Moving Beyond Case Studies: Using Social Network Analysis to Study Learning as Participation in Communities of Practice

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Abstract: We argue that social network analysis is a useful methodology to study learning under the participation metaphor and to extend scholarly knowledge on the process of legitimate peripheral participation in communities of practice. We emphasize that it is necessary to extend current research about the epistemic aspects of participative learning and to take also the social aspects into account; we first review work on legitimate peripheral participation and how research on this topic is currently conducted. Then we describe the theoretical and methodological foundations of social network analysis. Exemplary studies that use social network analysis including studies on legitimate peripheral participation are presented. We conclude that social network analysis can enable us to make inferences about participative learning across specific setting and individual communities. For the future, the challenge is to relate dynamically changing patterns of legitimate peripheral participation to emerging and changing epistemic practices of a community.

Introduction

The perspective of learning as becoming in practice is closely related to what Sfard (1991) termed the participation metaphor of learning. Learning as seen through the lens of this metaphor focuses on the development of individuals' identity by engaging in certain practices and participating that way in a specific social environment. This approach seems especially valuable for research on informal and workplace learning in which learning goals and paths are very individual and can often hardly be defined by outsiders. Learning under the participation metaphor takes into account that the process of learning and the individual learning goals are situated in the learner's social and epistemic environment. However, most research in this direction still focuses on the epistemic dimension of participation, by analyzing practices and artifacts produced by participative learners. The social dimension has only rarely been the focus of research, probably in part because of a lack in research methodologies that would allow for meaningful ways of analysis.

In this paper, we argue that social network analysis (SNA) is a very promising methodology to study learning under the participation metaphor. SNA is not a new methodology to the ISLS community. Yoon (2011), for example, introduced SNA as a visualization tool to foster students' interaction. It also has been used to analyze community building in scientific communities (Hoadley, 2005). However, using SNA in a pure methodological way to operationalize and analyze learning processes and outcomes is still a mostly unexplored field in the Learning Sciences.

To show how SNA can be applied as a research methodology to enhance our understanding of learning as participation, we first review work on the theoretical approach behind the view of learning as participation and the empirical evidence gathered so far. We will then argue how SNA can be applied to study learning under the participation metaphor, followed by two exemplary studies in which this methodology has been applied. In the conclusion, we come back to the question to what extent SNA is a useful methodology to study learning and what possibilities it provides for future research.

Learning as Participation

Research with the perspective of learning as participation mostly focusses on the understanding of real-world learning occurring outside of formal learning situations. It is a situated approach to learning based on the idea of legitimate peripheral participation of a learner in a community of practice which is considered to lead to a transformation of the learner's identity (Lave & Wenger, 1991; Wenger, 1998). Through participation in activities which are specific to the community of practice, a newcomer is confronted with the community's artifacts, and has opportunities to learn the relevant practices, and participates in the community's process of negotiating meaning.

Learning as Legitimate Peripheral Participation in Communities of Practice

One of the central aspects of learning under the participation metaphor is the epistemic and social context in which learning takes place. Lave and Wenger (1991) termed this context "community of practice" (CoP). Capturing the CoP concept adequately is tricky, although (or probably even because) it is widely used and applied by researchers and practitioners in several disciplines and professions. However, Barab and colleagues have worked on a comprehensive set of characteristics that define a CoP and make the concept graspable and

workable with for Learning Scientists (Barab & Duffy, 2000; Barab, MaKinster, & Scheckler, 2003). They define a CoP by several epistemic and social aspects: shared knowledge, values and beliefs, overlapping histories and mutual interdependence among members, mechanisms for reproduction, a common practice and/or mutual enterprise, opportunities for interactions and participation, meaningful relationships, and respect for diverse perspectives and minority views.

This set of characteristics clearly shows the importance of both epistemic and social aspects that characterize the CoP concept, although most research based on the concept has so far emphasized the epistemic part, especially the shared practices, and more or less neglected the social aspects. However, Wenger, McDermott, and Snyder (2002) have made some further claims on the social structure of a CoP and differentiate between members that belong to a small core group that leads the CoP, a larger group of active members that run the CoP, an often even larger group of peripheral members that only participate irregularly in the CoP, and finally outsiders who might be influenced by the CoP but are not directly involved. Some CoPs also have a coordinator to facilitate the actions among the CoP members. Another way of speaking about the social structure, especially relevant for learning, is the differentiation between newcomers and old-timers who engage in the CoP in different ways. The transition process from being a newcomer to becoming an experienced old-timer in the CoP was described by Lave and Wenger (1991) as legitimate peripheral participation (LPP).

They describe LPP as a natural form of learning which happens all the time, no matter whether there is an intended educational situation or not. The main focus of this perspective on learning is an increase of newcomers' level of participation within a specific CoP. A newcomer usually starts as a mostly passive outsider and becomes a more capable and active member over time, accompanied by a transformation of his or her identity. This transformation includes a change in cognition, communication, and behavior towards the shared practices of a CoP and is based on a CoP-specific, socially shared learning history. These changes cannot merely be found in individual minds but also in the increased participation in CoP practices and tasks. Also, the relations between newcomers and more experienced members develop with the newcomers' engagement in the practices of a CoP practices.

Peripheral participation means an increase of newcomers' involvement, starting with rather passive activities in the beginning like observing how old-timers talk, interpret new situations, react to them, and deal with problems. Newcomers can take over simple and easily manageable tasks that do not require much knowledge about the CoP. Later, when newcomers have learned more, they can take over less peripheral and more complex tasks that require more responsibility and are more important to the CoP. One of the remarkable differences between LPPand learning in deliberately designed educational settings is the "design" of the curriculum. The curriculum in the LPP process is based on the practices and activities that occur in usual situations the CoP faces, but does not follow the steps an old-timer would follow to achieve a CoP goal (Lave & Wenger, 1991). Newcomers are only allowed to contribute to these activities of goal achievement that do not require more than they can accomplish because this would bare the danger for the whole CoP to fail their goal. This gives newcomers opportunities to actively participate in CoP life and get insight into its practices without having the role of a non-involved visitor. Newcomers have access to practices that are typically not explicated, like how individual members of the CoP interact with each other and with outsiders of the CoP..

The second important aspect of this kind of learning is the question of *legitimation* of newcomers' participation. Lave and Wenger (1991) assume that there are more or less strict entry criteria or barriers in each CoP. These entry criteria regulate newcomers' possibilities for learning. Only legitimate newcomers get access to community activities, information and resources and those are important for peripheral participation. Several case studies (for example Back, 2011; Fuller, Hodkinson, Hodkinson, & Unwin, 2005) have illustrated the relation between newcomers' legitimation in the CoP and their access to possibilities for peripheral participation. Members to whom the CoP does not grant access as legitimate members for some reason, cannot become more active participants. They form a special type of peripheral members, called marginalized members. Marginalization can have various reasons, most common are reasons related to the broader context of the group like hierarchies or positions in an organization that prevent that some persons can become members of a particular CoP. Certain characteristics, like gender, age, or ethnicity of marginalized persons can be other reasons for marginalization.

Lave and Wenger (1991) stated that the LPP process is dependent on how the resources that are important for newcomers' learning are structured in the community or how transparent the CoPs artifacts are. There is usually not much explicit teaching involved, but there can be masters, sponsors, and other newcomers who might help structure the learning process and make invisible artifacts a little more transparent. Communication plays therefore an important role for learning in CoPs, not only for transferring information but also to guide the attention of newcomers, engage them and coordinate collaboration. But according to the authors, most important for newcomers' learning are possibilities for participation. It can therefore be assumed that newcomer's exposure time to a CoP will play an important role for the learning process: The more time a newcomer can spend with CoP activities and other members of the CoP, the more opportunities for learning will arise. LPP should not be understood as "mere exposure effect" in which the amount of time spent in a CoP is the

only crucial factor for a newcomer's level of participation, as Lave and Wenger's examples of influencing factors show. They identify a research gap at that point wondering how the knowledge of CoPs can be made transparent to newcomers.

Research on Legitimate Peripheral Participation

Compared to the CoP concept, the LPP concept as the core element of the initial theory has been studied less intensively. However, it was applied to workplace learning and has proven to be a useful approach, for example in workplace learning of nurse teachers (Boyd & Lawley, 2009) and of police officers (Campbell, Verinikina, & Herrington, 2009). Researchers have also investigated, if online environments can be created to build CoPs for professionals in order to support newcomers to professions in which they usually have to work alone, for example coordinators of Canadian Community Adult Learning Councils (Gray, 2004), or teachers (Barab, MaKinster, & Scheckler, 2003).

Several researchers have found evidence for the importance of legitimacy and issues of power for LPP (e.g. Davies, 2005). The case study by Back (2011) on the LPP process of two newcomers in an Andean folkloric music band also supports the argument that legitimacy is the key to opportunities for learning. In this study, the cases of two band members were explored using ethnographic methods. Both newcomers had started with similar conditions regarding their experience as musicians and also their lack of speaking skills in the traditional Quichua language in which the band's music was performed. This language is closely related to the traditions of the long suppressed Otavalo culture, and it made a significant difference for the integration process of both members, to what extent they felt connected to this culture. Although both persons were willing to learn the language and to engage in the music business of the group, only the person who showed a personal connection to the Otavalo culture was fully integrated and granted access to opportunities for learning what was necessary for the CoP, namely the language, while the other person was marginalized.

Only little research has focused on the second part of the participative learning approach, the peripheral participation. An example of such a study is provided by Lambson (2010), who investigated the participative learning process of three newcomers in a CoP of literacy teachers who met regularly to discuss ideas about how to improve their teaching and to share classroom stories about teaching experiences. Legitimation was in this CoP never a problem for the three newcomers who were new teachers at the school. In the beginning, the two complete newcomers participated mostly passively and described feelings of insecurity because of their newcomer status, while the one who had already known the other teachers for some time, participated more actively. Over time, all of them showed more active forms of participation and reported that they felt more secure in their role as a teacher. Also changes in newcomers' talks was observed from mere reports of how they had designed the teaching in a class in the beginning towards a focus on students' reactions to the ways of teaching they tried.

In this CoP, also certain ways of facilitation of the LPP process were observed. The CoP had a leader who took care that every member was heard and often asked newcomers directly when she felt that they could contribute something. She engaged all members, including the newcomers, in conversations with herself and the rest of the community, shared her own experiences on questions relevant to newcomers, and provided access to relevant information and resources. This study points to the importance of the question of what exactly happens during peripheral participation. However, this question has attracted little attention so far and lacks systematic analysis.

Both studies are representative examples for current research on participative learning that focuses mostly on the epistemic parts of participative learning (newcomers' engagement in CoP practices) and only marginally explores the social aspects of the integration into a CoP.

Social Network Perspective on Learning as Participation

In the context of the LPP approach, process and outcome of learning are closely related, interdependent, and are necessary conditions for each other. There is no end of the learning process which would facilitate the measurement of a learning outcome. This is especially the case, because not only the individual person learns, but also the CoP as a whole develops during the learning processes of its individual members. For the learner in the CoP, learning is not only the acquisition of knowledge, but concerns identity. These conditions do hardly allow for applying "standard quantitative methodology" and we see that most research on CoPs and learning in CoPs is ethnographic and of qualitative nature so far and only few quantitative studies have been conducted (Nistor & Fischer, 2012). Another reason for the sparseness of quantitative methods on the topic might be that researchers have mostly focused on the epistemic/practice part of CoPs in their studies and practices are highly complex, often seemingly unique and require in-depths analyses. However, the social aspects of learning in CoPs is also very important within this concept and this aspects better allows for the use of quantitative measures.

A corresponding statement that relations between newcomers and old-timers in the CoP and their changes over time are central aspects of LPP, can also be found in the original book on LPP (Lave & Wenger, 1991, p. 59/60):

> "[...] learning as increasing participation in communities of practice concerns the whole person acting in the world. Conceiving of learning in terms of participation focuses attention on ways in which it is an evolving, continuously renewed set of relations; this is, of course, consistent with a relational view, of persons, their actions, and the world, typical of a theory of social practice."

On this background we suggest that SNA is suitable way for the investigation of LPP in CoPs, because it has the potential to extend our current knowledge on LPP in ways other methodological approaches cannot provide.

Social Network Theory as a Methodology to Analyze LPP in CoP

The basis of all social networks are relations between individuals, called ties. Individuals are usually persons, but can also be organizations or larger groups of persons. Two individuals in a social network can be linked by three different types of ties (Borgatti, Mehra, Brass, & Labianca, 2009). (1) a tie can be based on similarities; this can be being member of the same group or sharing an attribute. (2) a tie can be based on social roles within the social network; these roles can e.g. be based on forms of cohabitation like being friends or colleagues, but also based on affective (e.g. liking, or hating each other) or cognitive states (e.g. knowing something about someone). (3) a tie can be based on interactions between individuals, e.g. if two individuals talk to each other.

Additionally, ties can either be seen as absent, weak or strong (Granovetter, 1973). The strength of a tie between two individuals depends on the amount of time they spend with each other, the intensity of their emotional attachment, or the reciprocal services. Granovetter (1973) argues, and his hypotheses have been supported by empirical findings (e.g. Granovetter, 1983) that individuals live in close knit social networks with strong ties (like family and friends), which support them in many ways. However, individuals have also several weak ties (acquaintances), which are bridges to the otherwise unrelated close knit networks of the acquaintances. These weak ties can therefore have positive attributes that cannot be found in strong ties, a prominent example is the access to new information like job offers. Wenger (1998) states that CoPs are networks of strong ties (with a focus on the practice and not only on information flow). However, it can be assumed that many forms of strong ties have developed from weak ties.

The second element of social network theory (Borgatti, Mehra, Brass, & Labianca, 2009) is the importance of structure. Social network research revealed several underlying structures and rules which affect the development of human interaction. For a social network as a whole, social network theory provides evidence that not only the composition of the network regarding important attributes of its individual actors can explain its functioning, but that the relations between the individuals are of high importance; for instance team performance is not only subject to the skills and knowledge of the team members but to a high extent of the relations between the members and the way they interact with each other. For an individual, on the other hand, her position and embeddedness in a specific social network as well as the structure of the person's own social network are also of high importance and of a great predictive value.

Social network research is, furthermore, characterized by specific types of research questions that take ties between individuals and/or the structure of a social network into account, which distinguishes it from other types of research in the social sciences, and it focuses on specific varieties of networks in different contexts, which distinguishes SNA from network research in science. A typical set of research questions deals with the consequences of social network structures, trying to predict various kinds of outcomes leading them back to variances in the social network structures of groups. Another research focus is on the antecedents of network formation, mostly focusing on dyads. This research investigates for examples factors that can predict a dyad's likelihood to form a friendships tie (Borgatti, Mehra, Brass, & Labianca, 2009).

The usually underlying theoretical mechanisms of SNA are adaption, binding, and exclusion (Borgatti, Mehra, Brass, & Labianca, 2009). It is assumed that something relevant, such as knowledge, flows between the ties of a social network. This flow can either lead to adaption in form of convergence between the connected individuals, or to a binding which can be understood similar to a chemical binding in which two elements form a new entity when they connect. Exclusion as the third mechanism applies to situations in which the number of possible relations is restricted and the formation of one tie means that other ties cannot be formed.

Methodological Foundations of Social Networks

A social network consists of two elements: The individuals, which are in SNA termed as actors or nodes, and the relations that connect them, which are usually referred to as ties or edges (Scott, 2000). Analysis and presentation of social networks relies on the one hand on sociograms which visualize the social network using dots of various shapes to display the actors and lines or arrows as representations for ties. A social network is a

multidimensional object, with each additional actor requiring a further dimension, which makes visualization in two dimensions (or three at a maximum) a challenging task. Additionally, more complex mathematical approaches are used to satisfy the requirements of the multidimensional complexity of social networks. Matrix algebra and graph-theory form the basis for SNA (Borgatti, Mehra, Brass, & Labianca, 2009).

From a researcher's perspective, two forms of SNA are possible (Hatala, 2006). An *ego*-network is the social network of one particular actor. The main actor, called ego, is the center of the network and all actors to which ego has ties appear in that network. A *complete* network analysis, by contrast, focuses on the whole network consisting of a defined set of actors and the ties between all the actors are collected. A complete social network can be analyzed on three different levels (Hatala, 2006). (1) The level of the whole network allows describing its structure. Some of the most popular measures on that level are density or cohesion, which indicate if a network is dense or loose regarding the amount of ties between the actors. Another prominent measure is centralization, which describes the network's structure as more centralized with a clear core or as rather distributed. Also modularity is a relevant measure; it indicates if a network consists of many small clusters or if all members are evenly connected to each other.

(2) On the actor level, the situation of individual actors within the network can be analyzed. On that level, the most studied concept is centrality which measures the structural importance and prominence of an actor within a social network (Borgatti, Mehra, Brass, & Labianca, 2009). Degree centrality is the simplest centrality measures and is, in short, the sum of all ties of an actor. In larger networks, it can be relevant to distinguish between global degree centrality which is the sum of all ties an actor has in the whole network, and local degree centrality which indicates the actor's centrality between several clusters of the network (Hatala, 2006). Additionally, the measurement of the tie influences the computation of centrality. There are cases in which a tie is undirected, like actor A and actor B are in the same class, and so a simple measure of centrality can be computed, but the tie can also be directed which means it can be seen differently by actor A and B, like A gives information to B, but B does not give information to A. In this case, it is necessary to distinguish between indegree-centrality and outdegree-centrality. Indegree-centrality is based on the amount of ties that are directed towards an actor, whereas outdegree-centrality is based on the amount of ties that are direct from the actor to the others. Also others, more complex measures for centrality were developed like betweenness centrality which is not only based on an actor's direct ties, but also the indirect ties that an actors has over the actors to whom she is connected (Scott, 2000). Closeness-centrality, as a further measure, is even more complex. It measures an actor's closeness to all other actors in the network (Freeman, 1979). However, degree centrality is the most common centrality measure and it allows for a more straight forward interpretation than the other centrality measures.

(3) The third level for SNA is the tie-level which usually deals with dyads and how two actors are related. For each dyad can be said, if a certain type of relation is present or not. Sometimes, it is also useful to have not yes or no outcome for a relation, but a valued relation which represents the intensity of the relation. For example, it can be asked if two persons had talked to each other, and also how long or how often they had talked to each other.

With the emergence of online social networks sites, the awareness of people about their own social network increases. Also research on social network can increase participants' awareness on their social network. Borgatti and colleagues (2009) see this as similar to the Heisenberg uncertainty principle of which researchers should be aware. However, this effect provides also potential for constructive use, when network visualizations are used to enhance actors' awareness of the structure or risky positions of individual actors in the social network, and provides possibilities to intervene. The work of Yoon (2011) builds on that idea.

As we argued before, participative learning in the form of LPP can be understood as an increase of newcomers' participation within a social network. Therefore, the social network as a whole is not as relevant, as the person-level and the tie-level are for the investigation of learning. On the person-level, one of the most used indicators is centrality, a measure, which is also relevant for studying participative learning. Centrality measures to what extent an individual is related to other persons in the network. So, successful LPP can be operationalized as an increase of newcomer's centrality. But also the tie-level can be relevant, to study which factors have influence of a tie's probability to turn into a certain type of relation.

Examples of Applied Social Network Analysis to Study Learning

In the Learning Sciences SNA is not yet a standard approach, but also not unknown. Some studies can be found that are based on this methodology. CSCL, for example, has been studied in formal settings using SNA approaches. Nurmela, Lethinen, and Palonen (1999), for instance, applied a social network approach in a study on students who participated in a university course on educational psychology and worked on a learning platform. The students worked in dyads for a semester and had to complete weekly assignments. The online learning environment allowed the joint writing of assignment texts and commenting to texts of other students' assignment texts. A tutor encouraged interaction across the student dyads. SNA was used to analyze logfiles of the joint writing process and the interaction of students via the commenting tool. The social network approach

provided a way to display the interaction of students in a structured way, to identify central actors in the commenting process, to show inequalities between the dyads and to identify the key documents of joint engagement in the commenting process.

Another social network study on CSCL by Reffai and Chanier (2000) investigated cohesion in a large scale distance-learning course on French as a foreign language. Cohesion, in the sense of regular participation and commitment to the class, is considered as highly important for collaborative learning as it is the basis for the learners' motivation and ability to benefit from the teaching approach. Similar to the study by Nurmela and colleagues (1999), social network measures were applied to make the complex communication in the virtual learning platform visible, finding cliques as well as central or isolated students in the discussions. Reffai and Chanier (2000) conclude that such measures can be very useful for tutors and lecturers to monitor the complex communication and a monitoring tool based on SNA would be a helpful tool.

In contrast to formal learning settings, SNA has rarely been applied in informal settings to study learning. As we argued, especially for these settings and when studying learning as participation, SNA has high potential to push research forward. To illustrate this kind of research, we will describe two studies we conducted with the aim to bring further our understanding of learning as participation by focusing on the social aspects of this approach.

Using SNA to Study the Role of Integration Tactics on Newcomers Participation

As our review of research on legitimate peripheral participation has shown, the role of old-timers facilitation of the LPP process has rarely been explored although scattered findings indicate its importance. Therefore, we conducted a study with the goal to investigate how old-timers of CoPs structure the participative learning process of newcomers (Eberle, Stegmann, & Fischer, 2014).

Our sample consisted of the members of 14 faculty student councils, which are CoPs of university students at one particular faculty sharing the goal to improve student life and education from the student perspective. We implemented a mixed-method approach including SNA to tackle the question. To capture how old-timers' facilitate and influence the participative learning process of newcomers in their CoP, we interviewed an experienced member of each CoP and extracted several distinct integration strategies using qualitative content analysis. We then assigned a quantified value for the use of each of the integration strategies within the individual CoPs to allow for a regression analysis to explore the relation of these integration tactics to the state of participative learning in the newcomers of the CoPs.

SNA methodology was applied to identify newcomers' states of participative learning. We asked all members to fill a social network questionnaire and to indicate on a Likert-scale for each of the other members to what extent they had collaborated with them during the last three months. We received a collaboration network with valued ties for each of the CoPs and decided to take the indegree-centrality measure of the newcomers as indicator for their state of participative learning, taking only the ratings of old-timers into account. We opted for a degree-centrality measure as its interpretation is the easiest compared to other centrality measures. The decision for using the indegree-centrality was based on the finding that old-timers rated much more conservative then newcomers who probably lacked the experience to estimate the intensity collaboration can have in the particular CoP as it is perceived by experienced members.

HLM models based on our measures for integration tactics of the CoPs and individual states of participative learning of their newcomers showed that certain tactics (especially the tactic to make specific community knowledge accessible to the newcomers) seem to be influential during the LPP process of newcomers across several CoPs. Our focus on the social aspects of LPP using SNA gave as the possibility to investigate LPP across the very specific individual conditions in CoPs which would have hardly been possible if we had focused on epistemic aspects like identifying newcomers' use of certain CoP specific practices. In this study, SNA was the key to go beyond case studies within one CoP and to make comparison between participative learning processes in different CoPs possible.

Using SNA to Study the Role of Integration Tactics on Newcomers Participation

In our second study (Eberle et al., 2013), we wanted to explore if the most promising integration tactic we found in faculty student councils is also influential in another type of CoP and investigate the detailed effects of this tactic more in depth. The integration tactic we looked at was the provision of access to community knowledge which can be implemented in several ways from written information to oral instructions, and from information about community practices to information about individual community members.

We set up a quasi-experimental study in a scientific community and studied the differences that occurred between members who had received supportive access to community knowledge and those who did not receive this support measure during a scientific event. Our support measure was a brochure with information about the other members.

This study was solely based on an SNA approach and several ways of data collection about the social network structure and ties between individuals were implemented: (1) we tracked the interaction between the

CoP members during the scientific event using RFID devices that captured who interacted with whom, (2) we distributed SNA questionnaires asking the members with whom they had collaborated before the event and with whom they planned to collaborate afterwards, and (3) we run a google scholar search 1.5 years after the event to identify coauthored publications. The analysis focused on the emerging ties between the members and revealed that our intervention had an influence on the interactions between members at the event with those in the group who received access to community knowledge interacting with less other members than those without access to community knowledge, leaving more time for longer interactions; longer interaction times, furthermore, lead to a higher probability of identifying potential for future collaboration.

Our SNA based study design allowed for a very detailed data collection of occurring collaboration and interaction that would not have been possible with traditional approaches like video studies. We were able to follow the participants' behavior during a 4 day period during the whole day and in a wide locational range without disturbing or hindering spontaneously occurring interaction. Through the combination of the behavioral measures for interaction and the SNA questionnaire, we were able to capture natural interaction behavior as well as the individuals' interpretations of these interactions had for the observed persons. We were even able to identify to what extent intended behavior had culminated in productivity and the production of artifacts that are of high value for the particular community. The triangulation of these different aspects of embeddedness in the social structures of the CoP allowed us to identify the current state of a person within the CoP in a sophisticated multi-facetted way.

Conclusions

We have argued that research based on the metaphor of learning as participation, which is closely related to the approach of LPP in CoPs, has so far focused mostly on the development an re-instantiations of practices – which can be seen as the epistemic aspect of participative learning. We suggest taking the social aspects, namely the integration of newcomers into the social network of a CoP more into account. From a methodological perspective, the two studies we presented on learning as participation using an SNA approach are rare cases of quantitative research in the field of learning in CoPs (Nistor & Fischer, 2012). Case studies are so far the dominant research method for participative learning in CoPs. An important reason for that probably is that each CoP is a complex and distinct constellation of factors; some practices are only relevant in that specific CoP and also the way how members mutually engage do differ remarkably between CoP. Therefore, it is a critical question to what extent findings from one CoP can be transferred to another or if these results are only valid for the specific context. However, learning has always be seen as a complex process with important individual and contextual influences, no matter under which paradigm it is investigated. It is a main characteristic of quantitative research that it aims at identifying re-occuring and hence maybe generalizable patterns that are valid across individual and contextual characteristics. Such general patterns are still missing in research on participative learning in CoPs. In contrast to this, the use of SNA that allows for research across individual CoPs can also show which aspects are indeed specific for certain CoPs and cannot be transferred. At the moment, we just have a scattered body of research that neither allows for conclusions about CoPs and participative learning in general, nor for the argumentation that findings are specific to certain CoPs or types of CoPs. Instead, the accumulated body of research is very diverse and full of different understandings of the core concept. After more than 30 years of research in this field, it seems not too early to explore the concepts also more systematically including also quantitative means.

Taking a look at the social aspects of participative learning instead of only on the epistemic aspects seems to be a promising approach in this direction. Means of SNA have turned out to be a promising approach for this endeavor. The focus on social aspects identified by applying means of SNA allow for comparison across specific epistemic settings and individual cases. It allows research in so far under-investigated areas of learning, especially in informal learning settings that can hardly be approached using traditional methodology because it is impossible to predict when and where informal learning opportunities occur and what they will be about. Developing technological means like the use of RFID devices attached to individuals in physically co-present communities allow new approaches to collect data in these areas that have mostly been "un-researchable" until now. Also developments in data analysis methods, like dynamic SNA and other means of capturing network evolution, allow for new research questions and extension of the current focus. The combination of newly developing and more traditional methods like questionnaires and interviews seems especially promising, as it not only allows for capturing different types of data but also for triangulating and validating these data.

However, only very few of the possibilities that SNA theory and methods offers have been applied in the Learning Sciences so far. Not only research on learning on CoPs could benefit from SNA, disciplines like education and the learning sciences have not yet identified the full potential of this approach for the understanding learning and social factors related to education. However, the most beneficial step would be to integrate both perspectives, the epistemic and the social perspective for further investigation of learning under the participation metaphor, by looking at emerging and changing practices in communities in relation to the emerging and dynamically changing participation processes of individuals and groups of individuals.

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