Social Network Analysis and Evaluation of Communities of Practice of Teachers: A Case Study

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Abstract. *Communities of Practice* (CoPs) may be interpreted as kinds of a vertical evolution of social networks, where members share common interests in a particular domain or area, and exchange practical experiences to increase their knowledge and skills with respect to that specific field. In this paper we present some evaluation aspects of an experiment conducted within the framework of the European project *UnderstandIT*. The experiment involved the use of a CoP providing an educational program on *Web2.0 Technologies for education* for Vocational Education and Training teachers. The CoP was designed on the basis of the foundational Wenger's concepts of *domain*, *community* and *practice*. In particular, we present a study of some social aspects of the CoP dynamics, basing our study on some evaluation metrics coming from the Social Network Analysis research area, i.e., using metrics such as *betweenness*, *centrality*, and *closeness*, in order to elicit useful relationships information. The experimental results confirm the goodness of the use of such approach for the elicitation of hidden information in the communicative network processes.

1 Introduction

Communities of Practice (CoPs) may be interpreted as kinds of a vertical evolution of social networks, where members share a common interest in a particular domain or area, and exchange practical experiences to increase knowledge and skills related to that specific field [24]. CoPs are in fact based on a very flexible model of organization and interaction, which in principle does not necessarily prescribe the use of the Internet; yet the applicability of CoPs is significantly boosted by the use of network technology and communication tools based on

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the web. In this way CoPs can widely extend their usefulness to the field of professional education and lifelong learning through the use of a social web-based environment. Focusing on the topic of education, it is generally agreed that a significant part of knowledge, protocols, strategies and rules of a professional activity, may remain only partially covered in educational activities, or even reach the extreme of being implicit and hidden. In other words, traditional training may fail to provide a ready-to-exploit expertise, which is effective in real situations. CoPs can provide a good approach to that problem, as their model can be easily adapted to support career education. In this paper we present some evaluation aspects of an experiment conducted within the framework of the european project *UnderstandIT*[1]. The experiment involved the use of a CoP (*UnderstandIT*[2]) providing an educational program on *Web2.0 Technologies for education* dedicated to Italian *Vocational Education and Training* (VET) teachers. Technical information and best practices were presented to use some Web 2.0 tools and systems for the development and administering of educational activities pertaining everyday teaching activity.

The UnderstandIT project arose from the need to bridge the gap between the use of Web 2.0 by teachers, compared to that by pupils, and to make digital immigrants (the former) and digital natives (the latter) encounter on a common ground [19] and share a common suite of languages and tools. In fact, the underlying hypothesis is that the use of these tools has great potentialities to make teaching more effective. The UnderstandIT CoP was designed based on the concepts of *domain*, *community* and *practice* [23]. The domain of shared competence addressed here is the teaching activity for VET education; the community members are VET teachers while the practice is the use of the Web 2.0 instruments and tools in the teaching activities. We used the open source ELGG social network engine[3] as the technological platform. It is one of the most used frameworks delivering the building blocks that enable companies, schools, universities and associations to create their own fully-featured social networks and applications. This web engine runs as a web application, providing a social environment with a wide range of Web 2.0 services such as forum, chat, wiki and so on: members are free to create wiki activities and to participate to all the social activities put on line by the platform. As introduced above, the main aim of this paper is to present an evaluation of the social activities carried on by its members. An early research question of our work was to test whether the approach to learning and teaching allowed by the UnderstandIT community was beneficial for the learners and fostered a social interaction among them, aimed at sharing and learning. In [4] we presented the UnderstandIT CoP at its early stage of development, discussing an early research question, related to learners participation in the network social activities (e.g.: blogs, wiki, forum,...). Then the research question has been expanded and we have investigated other aspects of the CoP dynamics. Here we present an evaluation of the UnderstandIT CoP,

[1] http://aitel.hist.no/understandit/
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[3] http://elgg.org

based on the techniques coming from Social Network Analysis: we base the analysis on metrics such as *betweeness*, *centrality*, and *closeness*, in order to gather more information about the network dynamics, that would be not directly available by means of the simple descriptive statistics we used earlier. The rest of the paper presents in Sect. 2 some related work in the area of CoP. In Sect. 3 a brief description of the Social Network Analysis is given while in Sect. 4 the experimental results are reported. Finally, in Sect. 5 conclusions are drawn.

2 CoPs: Literature Review and Related Work

In the past, learning and training were almost always based on the role of "imitation" and on the predecessor of the modern "learning by doing". The artisan workshops were the privileged places for transmitting and preserving arts and crafts, looking at the "master" or "maestro" and at more expert companions. Common practice and storytelling were the vehicles of knowledge/skill transmission. Even if this was mostly true for "concrete" skills more than for knowledge, it is true that in a wider perspective even abstract knowledge was enforced through continuous debates and sharing with other scholars. Therefore, it sounds strange that the industrial age, with the triumph of materialism and practical intelligence, also stated the prevalence of "abstract knowledge" over actual concrete practice, whose details were considered as contingent, easily derived after the relevant abstractions, and therefore less essential. This soon established a separation between learning and working, and most of all between learners and workers. This separation had as a consequence that a large part of experiential knowledge, the so-called implicit knowledge acquired while performing concrete tasks in an ecologically significant context, was left out from training. This may cause confusion and difficulties in the following application of training to real working situations. We are all aware that people often work according to patterns and rules which are quite different from manuals guidelines and from the "theoretical" descriptions of job tasks. It often happens that complementary or even completely alternative strategies and rules drive the actual practice, except for very basic and "gross" activities. Experience suggests a number of workarounds and shortcuts that support a more effective activity, and are the most precious achievement given by a long experience. Nonetheless, organizations tend(ed) to rely on a "static" form of training to transmit work practice. However the success of the term and the spreading of its concrete practices were finally spurred by the works of Lave and Wenger [10,11]. They built on a theory of learning based on practice. Its core concept is the *Legitimate Peripheral Participation* in CoPs [11]. In a CoP external observers may be allowed to watch, though without actively participating. The novices firstly access the community from the periphery. They acquire experience though the support of more experienced members, and gain reputation also a consequence of the support that they in turn are able to provide to companions. In this way, they finally achieve full participation and membership. In general, the structure of a CoP is characterized by: (1) a group of core experts, who achieved high reputation and trustworthiness, as assessed

by their peers, (2) the major group of active participants, who fully participate to the exchange of information and experiences, and (3) the peripheral participants, who start as observers and can gradually level-up. At the same time, the community itself develops through different levels of interaction among the members. Self-development originates by active participation to the community, and the community develops together with its members. Two central elements of the CoP approach are situated learning [8] and community reflection on practice. Knowledge is acquired from and applied back to everyday real settings, while discussing it with peers and experts in a rich social system [23]. Starting from the earliest forms of forums, till to the modern Social Networks (SN), supported by Web2.0 technologies, it is the most powerful vehicle of participatory growth. According to the above described perspective, we can consider learning as the main activity but even as the core topic of the CoP strategies. In [2] the authors underline "the growing need to integrate educational research and practice" in order to connect what we know with what we do. The back of the coin is in that shared lists of recommended practices often fail to promote the personal responsibility and exploration ability. This not only affects educational researchers and teachers, but also students and their parents. On the contrary, the main achievement of a CoP should be to encourage and motivate every member of the educational community to personally analyze, constructively criticize, and effectively complement each other's experiences. Teachers should be encouraged in taking active part in research activities. The authors consider CoPs a very promising tool, able to allow reaching these goals, even compared with other strategies to join research and practice, e.g., action research [3], or professional development schools. The common goal is breaking "the linear relationship through which information is handed down from those who discover professional knowledge to those who provide and receive educational services" [2]. Other approaches that can find a joint implementation with CoPs tools in a comprehensive educational framework are: (i) a personalized learning, through a didactic able to adapt its patterns to the learners' specific real needs (see for example [7,13,14,16,20]) (ii) an approach related to ontology-based systems helping teachers to search for suitable educational material in the Internet (see [12]). Technology enhanced learning can further take advantage from research lines (e.g. [5,6]) aiming at integrating more traditional individualized e-learning and social-collaborative e-learning [15]. Finally, a project very similar to our proposal is the SEDA project [18]. This project supports members working in higher education institutions. The proposed CoP is an environment where educational developers can highlight their needs and fruitfully share their experiences. The spirit of the SEDA project is the mutual support provided by the members of the community.

3 Social Network Analysis

A Social Network is a group of collaborating and/or competing individuals or entities that are related to each other and is formally defined as a set of social actors, or nodes, that are connected by one or more types of relations [22].

Social Network Analysis (SNA) deals with the analysis of social networks in order to trace the relationships, learn their meanings and apply the information inferred among the members of the network. SNA borrows many concepts and tools from the graph theory because a Social Network can be represented as a graph where the actors are represented by the nodes and the relationships among them by the edges of the graph and where weights can be assigned to the edges between nodes to designate different interactions strengths [17,22,25]. Consequently, graph theory is used to describe Social Networks together with their dynamics among individuals or groups. To this aim many graph tools have been developed to help researchers to visualize Social Networks. For our goals we used the *Gephi* graph tool, an open source tool useful for Social Network analysis. In this Section we show the metrics we based our study on. In the literature there are a lot of metrics proposed to discover the characteristics of a Social Networks, like *Size* and *Density*, all type of centralities like *Degree*, *Betweenness*, *Closeness* and *Eigenvector*, clustering coefficient, path analysis (reachability, reciprocity, transitivity and distance), flow, cohesion and influence, and other useful information obtained by various types of analysis [21]. In particular, our analysis was carried out starting from the log files generated during the Social Network life. We used the following metrics [9,25]:

- *Degree Centrality.* This metric aims to detect the most *important nodes* in the network. The *degree* of a node is defined as the number of direct connections a node has with other actors or nodes. A node with a high degree centrality acts as a hub in the network having it a lot of edges coming in and a lot of edges coming out. It signifies activity or popularity;
- *Betweenness Centrality.* This metrics measures how the position of a node is important, and is defined as the number of times a node connects pairs of other nodes, who otherwise would not be able to reach one another or to what extent a node can play the role of intermediary in the interaction between the other nodes. A node can have fewer connections than another node, but its position could be more relevant with respect to the network flows;
- *Closeness Centrality.* This metric is based on the notion of the geodesic distance (i.e., shortest path) among the nodes of the graph and measures the independence of a node. It is defined as the mean geodesic distance between a node and all other nodes reachable from it. Closeness can be regarded as a measure of how long it will take information to spread from a given node to other nodes in the network;
- *Density.* This metric describes the general level of linkage among the nodes of a graph. A *complete* graph is a graph having all its nodes directly connected, i.e., each node is connected to each other by e direct link. This metric aims to measure how far from this state of completion the graph is. Given a direct graph, $G \equiv (V, E)$, Density is defined as: $Density = \frac{|E|}{|V|*(|V|-1)}$, being $|V|$ the total number of vertices and $|E|$ the total number of the edges of the graph.
- *Clique.* A clique is a sub-set of nodes where all possible pairs of nodes are directly connected. Detecting cliques in a graph is important in order to elicit sub-communities.

4 A Social Analysis of the UnderstandIT CoP

In this Section we present a first study of the UnderstandIT CoP with the aim to elicit some useful information by means of the use of SNA and in particular of the metrics shown in Sect. 3. There are a lot of tools for graph management and SNA like NodeXL[4], NetMiner[5], Pajek[6], Gephi[7] and many others. As already mentioned in Sect. 3, we used the *Gephi* graph tool. *Gephi* is an open source software for graph and network analysis. It uses a 3D render engine to display large networks in real-time and to speed up the network exploration. Moreover, it provides easy and broad access to network data and allows for filtering, navigating, manipulating and clustering [1]. In a recent paper [4] we introduced the UnderstandIT CoP, together with a brief description and evaluation of the main activities carried out by its members. We used some popular CoP descriptive metrics such as the number of visits, the number of blog posts and so on and, after having shown the participation, we evaluated the feeling of the CoP teachers with respect to the Web 2.0 instruments and tools by means of a pre-test and post-test questionnaire. Here we propose the study of the CoP from a social point of view, with the goal of elicit information from the dynamics of the relationships among the members of the network. To this aim we used a subset of the metrics of Sect. 3. In particular, we present some preliminary studies about the following relationships: Participation to groups activities, Friendship relationships and Exchange of messages for knowledge sharing, starting from the log files generated by the ELGG platform.

4.1 Friendship Relationships

In Fig. 1 is shown the graph of the CoP, having 292 edges and 77 nodes, based on the *Friendship* Relationships. The system discovered four sub-communities among members. This graph presents 2313 shortest paths with $Density = 0,05$ and $AveragePathLenght = 4$.

4.2 Members Participation to Group Activities

In Fig. 2 the network representing the participation of the community members to web 2.0 social activities is shown. The social activities were: forum, blog, file and so on. The graph was formed by 50 nodes and 80 edges with a $density = 0.03$, with 5 sub-communities, with 80 shortest paths.

4.3 Knowledge Exchanges

In Fig. 3 is shown the graph representing the exchange of knowledge among members, after a brief period of the online activities. The Gephi tool revealed 4

[4] www.nodexl.org
[5] www.netminer.com
[6] vlado.fmf.uni-lj.si/pub/networks/pajek/
[7] www.gephi.org

Fig. 1. The Friendship relationships. It is easy to individuate four sub-communities.

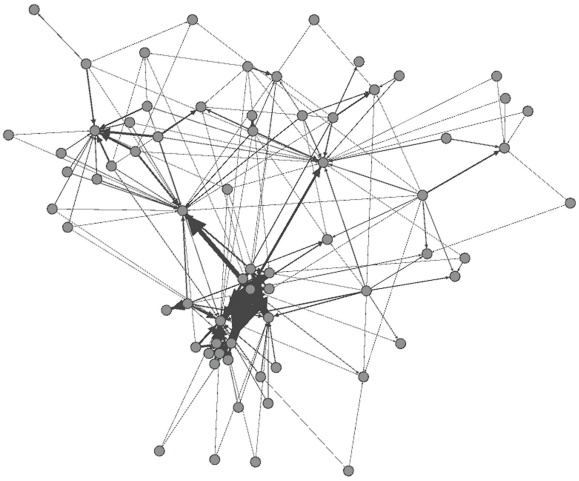

Fig. 2. Members participation to social activities.

sub-communities, $density = 0.096$, number of shortest paths: 186, $AveragePath\ Lenght = 2.62$ and 7 edges equally distributed from 10 to 40.

4.4 Lesson Learned

The application of the SNA methods and techniques to our case study, i.e., the UnderstandIT CoP, allowed us to perform a structural analysis of the network

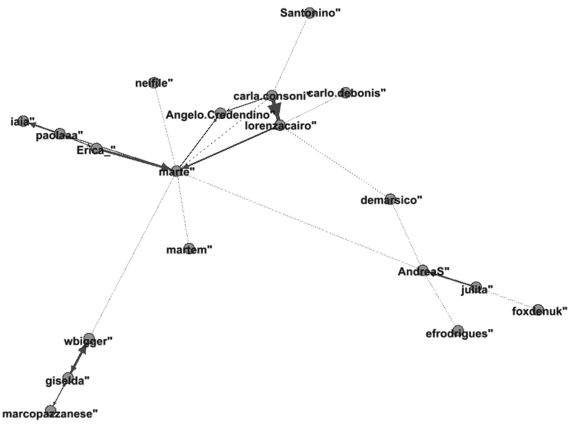

Fig. 3. Knowledge exchange among members.

from the point of view of the relationships among all the members involved in the learning process in a more deeper way and focussed on the dynamics of the members relationships of a community. For example, we discovered different sub-communities showing a few integration among all the members in all the activities carried out and that there are key figures in the information flows between them. Of course, being in the context of a spontaneous flow of information as the one spurred in a CoP setting, it is not possible to force changes in the pace of communication. However, it is true that an appropriate feeding by the most estimated members (the core of the CoP, i.e., those with higher reputation), a prompt feedback to inquiries, most of all from novice members, and the organization of online events, can maintain the community alive and healthy. In a worth while multi-lingual setting, it would be quite natural that the language dimension should prevail on other aspects, unless appropriate translation services are provided. As a matter of fact, in a future perspective we plan to include keyword translation for multilingual labeling of contents and online translation of pages. On the other hand, a hierarchical inspection of detected clusters and the use of finer measures, or even of the same ones on a restricted set of participants, can help highlighting more covered processes.

5 Conclusions and Future Work

In this paper we presented the study of the UnderstandIT Community of Practice from a social point of view. In a previous work we proposed an evaluation of the same CoP from a *degree of satisfaction* point of view, i.e., by submitting a pre-test and a post-test questionnaires and finally a happy sheet to the community members. Here we focussed on the members relationships to elicit useful information about the CoP dynamic from a social point of view. To this aim we used one of the graph visualization and analysis tools proposed in the literature and studied some social activities, using some classical centrality metrics.

By this approach we discovered some unknown social structures in the network such as sub-communities and other important weighed relationships, strengthening the validity of this approach. As a future work we plan to investigate the relationships between these metrics and the learning process behind the network dynamics.

References

1. Bastian, M., Heymann, S., Jacomy, M.: Gephi: An open source software for exploring and manipulating networks. In: Proceedings of the International AAAI Conference on Weblogs and Social Media (2009)
2. Buysse, V., Sparkman, K.L., Wesley, P.W.: Communities of practice: connecting what we know with what we do. Except. Child. **69**(3), 263–278 (2003)
3. Calhoun, E.F.: How to Use Action Research in the Self-Renewing School. Association for Supervision and Curriculum Development, Alexandria (1994)
4. De Marsico, M., Limongelli, C., Sciarrone, F., Sterbini, A., Temperini, M.: Understandit: A community of practice of teachers for vet education. In: Proceedings of Webist 2014: 10th International Conference on Web Information Systems and Technologies, pp. 338–345 (2014)
5. De Marsico, M., Sterbini, A., Temperini, M.: The definition of a tunneling strategy between adaptive learning and reputation-based group activities. In: Proceedings of 11th IEEE International Conference on Advanced Learning Technologies, ICALT, pp. 498–500 (2011)
6. De Marsico, M., Sterbini, A., Temperini, M.: A strategy to join adaptive and reputation-based social-collaborative e-learning, through the zone of proximal development. Int. J. Distance Educ. Technol. **19**(2), 105–121 (2012)
7. De Marsico, M., Temperini, M.: Average effort and average mastery in the identification of the zone of proximal development. In: Proceedings of 17th IEEE International Conference on System Theory, Control and Computing, ICSTCC 2013 (2013)
8. Hummel, H.G.K.: Distance education and situated learning: paradox or partnership? Educ. Technol. **33**(12), 11–22 (1993)
9. Hussain, D.M.A.: Investigation of key-player problem in terrorist networks using bayes conditional probability. In: Furht, B. (ed.) Handbook of Social Network Technologies, pp. 523–547. Springer, New York (2010)
10. Lave, J.: Situating learning in communities of practice. In: Resnick, L.B., Levine, J.M., Teasley, S.D. (eds.) Perspectives on Socially Shared Cognition, Chap. 4, pp. 63–82. American Psychological Association, Washington, DC (1991)
11. Lave, J., Wenger, E.: Situated Learning: Legitimate Peripheral Participation. Cambridge University Press, Cambridge (1991)
12. Limongelli, C., Mosiello, G., Panzieri, S., Sciarrone, F.: Virtual industrial training: Joining innovative interfaces with plant modeling. In: Proceedings of ITHET 2012, pp. 1–6. IEEE (2012)
13. Limongelli, C., Sciarrone, F., Temperini, M., Vaste, G.: Lecomps5: A web-based learning system for course personalization and adaptation. In: Proceedings of IADIS 2008, Amsterdam, The Netherlands, July 22–25, 2008, pp. 325–332 (2008)
14. Limongelli, C., Sciarrone, F., Temperini, M., Vaste, G.: The lecomps5 framework for personalized web-based learning: a teacher's satisfaction perspective. Comput. Hum. Behav. **27**(4), 1310–1320 (2011)

15. Limongelli, C., Sciarrone, F., Vaste, G.: LS-Plan: an effective combination of dynamic courseware generation and learning styles in web-based education. In: Nejdl, W., Kay, J., Pu, P., Herder, E. (eds.) AH 2008. LNCS, vol. 5149, pp. 133–142. Springer, Heidelberg (2008)
16. Limongelli, C., Sciarrone, F., Vaste, G.: Personalized e-learning in moodle: the moodle-ls system. J. E-Learning Knowl. Soc. **7**(1), 49–58 (2011)
17. Marin, A., Wellman, B.: Social network analysis: an introduction. In: Carrington, P., Scott, J. (eds.) Handbook of Social Network Analysis. Sage, Thousand Oaks (2010)
18. Nixon, S., Brown, S.: A community of practice in action: Seda as a learning community for educational developers in higher education. Innov. Educ. Teach. Int. **50**(4), 357–365 (2013)
19. Prensky, M.: Digital natives, digital immigrants part 1. Horiz. **9**(5), 1–6 (2001)
20. Sciarrone, F.: An extension of the q diversity metric for information processing in multiple classifier systems: a field evaluation. Int. J. Wavelets Multiresolut. Inf. Process. **11**(6) (2013)
21. Slaninova, K., Martinovic, J., Drazdilova, P., Obadi, G., Snasel, V.: Analysis of social networks extracted from log files. In: Furht, B. (ed.) Handbook of Social Network Technologies, pp. 115–146. Springer, New York (2010)
22. Wasserman, S., Faust, K.: Social Network Analysis: Methods and Applications. Cambridge University Press, Cambridge (1994)
23. Wenger, E.: Communities of practice: learning as a social system. Syst. think. **9**(5), 2–3 (1998)
24. Wenger, E.: Communities of practice and social learning systems: the career of a concept. In: Blackmore, C. (ed.) Social Learning Systems and Communities of Practice, Chap. 11, pp. 179–198. The Open University, London (2010)
25. Zhang, M.: Social network analysis: History, concepts, and research. In: Furht, B. (ed.) Handbook of Social Network Technologies, pp. 3–21. Springer, New York (2010)