Exploring Co-Learning Behavior of Conference Participants with Visual Network Analysis of Twitter Data

Heli Aramo-Immonen
Tampere University of Technology
P.O. Box 300, FIN-28101 Pori
Exeter University, Business School UK
+358 40 8262931
heli.aramo-immonen@tut.fi

Jari Jussila
Tampere University of Technology
P.O. Box 541
FIN-33101 Tampere
+358 40 717 8345
jari.j.jussila@tut.fi

Jukka Huhtamäki
Tampere University of Technology
P.O. Box 541
FIN-33101 Tampere
+358 40 585 4771
jukka.huhtamaki@tut.fi

ABSTRACT
Knowledge management has acknowledged organizational learning as a key factor for creating competitive advantage for companies already from early 1990. However, the studies of co-learning in this connection are in their infancy. This article contributes to an emerging field of 'smart data' research on Twitter by presenting a case study of how community managers in Finland used this social media platform to construct a co-learning environment around an annually organized conference. In this empirical study we explore the co-learning behavior in project contexts especially by analyzing and visualizing co-learning behavior from conference participants Twitter data.

1. INTRODUCTION
Learning is the vehicle for individuals, companies, and communities to utilize past experiences, adapt to environmental changes and enable future options. Interest in learning has grown in companies, especially since managers were informed that our economy has turned into a knowledge economy (Drucker, 1994) and that knowledge and learning are of prime importance for creating and sustaining competitive advantage (Barney, 1991; Nonaka & Takeuchi, 1995; Choo, 1996; Grant, 1996; Alavi & Leidner, 2001). However, the studies of co-learning in knowledge management literature are in their infancy (Liao, 2003; Kakabadse, Kakabadse, & Kouzmin, 2003; Dasgupta & Gupta, 2009). Furthermore the utilization of 'smart data' (e.g. Patil, 2012) captured from social media using data science approach is explored in this connection. Our attempt is to use Twitter data to describe and further understanding of co-learning behavior of participants of professional conference. For this we focus on analysis of Twitter data collected during conference.

Our aim is to discover what the community of "community managers" is discussing during the annual face-to-face event. We visualize the most popular discussions of the community, identify the most active and prestigious community members and different subgroups and networks that emerge from the discussions. By applying the process of data-driven visual network analytics we seek to understand the co-learning behavior of the community and to make propositions on the role of social media as a co-learning environment.

In this article we introduce in the theoretical sections the concepts of co-learning, informal and formal learning, activity theory based informal expansive learning, internal and external memory aids, motivation to learn and context of communities of practice as co-learning environments. In the empirical part of this article we discuss Twitter as a co-learning environment and the visual network analytics of Twitter data. We introduce some visualization of hashtag metrics of people tweeting during the CMAD 2014 conference day. Finally we conclude our findings as practical propositions for utilizing social media as mediator in co-learning.

2. THEORY AND RELATED RESEARCH

2.1 Informal and Formal Co-Learning
Collaborative learning also named co-learning is a method of learning and teaching in which learners team together to explore a significant question or create a meaningful project. A group of learners discussing face-to-face or working together over the Internet on a shared assignment are both examples of collaborative learning. Collaborative learning has been mostly studied in university and school context (e.g. Francescato et al., 2006) with little existing research in project work context. In this article the main focus is on informal collaborative learning in Twitter in project work context.

Learning in firms can be divided into three parts: informal, formal, and non-formal learning. Informal learning consists of all that is related to the work process itself, including the doing of the work (Raivola & Ropo, 1991). At all levels and sectors of the work process, new things are learned that affect the work processes one way or another, either directly or indirectly. Informal learning is often not noticed or realized. Therefore, it can be called tacit knowledge and know-how accumulation (Aramo-Immonen, Koskinen, & Porkka, 2011). Tacit knowledge and know-how have a central significance for the professional identity and they form a part of qualifications that cannot be taught. Non-formal learning means learning that takes place outside the daily routines of the work place or school.

According to García-Peñalvo, Colomo-Palacios and Lytras (2012) informal learners usually set their own learning objectives. They learn when they feel a need to know. The proof of their learning is their ability to do something they could not do before. Informal learning is often a pastiche of small chunks of observing how others do things, asking questions, trial and error, sharing stories with others and casual conversation. (García-Peñalvo et al., 2012)

Small team activity is a means towards company-based learning (Sarala, 1993). The efficiency of working life today is increasingly based on smooth and innovative co-operation of the parties (e.g., projects, events and conferences) working together. In case of volunteer work in events or non-profitable work in conferences money cannot be the motivator. The satisfaction has to be gained through being a part of a community for example. An operating system – conference committees in our case - can only be efficient if its parts are efficient. This calls for co-operation, planning, and realisation of operation in virtual teams, and furthermore,

development of creativity and increased utilization of social media like Twitter for example.

However, compared with the systematic learning that takes place in functional organizations, the one-off and non-recurring nature of project activities (such as focal conference preparations) provides little scope for routine learning (Hobday, 2000) or systematic repetition (Gann & Salter, 2000). The problem with this perspective on project-based learning is that it equates project-based activities with non-routine behaviour. Davies and Brady (2000) argue that performance can be increased through exploitative learning because companies undertake 'similar' categories of projects in mature or new product markets, involving repeatable and predictable patterns of activities. Furthermore conferences and events even though they are unique they also have repeatable patterns of activities and similar repeatable structures and ways to organize.

The perception that conferences and events perform only unique and non-routine tasks often conceals many potentially transferable lessons. Learning can occur at several different levels, e.g., individual, project, and company levels (DeFilippi & Arthur, 2002). Many firms have tried to create learning mechanisms as deliberate attempts to capture the experience gained through projects (Prencipe & Tell, 2001; Aramo-Immonen, 2009). These mechanisms refer to the institutionalized, structural and procedural arrangements that allow companies to systematically collect, analyse, store, disseminate, and use knowledge (Popper & Lipshitz, 1998; Aramo-Immonen, 2009). Conferences and events, could develop their own momentum that leads to the pursuit of new objectives. There is a possibility to learn within the parameters set for the conference for example.

2.2 Co-Learning Environment Seen Through Activity Theory

The activity theory distinguishes between temporary, goal-directed actions and durable, object-oriented activity systems (Vygotsky, 2012; Engestrom, 2000). Here, within the conference context, the latter are discussed. The use and utilization of knowledge is not a spontaneous phenomenon in the development process of an organized community. According to the socio-cultural historical activity theory, there has to be a triggering action, such as a conflictual questioning of the existing standard practice in the organization in order to generate expansive learning (Engestrom, 2000). Expansive learning produces culturally new patterns of activity. In this context, the 'activity' has a broader meaning than 'action' or 'operation'. Here, the activity is the conference as a whole. As used in the activity theory, the concept of activity is linking ´events´ to the contexts within which they occur (Blackler, Crump, & McDonald, 1999).

The object of expansive learning activity is the entire organization (i.e. community of the focal conference here) in which learners (i.e. conference members and attendees) are performing (Engeström, 2001). In other words, the project work context in conference forms the learning environment. Figure 1 illustrates the systemic structure of collective activity. Technologies used and language (instruments in Figure 1) mediate the relationship between worker and working community. Division of labour mediates the relationship between community members and shared activity (Blackler et al., 1999; Engestrom, 2000). Together, these constitute the co-learning environment, i.e. infrastructure through which individuals' 'action learning' (Revans, 1982) takes place.

Triggering an action, which causes an expansive learning activity, can grow from tensions between the project team members. Therefore, findings of a tense working atmosphere are not inevitably negative features. This can occur in virtual teams as well. However, the feeling of ease can be problematic if nothing is seen to be worth developing in the community. Furthermore, people also fail to act intelligently. This is not because they as individuals lack intelligence, but because they are following this or that organizational order or practice (rules in Figure 1). Organizational context determines, to a great extent, whether people are allowed or encouraged to use their intelligence, for instance, by pointing out inadequacies in existing practices. The advantage of informal Twitter communities is the freedom to be critical concerning contemporary ways of doing things. In other words individuals do tend to criticize and express their feelings more easily in social media than in face-to-face contact.

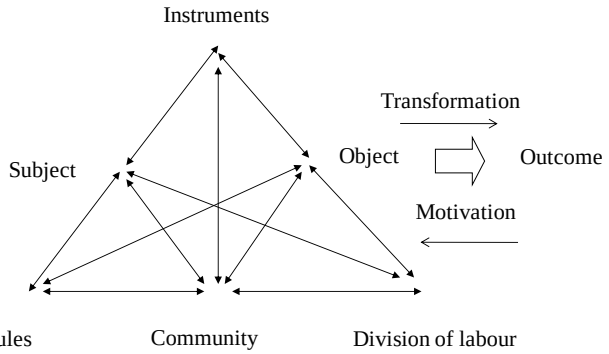

Figure 1. System of collective activity applying (Engestrom, 2000)

Thus, in order to meet conference attendees requirements, a conference committee community has to perform transformations which are not yet there. In other words, the organization has to learn in parallel of doing. In this Twitter (and other social media means, such as Facebook and Google Drive) offers novel ways to involve conference attendees into developing processes on real time. Traditional learning theories, such as single-loop and double-loop learning (Argyris & Schon, 1978), have little to offer in such a situation. Expansive learning at work produces new forms of work activity (Engeström, 2001). An essential component of expansive learning is shared knowledge. This accumulates in explicit form, such as rules and instruments (artefacts and tools) and in tacit form, which includes cultural-, historical-, social-, and experience-based knowledge. This collective type of contemporary learning requires knowledge-sharing arenas as a field of growing. In focal conference case learning environment informal face-to-face contact and opportunities to hold mutual discussions are offered in physical conference. To be emphasized that before, during, and after conference tweeting provides online computer-aided communication. This forms an efficient and effective co-learning environment. Moreover it performs also as a knowledge storage for further utilization in next conferences and events.

2.3 Internal and External Memory Aids

Memory aids are devices or strategies that are deliberately used to enhance an individual's memory (Intons-Peterson & Fournier,

1986). Simple and ordinary as the memory aids may seem, they may play major roles also in a project work context, such as conference and event organization.

These memory aids may be classified into two different types (e.g. Harris, 1984). Internal aids involve reliance on an individual's internal memory like in the cases of mental rehearsing (i.e., mentally repeating to oneself, what he or she wants to remember) and alphabetic searching (i.e., going through the alphabet one letter at a time to see if it sparks a memory). External aids, in turn, involve the use of tangible, physical aids such as making lists and sketch notes. And then, putting an item in a special place where he or she will be sure to see it. Generally speaking, internal aids correspond to the variables that are often tested in laboratory research (Intons-Peterson & Fournier, 1986), whereas external aids correspond to the techniques people – for example, project team members - claim to use as memory prompts in their work duties. (Koskinen & Aramo-Immonen, 2008)

2.4 Personal Notes in Social Media as External Memory Aids

Koskinen and Aramo-Immonen (2008) studied whether the engineer's personal notes are available for utilisation in problem solving situations within the implementation of projects. On the basis of the results presented from the study could be concluded that note making and the utilisation of these notes is a common practice in a project work context. The people working in a project work context see that their personal notes play a very important role on the individual level and rather important role on the project level. Moreover, knowledge hoarding is not so common a phenomenon in a project work context as it is often reported to be in functional organisations. The understanding of colleagues' notes often however need help from the knowledge makers (Koskinen & Aramo-Immonen, 2008), which need to be contacted in some way. Twitter lowers the barrier of contacting a person, as unlike on most online social networking sites, such as Facebook or MySpace, the relationship of following and being followed requires no reciprocation (Kwak, Lee, Park, & Moon, 2010), and you can message any user whether or not s/he is following you.

External memory aids come in many forms, e.g., making notes in a meeting, entering an appointment in a calendar, photographs, drawings, maps and the like (Intons-Peterson & Newsome III, 1992). Asking someone else is also used as an external memory aid. This means that external memory aids are used to retrieve memories from the past. Very common is the use of external memory aids to facilitate remembering in the future. Therefore, people write notes in a diary. Some external memory aids are distinctly verbal in nature (e.g., reminder notes, calendar entries), others are more spatial (e.g., pictures, maps, sketch notes). (Koskinen & Aramo-Immonen, 2008). Rich pictures were particularly developed as part of Peter Checkland's Soft Systems Methodology for gathering information about a complex situation (1981; 1990). In social media photographs have special role as an mediator of knowledge. "One picture tells more than one thousand words".

In order to remember something people commonly rely on placing reminders in different places or on following their calendars (Meacham & Leiman, 1982). However, repositories like these are not only used as an aid, they are often the central storage areas for large amounts of knowledge that cannot be retrieved elsewhere (Koskinen & Aramo-Immonen, 2008). Recently social media however has began to perform as common memory aid shared by communities. The scrawls an individual project team member makes in a diary, may become the only record of many solutions made in a project. But discussion on shared community such as Twitter for example functions as a collaborative memory aid. When an individual is not able to reconstruct a problem solution without recourse to a diary, the diary often provides reminders. Thus, through the creation of personal notes it is possible to make an individual less vulnerable to loss of knowledge about problem solutions and by sharing these notes in social media (e.g. Twitter, Facebook, Google Drive, Evernote) individuals can form shared knowledge with others. Furthermore, certain individuals can take different roles based on their unique skill sets, like sketching conference plans or presentations as sketchnotes and sharing these sketchnotes in Twitter for the benefit of all attendees (Jussila, Huhtamäki, Henttonen, Kärkkäinen, & Still, 2014). Thus social media forms the base for new kind of collaborative knowledge creation (Jussila, Kärkkäinen, & Leino, 2012; Kärkkäinen & Jussila, 2013; Merigó, Rocha, & Garcia-Agreda, 2013) that takes advantage of networks in creating value by solving problems that exceed the capacities of one professional (Schultze & Stabell, 2004).

2.5 Motivation to Learn from Conferences

Conferences and events can use a variety of methods to encourage a learning culture. For an individual to learn, he or she must move to a learning mentality. In other words, the individual has to be motivated. The motivation can be intrinsic, i.e. from within the individual, or extrinsic, i.e. imposed from outside. Buckler (1996) proposes that an individual moves through a number of stages in the process of becoming learning oriented:

Ignorance - If an individual accepts that no one knows what they do not know, the no blame can be attached to any individual who finds himself or herself in a state of ignorance.

Awareness - After awareness, motivation is needed from the individual to put in the effort for understanding of the subject or problem. Barriers to this are attitudes such as, 'It is not my job', and, 'I am not paid to know that', which are typical responses.

Understanding - Understanding develops as the depth of knowledge increases. Superficial understanding generally leads to single-loop learning, whereas double-loop learning requires much deeper understanding. Usually, commitment starts to develop as understanding rises.

Commitment - Commitment cannot be achieved without intrinsic interest and curiosity. Without it, the move to action is not likely to take place. Such desire cannot be directed, but must come from within the individual.

Enactment - It is only when individuals working within teams move to enactment that real improvements through learning start to emerge. Effective discovery-learning systems can enable individuals to move to this stage.

Reflection - This is a key step in the learning process, and is the stage most often missing in 'taught' organizations. In this stage, actions, outcomes, and theories are evaluated, and deep learning takes place.

We utilize this categorization in our assessment of online and face-to-face co-learning environments (see Table 1 further)

2.6 Community of Practice as Co-Learning Environment

"A community of practice is a collection of people who engage on an ongoing basis in some common endeavor. Communities of practice emerge in response to common interest or position, and play an important role in forming their members' participation in, and orientation to, the world around them. It provides an accountable link, therefore, between the individual, the group, and place in the broader social order, and it provides a setting in which linguistic practice emerges as a function of this link." (Eckert, 2006)

Wenger et al. (1991; 1998; 2002) link the concept of communities of practice directly to organizational learning. For them, organizations are made up of communities of practice, and so, if organizational learning is to take place, then learning in communities needs to be stimulated (Ropes, 2010). For Wenger, learning is an ongoing social process that has four specific elements, which are interdependent and intertwined. These elements of learning are:

Meaning - A way of talking about our (changing) ability- individually and collectively- to experience our life and the world as meaningful.

Practice - A way of talking about the shared historical and social resources, frameworks, and perspectives that can sustain mutual engagement in action.

Community - A way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence.

Identity - A way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities.

Two conditions of a community of practice are crucial in mutual sense-making: shared experience over time, and a commitment to shared understanding (Eckert, 2006). Therefore community of practice in social media is nurturing co-learning environment.

2.7 Twitter as Co-Learning Environment

Twitter unlike social network sites, such as Facebook or LinkedIn, was not originally intended primarily as a platform for community building, but as a tool for information dissemination (Gruzd, Wellman, & Takhteyev, 2011). There is, however, a growing body of research that has explored the possibilities of communities forming on Twitter (Erickson, 2008; Gruzd et al., 2011; Huberman, Romero, & Wu, 2008; Java, Song, Finin, & Tseng, 2007; Loureiro-Koechlin & Butcher, 2013; Zappavigna, 2012; Stephansen & Couldry, 2014). There is also growing stream of literature on the use of Twitter in formal and informal learning. However, the existing research has tended to focus on the effectiveness of Twitter as a tool for formal learning, for example to improve linguistic competency (Cano, 2012), memory of concepts (Blessing, Blessing, & Fleck, 2012), or the delivery of large-lecture courses (Elavsky, Mislan, & Elavsky, 2011). (Stephansen & Couldry, 2014) Most studies that have explored the use of Twitter in informal co-learning processes and social relationships (e.g. Ebner, Lienhardt, Rohs, & Meyer, 2010; Junco, Heiberger, & Loken, 2011; Junco, Elavsky, & Heiberger, 2013; Kassens-Noor, 2012; Dabbagh & Kitsantas, 2012; Stephansen & Couldry, 2014) have focused on school environment, e.g. college or university context, whereas informal co-learning in communities of practice and project work context has received little attention.

This article contributes to this emerging field of research on informal learning in communities of practice and project work context by presenting a detailed case study of how community managers from various organizations in Finland have used Twitter to construct and co-learning environment.

3. RESEARCH APPROACH

3.1 Research Method

In this study, we follow data science research approach (e.g. Hey, Tansley, & Tolle, 2009) and apply the process of data-driven visual network analytics (Card, Mackinlay, & Shneiderman, 1999) for providing insights for the community of community managers co-learning based on Twitter data retrieved of the CMAD 2014 conference day. As Twitter can be seen to present an information system, we utilize case study method, which has been found to be a legitimate way of adding to the body of knowledge in the information systems field; it provides detailed and analyzed information about real world environments through examples of phenomena under research (Benbasat, Goldstein, & Mead, 1987).

3.2 Case CMAD 2014

Our case co-learning environment is community managers online discussions in social media, especially in Twitter (#cmadfi), in connection to yearly organized Community Manager Appreciation Day (CMAD 2014) event in Finland. The most recent event took place on January 27, 2014 in Hämeenlinna, Finland. CMAD events have been organized globally since 2010 and they originate from Jeremiah Owyang's blog to recognize and celebrate the efforts of community managers around the world using social media and other tools to improve customer experiences. The organizing committee of the third CMAD event (CMAD 2014) in Finland included more than 200 people, with 23 people participating in the planning meetings. Total of 225 people participated in the CMAD 2014 event.

It can be argued that discussions in social media represent only a small or a very small part of the overall communication between community members in professional communities and their co-learning, because many professionals do not either have a Twitter account or are not active in Twitter. As a consequence data science approaches can be seen as a limitedly useful in studying professional communities. In this case, however, majority of the community members belonging to the community of community managers can be considered as advanced lead users of social media and online community management approaches, with most of them being highly active in Twitter. Second, related to learning events and conferences, it has been observed that most of the activity take place during the learning event or conference, with little communication before and after (Ebner & Reinhardt, 2009), making it questionable to draw any legitimate conclusions from data collected before and after the conference. We agree that by collecting data before, during and after the conference using the hashtag (e.g. #cmadfi) of the conference (see e.g. Jussila et al., 2014), this usually is the case. However, based on previous studies of community managers in Finland (Aramo-Immonen, Jussila, & Huhtamäki, 2014; Jussila et al., 2013, 2014), we argue that community managers communicate with each other also between events, and have also participated actively in planning the event, and assume that by collecting data based on these

community members all discussions (not only using #cmadfi hashtag) we can capture sufficient and representative amount of data to draw conclusions.

3.3 Data Science Research Approach

Data science has been used as a general term to refer to a wide set of skills and practices required to operate in the big data sphere (e.g. Davenport, 2014), and also to refer to the fourth paradigm for science (Hey et al., 2009). From research viewpoint, a scientific approach is in-built, quantitative analysis is a core methodology, and business researchers seek to answer the questions that are of interest to business. Data science does, however, highlight two areas that can benefit state-of-the-art research. First, applying novel approaches in collecting data from online sources, referred by Davenport (2014) as hacking, allows the use of new kind of data in research. Second, using information visualization and other means of presenting the results of the analysis coupled with storytelling practices seeks to increase the impact of analysis. According to Ware (2004), information visualization can amplify the cognition of the user through expressive views, thus providing insight on phenomena represented by the data. Overall the process of data analysis "covers a whole range of activities throughout the workflow pipeline including the use of databases (versus a collection of flat files that a database can access), analysis and modeling, and then data visualization." (Hey et al., 2009). Previous related studies on information visualization and visual analysis that have been conducted in connection to eLearning following a similar research approach include (Silius et al., 2010; Gomez-Aguilar, Conde-Gonzalez, Theron, & Garcia-Peñalvo, 2011; Tervakari et al., 2012; Silius, Tervakari, & Kailanto, 2013; D. A. Gómez-Aguilar, Therón, & García Peñalvo, 2013; D.-A. Gómez-Aguilar, García-Peñalvo, & Therón, 2014).

3.4 Collection and Extraction of Social Media Data

A total of 1859 tweets were collected for this study. As the use of a particular hashtag, #cmadfi2014, was instructed clearly to the participants of the Finnish chapter of Community Manager Appreciation Day 2014, we used the hashtag as our sole search filter.

To collect the tweets, we implemented a batch script in Python that queries Twitter REST Application Programming Interface (API) for tweets using #cmadfi2014. Twitter REST API was sufficient for collecting the tweets because it allows implementing 180 queries per 15-minute window with each of the queries potentially resulting into maximum of 100 tweets. The analysis of more high-volume Twitter streams insists applying Twitter Streaming API instead of the REST API.

Twitter API serves the tweets in a highly structured format, particularly when the inclusion of entity data is enabled as in our vase. The tweets in JSON format were stored in a MongoDB database running in the same private server we used to run the batch script. MongoDB is an open source NoSQL (Not Only SQL) database that allows storing and querying data that does not follow a specific schema. The batch script was run on a five-minute interval to make sure we are able to capture all the tweets while following the 150 requests in 15 minutes interval set by the API.

We used the appropriate JSON fields to collect tweet senders, Twitter users mentioned in the tweets as well as the hashtags used in tweets. An alternative approach would have been to parse the text content of the tweets. As Python, the programming language we used to implement

3.5 Cleaning and Processing of Social Network Data

In general, Twitter data allows straightforward analysis. The used REST API puts out tweet data including both the 140 character messages and, in addition, includes rich metadata for each tweet, for example details e.g. tweet sender, time when the tweet was sent, the optional geolocation, i.e. the place where the tweet was sent. Importantly, version 1.1 of the Twitter REST API includes by default additional details of tweet sender, all the users mentioned in the tweet as well as the hashtags that are used in tweets. This further eases the analysis of the data as these details do not have to be parsed from the actual message content.

As Python, the programming language used to implement the computational processes to analyze and visualize the data, treats strings as case-sensitive, we decided to transform all user names and hashtags to lowercase strings.

To assist the analysis, a process for serializing the key fields of each of the tweets in CSV was implemented to allow all the investigators to be able to access the raw data.

Moreover, a process was implemented to transform tweet data into three networks:

- The first network is a two-mode network including two types of nodes, representing both Twitter users and hashtags. A pair of users is connected to each other when one has mentioned the other. Users are also connected to the hashtags they have used in their tweets as well as to the hashtags that are used in the tweets they have been mentioned in.

- The second network shows the interconnections between people communicating over Twitter. More specifically, with interconnections, we refer to users mentioning each other in tweets through commenting, discussions and retweets.

- The third network represents the co-occurence of hashtags included in the tweets. The weight of the connection indicates the number of times a user has mentioned another user in a tweet.

The Python script uses NetworkX library (version 1.9) to construct the network and serialize it in Graph Exchange XML Format or GEXF (version 1.2). For temporal analysis, another Python script was implemented, to transform the data in Data Tables into timeline-based Visual Structure. Highcharts (version 2.1.9), a JavaScript-based software library for developing interactive charts, was used to implement the timelines. Python library Cheetah was used to aid the creation of the visualizations.

3.6 Data Analysis and Visualization

For structuring the analysis process, we applied the Network Analysis and Visualization (NAV) process model (Hansen et al., 2009). For analyzing and visualizing the networks, we used Gephi, an interactive visualization and exploration platform available in open source (Bastian, Heymann, & Jacomy, 2009). Following the NAV model, Gephi was used to layout the

networks, calculate metrics for the network nodes, analyze networks for possible subnetworks or clusters and adjust the visual properties of the visualized network according to the analysis.

In this particular case, we decided to use the value of weighed node indegree to define node size. Indegree refers to the amount of connections pointing to a node, in this case the number of mentions that a particular used has received. The weighed value takes into account multiple incoming connections, i.e. connections in which a person has mentioned another are more important than individual mentions.

The layout of the networks in this study is the result of a force driven layout algorithm in which nodes repel each other and the edges connecting the nodes act as springs pulling the nodes back together (Fruchterman & Reingold, 1991). As a result, nodes that are interconnected will be placed close to each other.

For distributing interactive versions of the network visualizations over the Web, we used Gexf.js, a Javascript-based GEXF Viewer for Gephi.

4. RESULTS AND FINDINGS

4.1 Assessment of Twitter Data

In order to learn there has to be motivation to learn. Co-learning environments merges from the community's mutual interest to curtain subjects. Therefore, motivation generation is base for co-learning. In table one we have assessed when does each motivation stage emerge in conference event process. What we could find was that before conference online discussions woke the interest to learn. In other word awareness of different learning interest was created already before the actual conference. During the conference the understanding and commitment took place in both face-to-face and online discussions. We also found that commitment to learn and enactment continued in online discussions after the actual face-to-face event. However after conference reflection online can have bigger affects to motivation to learn and sustain the knowledge learned that we know based contemporary research.

Table 1. Assessment of how does learning motivation stages differ in online and in face-to-face co-learning environments. Based on our observation during this study. (online/face to face is marked in the table X=exists and - =does not exist)

Motivation stages	Before conference	During conference	After conference
Ignorance	x / -	- / -	x / -
Awareness	x / -	x / x	x / x
Understanding	- / -	x / x	- / x
Commitment	x / x	x / x	- / x
Enactment	- / -	- / -	- / x
Reflection	- / -	- / -	x / x

After CMAD 2014 conference, the sketchnotes, and various other discussions related to the presentations (from Twitter and other social media) were also documented on the community managers' social media platform (Flockler), available from cmad.fi, to serve as a collective knowledge repository (see http://cmad.fi/tweetit for example).

After conference tweets like "Community managers, what are the top 3 apps you can't live without? #CMADfi" indicated that twitter was used by community managers as discussion board several months after conference. There were also tweets sharing notes, sketches, slides and links that can be identified as a typical external memory aids.

4.2 Visual Analysis of Twitter Data

To discover the most popular discussions of community managers during the conference day a hashtag table was constructed (Table 2). The table enables interactive sorting by hashtag name, volume, number of related hashtags and by related hashtags. Sorting by volume in descending order quickly reveals the most popular topics and related subtopics of discussions by community managers. The top 5 discussions based on volume point out to 1) the global CMAD conference, 2) social media, 3) Hämeenlinna - the city where the conference took place, 4) the arranged transportation for the conference participants from Helsinki to the conference location, and 5) the Digitalist network.

Table 2. Top 5 hashtags that CMAD2014 participants used during conference day. Interactive version is available: http://www.tut.fi/novi/case/2015-chb-cmadfi2014-colearning/list.

Name	Volume	No. of Related Hashtags	Related Hashtags
cmad	121	18	applause, bigdata, cmadselfie, cmgrhangout, cmgrhanout, communitymanager, communitymidwife, contentmarketing, finland, funday, hangout, hämeenlinna, johto, nettikätilö, pikavoitot, smartdata, sonerapartio, viestintä
some	44	18	asiakaspalvelu, bigdata, crowdsourcing, data, hämeenlinna, innovaatiot, järjestöt, muutos, organisaatio, pallo, pelillisyys, someanalyysi, sonera, sryhmä, teollisuus, tuotekehitys, yhteisöllisyys, älykkäätkoneet
hämeenlinna	33	6	cmad, hamk, huomenta, parhautta, some, somesuku
cmadbussihki	25	3	cmadfi2014, digitalist, vr
digitalist	25	6	cmadbussihki, dmf, huomenta, jee, suomisome, vr

The table however, does not give a good picture of what kind of discussions are most related to each other, and what kind of issues are most interrelated. For this purpose, a second visualization was constructed to display the co-occurrence of hashtags in matrix form. In the matrix the discussions are clustered based on the choice of sorting parameter: volume, partition and total number of co-occuring tweets. Observing from the co-occurrence of hashtags matrix, and sorting by partitions, we identified 7 larger different partitions, representing 7 different subgroups of discussions inside the community of community managers. In the Figure 2, the different partitions (clusters) can be identified by different colors, some partitions are more dense (e.g. second partition) and some more scattered (e.g. first partition). See interactive version of Figure 2 for more details. The partitions included a range of related discussion topics and based on the content can be categorized into the following categories: 1) workplace learning, 2) conference related feelings, 3) selfies and similar social media

phenomena, 4) sponsoring organizations, 5) bolstering community spirit, 6) social media in Finland and Digitalist network, 7) social media customer service and content creation.

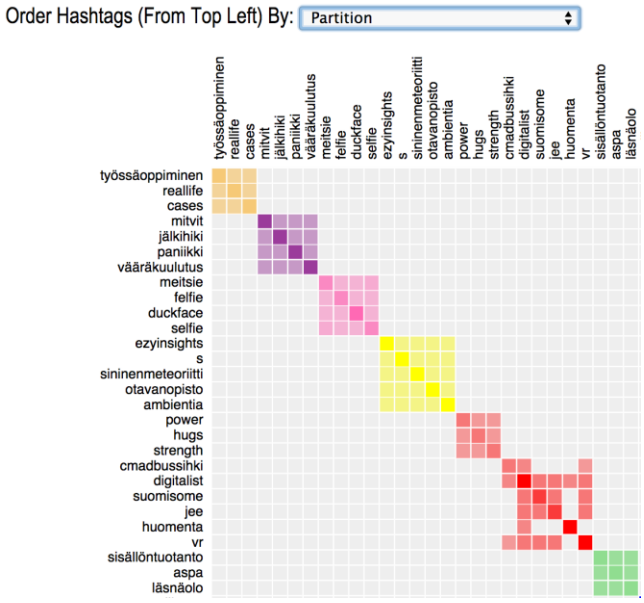

Figure 2. Hashtag metrics of people tweeting during the CMAD 2014 conference day. Interactive visualization is available: http://www.tut.fi/novi/case/2015-chb-cmadfi2014-colearning/matrix.

These two visualization together help to organize and facilitate discussions and networking events for the actual conference on themes that the community managers perceive important, for example social media and recruitment. They do not however, tell who is talking about what. To understand, which sub groups are interested in certain topics, e.g. social media or recruitment, other kinds of visualizations are needed. For this purpose, an interactive social network of people and hashtags was constructed (Figure 3).

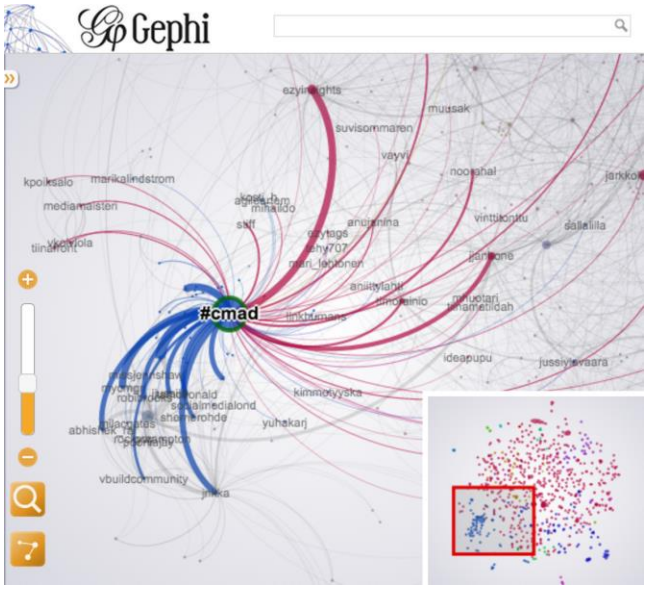

Figure 3. Interactive visualization of people tweeting and their hashtags during the conference day. Interactive visualization is available: http://www.tut.fi/novi/case/2015-chb-cmadfi2014-colearning/network.

The interactive visualization of people and hashtags enables to look at specific nodes, e.g. you can look at a specific people node, and see which other people are discussing with this node and to which discussion topics this node is related. The other way around, you can look at a specific hashtag node (e.g. social media) and see which people are talking about the topic and what other topics are related to the topic.

The figure 3 can be used by people to find people with similar interest, to network with and share knowledge even before the conference. For the organizers the figure 3 gives clues which people should be e.g. seated at same tables at lunch to generate fruitful further discussions.

5. DISCUSSION

Proposition 1: Discussions in social media network can perform as virtual collaborative co-learning environments.

Based on literature making notes is vital part of organizational memory. Discussion in social media can perform as collaborative memory aid (community notes). Possibility to exchange easily pictures and photographs enhances discussions to rich knowledge sharing arenas. Based on our empirical findings these kinds of activities took place before, during and after the conference. For example, conference participants used Twitter to ask and answer questions on the identified interest areas of community managers before the conference. Reflecting on previous study of CMAD 2013 event (Jussila et al., 2014) and the situation after CMAD 2014, the participants also created rich pictures of conference presentations in the form of sketchnotes during the conference that were shared to the community. After CMAD 2014 conference, the sketchnotes, and various other discussions related to the presentations (from Twitter and other social media) were also documented on the community managers' social media platform (flockler.com), available from cmad.fi, to serve as a collective knowledge repository.

Proposition 2: Physical informal co-learning environments can be built based on information gained from interactive visualization of people's behaviour in social network before and during the event.

In physical conference event workshops, lunch tables and coffee rooms for example could be arrange according to interest groups emerged in earlier virtual discussions. Moreover, the topical discussions and special groups around themes could be arranged based on this information.

Proposition 3: Before event virtual discussions can increase the motivation to learn collaboratively during the conference.

As illustrated in Table 1 early stages of motivation creation are affected by online discussions. Therefore we suggest that network discussions enforce the co-learning process in physical face-to-face conference situation.

We also suggest that after event virtual discussions can lead to in-depth learning and sustainable performance changes and new knowledge creation. However, this phenomena has to be studied more in order to draw this conclusion. Therefore we suggest this to be a future research question.

6. REFERENCES

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge Management and Knowledge Management Systems: Conceptual

Foundations and Research Issues. *MIS Q.*, *25*(1), 107–136. doi:10.2307/3250961

Aramo-Immonen, H. (2009). Project management ontology-The organizational learning perspective. *Tampereen Teknillinen Yliopisto. Julkaisu-Tampere University of Technology. Publication; 836*. Retrieved from http://dspace.cc.tut.fi/dpub/handle/123456789/6495

Aramo-Immonen, H., Jussila, J., & Huhtamäki, J. (2014). Visualizing informal learning behavior from conference participants Twitter data. In *Proceedings of the Second International Conference on Technological Ecosystems for Enhancing Multiculturality* (pp. 603–610). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=2669962

Aramo-Immonen, H., Koskinen, K. U., & Porkka, P. L. (2011). The significance of formal training in project-based companies. *International Journal of Managing Projects in Business*, *4*(2), 257–273.

Argyris, C., & Schon, D. (1978). Organizational learning: A theory of action approach. *Reading, MA: Addision Wesley*.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, *17*(1), 99–120.

Bastian, M., Heymann, S., & Jacomy, M. (2009). Gephi: An open source software for exploring and manipulating networks. In *International AAAI conference on weblogs and social media* (Vol. 2). Retrieved from http://www.aaai.org/ocs/index.php/ICWSM/09/paper/viewPDFInterstitial/154Forum/1009

Benbasat, I., Goldstein, D. K., & Mead, M. (1987). The case research strategy in studies of information systems. *MIS Quarterly*, 369–386.

Blackler, F., Crump, N., & McDonald, S. (1999). Managing experts and competing through innovation: An activity theoretical analysis. *Organization*, *6*(1), 5–31.

Blessing, S. B., Blessing, J. S., & Fleck, B. K. (2012). Using Twitter to reinforce classroom concepts. *Teaching of Psychology*, *39*(4), 268–271.

Buckler, B. (1996). A learning process model to achieve continuous improvement and innovation. *Learning Organization, The*, *3*(3), 31–39.

Cano, E. V. (2012). Mobile learning with Twitter to improve linguistic competence at secondary schools. *New Educational Review*, *29*(3), 134–147.

Card, S. K., Mackinlay, J. D., & Shneiderman, B. (1999). *Readings in information visualization: using vision to think*. Morgan Kaufmann Pub. Retrieved from http://www.google.com/books?hl=fi&lr=&id=wdh2gqWfQmgC&oi=fnd&pg=PR13&dq=card+1999+information+visualisation&ots=olFC3zvJRs&sig=jSDLENOhswJwV1f5T_UIp4OvocM

Checkland, P. (1981). *Systems thinking, systems practice*. J. Wiley.

Checkland, P. B., & Scholes, J. (1990). *Soft systems methodology in action*. John Wiley & Sons Australia, Limited.

Choo, C. W. (1996). The knowing organization: How organizations use information to construct meaning, create knowledge and make decisions. *International Journal of Information Management*, *16*(5), 329–340. doi:10.1016/0268-4012(96)00020-5

Dabbagh, N., & Kitsantas, A. (2012). Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. *The Internet and Higher Education*, *15*(1), 3–8.

Dasgupta, M., & Gupta, R. K. (2009). Innovation in Organizations A Review of the Role of Organizational Learning and Knowledge Management. *Global Business Review*, *10*(2), 203–224.

Davenport, T. (2014). *Big Data at Work: Dispelling the Myths, Uncovering the Opportunities*. Harvard Business Review Press.

Davies, A., & Brady, T. (2000). Organisational capabilities and learning in complex product systems: towards repeatable solutions. *Research Policy*, *29*(7), 931–953.

DeFilippi, R. J., & Arthur, M. B. (2002). Project-based learning, embedded learning contexts and the management of knowledge. *Research Paper, Suffolk University, Boston*.

Drucker, P. F. (1994). The age of social transformation. *The Atlantic Monthly*, 53–80.

Ebner, M., Lienhardt, C., Rohs, M., & Meyer, I. (2010). Microblogs in Higher Education–A chance to facilitate informal and process-oriented learning? *Computers & Education*, *55*(1), 92–100.

Ebner, M., & Reinhardt, W. (2009). Social networking in scientific conferences–Twitter as tool for strengthen a scientific community. In *Proceedings of the 1st International Workshop on Science* (Vol. 2, pp. 1–8).

Eckert, P. (2006). Communities of practice. *Encyclopedia of Language and Linguistics*, *2*, 683–685.

Elavsky, C. M., Mislan, C., & Elavsky, S. (2011). When talking less is more: exploring outcomes of Twitter usage in the large-lecture hall. *Learning, Media and Technology*, *36*(3), 215–233.

Engestrom, Y. (2000). Activity theory as a framework for analyzing and redesigning work. *Ergonomics*, *43*(7), 960–974.

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work*, *14*(1), 133–156.

Erickson, I. (2008). The translucence of Twitter. In *Ethnographic Praxis in Industry Conference Proceedings* (Vol. 2008, pp. 64–78). Wiley Online Library. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1559-8918.2008.tb00095.x/abstract

Francescato, D., Porcelli, R., Mebane, M., Cuddetta, M., Klobas, J., & Renzi, P. (2006). Evaluation of the efficacy of collaborative learning in face-to-face and computer-supported university contexts. *Computers in Human Behavior*, *22*(2), 163–176.

Fruchterman, T. M., & Reingold, E. M. (1991). Graph drawing by force-directed placement. *Software: Practice and Experience*, *21*(11), 1129–1164.

Gann, D. M., & Salter, A. J. (2000). Innovation in project-based, service-enhanced firms: the construction of complex products and systems. *Research Policy*, *29*(7), 955–972.

García-Peñalvo, F. J., Colomo-Palacios, R., & Lytras, M. D. (2012). Informal learning in work environments: training with the Social Web in the workplace. *Behaviour & Information Technology*, *31*(8), 753–755.

Gómez-Aguilar, D.-A., García-Peñalvo, F.-J., & Therón, R. (2014). ANALíTICA VISUAL EN e-learning. *El Profesional de La Información*, *23*(3), 236–245.

Gómez-Aguilar, D. A., Therón, R., & García Peñalvo, F. J. (2013). Reveal the relationships among student's participation and its outcomes on eLearning environments: Case study. In *Advanced Learning Technologies, 2013. ICALT 2013. 13th IEEE International Conference on* (pp. 15–18).

Gomez-Aguilar, D., Conde-Gonzalez, M., Theron, R., & Garcia-Peñalvo, F. (2011). Supporting moodle-based lesson through visual analysis. In *Human-Computer Interaction–INTERACT 2011* (pp. 604–607). Springer. Retrieved from http://link.springer.com/chapter/10.1007/978-3-642-23768-3_93

Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, *17*, 109–122.

Gruzd, A., Wellman, B., & Takhteyev, Y. (2011). Imagining Twitter as an imagined community. *American Behavioral Scientist*, *55*(10), 1294–1318.

Hansen, D. L., Rotman, D., Bonsignore, E., Milic-Frayling, N., Rodrigues, E. M., Smith, M., … Capone, T. (2009). Do you know the way to SNA?: A process model for analyzing and visualizing social media data. *U. of Maryland Tech Report: HCIL-2009-17*. Retrieved from http://www.smrfoundation.org/wp-content/uploads/2010/05/2009-UMD-TechReport-Do-you-know-the-way-to-SNA.pdf

Harris, J. E. (1984). Remembering to do things: A forgotten topic. *Everyday Memory, Actions and Absent-Mindedness*, 71–92.

Hey, A. J., Tansley, S., & Tolle, K. M. (2009). The fourth paradigm: data-intensive scientific discovery. Retrieved from http://iw.fh-potsdam.de/fileadmin/FB5/Dokumente/forschung/tagungen/i-science/TonyHey_-__eScience_Potsdam__Mar2010____complete_.pdf

Hobday, M. (2000). The project-based organisation: an ideal form for managing complex products and systems? *Research Policy*, *29*(7), 871–893.

Huberman, B. A., Romero, D. M., & Wu, F. (2008). Social networks that matter: Twitter under the microscope. *arXiv Preprint arXiv:0812.1045*. Retrieved from http://arxiv.org/abs/0812.1045

Intons-Peterson, M. J., & Fournier, J. (1986). External and internal memory aids: When and how often do we use them? *Journal of Experimental Psychology: General*, *115*(3), 267.

Intons-Peterson, M. J., & Newsome III, G. L. (1992). External memory aids: Effects and effectiveness. In *Memory Improvement* (pp. 101–121). Springer. Retrieved from http://link.springer.com/chapter/10.1007/978-1-4612-2760-1_7

Java, A., Song, X., Finin, T., & Tseng, B. (2007). Why we twitter: understanding microblogging usage and communities. In *Proceedings of the 9th WebKDD and 1st SNA-KDD 2007 workshop on Web mining and social network analysis* (pp. 56–65). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=1348556

Junco, R., Elavsky, C. M., & Heiberger, G. (2013). Putting twitter to the test: Assessing outcomes for student collaboration, engagement and success. *British Journal of Educational Technology*, *44*(2), 273–287.

Junco, R., Heiberger, G., & Loken, E. (2011). The effect of Twitter on college student engagement and grades. *Journal of Computer Assisted Learning*, *27*(2), 119–132.

Jussila, J., Huhtamäki, J., Kärkkäinen, H., & Still, K. (2013). Information visualization of Twitter data for co-organizing conferences. In *Proceedings of the 17th International Academic MindTrek Conference: Making Sense of Converging Media*. Tampere.

Jussila, J., J Huhtamäki, K Henttonen, H Kärkkäinen, & K Still. (2014). Visual Network Analysis of Twitter Data for Co-organizing Conferences: Case CMAD 2013. In *Proceedings of the 47th Annual Hawaii International Conference on System Sciences* (Vol. January 6–9).

Jussila, J. J., Kärkkäinen, H., & Leino, M. (2012). Learning from and with Customers with Social Media: A Model for Social Customer Learning. *International Journal of Management, Knowledge and Learning*, *1*(1), 5–25.

Kakabadse, N. K., Kakabadse, A., & Kouzmin, A. (2003). Reviewing the knowledge management literature: towards a taxonomy. *Journal of Knowledge Management*, *7*(4), 75–91.

Kärkkäinen, H., & Jussila, J. J. (2013). Can Social Media Help Business-to-Business Companies to Learn from their Customers? Retrieved from http://www.worldfinancialreview.com/?p=756

Kassens-Noor, E. (2012). Twitter as a teaching practice to enhance active and informal learning in higher education: The case of sustainable tweets. *Active Learning in Higher Education*, *13*(1), 9–21.

Koskinen, K. U., & Aramo-Immonen, H. (2008). Remembering with the help of personal notes in a project work context. *International Journal of Managing Projects in Business*, *1*(2), 193–205.

Kwak, H., Lee, C., Park, H., & Moon, S. (2010). What is Twitter, a social network or a news media? In *Proceedings of the 19th international conference on World wide web* (pp. 591–600). ACM. Retrieved from http://dl.acm.org/citation.cfm?id=1772751

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge university press. Retrieved from http://www.google.com/books?hl=fi&lr=&id=CAVIOrW3vYAC&oi=fnd&pg=PA11&dq=situated+learning+legitimate+peripheral+participation&ots=OBkBqtZHBi&sig=-66nkDbHt-t2M5f90QqOihkr7wk

Liao, S. (2003). Knowledge management technologies and applications—literature review from 1995 to 2002. *Expert Systems with Applications*, *25*(2), 155–164.

Loureiro-Koechlin, C., & Butcher, T. (2013). The emergence of converging communities via Twitter. *The Journal of Community Informatics*, *9*(3). Retrieved from http://ci-journal.taniasunde.com/index.php/ciej/article/view/705

Meacham, J. A., & Leiman, B. (1982). Remembering to perform future actions. *Memory Observed: Remembering in Natural Contexts*, 327–336.

Merigó, J. M., Rocha, C., & Garcia-Agreda, S. (2013). Entrepreneurial intervention in electronic markets: the influence of customer participation. *International Entrepreneurship and Management Journal*, *9*(4), 521–529.

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation: How Japanese Companies Create the Dynamics of Innovation*. New York: Oxford University Press. Retrieved from http://www.google.com/books?hl=fi&lr=&id=B-qxrPaU1-MC&oi=fnd&pg=PA3&dq=nonaka+knowledge+creating+company&ots=XgZMnwsihY&sig=uZcw6er74CSraZHdULf_2R8-fKw

Patil, D. J. (2012). *Data Jujitsu: The Art of Turning Data into Product*. O'Reilly Media, Inc.

Popper, M., & Lipshitz, R. (1998). Organizational learning mechanisms a structural and cultural approach to organizational learning. *The Journal of Applied Behavioral Science*, *34*(2), 161–179.

Prencipe, A., & Tell, F. (2001). Inter-project learning: processes and outcomes of knowledge codification in project-based firms. *Research Policy*, *30*(9), 1373–1394.

Raivola, R., & Ropo, E. (1991). Jatkuva Koulutus ja Elinikäinen Oppiminen (Continuous Training and Life-long Learning). *Tampere, TAY Julkaisusarja A: Tutkimusraportti*, *9*.

Revans, R. W. (1982). *The origins and growth of action learning*. Studentlitteratur.

Ropes, D. C. (2010). Organizing professional communities of practice. Retrieved from http://dare.uva.nl/document/177064

Sarala, U. (1993). *Madaltuvat organisaatiot, itseohjautuvat pienryhmät: kahvikerhosta oppivaan organisaatioon*. Suomen laatuyhdistys, laatupiirijaos.

Schultze, U., & Stabell, C. (2004). Knowing what you don't know? Discourses and contradictions in knowledge management research. *Journal of Management Studies*, *41*(4), 549–573.

Silius, K., Miilumaki, T., Huhtamaki, J., Tebest, T., Merilainen, J., & Pohjolainen, S. (2010). Social media enhanced studying and learning in higher education. In *Education Engineering (EDUCON), 2010 IEEE* (pp. 137–143). IEEE. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5492586

Silius, K., Tervakari, A.-M., & Kailanto, M. (2013). Visualizations of user data in a social media enhanced web-based environment in higher education. In *Global Engineering Education Conference (EDUCON), 2013 IEEE* (pp. 893–899). IEEE. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6530212

Stephansen, H. C., & Couldry, N. (2014). Understanding micro-processes of community building and mutual learning on Twitter: a "small data"approach. *Information, Communication & Society*, (ahead-of-print), 1–16.

Tervakari, A., Silius, K., Tebest, T., Marttila, J., Kailanto, M., & Huhtamaki, J. (2012). Peer learning in social media enhanced learning environment. In *Global Engineering Education Conference (EDUCON), 2012 IEEE* (pp. 1–9). IEEE. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6201109

Vygotsky, L. S. (2012). *Thought and language*. MIT press. Retrieved from http://www.google.com/books?hl=fi&lr=&id=B9HClB0P6d4C&oi=fnd&pg=PR4&dq=Thought+and+Language&ots=TrEbUhe2No&sig=LOAV8zqENIKk3ziyeemw-geus2o

Ware, C. (2004). *Information Visualization: Perception for Design.* San Francisco: Elsevier.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge university press. Retrieved from http://www.google.com/books?hl=fi&lr=&id=heBZpgYUKdAC&oi=fnd&pg=PR11&dq=communities+of+practice+learning+meaning+and+identity&ots=kekdXr9y4l&sig=88nqnWC-lksnMoDvfELfSg7kFLg

Wenger, E., McDermott, R. A., & Snyder, W. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Harvard Business Press. Retrieved from http://www.google.com/books?hl=fi&lr=&id=m1xZuNq9RygC&oi=fnd&pg=PR9&dq=Cultivating+communities+of+practice&ots=ZU17dL6fd-&sig=EmRtAsYUGp7ssqwHUh3uthpiWLo

Zappavigna, M. (2012). *Discourse of Twitter and social media: How we use language to create affiliation on the web*. Bloomsbury Publishing.