineering education; Project-led education; Social networks; Social network-based projects; Social network analysis.

1. Introduction

Research on social networks has grown significantly over the last few years (Borgatti & Halgin, 2011). A social network consists of a finite set of actors and the ties between them (Wasserman, 1994). The three basic elements in social networks are actors, ties and graphs (Hawe et al., 2004). Actors are network members that can be distinct individuals or collective units. Ties, which can be formal or informal, link actors within a network. Graphs are visual representations of networks, displaying the actors as nodes and the ties as lines (Barabási, 2002).

Social network analysis (SNA) is the study of social structure (Wellman & Berkowitz, 1988). SNA describes a group of quantitative methods for analyzing the ties among social entities and their implications (Wasserman, 1994). An important aspect in social network analysis is to identify key players in a network (Borgatti, 2006). The main measures calculated in SNA are cohesion measures and centrality measures. Cohesion describes the interconnectedness of actors in a network (Hawe et al., 2004). The main measure of cohesion is the density of the network, which corresponds to the total number of ties divided by the total possible number of ties. Centrality measures identify the most prominent actors, i.e. those extensively involved in relationships with other network members (Freeman, 1979). The most commonly used centrality measures are: degree, betweenness and closeness (Opsahl et al., 2010). Degree centrality is the number of actors with whom a particular actor is directly related. Betweenness centrality and closeness centrality are related to the distance (neighborhood) between actors in a network. Betweenness centrality is the number of times an actor connects pairs of other actors

(Hawe et al., 2004). Closeness centrality presents distances between actors and describes how closely actors are connected to the entire network population (Hanneman & Riddle, 2005).

Over the years, learning through projects has become increasingly important for the learning process of students. Project-led Education (PLE) is a learning approach where students work together in teams to solve large-scale open-ended projects (Powell & Weenk, 2003). This type of project is focused on the students and on their performance, fostering the development of several types of skills, such as communication, time management, project management or entrepreneurship (Powell & Weenk, 2003; Helle et al., 2006; Lima et al., 2007).

This paper presents a case study of a social network-based project following the methodology of PLE. The main objective of this paper is to analyze the impact and the relevance of this new type of project on the students' learning process. It is also intended to show that SNA techniques can be effectively applied in this kind of social network-based project and to present some ideas of how those techniques can be used for the students´ evaluation process. This project represents a pioneer experience and was performed during two months with students from an industrial engineering and management master course. The idea of creating this new type of learning methodology was designed to stimulate a new way of working, in order to prepare the students for a completely different professional context. With the unpredictable employment situation, it is important to instruct students to deal with different approaches (i.e. working in social network-based projects or working as freelancers), which differ from the approaches that they are accustomed to (i.e. working in group projects or working with traditional companies).

Besides this Section 1 of the introduction and brief literature review, this paper includes five more sections. In Section 2 the concept of social network-based project is described. Section 3 presents a case study of a social network-based project. Section 4 shows the social network analysis with some important measures of network structure. In Section 5 some hypotheses and directions for future work are discussed. Finally, the conclusions about this study are presented in Section 6.

2. Social network-based project

The concept of social network-based project can be considered as a project where participants are seen as a social network, in which work assignments could be done in a crowdsourcing manner and where participants may use or not social networks platforms and tools to perform the tasks of the project. This kind of projects could promote also collaborative environment where two or more people can interact with each other and edit documents at the same time. A key aspect of social network-based projects is that it can foster the development of agility and self-organization.

In education, social network-based project can be understood as a further development of the PLE methodology, since the teaching method is based on the project that integrates two or more subject courses. From other side, while the traditional PLE is based on fixed working groups by students along the course (the group formed by students themselves or by teachers), in the social network-based PLE project similarly there are predefined groups (which corresponds to one type of the actors of the social network) but there also exist other types of actors (project coordinators and individual resources) that permits self-organization and higher levels of agility.

3. Case study

The social network-based project presented in this paper followed the PLE methodology and was performed on an engineering course during a period of two months. The project was part of the evaluation of the curricular units of Computer Assisted Design/Computer Assisted Process Plan (CAD/CAPP) and Computer Assisted Manufacturing (CAM) of the 4th year of the Industrial Engineering and Management master course of University of Minho. This was the first time that this experience occurred in the course. A total of 43 students participated in the project where 6 of them were defined as project coordinators and the remaining 37 students were assigned as resources of two types, namely, as individual resources and group resources. Each one of those 37 remaining students were assigned as an individual resource and were also organized in 6 working groups, in accordance with traditional PLE methodology, and each working group were assigned as a group resource type. So, the total number of participants were 43 students but in total, the "social network" to

realize the assigned projects consisted of 49 actors, i.e. 6 project coordinators (C1, C2, etc.), 37 individual resources (R1, R2, etc.) and 6 working groups (G1, G2, etc.).

In this paper the SNA was only applied to the sub-network of actors of the individual type, i.e. the 6 project coordinators and the 37 individual resources.

The assigned projects to be realized were divided in a number of tasks that were launched by the project coordinators to all actors simultaneously and these tasks were assigned to individual "resources" (students) based on the negotiation between the coordinator and the candidate "resource" (student). The ties among the actors of the social network, that could be the subject of the SNA, could be of different types, such as communication processes, accomplished tasks and failed tasks. In this paper it was only considered the type of accomplished tasks for the application of SNA. That is, for each accomplished task, there will be established a link between the coordinator that launched that task and the individual resource that accomplished it.

4. Social network analysis

4.1. Network modelling

The first thing to do in social network analysis is the network modelling. For this purpose, firstly, it was created a matrix with all ties that occurred between the project coordinators and the individual resources, only regarding the accomplished tasks at the end of the project. In that matrix, 1 was assigned in cases when an individual resource accomplish a task for a coordinator and 0 for the opposite situation. The matrix was uploaded in the software UCINET, which was the software tool for the SNA execution. Figure 1 represents part of the matrix uploaded.

	Coord 1	Coord 2	Coord 3	Coord 4	Coord 5	Coord 6	Res 1	Res 2	Res 3	Res 4
Coord 1	0	0	0	0	0	0	0	0	1	0
Coord 2	0	0	0	0	0	0	0	1	0	1
Coord 3	0	0	0	0	0	0	0	0	0	0
Coord 4	0	0	0	0	0	0	0	0	0	0
Coord 5	0	0	0	0	0	0	1	1	1	0
Coord 6	0	0	0	0	0	0	1	0	0	0
Res 1	0	0	0	0	1	1	0	0	0	0
Res 2	0	1	0	0	1	0	0	0	0	0
Res 3	1	0	0	0	1	0	0	0	0	0
Res 4	0	1	0	0	0	0	0	0	0	0
Res 6	0	1	1	0	0	0	0	0	0	0
Res 7	0	1	0	0	1	0	0	0	0	0

Figure 1. Part of the matrix

After that, in the same software, the social network graph was created (Figure 2). Figure 2 represents all ties that occurred between the different actors during the project, in terms of accomplished tasks. With this social network graph it is possible to see with how many individual resources the coordinators interacted with and also to have an idea of the actors who had more activity in the project.

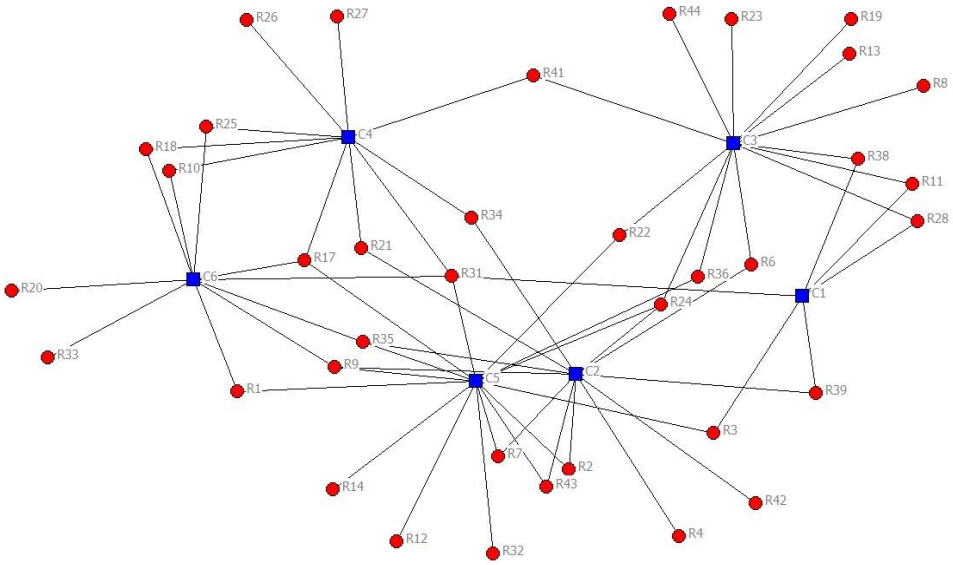

Figure 2. Social network graph of the project

4.2. Measures of network structure

This sub-section presents four important SNA measures: density (a cohesion measure) and degree, betweenness and closeness (some centrality measures).

4.2.1. Density

To calculate the density of the network Equation 1 was used.

$$D = T/PT \quad (1)$$

Where D, T, and PT refer to Density, Ties, and Possible Ties, respectively. In this case there were only ties between the project coordinators and the individual resources, and not ties between coordinators neither between individual resources. Since the total number of individual resources is 37 and the total number of coordinators is 6, PT value is 222 (37x6). The T value is obtained analyzing the various ties that occurred. For this case there were 66 different ties of the 222 possible ties. The network density is then 0.297 (66/222), i.e. 29.7% of density. This result indicates that the network has low connectivity. This was an expected result since in this social network-based project it is not possible to have ties between individual resources or between project coordinators. In the case of this measure it is also possible to obtain the density value for each actor. Supposing that Coordinator 1 had interactions with five individual resources, then its density value would be 0.135 (5/37), i.e. 13.5%.

4.2.2. Centrality

The centrality measures of degree, betweenness and closeness were calculated with the help of UCINET. Table 1 shows the results obtained for the centrality measures for each actor.

Table 1. Results for centrality measures.

ID	Degree	Betweenness	Closeness
Coordinator 1	14.286	8.477	38.532
Coordinator 2	28.571	24.257	43.299
Coordinator 3	30.952	32.304	41.584
Coordinator 4	23.810	21.249	41.584
Coordinator 5	**35.714**	**35.696**	**46.154**

Coordinator 6	23.810	16.926	37.168
Resource 1	4.762	1.357	35.000
Resource 2	4.762	0.857	35.593
Resource 3	4.762	1.223	34.426
Resource 4	2.381	0.000	30.435
Resource 6	4.762	3.501	36.842
Resource 7	4.762	0.857	35.593
Resource 8	2.381	0.000	29.577
Resource 9	7.143	4.163	39.623
Resource 10	4.762	0.627	32.308
Resource 11	4.762	0.849	32.813
Resource 12	2.381	0.000	31.818
Resource 13	2.381	0.000	29.577
Resource 14	2.381	0.000	31.818
Resource 17	7.143	4.306	38.889
Resource 18	4.762	0.627	32.308
Resource 19	2.381	0.000	29.577
Resource 20	2.381	0.000	27.273
Resource 21	4.762	1.923	35.000
Resource 22	4.762	3.482	38.182
Resource 23	2.381	0.000	29.577
Resource 24	7.143	7.840	42.857
Resource 25	4.762	0.627	32.308
Resource 26	2.381	0.000	29.577
Resource 27	2.381	0.000	29.577
Resource 28	4.762	0.849	32.813
Resource 31	**9.524**	**10.411**	**42.857**
Resource 32	2.381	0.000	31.818
Resource 33	2.381	0.000	27.273
Resource 34	4.762	1.923	35.000
Resource 35	7.143	4.163	39.623
Resource 36	4.762	3.482	38.182
Resource 38	4.762	0.849	32.813
Resource 39	4.762	1.503	33.333
Resource 41	4.762	7.022	36.207
Resource 42	2.381	0.000	30.435
Resource 43	4.762	0.857	35.593
Resource 44	2.381	0.000	29.577

Regarding degree centrality, the central actor or key player of this social network was Coordinator 5, with a degree value of 36%. This means that Coordinator 5 established direct ties with 36% of the overall network. In terms of resources, Resource 31 was the most active in the project with a degree value of 10%. In this project, as the individual resources could only interact with the project coordinators, the value 10% is very significant and indicates that Resource 31 interacted with almost all coordinators. These actors, who had higher degree centrality and consequently many ties, may have advantages over the other actors since they present alternative ways of satisfying needs and are less dependent on other actors.

The highest betweenness centrality values were also for Coordinator 5 (36%), in the case of coordinators, and Resource 31 (10%), in the case of resources. Those values can be interpreted following the idea that the more actors depend on one certain actor to make connections with other actors, the more power this actor will

have. It is also possible to perceive that there was a great variation in actors' betweenness (from 0.000 to 35.696)

Finally, in the case of closeness centrality, once again Coordinator 5 and Resource 31 registered the highest values, 46% and 43% respectively. Closeness centrality measure gives emphasis to the distance between an actor and all the others in the network. Then, the higher the value of closeness centrality, the shorter these distances will be.

5. Some hypotheses for using SNA in students' evaluation process

The present study brought the need to point out some ideas and hypotheses on how to use SNA for the improvement of the learning methodology including the students' evaluation process on social network-based projects. This new type of learning methodology can have a great impact on the students' learning process, fostering the development of new types of skills and, in this way, contributing for the methodology of project-led education. In this way, the hypotheses for social network-based projects are:

- Students tend to interact with "project coordinators" they already know;
- Students' final grades are correlated to their degree centrality values;
- Social network-based projects can foster the development of agility and self-organization;
- Social network analysis can contribute to the design of work projects for students, as well as to the design of students' evaluation model, with the objective of improving the performance parameters and other education methodology and process elements, in accordance with the learning objectives.

6. Conclusion

This paper has verified that social network analysis can be applied to analyze behaviors and the most important actors in a social network-based project. Some hypotheses about the importance of using SNA for students' evaluation were also identified. Further research can be done with the introduction of project tasks into the network to make the system more complex and to have more precise measures.

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