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# Effects of Hierarchical Levels on Social Network Structures within Communities of Learning

**Martin Rehm[a], Wim Gijselaers[b], Mien Segers[b]**

[a] University Duisburg-Essen, Germany

[b] Maastricht University, the Netherlands

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## Abstract

*Facilitating an interpersonal knowledge transfer among employees constitutes a key building block in setting up organizational training initiatives. With practitioners and researchers looking for innovative training methods, online Communities of Learning (CoL) have been promoted as a promising methodology to foster this kind of transfer. However, past research has only provided limited data from actual organizations and largely neglected characteristics that constitute a major obstacle to such collaborative processes, namely participants' hierarchical levels. The current study addresses these shortcomings by providing empirical evidence from 25 CoL of an online training program, provided for 249 staff members of a global organization. Using social network analysis, we are able to show significant differences in participants' network behaviour and position based on their hierarchical rank. This translates into higher in- and out-degree network ties, as well as centrality scores among participants from higher up the hierarchical ladder. Finally, based on a longitudinal analysis of all indicated network measures, our results indicate that the main trend develops predominately during the first half of the training program. By incorporating these insights into the implementation of future CoL, it is not only possible to anticipate participants' behaviour. Our findings also allow to draw conclusions about how collaborative activities within CoL should be designed and facilitated, in order to provide participants with a valuable learning experience.*

*Keywords:* Social Learning Networks; Longitudinal Analysis; Centrality; Hierarchical Levels

*Corresponding author*: Martin Rehm, Department of Educational Media & Knowledge Management, University Duisburg-Essen, Forsthausweg 2, 47057 Duisburg, Germany, Phone: +49-203-3794323, Email: martin.rehm@uni-due.de

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## 1. Introduction

Researchers have stipulated that organizations are transactive knowledge systems, where the vast majority of knowledge is stored in the heads of individual employees (Cross, Borgatti, & Parker, 2001). Consequently, it has been suggested that facilitating an interpersonal knowledge transfer among employees constitutes a key building block in setting up organizational training initiatives (Argote & Ingram, 2000). This notion is further supported by researchers who suggested that knowledge is being created while collaborating in social networks composed of diverse groups of people (e.g. Hakkarainen, Palonen, Paavola, & Lehtinen, 2004; Paavola, Lipponen, & Hakkarainen, 2004). In practice, this process of connecting people greatly builds upon the extensive use of electronic communication tools, such as asynchronous discussion forums. These types of communication channels have been proposed by scholars to effectively enable the establishment and development of new ways in which training can build upon networked communities (e.g. Venkatraman, 1994). Yet, organizations cannot assume that once a technology is introduced and the appropriate structure has been designed the rest will follow. Instead, previous research has established that for social (learning) networks to achieve their intended goals, a clear understanding is needed of how existing organizational structures influence not only the adoption of electronic communication tools, but also their implementation (Zack & Mckenney, 1995).

With practitioners and researchers starting to increasingly look for new approaches to design and implement organizational training programs (Yamnill & McLean, 2001), online collaborative learning has received a growing amount of attention in recent years (Brower, 2003). In the context of this study, we consider (online) collaborative learning as a setting where "*[participants] are working in groups on a shared task or problem, in which they are expected to have equal contributions and participation*" (de Laat, Lally, Simons, & Wenger, 2006, p. 103). One promising methodology that has been developed within this framework is the concept of online *Communities of Learning* (CoL). Being defined as groups of people "*engaging in collaborative learning and reflective practice involved in transformative learning*" (Paloff & Pratt, 2003, p. 17), CoL have been proposed to foster the effective exchange of knowledge and experience between members of an organization's workforce (e.g. Stacey, Smith, & Barty, 2004). Moreover, online communities, like CoL, have been considered as an almost ready-made laboratory for analysing collaboration in social (learning) networks over time (Haythornthwaite, 2001).

In order to conduct these types of analysis, numerous researchers have suggested social network analysis (SNA) as a valuable tool for describing and understanding whether and how members of a (learning) network interact with each other (e.g. Daradoumis, Martínez-Monés, & Xhafa, 2004; de Laat, Lally, Lipponen, & Simons, 2007). According to Aviv, Erlich, Ravid and Geva (2003) a social network can be defined as "*a group of collaborating (and/or) competing entities that are related to each other*" (p. 4). SNA has been used to analyse various networks from several academic domains, ranging from social sciences, communication studies, economics, to computer networks and different other fields (Aviv et al., 2003). Moreover, Garton and colleagues (2006) specifically suggest using SNA methods in the context of online learning networks. When considering their structure and development, and following the seminal work of Erdös and Rényi (1960), social networks should evolve according to the concept of random graph theory. In essence, the underlying supposition of this theory is that while some participants of a network might get in touch with more people than others, on average everyone should have made the same amount of contacts, similar to a random distribution of connections. In other words, all participants of a network should have an equal chance of making connections (Rienties, Tempelaar, Giesbers, Segers, & Gijselaers, 2012). However, if everyone did indeed have equal chances of getting connected with others, why can we then observe so many biased networks in the real world (Barabási, 2003)?

More specifically, based on numerous studies of newly emerging online communities, researchers have found that a small minority of participants (15%) is gravitating around the centre of their community's activity, while a considerable larger group (40%) is barely engaging into communication with their colleagues (e.g. Cross, Laseter, Parker, & Velasquez, 2006). In order to explain these observed patterns, some researchers have referred to the fact that communication is an inherently social act (Pearce, 1976). New tools and methodologies can only reach their full potential, if organizers fully understand how existing social relationships influence communication patterns and participants' behaviour therein (Wellman, 2001). Moreover, de Laat and Lally (2003) stipulated that the social and contextual frameworks in which the learning takes place have a considerable influence on how participants behave and perform within online learning networks. Furthermore, the nature of social networks, as well as their development over time, is significantly affected by the background characteristics of their individual members (e.g. Barabasi & Albert, 1999). Yet, past research has largely been concerned with the static features of online communities (Panzarasa, Opsahl, & Carley, 2009). While this offers preliminary insights on the overall processes that take place within these communities, it lacks a more refined picture of how social relationships might develop over time (e.g. Aviv et al., 2003; Haythornthwaite, 2001). Additionally, the vast amount of research has neglected a particular background characteristic that can have a severe effect on the underlying learning processes, namely participants' hierarchical levels (Carley, 1992; Griffith & Neale, 2001; Romme, 1996).

The present study addresses these shortcomings by providing empirical evidence from 25 CoL of an online training program that was provided for 249 staff members of a global organization. Each CoL consisted of 7 – 13 participants and was centred on asynchronous discussion forums, where participants from different parts of the organization's hierarchical ladder collaboratively enhanced their knowledge and skills. In order to analyse whether participants' network behaviour was influenced by their hierarchical level, social network analysis (SNA) was employed. Based on the resulting findings of our study, organizers of CoL will able to anticipate (groups of) individuals holding crucial positions and design actions targeted at participants who tend to be situated more towards the fringe of the network (Hatala, 2006). Moreover, incorporating our findings into the design and implementation strategies of future CoL will allow a more refined setup that contributes to employees' learning experience and can foster the knowledge creation within an entire organization.

## 2. Effects of Hierarchical Levels on Social Network Structures within CoL

One of the key elements of online (learning) communities is that they allow for an open dialogue between participants (Amin & Roberts, 2006). Yet, when considering the findings and experiences from real-life communities within organizations, there is increasing evidence that information flows are constrained by underlying organizational structures, such as departments, units and hierarchical levels (e.g. Cross, Laseter, Parker, & Velasquez, 2004). One possible explanation for this finding has been put forth by authors like Drazin (1990), who stipulated that professionals might not join communities with the intention of learning. Instead, individuals would primarily engage into discussion with colleagues, in order to secure their role, and gain access to and control over information. Holmqvist (2009) indicated that all organizational learning processes are subject to the influence of a dominant individual or group of individuals. Similarly, van der Krogt (1998) postulated that "*[…] powerful work actors will attempt to influence both the work and the learning network*" (p. 170). Furthermore, Yates and Orlikowski (1992) argued that top management will spent more time proactively setting the tone, as they are concerned with losing control of online groups, which could potentially feed through to the real world. Considering the role of middle management, Bird (1994) advocated that they would act as a "*nexus between the real and the ideal*" (p. 333). In practice this would result in members of this hierarchical level to "translate" information from one level to the next, providing clarifications and elaborating on shared information. Focusing on the lower end of the hierarchical ladder, Edmondson (2002) has shown that lower level management is particularly concerned about how colleagues perceive them and their work. Consequently, they tend to limit their interaction with colleagues from higher hierarchical levels. Additionally, members of this group have been suggested to be more passive in discussions within training programs (Nembhard & Edmondson, 2006). Fox (2000) has described this situation as being "*caught in a dilemma*" (p.856). On the one hand, individuals would like to establish a reputation of being knowledgeable. On the other hand, they also need to consider the existing rules of conduct. Sutton and colleagues (2000) follow this notion and propose that members from lower hierarchical levels will mainly try to blend in while not upsetting the status quo. In practice, this then translates into activities such as flattering, where lower level management frequently contacts their colleagues from higher hierarchical levels (Bird, 1994).

Regarding the overall structure of a (learning) network, it has been established that the position of individuals within such a network is related to their access to valued resources (e.g. Ibarra & Andrews, 1993; Sparrowe, Liden, Wayne, & Kraimer, 2001). Casciaro (1998) noted that occupying high-level positions within an organization provides individuals with an intrinsic attraction to lower level management. Studying three research centres of an Italian university, the author implied that, given their position within the organization, higher level management has privileged access to (vital) information and knowledge sources that are relevant for all employees. Moreover, this power can create a type of vortex, where lower level management is trying to get connected and, over time, stay in contact with higher level management (Krackhardt, 1990). Additionally, Borgatti and Cross (2003) have argued that lower level management, with only constrained access to valued resources, will be less likely to be contacted for information. As a result, they should hold more peripheral network positions. Johnson-Cramer, Parise and Cross (2007) have found empirical evidence for this argument. In their study of a consumer electronic company, they were able to show that higher level management held more central positions in the organization's information sharing network. On the contrary, lower level management primarily occupied positions at the outer fringe of the same network.

Based on these considerations, and taking into the suggestions of previous studies that called for more longitudinal research (e.g. Haythornthwaite, 2001), we formulate three research hypotheses:

*Hypothesis 1 (H1): Over time, participants' propensity to actively contact other colleagues will be positively influenced by their hierarchical level.*
*Hypothesis 2 (H2): Over time, participants' ability to attract connections from other colleagues will be positively related to their hierarchical level.*
*Hypothesis 3 (H3): Over time, the higher a participant's hierarchical level, the higher her degree of centrality within CoL.*

## 3. Organisational setting

The data was collected from an online training program that aimed at enhancing the capacity and skills of a global organization's staff, operating in the sector of economic development. Overall, the organization has more than 7.000 employees, operates in 126 countries worldwide, and has its headquarters located in Northern America. The training program was delivered twice over a time-span of 14 weeks and covered five pre-defined content modules on the general topic of Economics.
Operating in a fast changing environment, where new analyses and solutions are needed to address old problems, the organization wanted to embrace these developments by training their management staff accordingly. Participants engaged into two types of learning activities, namely self-study and collaborative learning. The self-study element included (multimedia) learning materials, such as web lectures and online quizzes. During the collaborative learning activities, which constituted the backbone of the training program, participants discussed real-life tasks via asynchronous discussion forums. The forums were nested in dedicated CoL that consisted of 10 – 15 randomly assigned participants. Each of the five content modules had a separate task, which were discussed within dedicated forums in chronological order. Participation in these forums was obligatory and assessed by academic staff members, who facilitated the CoL. More specifically, a team of two academic staff members was assigned to one CoL each. These facilitators graded participants' contributions, facilitated the discussions, and provided technical assistance. In practice, this could take the form of encouraging discussions and notifying participants when the communication departed too much from the intended focus of the discussion. Before engaging with their assigned CoL, all facilitators were trained on how to work with CoL and received elaborate guidelines for all collaborative learning activities. Additionally, regular meetings were scheduled where facilitators could discuss their experiences and streamline their behaviour and actions towards participants. Next to the obligatory, content-driven discussion forums, participants also had the opportunity to exchange private information and socialize via a so-called "Café-Talk" forum. Upon successful completion, participants could attain a certificate of

participation, together with academic credits that were based on the European Credit Transfer and Accumulation System (ECTS).

# 4. Method

## 4.1 Participants and sampling

Overall, 337 participants were randomly assigned to 30 CoL. However, the present study analyses a subset of 25 CoL and 249 participants (73.88%). The underlying reason for this smaller subset is twofold. On the one hand, we had incomplete datasets for some participants. On the other hand, we discovered that some CoL were biased, in the sense that not all applicable hierarchical levels were represented. Consequently, we dropped the applicable CoL from the analyses. The remaining 25 CoL had an average of 9.96 members (SD = 1.72, range = 7 – 13), the average age was 43.92 (SD = 7.33, range = 27 – 58), 54.61 percent of the participants were female, and more than 80 nationalities were represented. The educational backgrounds of participants were categorized into Master's (71.37 %), PhD's (14.51 %), Bachelor's (7.26 %), to other degrees (6.85 %). Particular examples of the latter category included, Health Sciences and International Law. Following the official job categories of the organization in question, participants' could be subdivided into "Low" (n = 82, 32.93 %), "Middle" (n = 93, 37.35 %) and "High" hierarchical levels (n = 74, 29.71 %).

## 4.2 Data collection procedure

Following the work of Daradoumis and colleagues (2004), and based on the collected log-files and user statistics from the underlying discussion forums, we subdivided the data according two different types of network links, namely *indirect* and *direct* links. Indirect links refer to passive connections that took the form of reading a colleague's contributions, but not replying to them. This type of activity was separately recorded in the log-files captured via *Read-Networks*. In case a participant actively reacted to another CoL member's contribution and replied, this established a direct link, created another applicable entry in the log-file, and was included in *Reply-Networks*. Based on this distinction it was then possible to make inferences about the type of learning actions underlying a certain network connection.

## 4.3 Data collection instruments

Participants reported their own hierarchical level via the training's official registration form. The indicated options were subject to the organization's official job categories. Based on the target group of the training program, three main categories were identified, namely "Low"-, "Middle"- and "High"-level hierarchical levels. Generally, representatives of the "Low" group were associated with project level work, contributing to sub-parts of the overall product. Members of the "Middle" group were leaders of such projects. Finally, participants from the "High" group were responsible for departments and often entire regions in which the organization was operating.

## 4.4 Data analysis procedure

The analyses of this study focus on data from individual participants. However, these participants were distributed over different CoL. Depending on the specific composition of a particular CoL, with respect to participants' hierarchical levels, this could have led to different dynamics and results. As a result, the validity of comparing across different learning networks might have been reduced. Hence, in order to account for possible differences in group compositions across CoL, we employed the Shannon Equitability Index (Magurran, 1988). The index ranges from 0 to fa1 and indicates the percentage share of diversity in relation to the maximal possible diversity within a given CoL. Focusing on participants' hierarchical levels as a source of diversity, the average score for the investigated 25 CoL was .44 (SD = .05, range = .35 – .55). Based on this value and the low standard deviation, we concluded that the CoL represented comparable sample for our analysis.

All network statistics were computed with the help of UCINET 6.357 (Borgatti, Everett, & Freeman, 2002). The visualization of an exemplary CoL network, in terms of sociograms, was conducted with the help of the incorporated visualization software NetDraw (Borgatti, 2002). The underlying data was based on the log-files and user statistics from the discussion forums within the different CoL. In order to determine the basic nature of the networks' structure, we measured the CoL *network density scores*. The density measure is based on the amount of actual ties, divided by the amount possible ties within a CoL. Consequently, it provides an indication of how well-connected participants within a particular CoL are (Hanneman & Riddle, 2005). The amount and nature of an individual's network connections was determined via the concept of *Freeman Degree Centrality*, including *in- and out-degree measures*. In-degree network connections indicate how often and by how many colleagues a particular individual was contacted from within a CoL. More specifically, in the context of the *Reply-Networks*, the measure captures how often an individual has been replied to by their colleagues. When considering the *Read-Networks*, it reveals how frequent an individual's contributions were read by her colleagues. Generally, a high amount of in-degree connections has been attributed to prominent participants within (learning) networks, with whom others would like to be connected (Hanneman & Riddle, 2005). Therefore, this constituted our main variable to check our second research hypothesis. The out-degree measure accounts for all those links that originate from a focal individual and summarizes how often that individual contacted her colleagues within the CoL. When distinguishing between *Reply*- and *Read-Networks*, the out-degree captures how often a participant has replied to their colleagues and read their contributions, respectively. Scholars have often equated a high level of out-degree connections with influential participants, who are able and willing to shape discussions (Hanneman & Riddle, 2005). Consequently, this measure formed the basis for testing the validity of our first research hypothesis. For the analysis of our third research hypothesis, we combined the results of the previous analyses. More specifically, taking into account that we were dealing with multiple CoL, we determined participants overall centrality on the basis of the *normalized* number of in- and out-degree ties, which allowed to control for the different sizes of the individual CoL (Hanneman & Riddle, 2005). In contrast to the more general, nominal network measures, these particular values provided more profound insights on how an individual's network ties affected their overall network position within their CoL.

In order to test for the parametric assumption of normality of the data's distribution, Kolmogorov-Smirnov tests (K-S) were conducted. The results revealed a violation of the normality assumption for all measured variables, which translated into statistically significant K-S results at the .01 level. Consequently non-parametric tests were used to examine the research hypotheses. More specifically, correlations were determined with the Spearman's rho measure ($r_s$). In order to assess whether mean differences in the chosen network measures between the different hierarchical levels could be observed, we employed Kruskal-Wallis tests (H). Jonckheere-Terpstra tests (J-T) were used to identify whether the potential main effect, as assessed by H, exhibited any possible linear trends. The results of this provided valuable information on how the different hierarchical levels differed in their network measures. The occurrence of possible patterns within the underlying H-test results was determined by post-hoc Mann-Whitney (U) tests. Being designed to only measure differences between two independent conditions, the U-test results were corrected by the Bonferroni method. As a result, our adjusted critical value of significance was .016 for this part of the analysis. In order to cater for the longitudinal nature of the data and to test for any possible changes in participants' network measures over time, a range of Wilcoxon Signed Rank test were used. The chosen points in time for the longitudinal study were based on the work of previous studies, who conducted similar research on networked learning within teacher education (de Laat et al., 2007). The authors of these studies chose for the beginning, the middle and the end phases of online (learning) community. In the context of this study, we decided to subdivide the overall duration of the underlying CoL of 14 weeks into six time intervals of about two weeks each. This allowed to capture a short "transition period", during which the focus of the discussions changed from one content module to the next. During this timeframe, participants rounded-up the discussion of the previous module and started preparing for the next one. Following the work of de Laat and colleagues (2007), out of the six time intervals, we then considered Intervals 1 (beginning), 3 (middle) and 6 (end) for our analysis. Finally, we also estimated the effect size of our findings. However, the vast majority of effect size measures are only suitable for parametric data (Snyder & Lawson, 1993). Consequently, we followed the suggestion of Rosenthal (1991) and approximated the effect size (r) on the basis of the U-results. This measure takes on values from 0 to 1, where small, medium and large effects are associated with .10, .30 and .50, respectively (Cohen, 1992).

### 4.5 Control measures

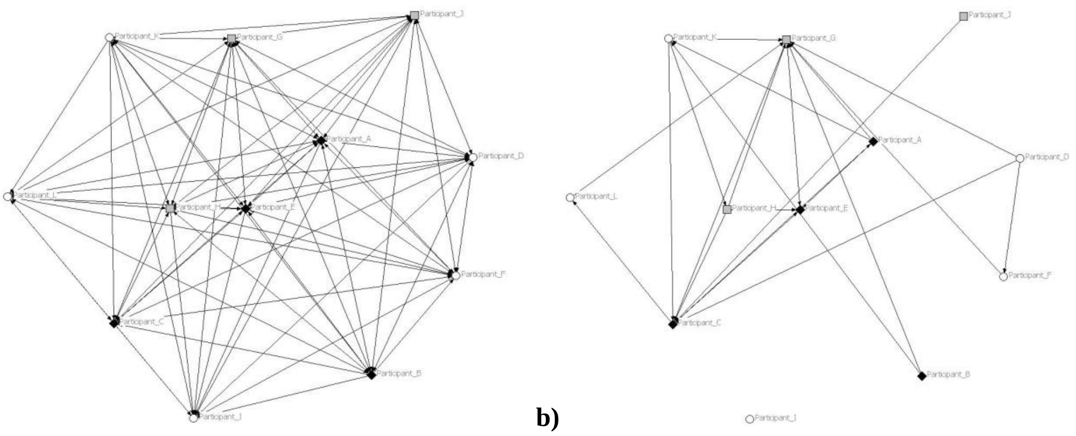
Although the focus of this research is on the impact of hierarchical levels, we acknowledge that this aspect might only explain parts of possible observed differences between participants. Consequently, we controlled for age, gender, educational background, prior knowledge, culture and motivation for attending the training, which have been suggested to influence online collaborative learning. With respect to age, some researchers have suggested that older employees tend to participate less in online training activities (e.g. Garavan, Carbery, O'Malley, & O'Donnell, 2010). Additionally, other empirical studies have been able to show that age similarity had the potential to trigger emotional conflicts within groups, resulting in lower participation rates (Pelled, Eisenhardt, & Xin, 1999). Regarding gender, Im and Lee (2004) stipulated that if males dominate women in a regular face-to-face environment, this is also likely to carry over to an online environment. In contrast, Joinson (2001) was able to show that online training environments had an equalizing effect on participants. When considering participants' educational background and prior knowledge, previous studies have highlighted the potential impact of participants' prior knowledge on their behaviour within learning initiatives (Dochy & McDowell, 1997). Even more so, there has been a growing consensus that individuals' prior knowledge constitutes an important variable in participants' activity patterns (Dochy, Segers, & Buehl, 1999). If a participant already possesses a considerable amount of prior knowledge about a certain topic, it can be expected that she will be more comfortable in contributing to discussions, thereby positively influencing her general activity and performance levels. Participants' cultural background has also been suggested to have an impact on participants' behave (Jehn & Bezrukova, 2004). More specifically, researchers like Pelled and colleagues (1999) suggested that some cultures tend to exhibit more competitive behaviours than others. Hence, representatives of a more competitive culture are also more likely to proactively engage into conversations, trying to shape discussions and thereby achieve higher potential benefits. Finally, numerous studies have highlighted the importance of motivation on participants' behaviour within the context of online learning (e.g. Rienties, Tempelaar, Van den Bossche, Gijselaers, & Segers, 2009). For example, Yang and colleagues (2006) conducted research in online learning environments and discovered that motivation was positively related with how learners perceive each other. Consequently, when participants share a similar level of motivation when starting a training program, they tend to "get along" better, which in turn affects their network behaviour (e.g. they connect more often).

In this study, participants' age, gender, educational background and culture, as assessed by participant's country of birth, were self-reported as part of the training programs official registration form. For educational background, participants were asked to indicate their highest attained educational degree, including Bachelor, Master, PhD and Other (e.g. vocational training). Prior knowledge was measured via a diagnostic test, consisting of 25 multiple choice questions. All five pre-defined content modules were assessed based on five dedicated questions each. These questions were created by academic experts and related to the working environment of the participants. The response rate for the test was 88.76 % and the internal consistency of participants' answers was acceptable (Cronbach $\alpha$ = .81) (Cortina, 1993). Participants' motivation for attending the training, were approximated based on a previously developed instrument (Rienties et al., 2009; Rienties, Tempelaar, Waterval, Rehm, & Gijselaers, 2006). The questionnaire consisted of 24 questions, subdivided into four categories, and was administered with a 7-point Likert scale ranging from 1 (not true for me at all) to 7 (completely true for me). The applicable categories for this study were (the number of questions are reported in brackets): "Reasons to join the Training" (6), and "Expectations and Goals" (10). The response rate was 88.51 % and the internal consistency was again acceptable (Cronbach $\alpha$ = .95) (Cortina, 1993).

## 5. Results

Overall, while the vast majority of posts were placed in the forums of the five content modules (86%), only few contributions were shared in the "Café-Talk" forums (14%). In order to visualise the underlying data, Figure 1 represents a graphical depiction of the final *Read*- and *Reply-Network* of an exemplary CoL. A first glance already indicated a great amount of divergence between these two types of networks. Participants were highly connected and exhibited very similar communication patterns with respect to their reading behaviour (Fig. 1a). However, considerable differences prevailed regarding whether and how participants replied to each other (Fig. 1b). Furthermore, a closer look at the figure also revealed a first preliminary sign that participants behaviour and network position were related to their hierarchical level within the organization.

An overall picture of the longitudinal nature of our data is depicted in Figure 2, which captures the average density values of the CoL across time. As can be seen from the applicable figure, the average density per time interval of the *Read-Networks* is about 10-times higher than those of the *Reply-Networks*. Yet, while the average density of the *Read-Networks* declined over time, the *Reply-Networks* increased in terms of density. Nonetheless, at the end of the CoL, the average density for the *Read-Networks* remained considerably higher at a value of 62.27 (range = 26.36 – 86.36), as compared to a final value of 11.54 (range = 0 – 28.21) for the *Reply-Networks*.



a) b)

*Figure 1.* Read (a) and Reply (b) Network of an exemplary Community of Learning.

The layout of the figure has been determined using iterative metric multidimensional scaling. The different hierarchical levels are denoted as: "Low" – light circle; "Middle" – grey square; "High" – dark diamond

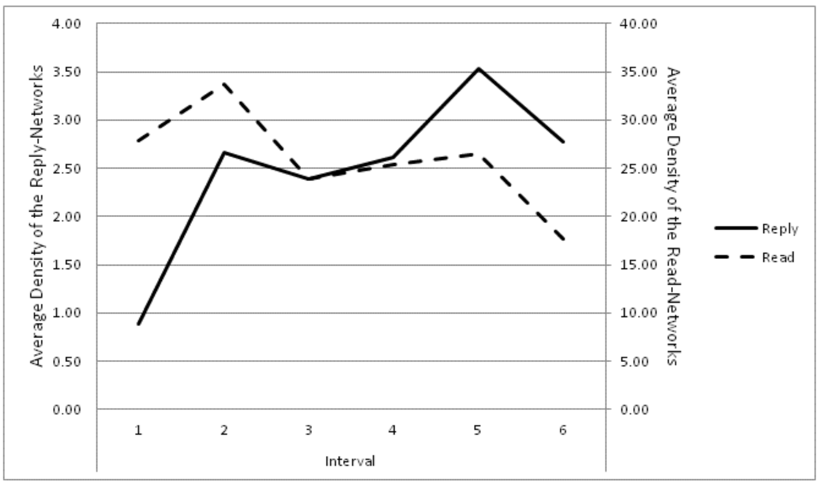



*Figure 2.* Longitudinal Data on Average Density Scores for the Communities of Learning.

### 5.1 Hypotheses 1 & 2

Table 1 summarizes the results of participants' overall in- and out-degree network ties for both types of networks. As can be seen from the table, all measures for the *Read-Networks* were statistically insignificant, which led us to reject research hypotheses 1 and 2 for these types of network. In contrast, our Kruskal-Wallis tests clearly indicated significant differences between hierarchical levels and the degree with which participants' either replied to their colleagues, or attracted replies from others. Moreover, the Jonckheere-Terpstra tests showed a clear trend that the amount of both in- and out-degree ties were both positively related to participants' hierarchical level. Additionally, an investigation of the underlying patterns revealed that the observed differences were especially pronounced between the "Low" and "High" groups (In-degree: $U = 2{,}261.50$, $p < .01$; Out-degree: $U = 2{,}338.00$, $p < .05$), which is also reflected in the observed effect sizes (rin-degree = -.23; rout-degree = -.20).

The results of our longitudinal analysis are represented in Table 2. As participants' behaviour within the *Read-Networks* did not show any signs of statistically significant differences, these networks were neglected from the analysis. Our results indicated a significant increase of in- and out-degree ties for the "Middle" and "High" groups over the entire duration of the CoL. The "Low" group did not exhibit a common, noticeable trend. Moreover, the evidence indicated that the increases for the "Middle" and "High" groups were mainly situated in the first half of the CoL. During the second half, only members of the "High" group showed significant signs of continued contact-seeking with their colleagues. Taken together, these findings indicate that, over time, higher level management was contacted more frequently than lower level management (H1). Moreover, our evidence also supported the supposition that over the duration of the CoL, participants from higher hierarchical levels were more likely to actively contact other CoL members, than lower level management (H2).

Table 1

*Results of Kruskal-Wallis and Jonckheere-Terpstra Tests for (Nominal) In- and Out-Degree Network Measures*

| | Kruskal-Wallis | | Jonckheere-Terpstra | | |
|---|---|---|---|---|---|
| | $\chi 2$ | df | # of Levels | N | J-T |
| In-Degree (Reply) | 8.89* | 2 | 3 | 249 | 11,938.50** |
| Out-Degree (Reply) | 6.66* | 2 | 3 | 249 | 11,819.00* |
| In-Degree (Read) | 1.16 | 2 | 3 | 249 | 10,898.00 |
| Out-Degree (Read) | 0.10 | 2 | 3 | 249 | 10,131.50 |

* $p < .05$; ** $p < .01$

Table 2

*Results of Wilcoxon Signed Ranked Test for (Nominal) In- and Out-Degree Measures (Reply-Networks).*

| Hierarchical Position | Timeframe (Intervals) | Z Score In-Degree | Z Score Out-Degree |
|---|---|---|---|
| "Low" | 1-6 (Overall Duration) | $-1.69^{a}$ | $-1.11^{a}$ |
| | 1-3 (First Half) | $-1.82^{a}$ | $-1.31^{a}$ |
| | 3-6 (Second Half) | $-.02^{b}$ | $-.58^{a}$ |
| "Middle" | 1-6 (Overall Duration) | $-2.96^{a,**}$ | $-2.60^{a,**}$ |
| | 1-3 (First Half) | $-3.50^{a,**}$ | $-2.87^{a,**}$ |
| | 3-6 (Second Half) | $-.02^{a}$ | $-.40^{b}$ |
| "High" | 1-6 (Overall Duration) | $-2.72^{a,**}$ | $-4.01^{a,**}$ |
| | 1-3 (First Half) | $-2.32^{a,*}$ | $-2.39^{a,*}$ |
| | 3-6 (Second Half) | $-1.30^{a}$ | $-2.05^{a,*}$ |

$^{a}$ based on negative ranks; $^{b}$ based on positive ranks; $^{*}$ $p < .05$; $^{**}$ $p < .01$

## 5.2 Hypotheses 3

Similarly to the previous findings, we again found no significant differences between hierarchical levels within the *Read-Networks*. However, as can be seen from Table 3, our results for the *Reply-Networks* did again sketch another picture. More specifically, the Kruskal-Wallis tests revealed significant in- and out-degree centrality measure differences between hierarchical levels. Another set of Jonckheere-Terpstra tests was then conducted to determine a possible underlying trend. The results showed that whether participants hold a central position within their network was significantly and positively influenced by their hierarchical level. In order to determine the pattern of the main effect, we conducted another range of Mann-Whitney tests. Similarly to hypotheses one and two, the most pronounced difference was again found between the "Low" and "High" groups (In-degree: U = 2,202.50, p < .01; rcentrality-in = -.23; Out-degree: U = 2,234.50, p < .05; rcentrality-out = -.24).

For the longitudinal analysis, based on the described results, we again decided to focus on the *Reply-Networks*. Table 4 summarizes the main results of the applicable analyses. As in the case of the more general network statistics, we did not find any significant results for the "Low" group. In contrast, participants from the "Middle" and "High" groups attained higher in- and out-degree centrality measures throughout the duration of the CoL. However, the main acceleration for this development again appeared to be situated in the first half of the CoL. Taking into account that the *Read-Networks* did again not yield any significant results, we did not find any support for the notion that, over time, higher level management will hold more central positions in their CoL network, compared to their colleagues from lower positions (H3). However, based on the statistically significant findings for the *Reply-Networks*, we accepted our third research hypothesis for these types of CoL networks.

Table 3

*Results of Kruskal-Wallis and Jonckheere-Terpstra Tests for (Normalized) In- and Out-Degree Network Measures*

| | Kruskal-Wallis | | Jonckheere-Terpstra | | |
|---|---|---|---|---|---|
| | $\chi 2$ | df | # of Levels | N | J-T |
| In-Degree (Reply) | $9.82^{**}$ | 2 | 3 | 248 | $11{,}958.50^{**}$ |
| Out-Degree (Reply) | $8.90^{*}$ | 2 | 3 | 248 | $11{,}930.50^{**}$ |
| In-Degree (Read) | .83 | 2 | 3 | 248 | 10,064.00 |
| Out-Degree (Read) | 2.67 | 2 | 3 | 248 | 11,205.00 |

$^{*}$ $p < .05$; $^{**}$ $p < .01$

Table 4

*Results of Wilcoxon Signed Ranked Test for (Normalized) Network Measures (Reply Networks).*

| Hierarchical Position | Timeframe (Intervals) | Z Score In-Degree | Z Score Out-Degree |
|---|---|---|---|
| "Low" | 1-6 (Overall Duration) | -.83[a] | -.63[a] |
| | 1-3 (First Half) | -.95[a] | -.59[a] |
| | 3-6 (Second Half) | -.09[b] | -.49[a] |
| "Middle" | 1-6 (Overall Duration) | -2.58[a, **] | -2.12[a, *] |
| | 1-3 (First Half) | -3.12[a, **] | -2.66[a, **] |
| | 3-6 (Second Half) | -.25[b] | -.98[b] |
| "High" | 1-6 (Overall Duration) | -1.80[a] | -2.96[a, **] |
| | 1-3 (First Half) | -2.28[a, *] | -2.10[a, *] |
| | 3-6 (Second Half) | -.49[b] | -.87[b] |

[a] based on negative ranks; [b] based on positive ranks; * $p < .05$; ** $p < .01$

## 5.3 Control measures

The investigation of whether participants differed in terms of age, gender, educational background, prior knowledge, culture, or motivation for attending the training, subject to their hierarchical levels, revealed no significant results. However, we also conducted a separate correlation analysis, where we investigated any possible, underlying relations between all variables included in this study. As can be seen from Table 5, in terms of our dependent and control variables, participants' hierarchical level was positively correlated with age. A closer look at the control variables revealed that age (*Reply-Networks*: In-Degree), gender (*Read-Networks*: In-Degree) and prior knowledge (*Read-Networks*: Out-Degree) were positively correlated with some of the network measures. Hence, in order to incorporate this finding in our analysis, we conducted a separate partial correlation analysis between hierarchical levels and the chosen network measures, while holding age, gender and prior knowledge constant. The results are presented in Table 6. While hierarchical levels continued to be significantly correlated with network measures, a more refined picture emerged. More specifically, the potential influence of hierarchical levels now seemed to be mainly applicable for the out-degree measures. Moreover, the partial correlation analysis showed this to be true for both the *Reply*- and *Read-Networks*. Consequently, when interpreting the main results of this research, these findings need to be taken into account.

Moreover, a closer look at the results also revealed that all measured network statistics were highly and significantly correlated with each other. In other words, if an individual participant attained a high amount of in-degree ties, for example, she would also be very likely to initiate a high amount out-degree ties and achieve a comparatively high degree of centrality within her CoL. As we have been able to show that hierarchical levels have a strong effect on each one of these measures, this provided additional support for our supposition that hierarchical levels have a significant impact on network structures within CoL.

# 6. Discussion

The purpose of this study was to determine whether and to what extend participants' hierarchical levels influence the network structures of CoL. We thereby were able to address a number of shortcomings in current research and contributed to the discussion about how existing organizational structures can affect training initiatives. In order to investigate the relationship between hierarchical levels and network structures, we employed social network analysis and conducted a longitudinal study to test for our research.

In the context of the investigated *Read-Networks*, we did not find any evidence for individuals' hierarchical levels influencing their network behaviour. However, when considering the *Reply-Networks*, our results clearly indicated that higher level management attracted more attention, contacted more colleagues, and attained more central positions within their CoL, as compared to their colleagues from lower level positions. Additionally, based on our longitudinal analyses of all network measures, we were able to show that the overall impact generally increased over time, and in particular during the first half of the training program.

Table 5

*Overview of Correlation Coefficients between Hierarchical Level, Control Variables and Network Measures.*

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Hierarchical Level | 1 | | | | | | | | | | | | | | | |
| 2 | Age | .16* | 1 | | | | | | | | | | | | | | |
| 3 | Gender | .04 | .16* | 1 | | | | | | | | | | | | | |
| 4 | Educational Background | .09 | .22** | .13* | 1 | | | | | | | | | | | | |
| 5 | Prior Knowledge | .00 | -.11 | .04 | -.02 | 1 | | | | | | | | | | | |
| 6 | Country of Birth | .11 | .00 | -.01 | -.11 | .12 | 1 | | | | | | | | | | |
| 7 | Reason to join the Training | .05 | -.16* | .08 | -.05 | -.03 | .07 | 1 | | | | | | | | | |
| 8 | Expectations and Goals | -.04 | -.08 | .15* | .00 | -.09 | .04 | .65** | 1 | | | | | | | | |
| | Reply - Networks | | | | | | | | | | | | | | | | |
| 9 | *In-Degree* | .16* | .13* | -.08 | .05 | .06 | .05 | -.05 | .02 | 1 | | | | | | | |
| 10 | *Out-Degree* | .16* | .06 | .01 | .00 | .08 | .06 | .07 | .08 | .67** | 1 | | | | | | |
| 11 | *In-Degree - normalized* | .19** | .13* | -.07 | .06 | .06 | .02 | -.09 | .03 | .93** | .57** | 1 | | | | | |
| 12 | *Out-Degree - normalized* | .18** | .05 | .01 | -.01 | .07 | .04 | .05 | .08 | .59** | .94** | .58** | 1 | | | | |
| | Read Networks | | | | | | | | | | | | | | | | |
| 13 | *In-Degree* | .06 | -.01 | -.13* | .00 | .05 | -.06 | .03 | .08 | .50** | .38** | .41** | .29** | 1 | | | |
| 14 | *Out-Degree* | .13* | .09 | .04 | .00 | .14* | .05 | .09 | .11 | .72** | .81** | .64** | .76** | .43** | 1 | | |
| 15 | *In-Degree - normalized* | -.02 | -.04 | -.15* | .01 | .10 | -.09 | .00 | .07 | .35** | .18** | .35** | .19** | .78** | .27** | 1 | |
| 16 | *Out-Degree - normalized* | .10 | .05 | .05 | .02 | .16* | .03 | .07 | .10 | .62** | .68** | .6** | .71** | .29** | .92** | .33** | 1 |

* p < .05. ** p < .01

Table 6

*Correlation Coefficients for Hierarchical Levels and Network Measures (Controlling for Age, Gender and Prior Knowledge).*

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Hierarchical Level | 1 | | | | | | | | |
| | Reply - Networks | | | | | | | | | |
| 2 | *In-Degree* | .04 | 1 | | | | | | | |
| 3 | *Out-Degree* | .14* | .69** | 1 | | | | | | |
| 4 | *In-Degree - normalized* | .10 | .76** | .44** | 1 | | | | | |
| 5 | *Out-Degree - normalized* | .22** | .39** | .71** | .47** | 1 | | | | |
| | Read - Networks | | | | | | | | | |
| 6 | *In-Degree* | -.01 | .44** | .38** | .26** | .17* | 1 | | | |
| 7 | *Out-Degree* | .15* | .75** | .73** | .58** | .55** | .44** | 1 | | |
| 8 | *In-Degree - normalized* | -.02 | .24** | .16* | .25** | .13 | .74** | .21** | 1 | |
| 9 | *Out-Degree - normalized* | .15* | .54** | .57** | .51** | .62** | .25** | .83** | .29** | 1 |

* p < .05, ** p < .01

In terms of the *Read-Networks*, which capture passive connections between participants (Daradoumis et al., 2004), this can be considered as a preliminary indication that CoL have the potential to stimulate an interpersonal knowledge transfer among participants (Argote & Ingram, 2000). However, the observed range of density scores across the different CoL varied considerably. Moreover, while the average overall density score of 62.27 can be regarded as reasonable, there still remains a considerable gap to be filled in order to achieve a situation where "everyone reads everything". Regarding the *Reply-Networks*, we were able to validate our second research hypothesis, which stated that over time, participants' ability to attract connections from other colleagues will be positively related to their hierarchical level (H2). This supports the work of Krackhardt (1990), who suggested the existence of a vortex that allows higher level management to attract more attention and connections from their colleagues. Additionally, our evidence suggested that higher level management will proactively set the tone in online discussions (H1), which confirms the work of Yates and Orlikowski (1992). We were also able to show that higher level management held central positions, while lower level management was located more towards the fringe of their CoL (H3) (Borgatti & Cross, 2003). Finally, when conducting longitudinal analyses of the underlying data, our results indicated that the observed general patterns increased over the duration of the CoL (e.g. Bird, 1994; Sutton et al., 2000). Additionally, this positive trend was particularly pronounced during the first half of the training program, which appears as a kind of "initiation phase". However, we also discovered that this trend was not statistically significant for the "Low" group. This finding can be considered as support for the work of Nembhard and Edmondson (2006), who suggested that members of this group generally tend to be more passive in discussions within training programs. Additionally, it could also be attributed to the importance of the "initiation phase". Once members from the "Middle" and "High" group have established their comparatively more central role within their CoL, it seems as if the "Low" group is content with the situation. Alternatively, it could also be that members of the "High" group convey such an "imposing message", trying to lead the group and becoming (more) central to the discussions, that representatives of the "Low" group rather not change their behaviour and become more active.

Furthermore, when reinvestigating the potential influence of hierarchical levels on the chosen network measures, while incorporating our control variables, an even more refined picture emerged. Our results indicate that age, gender and prior knowledge seem to have a mediating role in determining participants' network measures. More specifically, participants' hierarchical background mainly affected their out-degree behaviour, e.g. the degree with which they reply to colleagues in discussions. Additionally, this effect was applicable for both the *Reply-* and the *Read-Networks*, which suggests two main conclusions for higher level management. First, members of this group really try to set the tone and actively try to shape the discussions. Second, higher level management more carefully followed the discussions by reading the contributions of their colleagues from lower hierarchical levels.

Considering these findings, we can draw conclusions about how collaborative learning activities within CoL should be designed and facilitated, in order to provide participants with a valuable learning experience. For example, acknowledging the considerable influence of hierarchical levels, organizers can device targeted interventions that increase the potential benefits of CoL (Cross et al., 2006). More specifically, higher level management could be stimulated to actively draw upon the input of their colleagues, thereby allowing participants from lower level management to gradually move towards the centre of the CoL network. In practice, this could be achieved via two possible approaches. On the one hand, facilitators could try to foster a (more) active exchange of information between members of these two opposite parts of the organization. The potential benefit of this approach would be that connections between participants would be initiated and supported by an external party. This in turn could relax underlying norms and regulation that govern how members from different hierarchical levels communicate with each other. Alternatively, participants could be asked to complete assignments that build upon a type of mentoring system. With higher level management occupying more central positions, these participants could take their colleagues from lower hierarchical levels "by the hand" and actively include them in the discussions. This could create a pull-effect, whereby participants, who generally tend to occupy positions towards the fringe of a learning network, are drawn closer towards the centre. This not only has the potential to make them a more integral part of the CoL. It also would provide them with better opportunities to share their knowledge and insights. Using the analogy of Kozlowski and colleagues (2009), they could thereby more easily contribute their piece to the puzzle, which can enhance the success of the entire organization.

Finally, considering the longitudinal findings of our research, we have highlighted the importance of the "initiation phase" within CoL. During the beginning stages of the learning process, participants get to know each other's background characteristics, including professional experience and prior knowledge. Additionally, participants will also exchange either directly (as part of their introduction to the CoL), or indirectly (by making appropriate references) information about their hierarchical levels. This in turn will significantly influence their behaviour towards each other throughout the CoL. Consequently, facilitators of such communities should pay specific attention to this initiation process, in order to be able to possibly intervene in the discussions and assist the central participants to engage the entire group into the discussions.

## 7. Conclusions

### 7.1 Limitations

The current study exhibits two main limitations that should be taken into account when considering our results. First, we have based our social network statistics purely on observed links between participants. In contrast, previous studies have also commonly incorporated familiarity measures in the context of social network analysis (e.g. Krackhardt, 1990). These measures allow to control for the degree with which participants might already be acquainted with each other. This in turn could influence the comfort level of participants' and thereby affect their behaviour within CoL. Second, connections between participants did not take into account the content of the shared information. Consequently, network ties between individual participants might have reflected personal commonalities that have no direct link with the actual content of the training and are therefore difficult to control for by organizers of similar initiatives.

### 7.2 Future research

Building upon the findings of this study, future research should conduct (hierarchical) multilevel regression modelling (Goldstein, 1995). Our results indicate that age, gender, and prior knowledge also had an effect on participants' network behaviour. Consequently, in order to incorporate these findings and to further contribute to our understanding of whether and how hierarchical levels are transferred into the network structures of CoL, future studies should consider modelling a larger set of explanatory variables simultaneously. Moreover, future research should conduct a content analysis (CA) of the underlying discussions forums within CoL. This approach is widely accepted to assess the quality of learning processes and outcomes (de Laat & Lally, 2003) and allows to draw a more refined picture of the actual level of content and knowledge that has been exchanged between participants. Moreover, by mapping the CA results against the findings of a SNA analysis, it would be possible to provide detailed insights about who has been in contact with whom, what they talked about, and whether this has had an impact on their network position (de Laat et al., 2007). Additionally, future research should incorporate the role of facilitators into the analysis of CoL. Previous research has suggested that online learning communities must be cherished and protected in order to become an effective educational resource (Paloff & Pratt, 2003). In other words, facilitators' involvement can have a considerable influence on how learning networks develop and evolve over time (Anderson, Rourke, Garrison, & Archer, 2001). Yet, although a considerable amount of research has already investigated how online facilitation can affect learning processes, the vast majority of these studies has focused on the context of higher education (Berge, 1995; de Laat et al., 2006; Garrison, Anderson, & Archer, 2010) and largely neglected the field of training within organizations. By investigating the role of facilitators in CoL, it would be possible to provide profound insights that can serve as a springboard for facilitators to design and implement an effective teaching strategy for CoL. Consequently, the quality of learning process could be further augmented.

## Keypoints

- We assess the impact of hierarchical levels on online learning networks.
- The higher the hierarchical level, the higher the connectedness of participants.
- The higher the hierarchical level, the higher the centrality of participants.
- Our findings are particularly strong for the first half of the networks' duration.

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